

# KubiSat Firmware

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<b>1 Clock Commands</b>	<b>1</b>
<b>2 Topic Index</b>	<b>3</b>
2.1 Topics . . . . .	3
<b>3 Hierarchical Index</b>	<b>5</b>
3.1 Class Hierarchy . . . . .	5
<b>4 Class Index</b>	<b>7</b>
4.1 Class List . . . . .	7
<b>5 File Index</b>	<b>9</b>
5.1 File List . . . . .	9
<b>6 Topic Documentation</b>	<b>11</b>
6.1 Clock Management Commands . . . . .	11
6.1.1 Detailed Description . . . . .	11
6.1.2 Function Documentation . . . . .	11
6.1.2.1 handle_time() . . . . .	11
6.1.2.2 handle_timezone_offset() . . . . .	12
6.1.2.3 handle_clock_sync_interval() . . . . .	13
6.1.2.4 handle_get_last_sync_time() . . . . .	14
6.1.3 Variable Documentation . . . . .	14
6.1.3.1 systemClock . . . . .	14
6.2 Command System . . . . .	14
6.2.1 Detailed Description . . . . .	15
6.2.2 Typedef Documentation . . . . .	15
6.2.2.1 CommandHandler . . . . .	15
6.2.2.2 CommandMap . . . . .	15
6.2.3 Function Documentation . . . . .	15
6.2.3.1 execute_command() . . . . .	15
6.2.4 Variable Documentation . . . . .	16
6.2.4.1 commandHandlers . . . . .	16
6.3 Diagnostic Commands . . . . .	17
6.3.1 Detailed Description . . . . .	17
6.3.2 Function Documentation . . . . .	17
6.3.2.1 handle_get_commands_list() . . . . .	17
6.3.2.2 handle_get_build_version() . . . . .	18
6.3.2.3 handle_verbosity() . . . . .	19
6.3.2.4 handle_enter_bootloader_mode() . . . . .	20
6.4 Event Commands . . . . .	21
6.4.1 Detailed Description . . . . .	21
6.4.2 Function Documentation . . . . .	21
6.4.2.1 handle_get_last_events() . . . . .	21

---

6.4.2.2 handle_get_event_count()	22
6.5 GPS Commands	23
6.5.1 Detailed Description	23
6.5.2 Function Documentation	23
6.5.2.1 handle_gps_power_status()	23
6.5.2.2 handle_enable_gps_uart_passthrough()	24
6.5.2.3 handle_get_rmc_data()	25
6.5.2.4 handle_get_gga_data()	26
6.6 Power Commands	27
6.6.1 Detailed Description	27
6.6.2 Function Documentation	27
6.6.2.1 handle_get_power_manager_ids()	27
6.6.2.2 handle_get_voltage_battery()	28
6.6.2.3 handle_get_voltage_5v()	29
6.6.2.4 handle_get_current_charge_usb()	29
6.6.2.5 handle_get_current_charge_solar()	30
6.6.2.6 handle_get_current_charge_total()	31
6.6.2.7 handle_get_current_draw()	32
6.7 Storage Commands	33
6.7.1 Detailed Description	33
6.7.2 Function Documentation	33
6.7.2.1 handle_file_download()	33
6.7.2.2 handle_list_files()	34
6.7.2.3 handle_mount()	35
6.8 Frame Handling	36
6.8.1 Detailed Description	36
6.8.2 Function Documentation	36
6.8.2.1 frame_encode()	36
6.8.2.2 frame_decode()	37
6.8.2.3 frame_process()	38
6.8.2.4 frame_build()	39
6.9 Event Manager	41
6.9.1 Detailed Description	43
6.9.2 Enumeration Type Documentation	43
6.9.2.1 EventGroup	43
6.9.2.2 SystemEvent	44
6.9.2.3 PowerEvent	44
6.9.2.4 CommsEvent	44
6.9.2.5 GPSEvent	45
6.9.2.6 ClockEvent	45
6.9.3 Function Documentation	45
6.9.3.1 check_power_events()	45

---

6.9.3.2 __attribute__()	46
6.9.3.3 log_event()	46
6.9.3.4 get_event()	47
6.9.4 Variable Documentation	48
6.9.4.1 eventLogId	48
6.9.4.2 lastPowerState	48
6.9.4.3 FALL_RATE_THRESHOLD	48
6.9.4.4 FALLING_TREND_REQUIRED	48
6.9.4.5 VOLTAGE_LOW_THRESHOLD	48
6.9.4.6 VOLTAGE_OVERCHARGE_THRESHOLD	48
6.9.4.7 fallingTrendCount	49
6.9.4.8 lastSolarState	49
6.9.4.9 lastUSBState	49
6.9.4.10 systemClock	49
6.9.4.11 eventManager [1/2]	49
6.9.4.12 __attribute__	49
6.9.4.13 eventManager [2/2]	50
6.10 INA3221 Power Monitor	50
6.10.1 Detailed Description	50
6.10.2 Configuration Functions	50
6.10.2.1 Detailed Description	51
6.10.2.2 Function Documentation	51
6.10.3 Measurement Functions	60
6.10.3.1 Detailed Description	60
6.10.3.2 Function Documentation	60
6.10.4 Alert Functions	62
6.10.4.1 Detailed Description	63
6.10.4.2 Function Documentation	63
<b>7 Class Documentation</b>	<b>69</b>
7.1 BH1750 Class Reference	69
7.1.1 Detailed Description	69
7.1.2 Member Enumeration Documentation	69
7.1.2.1 Mode	69
7.1.3 Constructor & Destructor Documentation	70
7.1.3.1 BH1750()	70
7.1.4 Member Function Documentation	70
7.1.4.1 begin()	70
7.1.4.2 configure()	71
7.1.4.3 get_light_level()	71
7.1.4.4 write8()	71
7.1.5 Member Data Documentation	72

7.1.5.1 _i2c_addr . . . . .	72
7.2 BH1750Wrapper Class Reference . . . . .	72
7.2.1 Detailed Description . . . . .	73
7.2.2 Constructor & Destructor Documentation . . . . .	73
7.2.2.1 BH1750Wrapper() . . . . .	73
7.2.3 Member Function Documentation . . . . .	73
7.2.3.1 get_i2c_addr() . . . . .	73
7.2.3.2 init() . . . . .	73
7.2.3.3 read_data() . . . . .	74
7.2.3.4 is_initialized() . . . . .	74
7.2.3.5 get_type() . . . . .	74
7.2.3.6 configure() . . . . .	74
7.2.4 Member Data Documentation . . . . .	74
7.2.4.1 sensor_ . . . . .	74
7.2.4.2 initialized_ . . . . .	74
7.3 BME280 Class Reference . . . . .	75
7.3.1 Detailed Description . . . . .	76
7.3.2 Constructor & Destructor Documentation . . . . .	76
7.3.2.1 BME280() . . . . .	76
7.3.3 Member Function Documentation . . . . .	77
7.3.3.1 init() . . . . .	77
7.3.3.2 reset() . . . . .	77
7.3.3.3 read_raw_all() . . . . .	77
7.3.3.4 convert_temperature() . . . . .	77
7.3.3.5 convert_pressure() . . . . .	77
7.3.3.6 convert_humidity() . . . . .	78
7.3.3.7 configure_sensor() . . . . .	78
7.3.3.8 get_calibration_parameters() . . . . .	78
7.3.4 Member Data Documentation . . . . .	78
7.3.4.1 ADDR_SDO_LOW . . . . .	78
7.3.4.2 ADDR_SDO_HIGH . . . . .	79
7.3.4.3 i2c_port . . . . .	79
7.3.4.4 device_addr . . . . .	79
7.3.4.5 calib_params . . . . .	79
7.3.4.6 initialized_ . . . . .	79
7.3.4.7 t_fine . . . . .	79
7.3.4.8 REG_CONFIG . . . . .	79
7.3.4.9 REG_CTRL_MEAS . . . . .	79
7.3.4.10 REG_CTRL_HUM . . . . .	80
7.3.4.11 REG_RESET . . . . .	80
7.3.4.12 REG_PRESSURE_MSB . . . . .	80
7.3.4.13 REG_TEMPERATURE_MSB . . . . .	80

---

7.3.4.14 REG_HUMIDITY_MSB . . . . .	80
7.3.4.15 REG_DIG_T1_LSB . . . . .	80
7.3.4.16 REG_DIG_T1_MSB . . . . .	80
7.3.4.17 REG_DIG_T2_LSB . . . . .	80
7.3.4.18 REG_DIG_T2_MSB . . . . .	81
7.3.4.19 REG_DIG_T3_LSB . . . . .	81
7.3.4.20 REG_DIG_T3_MSB . . . . .	81
7.3.4.21 REG_DIG_P1_LSB . . . . .	81
7.3.4.22 REG_DIG_P1_MSB . . . . .	81
7.3.4.23 REG_DIG_P2_LSB . . . . .	81
7.3.4.24 REG_DIG_P2_MSB . . . . .	81
7.3.4.25 REG_DIG_P3_LSB . . . . .	81
7.3.4.26 REG_DIG_P3_MSB . . . . .	82
7.3.4.27 REG_DIG_P4_LSB . . . . .	82
7.3.4.28 REG_DIG_P4_MSB . . . . .	82
7.3.4.29 REG_DIG_P5_LSB . . . . .	82
7.3.4.30 REG_DIG_P5_MSB . . . . .	82
7.3.4.31 REG_DIG_P6_LSB . . . . .	82
7.3.4.32 REG_DIG_P6_MSB . . . . .	82
7.3.4.33 REG_DIG_P7_LSB . . . . .	82
7.3.4.34 REG_DIG_P7_MSB . . . . .	83
7.3.4.35 REG_DIG_P8_LSB . . . . .	83
7.3.4.36 REG_DIG_P8_MSB . . . . .	83
7.3.4.37 REG_DIG_P9_LSB . . . . .	83
7.3.4.38 REG_DIG_P9_MSB . . . . .	83
7.3.4.39 REG_DIG_H1 . . . . .	83
7.3.4.40 REG_DIG_H2 . . . . .	83
7.3.4.41 REG_DIG_H3 . . . . .	83
7.3.4.42 REG_DIG_H4 . . . . .	84
7.3.4.43 REG_DIG_H5 . . . . .	84
7.3.4.44 REG_DIG_H6 . . . . .	84
7.3.4.45 NUM_CALIB_PARAMS . . . . .	84
7.4 BME280CalibParam Struct Reference . . . . .	84
7.4.1 Detailed Description . . . . .	85
7.4.2 Member Data Documentation . . . . .	85
7.4.2.1 dig_t1 . . . . .	85
7.4.2.2 dig_t2 . . . . .	85
7.4.2.3 dig_t3 . . . . .	85
7.4.2.4 dig_p1 . . . . .	85
7.4.2.5 dig_p2 . . . . .	85
7.4.2.6 dig_p3 . . . . .	85
7.4.2.7 dig_p4 . . . . .	86

7.4.2.8 dig_p5 . . . . .	86
7.4.2.9 dig_p6 . . . . .	86
7.4.2.10 dig_p7 . . . . .	86
7.4.2.11 dig_p8 . . . . .	86
7.4.2.12 dig_p9 . . . . .	86
7.4.2.13 dig_h1 . . . . .	86
7.4.2.14 dig_h2 . . . . .	86
7.4.2.15 dig_h3 . . . . .	87
7.4.2.16 dig_h4 . . . . .	87
7.4.2.17 dig_h5 . . . . .	87
7.4.2.18 dig_h6 . . . . .	87
7.5 BME280Wrapper Class Reference . . . . .	87
7.5.1 Detailed Description . . . . .	88
7.5.2 Constructor & Destructor Documentation . . . . .	88
7.5.2.1 BME280Wrapper() . . . . .	88
7.5.3 Member Function Documentation . . . . .	89
7.5.3.1 init() . . . . .	89
7.5.3.2 read_data() . . . . .	89
7.5.3.3 is_initialized() . . . . .	89
7.5.3.4 get_type() . . . . .	89
7.5.3.5 configure() . . . . .	89
7.5.4 Member Data Documentation . . . . .	89
7.5.4.1 sensor_ . . . . .	89
7.5.4.2 initialized_ . . . . .	90
7.6 INA3221::conf_reg_t Struct Reference . . . . .	90
7.6.1 Detailed Description . . . . .	90
7.6.2 Member Data Documentation . . . . .	90
7.6.2.1 mode_shunt_en . . . . .	90
7.6.2.2 mode_bus_en . . . . .	90
7.6.2.3 mode_continious_en . . . . .	91
7.6.2.4 shunt_conv_time . . . . .	91
7.6.2.5 bus_conv_time . . . . .	91
7.6.2.6 avg_mode . . . . .	91
7.6.2.7 ch3_en . . . . .	91
7.6.2.8 ch2_en . . . . .	91
7.6.2.9 ch1_en . . . . .	91
7.6.2.10 reset . . . . .	92
7.7 DS3231 Class Reference . . . . .	92
7.7.1 Detailed Description . . . . .	92
7.7.2 Constructor & Destructor Documentation . . . . .	93
7.7.2.1 DS3231() . . . . .	93
7.7.3 Member Function Documentation . . . . .	93

7.7.3.1 <code>set_time()</code>	93
7.7.3.2 <code>get_time()</code>	94
7.7.3.3 <code>read_temperature()</code>	94
7.7.3.4 <code>set_unix_time()</code>	95
7.7.3.5 <code>get_unix_time()</code>	95
7.7.3.6 <code>clock_enable()</code>	95
7.7.3.7 <code>i2c_read_reg()</code>	96
7.7.3.8 <code>i2c_write_reg()</code>	97
7.7.3.9 <code>bin_to_bcd()</code>	97
7.7.3.10 <code>bcd_to_bin()</code>	98
7.7.4 Member Data Documentation	99
7.7.4.1 <code>i2c</code>	99
7.7.4.2 <code>ds3231_addr</code>	99
7.7.4.3 <code>clock_mutex</code>	99
7.8 <code>ds3231_data_t</code> Struct Reference	99
7.8.1 Detailed Description	99
7.8.2 Member Data Documentation	100
7.8.2.1 <code>seconds</code>	100
7.8.2.2 <code>minutes</code>	100
7.8.2.3 <code>hours</code>	100
7.8.2.4 <code>day</code>	100
7.8.2.5 <code>date</code>	100
7.8.2.6 <code>month</code>	100
7.8.2.7 <code>year</code>	100
7.8.2.8 <code>century</code>	101
7.9 <code>EventEmitter</code> Class Reference	101
7.9.1 Detailed Description	101
7.9.2 Member Function Documentation	101
7.9.2.1 <code>emit()</code>	101
7.10 <code>EventLog</code> Class Reference	102
7.10.1 Detailed Description	103
7.10.2 Member Function Documentation	103
7.10.2.1 <code>to_string()</code>	103
7.10.3 Member Data Documentation	103
7.10.3.1 <code>id</code>	103
7.10.3.2 <code>timestamp</code>	103
7.10.3.3 <code>group</code>	104
7.10.3.4 <code>event</code>	104
7.11 <code>EventManager</code> Class Reference	104
7.11.1 Detailed Description	105
7.11.2 Constructor & Destructor Documentation	105
7.11.2.1 <code>EventManager()</code>	105

7.11.2.2 ~EventManager() . . . . .	106
7.11.3 Member Function Documentation . . . . .	106
7.11.3.1 init() . . . . .	106
7.11.3.2 get_event_count() . . . . .	106
7.11.3.3 save_to_storage() . . . . .	107
7.11.3.4 load_from_storage() . . . . .	107
7.11.4 Member Data Documentation . . . . .	107
7.11.4.1 events . . . . .	107
7.11.4.2 eventCount . . . . .	108
7.11.4.3 writeIndex . . . . .	108
7.11.4.4 eventMutex . . . . .	108
7.11.4.5 nextEventId . . . . .	108
7.11.4.6 needsPersistence . . . . .	108
7.12 EventManagerImpl Class Reference . . . . .	109
7.12.1 Detailed Description . . . . .	110
7.12.2 Constructor & Destructor Documentation . . . . .	110
7.12.2.1 EventManagerImpl() . . . . .	110
7.12.3 Member Function Documentation . . . . .	111
7.12.3.1 save_to_storage() . . . . .	111
7.12.3.2 load_from_storage() . . . . .	111
7.13 FileHandle Struct Reference . . . . .	112
7.13.1 Detailed Description . . . . .	112
7.13.2 Member Data Documentation . . . . .	112
7.13.2.1 fd . . . . .	112
7.13.2.2 is_open . . . . .	112
7.14 Frame Struct Reference . . . . .	112
7.14.1 Detailed Description . . . . .	113
7.14.2 Member Data Documentation . . . . .	114
7.14.2.1 header . . . . .	114
7.14.2.2 direction . . . . .	114
7.14.2.3 operationType . . . . .	114
7.14.2.4 group . . . . .	114
7.14.2.5 command . . . . .	114
7.14.2.6 value . . . . .	114
7.14.2.7 unit . . . . .	114
7.14.2.8 footer . . . . .	115
7.15 HMC5883L Class Reference . . . . .	115
7.15.1 Detailed Description . . . . .	115
7.15.2 Constructor & Destructor Documentation . . . . .	115
7.15.2.1 HMC5883L() . . . . .	115
7.15.3 Member Function Documentation . . . . .	116
7.15.3.1 init() . . . . .	116

---

7.15.3.2 <code>read()</code>	116
7.15.3.3 <code>write_register()</code>	116
7.15.3.4 <code>read_register()</code>	117
7.15.4 Member Data Documentation	117
7.15.4.1 <code>i2c</code>	117
7.15.4.2 <code>address</code>	117
7.16 HMC5883LWrapper Class Reference	118
7.16.1 Detailed Description	119
7.16.2 Constructor & Destructor Documentation	119
7.16.2.1 <code>HMC5883LWrapper()</code>	119
7.16.3 Member Function Documentation	119
7.16.3.1 <code>init()</code>	119
7.16.3.2 <code>read_data()</code>	119
7.16.3.3 <code>is_initialized()</code>	119
7.16.3.4 <code>get_type()</code>	120
7.16.3.5 <code>configure()</code>	120
7.16.4 Member Data Documentation	120
7.16.4.1 <code>sensor_</code>	120
7.16.4.2 <code>initialized_</code>	120
7.17 INA3221 Class Reference	120
7.17.1 Detailed Description	122
7.17.2 Member Function Documentation	122
7.17.2.1 <code>_read()</code>	122
7.17.2.2 <code>_write()</code>	124
7.17.2.3 <code>get_current()</code>	125
7.17.3 Member Data Documentation	126
7.17.3.1 <code>_i2c</code>	126
7.17.3.2 <code>_i2c_addr</code>	126
7.17.3.3 <code>_shuntRes</code>	126
7.17.3.4 <code>_filterRes</code>	126
7.17.3.5 <code>_masken_reg</code>	126
7.18 ISensor Class Reference	126
7.18.1 Detailed Description	127
7.18.2 Constructor & Destructor Documentation	127
7.18.2.1 <code>~ISensor()</code>	127
7.18.3 Member Function Documentation	127
7.18.3.1 <code>init()</code>	127
7.18.3.2 <code>read_data()</code>	127
7.18.3.3 <code>is_initialized()</code>	127
7.18.3.4 <code>get_type()</code>	127
7.18.3.5 <code>configure()</code>	128
7.19 <code>INA3221::masken_reg_t</code> Struct Reference	128

---

7.19.1 Detailed Description . . . . .	128
7.19.2 Member Data Documentation . . . . .	128
7.19.2.1 conv_ready . . . . .	128
7.19.2.2 timing_ctrl_alert . . . . .	129
7.19.2.3 pwr_valid_alert . . . . .	129
7.19.2.4 warn_alert_ch3 . . . . .	129
7.19.2.5 warn_alert_ch2 . . . . .	129
7.19.2.6 warn_alert_ch1 . . . . .	129
7.19.2.7 shunt_sum_alert . . . . .	129
7.19.2.8 crit_alert_ch3 . . . . .	129
7.19.2.9 crit_alert_ch2 . . . . .	129
7.19.2.10 crit_alert_ch1 . . . . .	130
7.19.2.11 crit_alert_latch_en . . . . .	130
7.19.2.12 warn_alert_latch_en . . . . .	130
7.19.2.13 shunt_sum_en_ch3 . . . . .	130
7.19.2.14 shunt_sum_en_ch2 . . . . .	130
7.19.2.15 shunt_sum_en_ch1 . . . . .	130
7.19.2.16 reserved . . . . .	130
7.20 MPU6050Wrapper Class Reference . . . . .	131
7.20.1 Detailed Description . . . . .	132
7.20.2 Constructor & Destructor Documentation . . . . .	132
7.20.2.1 MPU6050Wrapper() . . . . .	132
7.20.3 Member Function Documentation . . . . .	132
7.20.3.1 init() . . . . .	132
7.20.3.2 read_data() . . . . .	132
7.20.3.3 is_initialized() . . . . .	132
7.20.3.4 get_type() . . . . .	132
7.20.3.5 configure() . . . . .	133
7.20.4 Member Data Documentation . . . . .	133
7.20.4.1 sensor_ . . . . .	133
7.20.4.2 initialized_ . . . . .	133
7.21 NMEAData Class Reference . . . . .	133
7.21.1 Detailed Description . . . . .	133
7.21.2 Constructor & Destructor Documentation . . . . .	134
7.21.2.1 NMEAData() . . . . .	134
7.21.3 Member Function Documentation . . . . .	134
7.21.3.1 update_rmc_tokens() . . . . .	134
7.21.3.2 update_gga_tokens() . . . . .	134
7.21.3.3 get_rmc_tokens() . . . . .	134
7.21.3.4 get_gga_tokens() . . . . .	134
7.21.4 Member Data Documentation . . . . .	134
7.21.4.1 rmc_tokens_ . . . . .	134

---

7.21.4.2 gga_tokens_ . . . . .	135
7.21.4.3 rmc_mutex_ . . . . .	135
7.21.4.4 gga_mutex_ . . . . .	135
7.22 PowerManager Class Reference . . . . .	135
7.22.1 Detailed Description . . . . .	136
7.22.2 Constructor & Destructor Documentation . . . . .	136
7.22.2.1 PowerManager() . . . . .	136
7.22.3 Member Function Documentation . . . . .	137
7.22.3.1 initialize() . . . . .	137
7.22.3.2 read_device_ids() . . . . .	137
7.22.3.3 get_current_charge_solar() . . . . .	137
7.22.3.4 get_current_charge_usb() . . . . .	137
7.22.3.5 get_current_charge_total() . . . . .	137
7.22.3.6 get_current_draw() . . . . .	138
7.22.3.7 get_voltage_battery() . . . . .	138
7.22.3.8 get_voltage_5v() . . . . .	138
7.22.3.9 configure() . . . . .	138
7.22.3.10 is_charging_solar() . . . . .	138
7.22.3.11 is_charging_usb() . . . . .	139
7.22.3.12 check_power_alerts() . . . . .	139
7.22.4 Member Data Documentation . . . . .	140
7.22.4.1 SOLAR_CURRENT_THRESHOLD . . . . .	140
7.22.4.2 USB_CURRENT_THRESHOLD . . . . .	140
7.22.4.3 VOLTAGE_LOW_THRESHOLD . . . . .	140
7.22.4.4 VOLTAGE_OVERCHARGE_THRESHOLD . . . . .	140
7.22.4.5 FALL_RATE_THRESHOLD . . . . .	140
7.22.4.6 FALLING_TREND_REQUIRED . . . . .	140
7.22.4.7 ina3221_ . . . . .	140
7.22.4.8 initialized_ . . . . .	141
7.22.4.9 powerman_mutex_ . . . . .	141
7.22.4.10 charging_solar_active_ . . . . .	141
7.22.4.11 charging_usb_active_ . . . . .	141
7.23 SensorWrapper Class Reference . . . . .	141
7.23.1 Detailed Description . . . . .	142
7.23.2 Constructor & Destructor Documentation . . . . .	142
7.23.2.1 SensorWrapper() . . . . .	142
7.23.3 Member Function Documentation . . . . .	143
7.23.3.1 get_instance() . . . . .	143
7.23.3.2 sensor_init() . . . . .	143
7.23.3.3 sensor_configure() . . . . .	143
7.23.3.4 sensor_read_data() . . . . .	144
7.23.4 Member Data Documentation . . . . .	144

---

7.23.4.1 sensors . . . . .	144
<b>8 File Documentation</b>	<b>145</b>
8.1 build_number.h File Reference . . . . .	145
8.1.1 Macro Definition Documentation . . . . .	145
8.1.1.1 BUILD_NUMBER . . . . .	145
8.2 build_number.h . . . . .	145
8.3 includes.h File Reference . . . . .	146
8.4 includes.h . . . . .	147
8.5 lib/clock/DS3231.cpp File Reference . . . . .	147
8.6 DS3231.cpp . . . . .	147
8.7 lib/clock/DS3231.h File Reference . . . . .	151
8.7.1 Macro Definition Documentation . . . . .	152
8.7.1.1 DS3231_DEVICE_ADDRESS . . . . .	152
8.7.1.2 DS3231_SECONDS_REG . . . . .	152
8.7.1.3 DS3231_MINUTES_REG . . . . .	152
8.7.1.4 DS3231_HOURS_REG . . . . .	152
8.7.1.5 DS3231_DAY_REG . . . . .	152
8.7.1.6 DS3231_DATE_REG . . . . .	152
8.7.1.7 DS3231_MONTH_REG . . . . .	153
8.7.1.8 DS3231_YEAR_REG . . . . .	153
8.7.1.9 DS3231_CONTROL_REG . . . . .	153
8.7.1.10 DS3231_CONTROL_STATUS_REG . . . . .	153
8.7.1.11 DS3231_TEMPERATURE_MSB_REG . . . . .	153
8.7.1.12 DS3231_TEMPERATURE_LSB_REG . . . . .	153
8.7.2 Enumeration Type Documentation . . . . .	153
8.7.2.1 days_of_week . . . . .	153
8.8 DS3231.h . . . . .	154
8.9 lib/comms/commands/clock_commands.cpp File Reference . . . . .	154
8.9.1 Macro Definition Documentation . . . . .	155
8.9.1.1 CLOCK_GROUP . . . . .	155
8.9.1.2 TIME . . . . .	155
8.9.1.3 TIMEZONE_OFFSET . . . . .	156
8.9.1.4 CLOCK_SYNC_INTERVAL . . . . .	156
8.9.1.5 LAST_SYNC_TIME . . . . .	156
8.10 clock_commands.cpp . . . . .	156
8.11 lib/comms/commands/commands.cpp File Reference . . . . .	158
8.12 commands.cpp . . . . .	158
8.13 lib/comms/commands/commands.h File Reference . . . . .	159
8.14 commands.h . . . . .	161
8.15 lib/comms/commands/diagnostic_commands.cpp File Reference . . . . .	162
8.16 diagnostic_commands.cpp . . . . .	162

---

8.17 lib/comms/commands/event_commands.cpp File Reference . . . . .	163
8.18 event_commands.cpp . . . . .	164
8.19 lib/comms/commands/gps_commands.cpp File Reference . . . . .	165
8.20 gps_commands.cpp . . . . .	165
8.21 lib/comms/commands/power_commands.cpp File Reference . . . . .	167
8.22 power_commands.cpp . . . . .	168
8.23 lib/comms/commands/storage_commands.cpp File Reference . . . . .	169
8.23.1 Macro Definition Documentation . . . . .	170
8.23.1.1 MAX_BLOCK_SIZE . . . . .	170
8.23.1.2 STORAGE_GROUP . . . . .	170
8.23.1.3 START_COMMAND . . . . .	170
8.23.1.4 DATA_COMMAND . . . . .	170
8.23.1.5 END_COMMAND . . . . .	171
8.23.1.6 LIST_FILES_COMMAND . . . . .	171
8.23.1.7 MOUNT_COMMAND . . . . .	171
8.24 storage_commands.cpp . . . . .	171
8.25 lib/comms/commands/storage_commands_utils.cpp File Reference . . . . .	173
8.25.1 Function Documentation . . . . .	173
8.25.1.1 calculate_checksum() . . . . .	173
8.25.1.2 send_data_block() . . . . .	174
8.25.1.3 receive_ack() . . . . .	174
8.26 storage_commands_utils.cpp . . . . .	175
8.27 lib/comms/commands/storage_commands_utils.h File Reference . . . . .	175
8.27.1 Function Documentation . . . . .	176
8.27.1.1 calculate_checksum() . . . . .	176
8.27.1.2 send_data_block() . . . . .	176
8.27.1.3 receive_ack() . . . . .	176
8.28 storage_commands_utils.h . . . . .	177
8.29 lib/comms/communication.cpp File Reference . . . . .	177
8.29.1 Function Documentation . . . . .	177
8.29.1.1 initialize_radio() . . . . .	177
8.29.2 Variable Documentation . . . . .	178
8.29.2.1 outgoing . . . . .	178
8.29.2.2 msgCount . . . . .	178
8.29.2.3 lastSendTime . . . . .	179
8.29.2.4 lastReceiveTime . . . . .	179
8.29.2.5 lastPrintTime . . . . .	179
8.29.2.6 interval . . . . .	179
8.30 communication.cpp . . . . .	179
8.31 lib/comms/communication.h File Reference . . . . .	180
8.31.1 Function Documentation . . . . .	181
8.31.1.1 initialize_radio() . . . . .	181

---

8.31.1.2 on_receive() . . . . .	181
8.31.1.3 handle_uart_input() . . . . .	182
8.31.1.4 send_message() . . . . .	183
8.31.1.5 send_frame() . . . . .	183
8.31.1.6 send_frame_uart() . . . . .	184
8.31.1.7 send_frame_lora() . . . . .	184
8.31.1.8 split_and_send_message() . . . . .	185
8.31.1.9 determine_unit() . . . . .	185
8.32 communication.h . . . . .	185
8.33 lib/comms/frame.cpp File Reference . . . . .	186
8.33.1 Detailed Description . . . . .	187
8.33.2 Typedef Documentation . . . . .	187
8.33.2.1 CommandHandler . . . . .	187
8.33.3 Variable Documentation . . . . .	187
8.33.3.1 eventRegister . . . . .	187
8.34 frame.cpp . . . . .	187
8.35 lib/comms/protocol.h File Reference . . . . .	189
8.35.1 Enumeration Type Documentation . . . . .	190
8.35.1.1 ExecutionResult . . . . .	190
8.35.1.2 OperationType . . . . .	190
8.35.1.3 CommandAccessLevel . . . . .	191
8.35.1.4 ValueUnit . . . . .	191
8.35.1.5 ExceptionType . . . . .	191
8.35.1.6 Interface . . . . .	192
8.35.2 Function Documentation . . . . .	192
8.35.2.1 exception_type_to_string() . . . . .	192
8.35.2.2 operation_type_to_string() . . . . .	193
8.35.2.3 string_to_operation_type() . . . . .	193
8.35.2.4 hex_string_to_bytes() . . . . .	194
8.35.2.5 value_unit_type_to_string() . . . . .	194
8.35.3 Variable Documentation . . . . .	196
8.35.3.1 FRAME_BEGIN . . . . .	196
8.35.3.2 FRAME_END . . . . .	196
8.35.3.3 DELIMITER . . . . .	196
8.36 protocol.h . . . . .	196
8.37 lib/comms/receive.cpp File Reference . . . . .	197
8.37.1 Detailed Description . . . . .	198
8.37.2 Function Documentation . . . . .	198
8.37.2.1 on_receive() . . . . .	198
8.37.2.2 handle_uart_input() . . . . .	199
8.38 receive.cpp . . . . .	199
8.39 lib/comms/send.cpp File Reference . . . . .	200

---

8.39.1 Detailed Description . . . . .	201
8.39.2 Function Documentation . . . . .	201
8.39.2.1 send_message() . . . . .	201
8.39.2.2 send_frame_lora() . . . . .	202
8.39.2.3 send_frame_uart() . . . . .	203
8.39.2.4 send_frame() . . . . .	203
8.39.2.5 split_and_send_message() . . . . .	204
8.40 send.cpp . . . . .	204
8.41 lib/comms/utils_converters.cpp File Reference . . . . .	205
8.41.1 Detailed Description . . . . .	206
8.41.2 Function Documentation . . . . .	206
8.41.2.1 exception_type_to_string() . . . . .	206
8.41.2.2 value_unit_type_to_string() . . . . .	206
8.41.2.3 operation_type_to_string() . . . . .	208
8.41.2.4 string_to_operation_type() . . . . .	208
8.41.2.5 hex_string_to_bytes() . . . . .	209
8.42 utils_converters.cpp . . . . .	210
8.43 lib/eventman/event_manager.cpp File Reference . . . . .	210
8.43.1 Detailed Description . . . . .	211
8.44 event_manager.cpp . . . . .	212
8.45 lib/eventman/event_manager.h File Reference . . . . .	213
8.45.1 Detailed Description . . . . .	215
8.45.2 Macro Definition Documentation . . . . .	215
8.45.2.1 EVENT_BUFFER_SIZE . . . . .	215
8.45.2.2 EVENT_LOG_FILE . . . . .	215
8.45.3 Function Documentation . . . . .	216
8.45.3.1 to_string() . . . . .	216
8.45.4 Variable Documentation . . . . .	216
8.45.4.1 id . . . . .	216
8.45.4.2 timestamp . . . . .	216
8.45.4.3 group . . . . .	216
8.45.4.4 event . . . . .	216
8.46 event_manager.h . . . . .	217
8.47 lib/location/gps_collector.cpp File Reference . . . . .	219
8.47.1 Macro Definition Documentation . . . . .	219
8.47.1.1 MAX_RAW_DATA_LENGTH . . . . .	219
8.47.2 Function Documentation . . . . .	220
8.47.2.1 splitString() . . . . .	220
8.47.2.2 collect_gps_data() . . . . .	220
8.47.3 Variable Documentation . . . . .	221
8.47.3.1 nmea_data . . . . .	221
8.48 gps_collector.cpp . . . . .	221

---

8.49 lib/location/gps_collector.h File Reference . . . . .	222
8.49.1 Function Documentation . . . . .	222
8.49.1.1 collect_gps_data() . . . . .	222
8.50 gps_collector.h . . . . .	223
8.51 lib/location/NMEA/NMEA_data.cpp File Reference . . . . .	224
8.51.1 Variable Documentation . . . . .	224
8.51.1.1 nmea_data . . . . .	224
8.52 NMEA_data.cpp . . . . .	224
8.53 lib/location/NMEA/NMEA_data.h File Reference . . . . .	225
8.53.1 Variable Documentation . . . . .	226
8.53.1.1 nmea_data . . . . .	226
8.54 NMEA_data.h . . . . .	226
8.55 lib/pin_config.cpp File Reference . . . . .	227
8.55.1 Variable Documentation . . . . .	227
8.55.1.1 lora_cs_pin . . . . .	227
8.55.1.2 lora_reset_pin . . . . .	228
8.55.1.3 lora_irq_pin . . . . .	228
8.55.1.4 lora_address_local . . . . .	228
8.55.1.5 lora_address_remote . . . . .	228
8.56 pin_config.cpp . . . . .	228
8.57 lib/pin_config.h File Reference . . . . .	229
8.57.1 Macro Definition Documentation . . . . .	230
8.57.1.1 DEBUG_UART_PORT . . . . .	230
8.57.1.2 DEBUG_UART_BAUD_RATE . . . . .	230
8.57.1.3 DEBUG_UART_TX_PIN . . . . .	230
8.57.1.4 DEBUG_UART_RX_PIN . . . . .	230
8.57.1.5 MAIN_I2C_PORT . . . . .	230
8.57.1.6 MAIN_I2C_SDA_PIN . . . . .	231
8.57.1.7 MAIN_I2C_SCL_PIN . . . . .	231
8.57.1.8 GPS_UART_PORT . . . . .	231
8.57.1.9 GPS_UART_BAUD_RATE . . . . .	231
8.57.1.10 GPS_UART_TX_PIN . . . . .	231
8.57.1.11 GPS_UART_RX_PIN . . . . .	231
8.57.1.12 GPS_POWER_ENABLE_PIN . . . . .	231
8.57.1.13 BUFFER_SIZE . . . . .	231
8.57.1.14 SD_SPI_PORT . . . . .	232
8.57.1.15 SD_MISO_PIN . . . . .	232
8.57.1.16 SD_MOSI_PIN . . . . .	232
8.57.1.17 SD_SCK_PIN . . . . .	232
8.57.1.18 SD_CS_PIN . . . . .	232
8.57.1.19 SD_CARD_DETECT_PIN . . . . .	232
8.57.1.20 SX1278_MISO . . . . .	232

---

8.57.1.21 SX1278_CS . . . . .	232
8.57.1.22 SX1278_SCK . . . . .	233
8.57.1.23 SX1278_MOSI . . . . .	233
8.57.1.24 SPI_PORT . . . . .	233
8.57.1.25 READ_BIT . . . . .	233
8.57.1.26 LORA_DEFAULT_SPI . . . . .	233
8.57.1.27 LORA_DEFAULT_SPI_FREQUENCY . . . . .	233
8.57.1.28 LORA_DEFAULT_SS_PIN . . . . .	233
8.57.1.29 LORA_DEFAULT_RESET_PIN . . . . .	233
8.57.1.30 LORA_DEFAULT_DIO0_PIN . . . . .	234
8.57.1.31 PA_OUTPUT_RFO_PIN . . . . .	234
8.57.1.32 PA_OUTPUT_PA_BOOST_PIN . . . . .	234
8.57.2 Variable Documentation . . . . .	234
8.57.2.1 lora_cs_pin . . . . .	234
8.57.2.2 lora_reset_pin . . . . .	234
8.57.2.3 lora_irq_pin . . . . .	234
8.57.2.4 lora_address_local . . . . .	234
8.57.2.5 lora_address_remote . . . . .	235
8.58 pin_config.h . . . . .	235
8.59 lib/powerman/INA3221/INA3221.cpp File Reference . . . . .	236
8.59.1 Detailed Description . . . . .	236
8.60 INA3221.cpp . . . . .	236
8.61 lib/powerman/INA3221/INA3221.h File Reference . . . . .	241
8.61.1 Detailed Description . . . . .	242
8.61.2 Enumeration Type Documentation . . . . .	242
8.61.2.1 ina3221_addr_t . . . . .	242
8.61.2.2 ina3221_ch_t . . . . .	243
8.61.2.3 ina3221_reg_t . . . . .	243
8.61.2.4 ina3221_conv_time_t . . . . .	244
8.61.2.5 ina3221_avg_mode_t . . . . .	244
8.61.3 Variable Documentation . . . . .	244
8.61.3.1 INA3221_CH_NUM . . . . .	244
8.61.3.2 SHUNT_VOLTAGE_LSB_UV . . . . .	245
8.62 INA3221.h . . . . .	245
8.63 lib/powerman/PowerManager.cpp File Reference . . . . .	247
8.64 PowerManager.cpp . . . . .	247
8.65 lib/powerman/PowerManager.h File Reference . . . . .	249
8.66 PowerManager.h . . . . .	250
8.67 lib/sensors/BH1750/BH1750.cpp File Reference . . . . .	251
8.68 BH1750.cpp . . . . .	251
8.69 lib/sensors/BH1750/BH1750.h File Reference . . . . .	252
8.69.1 Macro Definition Documentation . . . . .	253

8.69.1.1 _BH1750_DEVICE_ID . . . . .	253
8.69.1.2 _BH1750_MTREG_MIN . . . . .	253
8.69.1.3 _BH1750_MTREG_MAX . . . . .	254
8.69.1.4 _BH1750_DEFAULT_MTREG . . . . .	254
8.70 BH1750.h . . . . .	254
8.71 lib/sensors/BH1750/BH1750_WRAPPER.cpp File Reference . . . . .	254
8.72 BH1750_WRAPPER.cpp . . . . .	255
8.73 lib/sensors/BH1750/BH1750_WRAPPER.h File Reference . . . . .	256
8.74 BH1750_WRAPPER.h . . . . .	257
8.75 lib/sensors/BME280/BME280.cpp File Reference . . . . .	257
8.76 BME280.cpp . . . . .	258
8.77 lib/sensors/BME280/BME280.h File Reference . . . . .	261
8.78 BME280.h . . . . .	262
8.79 lib/sensors/BME280/BME280_WRAPPER.cpp File Reference . . . . .	264
8.80 BME280_WRAPPER.cpp . . . . .	264
8.81 lib/sensors/BME280/BME280_WRAPPER.h File Reference . . . . .	265
8.82 BME280_WRAPPER.h . . . . .	265
8.83 lib/sensors/HMC5883L/HMC5883L.cpp File Reference . . . . .	266
8.84 HMC5883L.cpp . . . . .	266
8.85 lib/sensors/HMC5883L/HMC5883L.h File Reference . . . . .	267
8.86 HMC5883L.h . . . . .	268
8.87 lib/sensors/HMC5883L/HMC5883L_WRAPPER.cpp File Reference . . . . .	268
8.88 HMC5883L_WRAPPER.cpp . . . . .	269
8.89 lib/sensors/HMC5883L/HMC5883L_WRAPPER.h File Reference . . . . .	270
8.90 HMC5883L_WRAPPER.h . . . . .	271
8.91 lib/sensors/ISensor.cpp File Reference . . . . .	271
8.91.1 Detailed Description . . . . .	272
8.92 ISensor.cpp . . . . .	272
8.93 lib/sensors/ISensor.h File Reference . . . . .	272
8.93.1 Enumeration Type Documentation . . . . .	273
8.93.1.1 SensorType . . . . .	273
8.93.1.2 SensorDataTypIdentifier . . . . .	274
8.94 ISensor.h . . . . .	274
8.95 lib/sensors/MPU6050/MPU6050.cpp File Reference . . . . .	275
8.96 MPU6050.cpp . . . . .	275
8.97 lib/sensors/MPU6050/MPU6050.h File Reference . . . . .	276
8.98 MPU6050.h . . . . .	276
8.99 lib/sensors/MPU6050/MPU6050_WRAPPER.cpp File Reference . . . . .	276
8.100 MPU6050_WRAPPER.cpp . . . . .	276
8.101 lib/sensors/MPU6050/MPU6050_WRAPPER.h File Reference . . . . .	276
8.102 MPU6050_WRAPPER.h . . . . .	277
8.103 lib/storage/storage.cpp File Reference . . . . .	278

---

8.103.1 Detailed Description . . . . .	278
8.103.2 Function Documentation . . . . .	279
8.103.2.1 <code>fs_init()</code> . . . . .	279
8.103.3 Variable Documentation . . . . .	280
8.103.3.1 <code>sd_card_mounted</code> . . . . .	280
8.104 <code>storage.cpp</code> . . . . .	280
8.105 <code>lib/storage/storage.h</code> File Reference . . . . .	280
8.105.1 Function Documentation . . . . .	281
8.105.1.1 <code>fs_init()</code> . . . . .	281
8.105.1.2 <code>fs_open_file()</code> . . . . .	282
8.105.1.3 <code>fs_write_file()</code> . . . . .	282
8.105.1.4 <code>fs_read_file()</code> . . . . .	283
8.105.1.5 <code>fs_close_file()</code> . . . . .	283
8.105.1.6 <code>fs_file_exists()</code> . . . . .	283
8.105.2 Variable Documentation . . . . .	283
8.105.2.1 <code>sd_card_mounted</code> . . . . .	283
8.106 <code>storage.h</code> . . . . .	283
8.107 <code>lib/utils.cpp</code> File Reference . . . . .	284
8.107.1 Detailed Description . . . . .	285
8.107.2 Function Documentation . . . . .	285
8.107.2.1 <code>get_level_color()</code> . . . . .	285
8.107.2.2 <code>get_level_prefix()</code> . . . . .	286
8.107.2.3 <code>uart_print()</code> . . . . .	287
8.107.2.4 <code>crc16()</code> . . . . .	288
8.107.3 Variable Documentation . . . . .	289
8.107.3.1 <code>uart_mutex</code> . . . . .	289
8.107.3.2 <code>g_uart_verbosity</code> . . . . .	289
8.108 <code>utils.cpp</code> . . . . .	289
8.109 <code>lib/utils.h</code> File Reference . . . . .	290
8.109.1 Detailed Description . . . . .	292
8.109.2 Macro Definition Documentation . . . . .	292
8.109.2.1 <code>ANSI_RED</code> . . . . .	292
8.109.2.2 <code>ANSI_GREEN</code> . . . . .	292
8.109.2.3 <code>ANSI_YELLOW</code> . . . . .	292
8.109.2.4 <code>ANSI_BLUE</code> . . . . .	292
8.109.2.5 <code>ANSI_CYAN</code> . . . . .	292
8.109.2.6 <code>ANSI_RESET</code> . . . . .	292
8.109.3 Enumeration Type Documentation . . . . .	292
8.109.3.1 <code>VerbosityLevel</code> . . . . .	292
8.109.4 Function Documentation . . . . .	293
8.109.4.1 <code>uart_print()</code> . . . . .	293
8.109.4.2 <code>crc16()</code> . . . . .	294

---

8.109.5 Variable Documentation . . . . .	295
8.109.5.1 g_uart_verbosity . . . . .	295
8.110 utils.h . . . . .	296
8.111 main.cpp File Reference . . . . .	296
8.111.1 Macro Definition Documentation . . . . .	297
8.111.1.1 LOG_FILENAME . . . . .	297
8.111.2 Function Documentation . . . . .	297
8.111.2.1 core1_entry() . . . . .	297
8.111.2.2 init_systems() . . . . .	298
8.111.2.3 main() . . . . .	298
8.111.3 Variable Documentation . . . . .	299
8.111.3.1 powerManager . . . . .	299
8.111.3.2 systemClock . . . . .	299
8.111.3.3 buffer . . . . .	299
8.111.3.4 bufferIndex . . . . .	299
8.112 main.cpp . . . . .	300
8.113 test/comms/test_converters.cpp File Reference . . . . .	301
8.113.1 Function Documentation . . . . .	302
8.113.1.1 test_operation_type_conversion() . . . . .	302
8.113.1.2 test_value_unit_type_conversion() . . . . .	302
8.113.1.3 test_exception_type_conversion() . . . . .	303
8.113.1.4 test_hex_string_conversion() . . . . .	304
8.114 test_converters.cpp . . . . .	304
8.115 test/comms/test_frame_build.cpp File Reference . . . . .	305
8.115.1 Function Documentation . . . . .	305
8.115.1.1 test_frame_build_success() . . . . .	305
8.115.1.2 test_frame_build_error() . . . . .	306
8.115.1.3 test_frame_build_info() . . . . .	306
8.116 test_frame_build.cpp . . . . .	307
8.117 test/comms/test_frame_coding.cpp File Reference . . . . .	307
8.117.1 Function Documentation . . . . .	308
8.117.1.1 test_frame_encode_basic() . . . . .	308
8.117.1.2 test_frame_decode_basic() . . . . .	308
8.117.1.3 test_frame_decode_invalid_header() . . . . .	309
8.118 test_frame_coding.cpp . . . . .	309
8.119 test/comms/test_frame_common.h File Reference . . . . .	310
8.119.1 Function Documentation . . . . .	311
8.119.1.1 create_test_frame() . . . . .	311
8.120 test_frame_common.h . . . . .	311
8.121 test/test_runner.cpp File Reference . . . . .	311
8.121.1 Function Documentation . . . . .	312
8.121.1.1 test_frame_encode_basic() . . . . .	312

---

8.121.1.2 test_frame_decode_basic() . . . . .	313
8.121.1.3 test_frame_decode_invalid_header() . . . . .	313
8.121.1.4 test_frame_build_success() . . . . .	314
8.121.1.5 test_frame_build_error() . . . . .	315
8.121.1.6 test_frame_build_info() . . . . .	315
8.121.1.7 test_operation_type_conversion() . . . . .	316
8.121.1.8 test_value_unit_type_conversion() . . . . .	317
8.121.1.9 test_exception_type_conversion() . . . . .	317
8.121.1.10 test_hex_string_conversion() . . . . .	318
8.121.1.11 main() . . . . .	318
8.122 test_runner.cpp . . . . .	319
<b>Index</b>	<b>321</b>



# Chapter 1

## Clock Commands

Member `handle_clock_sync_interval (const std::string &param, OperationType operationType)`

Command ID: 3.3

Member `handle_enable_gps_uart_passthrough (const std::string &param, OperationType operationType)`

Command ID: 7.2

Member `handle_enter_bootloader_mode (const std::string &param, OperationType operationType)`

Command ID: 2

Member `handle_file_download (const std::string &param, OperationType operationType)`

Command ID: 6.1

Member `handle_get_build_version (const std::string &param, OperationType operationType)`

Command ID: 1

Member `handle_get_commands_list (const std::string &param, OperationType operationType)`

Command ID: 0

Member `handle_get_current_charge_solar (const std::string &param, OperationType operationType)`

Command ID: 2.5

Member `handle_get_current_charge_total (const std::string &param, OperationType operationType)`

Command ID: 2.6

Member `handle_get_current_charge_usb (const std::string &param, OperationType operationType)`

Command ID: 2.4

Member `handle_get_current_draw (const std::string &param, OperationType operationType)`

Command ID: 2.7

Member `handle_get_event_count (const std::string &param, OperationType operationType)`

Command ID: 5.2

Member `handle_get_gga_data (const std::string &param, OperationType operationType)`

Command ID: 7.4

Member `handle_get_last_events (const std::string &param, OperationType operationType)`

Command ID: 5.1

Member `handle_get_last_sync_time (const std::string &param, OperationType operationType)`

Command ID: 3.7

Member `handle_get_power_manager_ids (const std::string &param, OperationType operationType)`

Command ID: 2.0

Member `handle_get_rmc_data (const std::string &param, OperationType operationType)`

Command ID: 7.3

Member `handle_get_voltage_5v (const std::string &param, OperationType operationType)`

Command ID: 2.3

Member `handle_get_voltage_battery (const std::string &param, OperationType operationType)`

Command ID: 2.2

Member `handle_gps_power_status (const std::string &param, OperationType operationType)`

Command ID: 7.1

Member `handle_list_files (const std::string &param, OperationType operationType)`

Command ID: 6.0

Member `handle_mount (const std::string &param, OperationType operationType)`

Command ID: 6.4

Member `handle_time (const std::string &param, OperationType operationType)`

Command ID: 3.0

Member `handle_timezone_offset (const std::string &param, OperationType operationType)`

Command ID: 3.1

Member `handle_verbosity (const std::string &param, OperationType operationType)`

Command ID: 1.8

# Chapter 2

## Topic Index

### 2.1 Topics

Here is a list of all topics with brief descriptions:

Clock Management Commands . . . . .	11
Command System . . . . .	14
Diagnostic Commands . . . . .	17
Event Commands . . . . .	21
GPS Commands . . . . .	23
Power Commands . . . . .	27
Storage Commands . . . . .	33
Frame Handling . . . . .	36
Event Manager . . . . .	41
INA3221 Power Monitor . . . . .	50
Configuration Functions . . . . .	50
Measurement Functions . . . . .	60
Alert Functions . . . . .	62



# Chapter 3

## Hierarchical Index

### 3.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

BH1750 . . . . .	69
BME280 . . . . .	75
BME280CalibParam . . . . .	84
INA3221::conf_reg_t . . . . .	90
DS3231 . . . . .	92
ds3231_data_t . . . . .	99
EventEmitter . . . . .	101
EventLog . . . . .	102
EventManager . . . . .	104
EventManagerImpl . . . . .	109
FileHandle . . . . .	112
Frame . . . . .	112
HMC5883L . . . . .	115
INA3221 . . . . .	120
ISensor . . . . .	126
BH1750Wrapper . . . . .	72
BME280Wrapper . . . . .	87
HMC5883LWrapper . . . . .	118
MPU6050Wrapper . . . . .	131
INA3221::masken_reg_t . . . . .	128
NMEAData . . . . .	133
PowerManager . . . . .	135
SensorWrapper . . . . .	141



# Chapter 4

## Class Index

### 4.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

BH1750 . . . . .	69
BH1750Wrapper . . . . .	72
BME280 . . . . .	75
BME280CalibParam . . . . .	84
BME280Wrapper . . . . .	87
INA3221::conf_reg_t Configuration register bit fields . . . . .	90
DS3231 . . . . .	92
ds3231_data_t . . . . .	99
EventEmitter Provides a static method for emitting events . . . . .	101
EventLog Represents a single event log entry . . . . .	102
EventManager Manages the event logging system . . . . .	104
EventManagerImpl Implementation of the <a href="#">EventManager</a> class . . . . .	109
FileHandle . . . . .	112
Frame Represents a communication frame used for data exchange . . . . .	112
HMC5883L . . . . .	115
HMC5883LWrapper . . . . .	118
INA3221 INA3221 Triple-Channel Power Monitor driver class . . . . .	120
ISensor . . . . .	126
INA3221::masken_reg_t Mask/Enable register bit fields . . . . .	128
MPU6050Wrapper . . . . .	131
NMEAData . . . . .	133
PowerManager . . . . .	135
SensorWrapper Manages different sensor types and provides a unified interface for accessing sensor data . . . . .	141



# Chapter 5

## File Index

### 5.1 File List

Here is a list of all files with brief descriptions:

<code>build_number.h</code> . . . . .	145
<code>includes.h</code> . . . . .	146
<code>main.cpp</code> . . . . .	296
<code>lib/pin_config.cpp</code> . . . . .	227
<code>lib/pin_config.h</code> . . . . .	229
<code>lib/utils.cpp</code> Implementation of utility functions for the Kabisat firmware . . . . .	284
<code>lib/utils.h</code> Utility functions and definitions for the Kabisat firmware . . . . .	290
<code>lib/clock/DS3231.cpp</code> . . . . .	147
<code>lib/clock/DS3231.h</code> . . . . .	151
<code>lib/comms/communication.cpp</code> . . . . .	177
<code>lib/comms/communication.h</code> . . . . .	180
<code>lib/comms/frame.cpp</code> Implements functions for encoding, decoding, building, and processing Frames . . . . .	186
<code>lib/comms/protocol.h</code> . . . . .	189
<code>lib/comms/receive.cpp</code> Implements functions for receiving and processing data, including LoRa and UART input . . . . .	197
<code>lib/comms/send.cpp</code> Implements functions for sending data, including LoRa messages and Frames . . . . .	200
<code>lib/comms/utils_converters.cpp</code> Implements utility functions for converting between different data types . . . . .	205
<code>lib/comms/commands/clock_commands.cpp</code> . . . . .	154
<code>lib/comms/commands/commands.cpp</code> . . . . .	158
<code>lib/comms/commands/commands.h</code> . . . . .	159
<code>lib/comms/commands/diagnostic_commands.cpp</code> . . . . .	162
<code>lib/comms/commands/event_commands.cpp</code> . . . . .	163
<code>lib/comms/commands/gps_commands.cpp</code> . . . . .	165
<code>lib/comms/commands/power_commands.cpp</code> . . . . .	167
<code>lib/comms/commands/storage_commands.cpp</code> . . . . .	169
<code>lib/comms/commands/storage_commands_utils.cpp</code> . . . . .	173
<code>lib/comms/commands/storage_commands_utils.h</code> . . . . .	175
<code>lib/eventman/event_manager.cpp</code> Implements the event management system for the Kabisat firmware . . . . .	210
<code>lib/eventman/event_manager.h</code> Manages the event logging system for the Kabisat firmware . . . . .	213

lib/location/gps_collector.cpp	219
lib/location/gps_collector.h	222
lib/location/NMEA/NMEA_data.cpp	224
lib/location/NMEA/NMEA_data.h	225
lib/powerman/PowerManager.cpp	247
lib/powerman/PowerManager.h	249
lib/powerman/INA3221/INA3221.cpp Implementation of the INA3221 power monitor driver	236
lib/powerman/INA3221/INA3221.h Header file for the INA3221 triple-channel power monitor driver	241
lib/sensors/ISensor.cpp Implements the SensorWrapper class for managing different sensor types	271
lib/sensors/ISensor.h	272
lib/sensors/BH1750/BH1750.cpp	251
lib/sensors/BH1750/BH1750.h	252
lib/sensors/BH1750/BH1750_WRAPPER.cpp	254
lib/sensors/BH1750/BH1750_WRAPPER.h	256
lib/sensors/BME280/BME280.cpp	257
lib/sensors/BME280/BME280.h	261
lib/sensors/BME280/BME280_WRAPPER.cpp	264
lib/sensors/BME280/BME280_WRAPPER.h	265
lib/sensors/HMC5883L/HMC5883L.cpp	266
lib/sensors/HMC5883L/HMC5883L.h	267
lib/sensors/HMC5883L/HMC5883L_WRAPPER.cpp	268
lib/sensors/HMC5883L/HMC5883L_WRAPPER.h	270
lib/sensors/MPU6050/MPU6050.cpp	275
lib/sensors/MPU6050/MPU6050.h	276
lib/sensors/MPU6050/MPU6050_WRAPPER.cpp	276
lib/sensors/MPU6050/MPU6050_WRAPPER.h	276
lib/storage/storage.cpp Implements file system operations for the Kubisat firmware	278
lib/storage/storage.h	280
test/test_runner.cpp	311
test/comms/test_converters.cpp	301
test/comms/test_frame_build.cpp	305
test/comms/test_frame_coding.cpp	307
test/comms/test_frame_common.h	310

# Chapter 6

## Topic Documentation

### 6.1 Clock Management Commands

Commands for managing system time and clock settings.

#### Functions

- `Frame handle_time (const std::string &param, OperationType operationType)`  
*Handler for getting and setting system time.*
- `Frame handle_timezone_offset (const std::string &param, OperationType operationType)`  
*Handler for getting and setting timezone offset.*
- `Frame handle_clock_sync_interval (const std::string &param, OperationType operationType)`  
*Handler for getting and setting clock synchronization interval.*
- `Frame handle_get_last_sync_time (const std::string &param, OperationType operationType)`  
*Handler for getting last clock sync time.*

#### Variables

- `DS3231 systemClock`

#### 6.1.1 Detailed Description

Commands for managing system time and clock settings.

#### 6.1.2 Function Documentation

##### 6.1.2.1 `handle_time()`

```
Frame handle_time (
    const std::string & param,
    OperationType operationType)
```

Handler for getting and setting system time.

**Parameters**

<i>param</i>	For SET: Unix timestamp as string, for GET: empty string
<i>operationType</i>	GET/SET

**Returns**

`Frame` containing success/error and current time or confirmation

**Note**

GET: **KBST;0;GET;3;0;;KBST**

When getting time, returns format "HH:MM:SS Weekday DD.MM.YYYY"

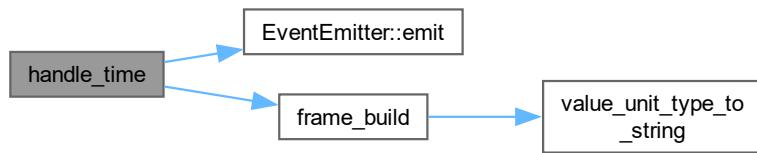
SET: **KBST;0;SET;3;0;TIMESTAMP;KBST**

When setting time, expects Unix timestamp as parameter

**Command** Command ID: 3.0

Definition at line 32 of file `clock_commands.cpp`.

Here is the call graph for this function:

**6.1.2.2 handle\_timezone\_offset()**

```
Frame handle_timezone_offset (
    const std::string & param,
    OperationType operationType)
```

Handler for getting and setting timezone offset.

**Parameters**

<i>param</i>	For SET: Timezone offset in minutes (-720 to +720), for GET: empty string
<i>operationType</i>	GET/SET

**Returns**

`Frame` containing success/error and timezone offset in minutes

**Note**

GET: **KBST;0;GET;3;1;;KBST**  
SET: **KBST;0;SET;3;1;OFFSET;KBST**

**Command** Command ID: 3.1

Definition at line 71 of file [clock\\_commands.cpp](#).

Here is the call graph for this function:



### 6.1.2.3 handle\_clock\_sync\_interval()

```
Frame handle_clock_sync_interval (
    const std::string & param,
    OperationType operationType)
```

Handler for getting and setting clock synchronization interval.

**Parameters**

<i>param</i>	For SET: Sync interval in seconds, for GET: empty string
<i>operationType</i>	GET/SET

**Returns**

**Frame** containing success/error and sync interval in seconds

**Note**

GET: **KBST;0;GET;3;3;;KBST**  
SET: **KBST;0;SET;3;3;INTERVAL;KBST**

**Command** Command ID: 3.3

Definition at line 115 of file [clock\\_commands.cpp](#).

Here is the call graph for this function:



#### 6.1.2.4 handle\_get\_last\_sync\_time()

```
Frame handle_get_last_sync_time (
    const std::string & param,
    OperationType operationType)
```

Handler for getting last clock sync time.

##### Parameters

<i>param</i>	Empty string expected
<i>operationType</i>	GET

##### Returns

Frame containing success/error and last sync time as Unix timestamp

##### Note

**KBST;0;GET;3;7;;KBST**

**Command** Command ID: 3.7

Definition at line 155 of file [clock\\_commands.cpp](#).

Here is the call graph for this function:



### 6.1.3 Variable Documentation

#### 6.1.3.1 systemClock

```
DS3231 systemClock [extern]
```

## 6.2 Command System

Core command system implementation.

## Typedefs

- using `CommandHandler` = `std::function<Frame(const std::string&, OperationType)>`  
*Function type for command handlers.*
- using `CommandMap` = `std::map<uint32_t, CommandHandler>`  
*Map type for storing command handlers.*

## Functions

- `Frame execute_command (uint32_t commandKey, const std::string &param, OperationType operationType)`  
*Executes a command based on its key.*

## Variables

- `CommandMap commandHandlers`  
*Global map of all command handlers.*

### 6.2.1 Detailed Description

Core command system implementation.

### 6.2.2 Typedef Documentation

#### 6.2.2.1 CommandHandler

```
using CommandHandler = std::function<Frame(const std::string&, OperationType)>
```

Function type for command handlers.

Definition at line 15 of file `commands.cpp`.

#### 6.2.2.2 CommandMap

```
using CommandMap = std::map<uint32_t, CommandHandler>
```

Map type for storing command handlers.

Definition at line 21 of file `commands.cpp`.

### 6.2.3 Function Documentation

#### 6.2.3.1 execute\_command()

```
Frame execute_command (
    uint32_t commandKey,
    const std::string & param,
    OperationType operationType)
```

Executes a command based on its key.

## Parameters

<i>commandKey</i>	Combined group and command ID (group << 8   command)
<i>param</i>	Command parameter string
<i>operationType</i>	Operation type (GET/SET)

## Returns

**Frame** Response frame containing execution result

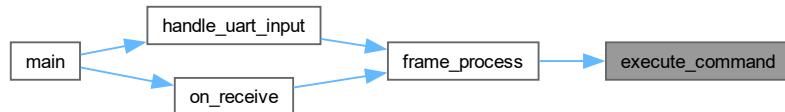
Looks up the command handler in commandHandlers map and executes it

Definition at line 63 of file [commands.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



## 6.2.4 Variable Documentation

### 6.2.4.1 commandHandlers

**CommandMap** commandHandlers

#### Initial value:

```

= {
    {((static_cast<uint32_t>(1) << 8) | static_cast<uint32_t>(0)), handle_get_commands_list},
    {((static_cast<uint32_t>(1) << 8) | static_cast<uint32_t>(1)), handle_get_build_version},
    {((static_cast<uint32_t>(1) << 8) | static_cast<uint32_t>(8)), handle_verbosity},
    {((static_cast<uint32_t>(1) << 8) | static_cast<uint32_t>(9)), handle_enter_bootloader_mode},
    {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(0)), handle_get_power_manager_ids},
    {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(2)), handle_get_voltage_battery},
    {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(3)), handle_get_voltage_5v},
    {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(4)), handle_get_current_charge_usb},
    {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(5)), handle_get_current_charge_solar},
    {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(6)), handle_get_current_charge_total},
}
  
```

```

{{(static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(7)), handle_get_current_draw},
{{(static_cast<uint32_t>(3) << 8) | static_cast<uint32_t>(0)), handle_time},
{{(static_cast<uint32_t>(3) << 8) | static_cast<uint32_t>(1)), handle_timezone_offset},
{{(static_cast<uint32_t>(3) << 8) | static_cast<uint32_t>(2)), handle_clock_sync_interval},
{{(static_cast<uint32_t>(3) << 8) | static_cast<uint32_t>(3)), handle_get_last_sync_time},
{{(static_cast<uint32_t>(5) << 8) | static_cast<uint32_t>(1)), handle_get_last_events},
{{(static_cast<uint32_t>(5) << 8) | static_cast<uint32_t>(2)), handle_get_event_count},
{{(static_cast<uint32_t>(6) << 8) | static_cast<uint32_t>(0)), handle_list_files},
{{(static_cast<uint32_t>(6) << 8) | static_cast<uint32_t>(1)), handle_file_download},
{{(static_cast<uint32_t>(6) << 8) | static_cast<uint32_t>(4)), handle_mount},
{{(static_cast<uint32_t>(7) << 8) | static_cast<uint32_t>(1)), handle_gps_power_status},
{{(static_cast<uint32_t>(7) << 8) | static_cast<uint32_t>(2)), handle_enable_gps_uart_passthrough},
{{(static_cast<uint32_t>(7) << 8) | static_cast<uint32_t>(3)), handle_get_rmc_data},
{{(static_cast<uint32_t>(7) << 8) | static_cast<uint32_t>(4)), handle_get_gga_data},
}

```

Global map of all command handlers.

Maps command keys (group << 8 | command) to their handler functions

Definition at line 27 of file [commands.cpp](#).

## 6.3 Diagnostic Commands

### Functions

- [Frame handle\\_get\\_commands\\_list](#) (const std::string &param, [OperationType](#) operationType)  
*Handler for listing all available commands on UART.*
- [Frame handle\\_get\\_build\\_version](#) (const std::string &param, [OperationType](#) operationType)  
*Get firmware build version.*
- [Frame handle\\_verbosity](#) (const std::string &param, [OperationType](#) operationType)  
*Handles setting or getting the UART verbosity level.*
- [Frame handle\\_enter\\_bootloader\\_mode](#) (const std::string &param, [OperationType](#) operationType)  
*Reboot system to USB firmware loader.*

### 6.3.1 Detailed Description

### 6.3.2 Function Documentation

#### 6.3.2.1 handle\_get\_commands\_list()

```

Frame handle_get_commands_list (
    const std::string & param,
    OperationType operationType)

```

Handler for listing all available commands on UART.

#### Parameters

<i>param</i>	Empty string expected
<i>operationType</i>	GET

#### Returns

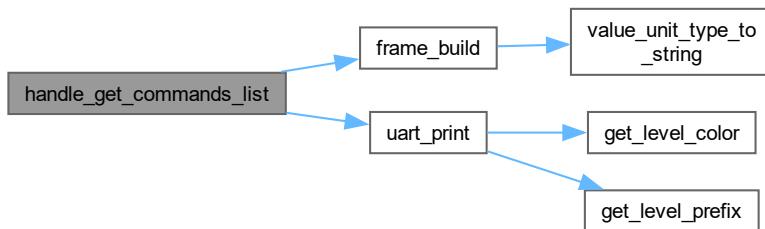
[Frame](#) containing success/error and command list

**Note****KBST;0;GET;1;0;;TSBK**

Print all available commands on UART port

**Command** Command ID: 0Definition at line 21 of file [diagnostic\\_commands.cpp](#).

Here is the call graph for this function:

**6.3.2.2 handle\_get\_build\_version()**

```
Frame handle_get_build_version (
    const std::string & param,
    OperationType operationType)
```

Get firmware build version.

**Parameters**

<i>param</i>	Empty string expected
<i>operationType</i>	GET

**Returns**`Frame` containing build number**Note****KBST;0;GET;1;1;;TSBK**

Get the firmware build version

**Command** Command ID: 1

Definition at line 56 of file [diagnostic\\_commands.cpp](#).

Here is the call graph for this function:



### 6.3.2.3 handle\_verbosity()

```
Frame handle_verbosity (
    const std::string & param,
    OperationType operationType)
```

Handles setting or getting the UART verbosity level.

This function allows the user to either retrieve the current UART verbosity level or set a new verbosity level.

#### Parameters

<i>param</i>	The desired verbosity level (0-5) as a string. If empty, the current level is returned.
<i>operationType</i>	The operation type. Must be GET to retrieve the current level, or SET to set a new level.

#### Returns

A [Frame](#) indicating the result of the operation.

- Success (GET): [Frame](#) containing the current verbosity level.
- Success (SET): [Frame](#) with "LEVEL SET" message.
- Error: [Frame](#) with error message (e.g., "INVALID LEVEL (0-5)", "INVALID FORMAT").

#### Note

**KBST;0;GET;1;8;;TSBK** - Gets the current verbosity level.

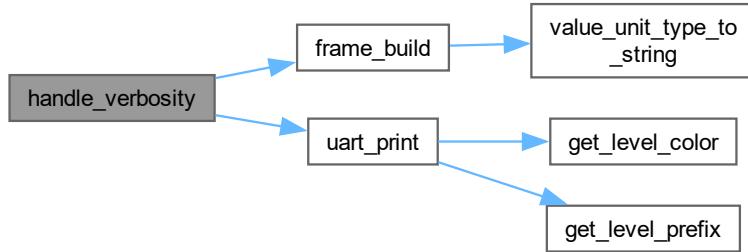
**KBST;0;SET;1;8;[level];TSBK** - Sets the verbosity level.

Example: **KBST;0;SET;1;8;2;TSBK** - Sets the verbosity level to 2.

**Command** Command ID: 1.8

Definition at line 88 of file [diagnostic\\_commands.cpp](#).

Here is the call graph for this function:



#### 6.3.2.4 `handle_enter_bootloader_mode()`

```
Frame handle_enter_bootloader_mode (
    const std::string & param,
    OperationType operationType)
```

Reboot system to USB firmware loader.

##### Parameters

<code>param</code>	Empty string expected
<code>operationType</code>	Must be SET

##### Returns

`Frame` with operation result

##### Note

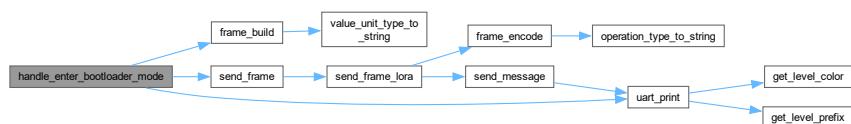
**KBST;0;SET;1;9;;TSBK**

Reboot the system to USB firmware loader

**Command** Command ID: 2

Definition at line 117 of file [diagnostic\\_commands.cpp](#).

Here is the call graph for this function:



## 6.4 Event Commands

Commands for accessing and managing system event logs.

### Functions

- `Frame handle_get_last_events (const std::string &param, OperationType operationType)`  
*Handler for retrieving last N events from the event log.*
- `Frame handle_get_event_count (const std::string &param, OperationType operationType)`  
*Handler for getting total number of events in the log.*

### 6.4.1 Detailed Description

Commands for accessing and managing system event logs.

### 6.4.2 Function Documentation

#### 6.4.2.1 handle\_get\_last\_events()

```
Frame handle_get_last_events (
    const std::string & param,
    OperationType operationType)
```

Handler for retrieving last N events from the event log.

##### Parameters

<code>param</code>	Number of events to retrieve (optional, default 10)
<code>operationType</code>	GET

##### Returns

`Frame` containing:

- Success: Hex-encoded events in format IIIITTTTTTGGE where:
  - III: Event ID (16-bit)
  - TTTTTTTT: Unix Timestamp (32-bit)
  - GG: Event Group (8-bit)
  - EE: Event Type (8-bit)
- Error: "INVALID OPERATION", "INVALID COUNT", or "INVALID PARAMETER"

**Note****KBST;0;GET;5;1;20;TSBK**

Returns up to 10 most recent events

**Command** Command ID: 5.1Definition at line 29 of file [event\\_commands.cpp](#).

Here is the call graph for this function:

**6.4.2.2 handle\_get\_event\_count()**

```
Frame handle_get_event_count (
    const std::string & param,
    OperationType operationType)
```

Handler for getting total number of events in the log.

**Parameters**

<i>param</i>	Empty string expected
<i>operationType</i>	GET

**Returns****Frame** containing:

- Success: Number of events currently in the log
- Error: "INVALID REQUEST"

**Note****KBST;0;GET;5;2;;TSBK**

Returns the total number of events in the log

**Command** Command ID: 5.2Definition at line 83 of file [event\\_commands.cpp](#).

Here is the call graph for this function:



## 6.5 GPS Commands

Commands for controlling and monitoring the GPS module.

### Functions

- `Frame handle_gps_power_status (const std::string &param, OperationType operationType)`  
*Handler for controlling GPS module power state.*
- `Frame handle_enable_gps_uart_passthrough (const std::string &param, OperationType operationType)`  
*Handler for enabling GPS transparent mode (UART pass-through)*
- `Frame handle_get_rmc_data (const std::string &param, OperationType operationType)`  
*Handler for retrieving GPS RMC (Recommended Minimum Navigation) data.*
- `Frame handle_get_gga_data (const std::string &param, OperationType operationType)`  
*Handler for retrieving GPS GGA (Global Positioning System Fix Data) data.*

### 6.5.1 Detailed Description

Commands for controlling and monitoring the GPS module.

### 6.5.2 Function Documentation

#### 6.5.2.1 handle\_gps\_power\_status()

```
Frame handle_gps_power_status (
    const std::string & param,
    OperationType operationType)
```

Handler for controlling GPS module power state.

##### Parameters

<code>param</code>	For SET: "0" to power off, "1" to power on. For GET: empty
<code>operationType</code>	GET to read current state, SET to change state

##### Returns

`Frame` containing:

- Success: Current power state (0/1) or
- Error: Error reason

**Note****KBST;0;GET;7;1;;TSBK**

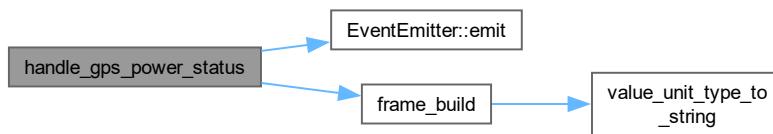
Return current GPS module power state: ON/OFF

**KBST;0;SET;7;1;POWER;TSBK**

POWER - 0 - OFF, 1 - ON

**Command** Command ID: 7.1Definition at line 26 of file [gps\\_commands.cpp](#).

Here is the call graph for this function:

**6.5.2.2 handle\_enable\_gps\_uart\_passthrough()**

```
Frame handle_enable_gps_uart_passthrough (
    const std::string & param,
    OperationType operationType)
```

Handler for enabling GPS transparent mode (UART pass-through)

**Parameters**

<i>param</i>	TIMEOUT in seconds (optional, defaults to 60)
<i>operationType</i>	SET

**Returns****Frame** containing:

- Success: Exit message + reason or
- Error: Error reason

**Note****KBST;0;SET;7;2;TIMEOUT;TSBK**

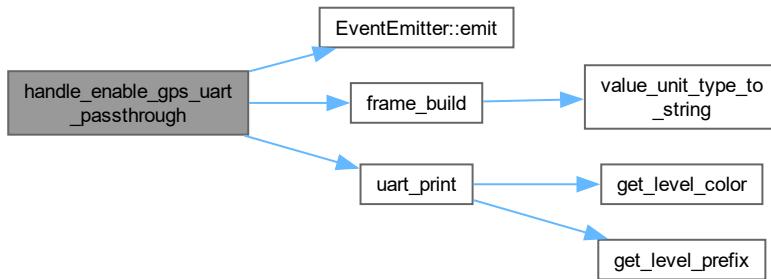
TIMEOUT - 1-600s, default 60s

Enters a pass-through mode where UART communication is bridged directly to GPS

Send "##EXIT##" to exit mode before TIMEOUT

**Command** Command ID: 7.2Definition at line 74 of file [gps\\_commands.cpp](#).

Here is the call graph for this function:

**6.5.2.3 handle\_get\_rmc\_data()**

```
Frame handle_get_rmc_data (
    const std::string & param,
    OperationType operationType)
```

Handler for retrieving GPS RMC (Recommended Minimum Navigation) data.

**Parameters**

<i>param</i>	Empty string expected
<i>operationType</i>	GET

**Returns****Frame** containing:

- Success: Comma-separated RMC tokens or
- Error: Error message

### Note

**KBST;0;GET;7;3;;TSBK**

**Command** Command ID: 7.3

Definition at line 170 of file [gps\\_commands.cpp](#).

Here is the call graph for this function:



### 6.5.2.4 handle\_get\_gga\_data()

```
Frame handle_get_gga_data (
    const std::string & param,
    OperationType operationType)
```

Handler for retrieving GPS GGA (Global Positioning System Fix Data) data.

#### Parameters

<i>param</i>	Empty string expected
<i>operationType</i>	GET

#### Returns

**Frame** containing:

- Success: Comma-separated GGA tokens or
- Error: Error message

### Note

**KBST;0;GET;7;4;;TSBK**

**Command** Command ID: 7.4

Definition at line 209 of file [gps\\_commands.cpp](#).

Here is the call graph for this function:



## 6.6 Power Commands

Commands for monitoring power subsystem and battery management.

### Functions

- `Frame handle_get_power_manager_ids (const std::string &param, OperationType operationType)`  
*Handler for retrieving Power Manager IDs.*
- `Frame handle_get_voltage_battery (const std::string &param, OperationType operationType)`  
*Handler for getting battery voltage.*
- `Frame handle_get_voltage_5v (const std::string &param, OperationType operationType)`  
*Handler for getting 5V rail voltage.*
- `Frame handle_get_current_charge_usb (const std::string &param, OperationType operationType)`  
*Handler for getting USB charge current.*
- `Frame handle_get_current_charge_solar (const std::string &param, OperationType operationType)`  
*Handler for getting solar panel charge current.*
- `Frame handle_get_current_charge_total (const std::string &param, OperationType operationType)`  
*Handler for getting total charge current.*
- `Frame handle_get_current_draw (const std::string &param, OperationType operationType)`  
*Handler for getting system current draw.*

### 6.6.1 Detailed Description

Commands for monitoring power subsystem and battery management.

### 6.6.2 Function Documentation

#### 6.6.2.1 handle\_get\_power\_manager\_ids()

```
Frame handle_get_power_manager_ids (
    const std::string & param,
    OperationType operationType)
```

Handler for retrieving Power Manager IDs.

##### Parameters

<code>param</code>	Empty string expected
<code>operationType</code>	GET

##### Returns

`Frame` containing:

- Success: String of Power Manager IDs
- Error: Error message

**Note****KBST;0;GET;2;0;;TSBK**

This command is used to retrieve the IDs of the Power Manager

**Command** Command ID: 2.0Definition at line 22 of file [power\\_commands.cpp](#).

Here is the call graph for this function:

**6.6.2.2 handle\_get\_voltage\_battery()**

```
Frame handle_get_voltage_battery (
    const std::string & param,
    OperationType operationType)
```

Handler for getting battery voltage.

**Parameters**

<i>param</i>	Empty string expected
<i>operationType</i>	GET

**Returns**

Frame containing:

- Success: Battery voltage in Volts
- Error: Error message

**Note****KBST;0;GET;2;2;;TSBK**

This command is used to retrieve the battery voltage

**Command** Command ID: 2.2Definition at line 49 of file [power\\_commands.cpp](#).

Here is the call graph for this function:



### 6.6.2.3 handle\_get\_voltage\_5v()

```
Frame handle_get_voltage_5v (
    const std::string & param,
    OperationType operationType)
```

Handler for getting 5V rail voltage.

#### Parameters

<i>param</i>	Empty string expected
<i>operationType</i>	GET

#### Returns

Frame containing:

- Success: 5V rail voltage in Volts
- Error: Error message

#### Note

**KBST;0;GET;2;3;;TSBK**

This command is used to retrieve the 5V rail voltage

**Command** Command ID: 2.3

Definition at line 76 of file [power\\_commands.cpp](#).

Here is the call graph for this function:



### 6.6.2.4 handle\_get\_current\_charge\_usb()

```
Frame handle_get_current_charge_usb (
    const std::string & param,
    OperationType operationType)
```

Handler for getting USB charge current.

### Parameters

<i>param</i>	Empty string expected
<i>operationType</i>	GET

### Returns

Frame containing:

- Success: USB charge current in millamps
- Error: Error message

### Note

**KBST;0;GET;2;4;;TSBK**

This command is used to retrieve the USB charge current

**Command** Command ID: 2.4

Definition at line 103 of file [power\\_commands.cpp](#).

Here is the call graph for this function:



### 6.6.2.5 handle\_get\_current\_charge\_solar()

```
Frame handle_get_current_charge_solar (
    const std::string & param,
    OperationType operationType)
```

Handler for getting solar panel charge current.

### Parameters

<i>param</i>	Empty string expected
<i>operationType</i>	GET

**Returns**

**Frame** containing:

- Success: Solar charge current in millamps
- Error: Error message

**Note**

**KBST;0;GET;2;5;;TSBK**

This command is used to retrieve the solar panel charge current

**Command** Command ID: 2.5

Definition at line 130 of file [power\\_commands.cpp](#).

Here is the call graph for this function:

**6.6.2.6 handle\_get\_current\_charge\_total()**

```
Frame handle_get_current_charge_total (
    const std::string & param,
    OperationType operationType)
```

Handler for getting total charge current.

**Parameters**

<i>param</i>	Empty string expected
<i>operationType</i>	GET

**Returns**

**Frame** containing:

- Success: Total charge current (USB + Solar) in millamps
- Error: Error message

### Note

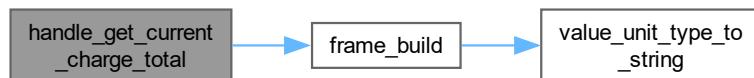
**KBST;0;GET;2;6;;TSBK**

This command is used to retrieve the total charge current

**Command** Command ID: 2.6

Definition at line 157 of file [power\\_commands.cpp](#).

Here is the call graph for this function:



### 6.6.2.7 handle\_get\_current\_draw()

```
Frame handle_get_current_draw (
    const std::string & param,
    OperationType operationType)
```

Handler for getting system current draw.

#### Parameters

<i>param</i>	Empty string expected
<i>operationType</i>	GET

#### Returns

**Frame** containing:

- Success: System current consumption in millamps
- Error: Error message

### Note

**KBST;0;GET;2;7;;TSBK**

This command is used to retrieve the system current draw

**Command** Command ID: 2.7

Definition at line 184 of file [power\\_commands.cpp](#).

Here is the call graph for this function:



## 6.7 Storage Commands

Commands for interacting with the SD card storage.

### Functions

- `Frame handle_file_download (const std::string &param, OperationType operationType)`  
*Handles the file download command.*
- `Frame handle_list_files (const std::string &param, OperationType operationType)`  
*Handles the list files command.*
- `Frame handle_mount (const std::string &param, OperationType operationType)`  
*Handles the SD card mount/unmount command.*

### 6.7.1 Detailed Description

Commands for interacting with the SD card storage.

### 6.7.2 Function Documentation

#### 6.7.2.1 handle\_file\_download()

```
Frame handle_file_download (
    const std::string & param,
    OperationType operationType)
```

Handles the file download command.

This function reads a file from the SD card and sends it to the ground station in blocks over LoRa. The ground station must acknowledge each block before the next block is sent. A checksum is calculated and sent at the end of the transmission to verify data integrity.

##### Parameters

<code>param</code>	The filename to download.
<code>operationType</code>	The operation type (must be GET).

##### Returns

A `Frame` indicating the result of the operation.

- Success: `Frame` with "File download complete" message.
- Error: `Frame` with error message (e.g., "File not found", "ACK timeout").

**Note**

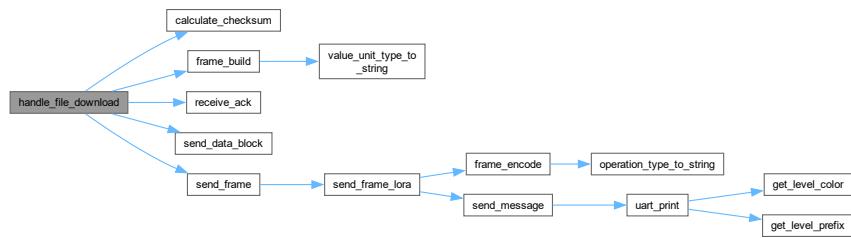
**KBST;0;GET;6;1;[filename];TSBK**

Example: **KBST;0;GET;6;1;test.txt;TSBK** - Downloads the file "test.txt".

### Command Command ID: 6.1

Definition at line 43 of file [storage\\_commands.cpp](#).

Here is the call graph for this function:



#### 6.7.2.2 handle\_list\_files()

```
Frame handle_list_files (
    const std::string & param,
    OperationType operationType)
```

Handles the list files command.

This function lists the files in the root directory of the SD card and sends the filename and size of each file to the ground station in separate frames.

##### Parameters

<i>param</i>	Unused.
<i>operationType</i>	The operation type (must be GET).

##### Returns

A [Frame](#) indicating the result of the operation.

- Success: [Frame](#) with "File listing complete" message.
- Error: [Frame](#) with error message (e.g., "Could not open directory").

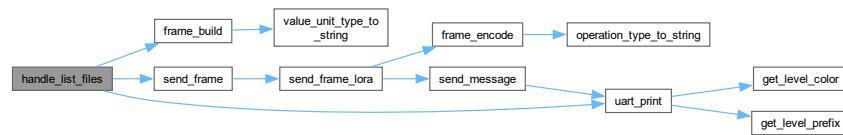
**Note****KBST;0;GET;6;0;;TSBK**

This command lists the files and their sizes in the root directory of the SD card.

**Command** Command ID: 6.0

Definition at line 120 of file [storage\\_commands.cpp](#).

Here is the call graph for this function:

**6.7.2.3 handle\_mount()**

```
Frame handle_mount (
    const std::string & param,
    OperationType operationType)
```

Handles the SD card mount/unmount command.

This function mounts or unmounts the SD card.

**Parameters**

<code>param</code>	"0" to unmount, "1" to mount.
<code>operationType</code>	The operation type (must be SET).

**Returns**

A `Frame` indicating the result of the operation.

- Success: `Frame` with "SD card mounted" or "SD card unmounted" message.
- Error: `Frame` with error message (e.g., "Invalid parameter", "Mount failed", "Unmount failed").

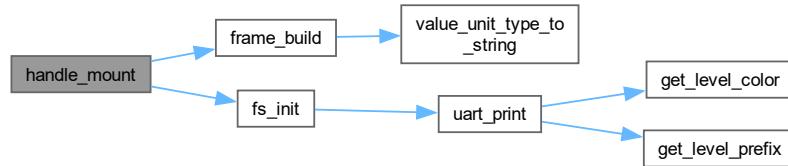
**Note****KBST;0;SET;6;4;[0|1];TSBK**

Example: **KBST;0;SET;6;4;1;TSBK** - Mounts the SD card.

**Command** Command ID: 6.4

Definition at line 180 of file [storage\\_commands.cpp](#).

Here is the call graph for this function:



## 6.8 Frame Handling

Functions for encoding, decoding and building communication frames.

### Functions

- `std::string frame_encode (const Frame &frame)`  
*Encodes a `Frame` instance into a string.*
- `Frame frame_decode (const std::string &data)`  
*Decodes a string into a `Frame` instance.*
- `void frame_process (const std::string &data, Interface interface)`  
*Executes a command based on the command key and the parameter.*
- `Frame frame_build (ExecutionResult result, uint8_t group, uint8_t command, const std::string &value, const ValueUnit unitType)`  
*Builds a `Frame` instance based on the execution result, group, command, value, and unit.*

### 6.8.1 Detailed Description

Functions for encoding, decoding and building communication frames.

### 6.8.2 Function Documentation

#### 6.8.2.1 `frame_encode()`

```
std::string frame_encode (
    const Frame & frame)
```

Encodes a `Frame` instance into a string.

##### Parameters

<code>frame</code>	The <code>Frame</code> instance to encode.
--------------------	--

**Returns**

The [Frame](#) encoded as a string.

The encoded string includes the frame direction, operation type, group, command, value, and unit, all delimited by the DELIMITER character. The string is encapsulated by FRAME\_BEGIN and FRAME\_END.

```
Frame myFrame;
myFrame.header = FRAME_BEGIN;
myFrame.direction = 0;
myFrame.operationType = OperationType::GET;
myFrame.group = 1;
myFrame.command = 1;
myFrame.value = "";
myFrame.unit = "";
myFrame.footer = FRAME_END;

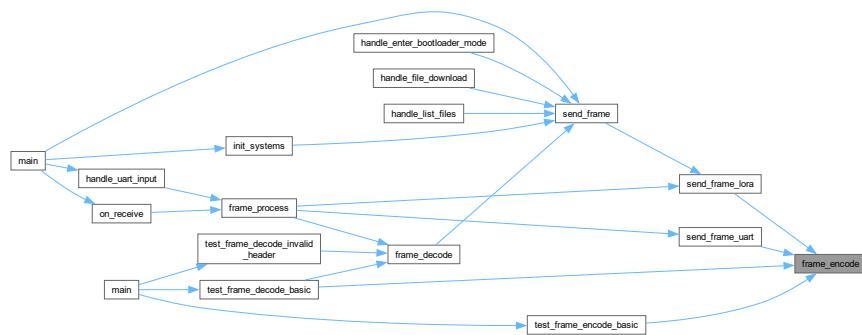
std::string encoded = frame_encode(myFrame);
// encoded will be "KBST;0;GET;1;1;TSBK"
```

Definition at line 37 of file [frame.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

**6.8.2.2 frame\_decode()**

```
Frame frame_decode (
    const std::string & data)
```

Decodes a string into a [Frame](#) instance.

## Parameters

<code>encodedFrame</code>	The string to decode.
---------------------------	-----------------------

## Returns

The [Frame](#) instance decoded from the string.

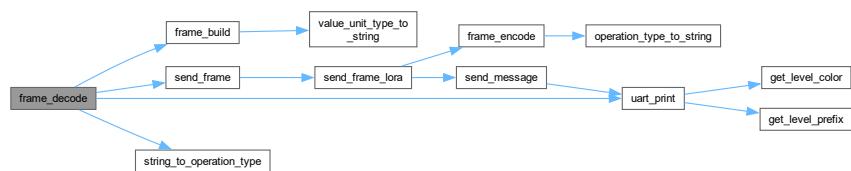
## Exceptions

<code>std::runtime_error</code>	if the frame is invalid.
---------------------------------	--------------------------

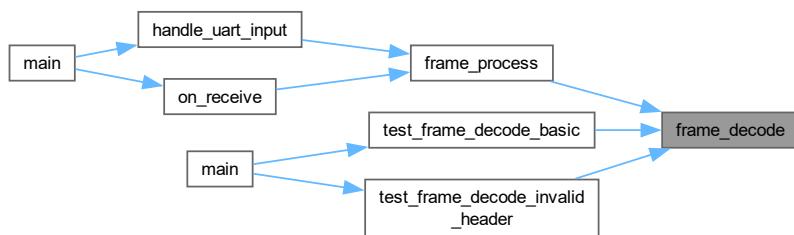
The decoded string is expected to be in the format: FRAME\_BEGIN;direction;operationType;group;command;value;unit;FRAME\_END

Definition at line [62](#) of file [frame.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 6.8.2.3 `frame_process()`

```

void frame_process (
    const std::string & data,
    Interface interface)
  
```

Executes a command based on the command key and the parameter.

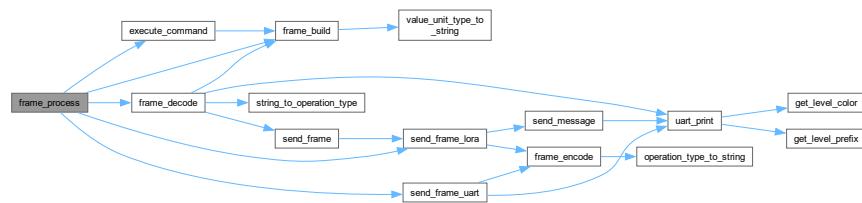
## Parameters

<code>data</code>	The <a href="#">Frame</a> data in string format.
-------------------	--

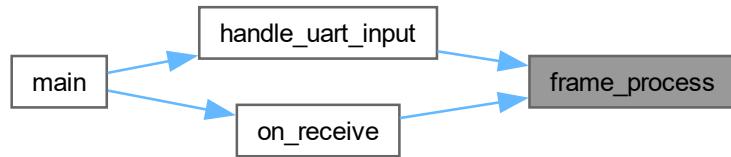
Decodes the frame data, extracts the command key, and executes the corresponding command. Sends the response frame. If an error occurs, an error frame is built and sent.

Definition at line 118 of file [frame.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

6.8.2.4 `frame_build()`

```
Frame frame_build (
    ExecutionResult result,
    uint8_t group,
    uint8_t command,
    const std::string & value,
    const ValueUnit unitType)
```

Builds a [Frame](#) instance based on the execution result, group, command, value, and unit.

## Parameters

<code>result</code>	The execution result.
<code>group</code>	The group ID.
<code>command</code>	The command ID within the group.
<code>value</code>	The payload value.
<code>unit</code>	The unit of measurement for the payload value.

**Returns**

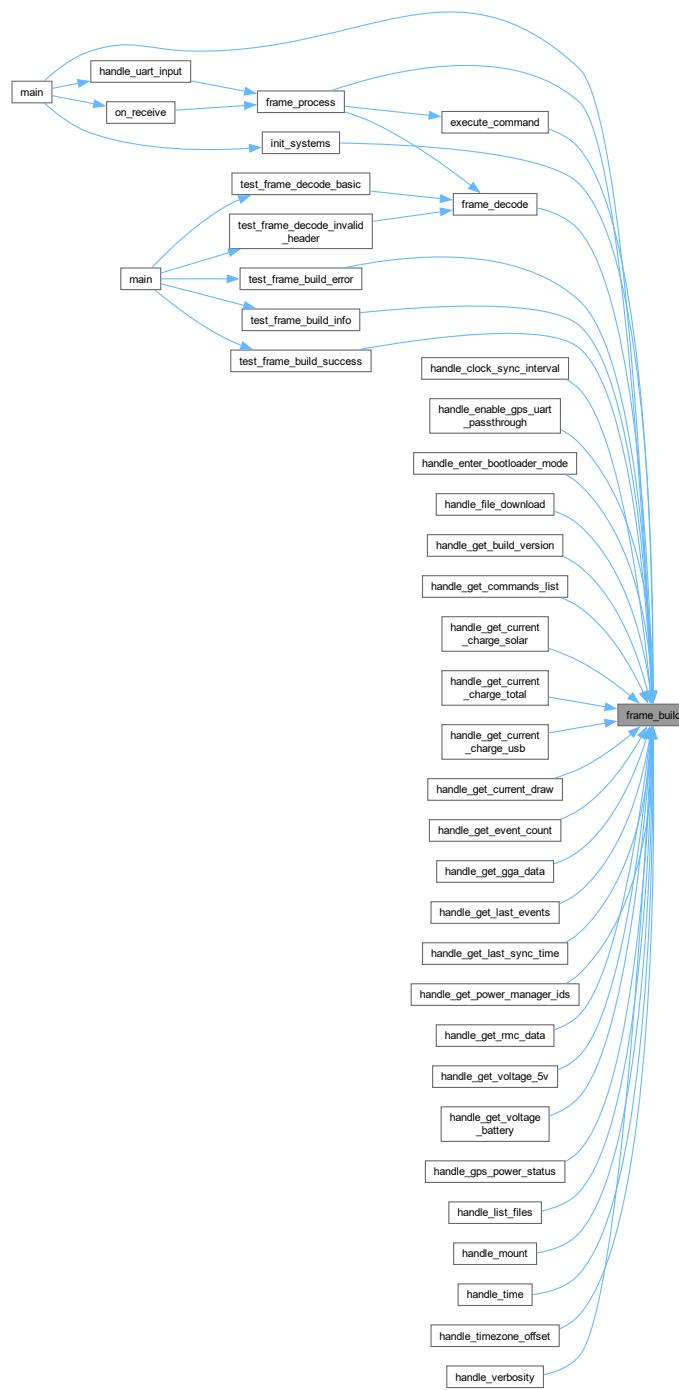
The [Frame](#) instance.

Definition at line 152 of file [frame.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



## 6.9 Event Manager

Classes and functions for managing event logging.

## Files

- file [event\\_manager.cpp](#)  
*Implements the event management system for the Kabisat firmware.*

## Classes

- class [EventLog](#)  
*Represents a single event log entry.*
- class [EventManager](#)  
*Manages the event logging system.*
- class [EventManagerImpl](#)  
*Implementation of the [EventManager](#) class.*
- class [EventEmitter](#)  
*Provides a static method for emitting events.*

## Enumerations

- enum class [EventGroup](#) : uint8\_t {  
 EventGroup::SYSTEM = 0x00 , EventGroup::POWER = 0x01 , EventGroup::COMMS = 0x02 ,  
 EventGroup::GPS = 0x03 , EventGroup::CLOCK = 0x04 }  
*Represents the group to which an event belongs.*
- enum class [SystemEvent](#) : uint8\_t {  
 SystemEvent::BOOT = 0x01 , SystemEvent::SHUTDOWN = 0x02 , SystemEvent::WATCHDOG\_RESET = 0x03 , SystemEvent::CORE1\_START = 0x04 , SystemEvent::CORE1\_STOP = 0x05 }  
*Represents specific system events.*
- enum class [PowerEvent](#) : uint8\_t {  
 PowerEvent::LOW\_BATTERY = 0x01 , PowerEvent::OVERCHARGE = 0x02 , PowerEvent::POWER\_FALLING = 0x03 , PowerEvent::POWER\_NORMAL = 0x04 , PowerEvent::SOLAR\_ACTIVE = 0x05 , PowerEvent::SOLAR\_INACTIVE = 0x06 , PowerEvent::USB\_CONNECTED = 0x07 , PowerEvent::USB\_DISCONNECTED = 0x08 }  
*Represents specific power-related events.*
- enum class [CommsEvent](#) : uint8\_t {  
 CommsEvent::RADIO\_INIT = 0x01 , CommsEvent::RADIO\_ERROR = 0x02 , CommsEvent::MSG RECEIVED = 0x03 , CommsEvent::MSG\_SENT = 0x04 , CommsEvent::UART\_ERROR = 0x06 }  
*Represents specific communication-related events.*
- enum class [GPSEvent](#) : uint8\_t {  
 GPSEvent::LOCK = 0x01 , GPSEvent::LOST = 0x02 , GPSEvent::ERROR = 0x03 , GPSEvent::POWER\_ON = 0x04 , GPSEvent::POWER\_OFF = 0x05 , GPSEvent::DATA\_READY = 0x06 , GPSEvent::PASS\_THROUGH\_START = 0x07 , GPSEvent::PASS\_THROUGH\_END = 0x08 }  
*Represents specific GPS-related events.*
- enum class [ClockEvent](#) : uint8\_t { ClockEvent::CHANGED = 0x01 , ClockEvent::GPS\_SYNC = 0x02 }  
*Represents specific clock-related events.*

## Functions

- void `check_power_events` (`PowerManager` &`pm`)  
*Checks power statuses and triggers events based on voltage trends.*
- class `EventLog __attribute__ ((packed))`
- void `EventManager::log_event` (`uint8_t group`, `uint8_t event`)  
*Logs an event.*
- const `EventLog & EventManager::get_event` (`size_t index`) const  
*Retrieves an event from the event buffer.*

## Variables

- volatile `uint16_t eventLogId` = 0  
*Global event log ID counter.*
- static `PowerEvent lastPowerState = PowerEvent::LOW_BATTERY`  
*Stores the last known power state.*
- static constexpr float `FALL_RATE_THRESHOLD` = -0.02f  
*Threshold for detecting a falling voltage rate.*
- static constexpr int `FALLING_TREND_REQUIRED` = 3  
*Number of consecutive falling voltage readings required to trigger a power falling event.*
- static constexpr float `VOLTAGE_LOW_THRESHOLD` = 4.7f  
*Voltage threshold for detecting a low battery condition.*
- static constexpr float `VOLTAGE_OVERCHARGE_THRESHOLD` = 5.3f  
*Voltage threshold for detecting an overcharge condition.*
- static int `fallingTrendCount` = 0  
*Counter for consecutive falling voltage readings.*
- bool `lastSolarState` = false  
*Stores the last known solar charging state.*
- bool `lastUSBState` = false  
*Stores the last known USB connection state.*
- `DS3231 systemClock`  
*External declaration of the system clock.*
- `EventManagerImpl eventManager`  
*Global instance of the `EventManager` implementation.*
- class `EventManager __attribute__ ((packed))`
- `EventManagerImpl eventManager`  
*Global instance of the `EventManagerImpl` class.*

### 6.9.1 Detailed Description

Classes and functions for managing event logging.

### 6.9.2 Enumeration Type Documentation

#### 6.9.2.1 EventGroup

```
enum class EventGroup : uint8_t [strong]
```

Represents the group to which an event belongs.

**Enumerator**

SYSTEM	System events.
POWER	Power-related events.
COMMS	Communication-related events.
GPS	GPS-related events.
CLOCK	Clock-related events.

Definition at line 26 of file [event\\_manager.h](#).

**6.9.2.2 SystemEvent**

```
enum class SystemEvent : uint8_t [strong]
```

Represents specific system events.

**Enumerator**

BOOT	System boot event.
SHUTDOWN	System shutdown event.
WATCHDOG_RESET	Watchdog reset event.
CORE1_START	Core 1 start event.
CORE1_STOP	Core 1 stop event.

Definition at line 43 of file [event\\_manager.h](#).

**6.9.2.3 PowerEvent**

```
enum class PowerEvent : uint8_t [strong]
```

Represents specific power-related events.

**Enumerator**

LOW_BATTERY	Low battery event.
OVERCHARGE	Overcharge event.
POWER_FALLING	Power falling event.
POWER_NORMAL	Power normal event.
SOLAR_ACTIVE	Solar charging active event.
SOLAR_INACTIVE	Solar charging inactive event.
USB_CONNECTED	USB connected event.
USB_DISCONNECTED	USB disconnected event.

Definition at line 60 of file [event\\_manager.h](#).

**6.9.2.4 CommsEvent**

```
enum class CommsEvent : uint8_t [strong]
```

Represents specific communication-related events.

Enumerator

RADIO_INIT	Radio initialization event.
RADIO_ERROR	Radio error event.
MSG RECEIVED	Message received event.
MSG SENT	Message sent event.
UART_ERROR	UART error event.

Definition at line 83 of file [event\\_manager.h](#).

#### 6.9.2.5 GPSEvent

```
enum class GPSEvent : uint8_t [strong]
```

Represents specific GPS-related events.

Enumerator

LOCK	GPS lock acquired event.
LOST	GPS lock lost event.
ERROR	GPS error event.
POWER_ON	GPS power on event.
POWER_OFF	GPS power off event.
DATA_READY	GPS data ready event.
PASS_THROUGH_START	GPS pass-through start event.
PASS_THROUGH_END	GPS pass-through end event.

Definition at line 100 of file [event\\_manager.h](#).

#### 6.9.2.6 ClockEvent

```
enum class ClockEvent : uint8_t [strong]
```

Represents specific clock-related events.

Enumerator

CHANGED	Clock changed event.
GPS_SYNC	Clock synchronized with GPS event.

Definition at line 124 of file [event\\_manager.h](#).

### 6.9.3 Function Documentation

#### 6.9.3.1 check\_power\_events()

```
void check_power_events (
    PowerManager & pm)
```

Checks power statuses and triggers events based on voltage trends.

### Parameters

<i>pm</i>	Reference to the <a href="#">PowerManager</a> object.
-----------	---

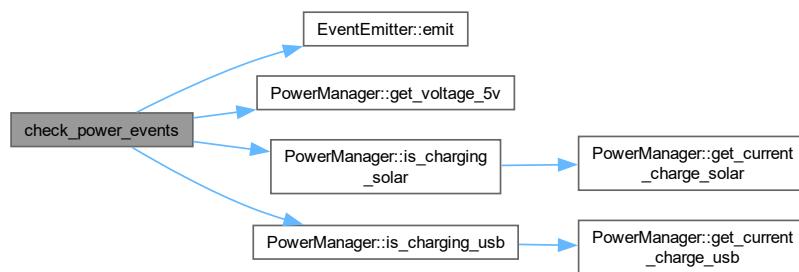
Monitors the 5V voltage level, detects falling voltage trends, and triggers events for low battery, overcharge, and normal power conditions. Also checks solar charging and USB connection states.

### Parameters

<i>pm</i>	Reference to the <a href="#">PowerManager</a> object.
-----------	---

Definition at line 154 of file [event\\_manager.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 6.9.3.2 [\\_\\_attribute\\_\\_\(\)](#)

```
class EventLog __attribute__ (
    packed) }
```

### 6.9.3.3 [log\\_event\(\)](#)

```
void EventManager::log_event (
    uint8_t group,
    uint8_t event)
```

Logs an event.

Logs an event to the event buffer.

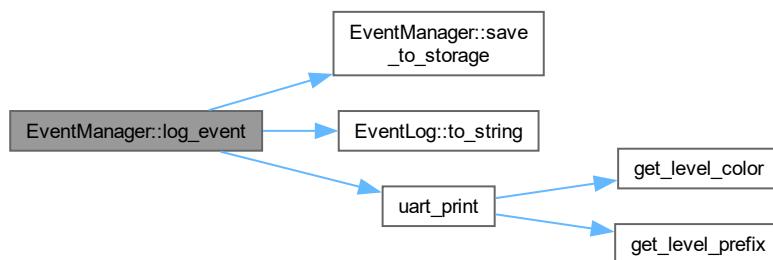
**Parameters**

<i>group</i>	The event group.
<i>event</i>	The event identifier.
<i>group</i>	The event group.
<i>event</i>	The event ID.

Logs the event with a timestamp, group, and event ID. Prints the event to the UART, and saves the event to storage if the buffer is full or if it's a power-related event.

Definition at line 93 of file [event\\_manager.cpp](#).

Here is the call graph for this function:

**6.9.3.4 get\_event()**

```
const EventLog & EventManager::get_event (
    size_t index) const
```

Retrieves an event from the event buffer.

**Parameters**

<i>index</i>	The index of the event to retrieve.
--------------	-------------------------------------

**Returns**

A const reference to the [EventLog](#) at the specified index.

**Parameters**

<i>index</i>	The index of the event to retrieve.
--------------	-------------------------------------

**Returns**

A const reference to the [EventLog](#) at the specified index. Returns an empty event if the index is out of bounds.

Definition at line 128 of file [event\\_manager.cpp](#).

## 6.9.4 Variable Documentation

### 6.9.4.1 eventLogId

```
volatile uint16_t eventLogId = 0
```

Global event log ID counter.

Definition at line [22](#) of file [event\\_manager.cpp](#).

### 6.9.4.2 lastPowerState

```
PowerEvent lastPowerState = PowerEvent::LOW_BATTERY [static]
```

Stores the last known power state.

Definition at line [28](#) of file [event\\_manager.cpp](#).

### 6.9.4.3 FALL\_RATE\_THRESHOLD

```
float FALL_RATE_THRESHOLD = -0.02f [static], [constexpr]
```

Threshold for detecting a falling voltage rate.

Definition at line [34](#) of file [event\\_manager.cpp](#).

### 6.9.4.4 FALLING\_TREND\_REQUIRED

```
int FALLING_TREND_REQUIRED = 3 [static], [constexpr]
```

Number of consecutive falling voltage readings required to trigger a power falling event.

Definition at line [40](#) of file [event\\_manager.cpp](#).

### 6.9.4.5 VOLTAGE\_LOW\_THRESHOLD

```
float VOLTAGE_LOW_THRESHOLD = 4.7f [static], [constexpr]
```

Voltage threshold for detecting a low battery condition.

Definition at line [46](#) of file [event\\_manager.cpp](#).

### 6.9.4.6 VOLTAGE\_OVERCHARGE\_THRESHOLD

```
float VOLTAGE_OVERCHARGE_THRESHOLD = 5.3f [static], [constexpr]
```

Voltage threshold for detecting an overcharge condition.

Definition at line [52](#) of file [event\\_manager.cpp](#).

#### 6.9.4.7 fallingTrendCount

```
int fallingTrendCount = 0 [static]
```

Counter for consecutive falling voltage readings.

Definition at line 58 of file [event\\_manager.cpp](#).

#### 6.9.4.8 lastSolarState

```
bool lastSolarState = false
```

Stores the last known solar charging state.

Definition at line 64 of file [event\\_manager.cpp](#).

#### 6.9.4.9 lastUSBState

```
bool lastUSBState = false
```

Stores the last known USB connection state.

Definition at line 70 of file [event\\_manager.cpp](#).

#### 6.9.4.10 systemClock

```
DS3231 systemClock [extern]
```

External declaration of the system clock.

#### 6.9.4.11 eventManager [1/2]

```
EventManagerImpl eventManager
```

Global instance of the [EventManager](#) implementation.

Global instance of the [EventManagerImpl](#) class.

Definition at line 82 of file [event\\_manager.cpp](#).

#### 6.9.4.12 \_\_attribute\_\_

```
class EventManager __attribute__
```

#### 6.9.4.13 eventManager [2/2]

`EventManagerImpl eventManager [extern]`

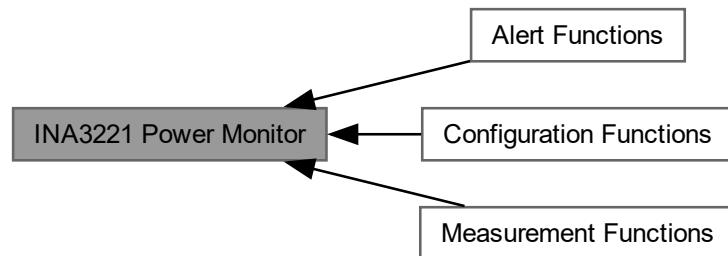
Global instance of the `EventManagerImpl` class.

Global instance of the `EventManagerImpl` class.

Definition at line 82 of file `event_manager.cpp`.

## 6.10 INA3221 Power Monitor

Collaboration diagram for INA3221 Power Monitor:



### Topics

- Configuration Functions
- Measurement Functions
- Alert Functions

#### 6.10.1 Detailed Description

#### 6.10.2 Configuration Functions

Collaboration diagram for Configuration Functions:



## Functions

- `INA3221::INA3221 (ina3221_addr_t addr, i2c_inst_t *i2c)`  
*Constructor for `INA3221` class.*
- `bool INA3221::begin ()`  
*Initialize the `INA3221` device.*
- `void INA3221::reset ()`  
*Reset the `INA3221` to default settings.*
- `uint16_t INA3221::get_manufacturer_id ()`  
*Get the manufacturer ID of the device.*
- `uint16_t INA3221::get_die_id ()`  
*Get the die ID of the device.*
- `uint16_t INA3221::read_register (ina3221_reg_t reg)`  
*Read a register from the device.*
- `void INA3221::set_mode_power_down ()`  
*Set device to power-down mode.*
- `void INA3221::set_mode_continuous ()`  
*Set device to continuous measurement mode.*
- `void INA3221::set_mode_triggered ()`  
*Set device to triggered measurement mode.*
- `void INA3221::set_shunt_measurement_enable ()`  
*Enable shunt voltage measurements.*
- `void INA3221::set_shunt_measurement_disable ()`  
*Disable shunt voltage measurements.*
- `void INA3221::set_bus_measurement_enable ()`  
*Enable bus voltage measurements.*
- `void INA3221::set_bus_measurement_disable ()`  
*Disable bus voltage measurements.*
- `void INA3221::set_averaging_mode (ina3221_avg_mode_t mode)`  
*Set the averaging mode for measurements.*
- `void INA3221::set_bus_conversion_time (ina3221_conv_time_t convTime)`  
*Set bus voltage conversion time.*
- `void INA3221::set_shunt_conversion_time (ina3221_conv_time_t convTime)`  
*Set shunt voltage conversion time.*

### 6.10.2.1 Detailed Description

Functions for configuring the `INA3221` device

### 6.10.2.2 Function Documentation

#### 6.10.2.2.1 `INA3221()`

```
INA3221::INA3221 (
    ina3221_addr_t addr,
    i2c_inst_t * i2c)
```

Constructor for `INA3221` class.

### Parameters

<i>addr</i>	I2C address of the device
<i>i2c</i>	Pointer to I2C instance

Definition at line 46 of file [INA3221.cpp](#).

#### 6.10.2.2.2 begin()

```
bool INA3221::begin ()
```

Initialize the [INA3221](#) device.

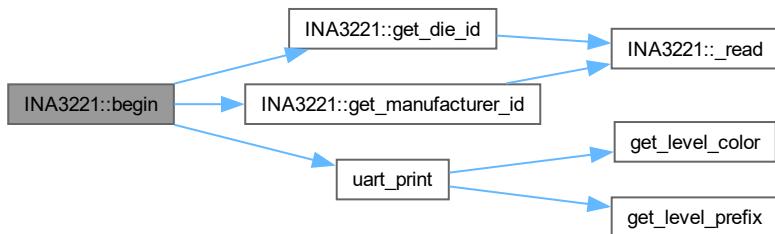
##### Returns

true if initialization successful, false otherwise

Sets up shunt resistors, filter resistors, and verifies device IDs

Definition at line 56 of file [INA3221.cpp](#).

Here is the call graph for this function:



#### 6.10.2.2.3 reset()

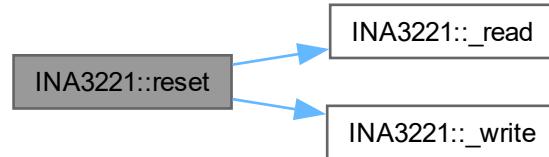
```
void INA3221::reset ()
```

Reset the [INA3221](#) to default settings.

Performs a software reset of the device by setting the reset bit

Definition at line 90 of file [INA3221.cpp](#).

Here is the call graph for this function:



#### 6.10.2.2.4 `get_manufacturer_id()`

```
uint16_t INA3221::get_manufacturer_id ()
```

Get the manufacturer ID of the device.

##### Returns

16-bit manufacturer ID (should be 0x5449)

Definition at line 104 of file [INA3221.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 6.10.2.2.5 get\_die\_id()

```
uint16_t INA3221::get_die_id ()
```

Get the die ID of the device.

#### Returns

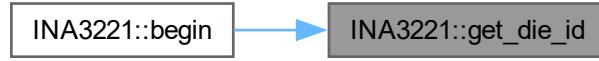
16-bit die ID (should be 0x3220)

Definition at line 116 of file [INA3221.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 6.10.2.2.6 read\_register()

```
uint16_t INA3221::read_register (
    ina3221_reg_t reg)
```

Read a register from the device.

#### Parameters

<i>reg</i>	Register address to read
------------	--------------------------

**Returns**

16-bit value read from the register

Definition at line 129 of file [INA3221.cpp](#).

Here is the call graph for this function:

**6.10.2.2.7 set\_mode\_power\_down()**

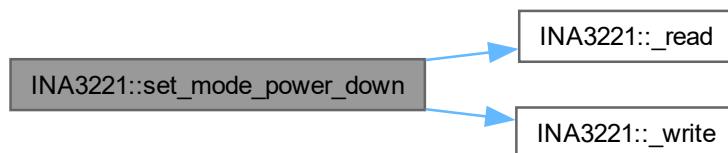
```
void INA3221::set_mode_power_down ()
```

Set device to power-down mode.

Disables bus voltage and continuous measurements

Definition at line 143 of file [INA3221.cpp](#).

Here is the call graph for this function:

**6.10.2.2.8 set\_mode\_continuous()**

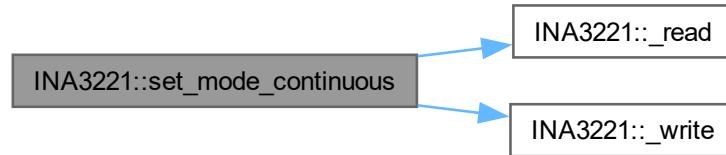
```
void INA3221::set_mode_continuous ()
```

Set device to continuous measurement mode.

Enables continuous measurement of bus voltage and shunt voltage

Definition at line 158 of file [INA3221.cpp](#).

Here is the call graph for this function:



#### 6.10.2.2.9 `set_mode_triggered()`

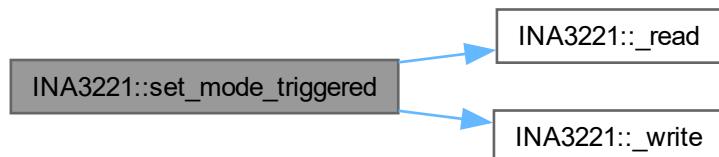
```
void INA3221::set_mode_triggered ()
```

Set device to triggered measurement mode.

Disables continuous measurements, requiring manual triggers

Definition at line 172 of file [INA3221.cpp](#).

Here is the call graph for this function:



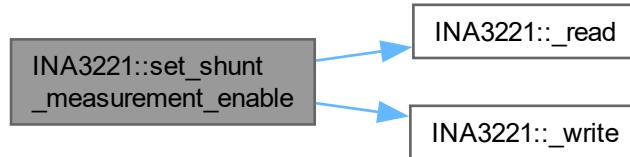
#### 6.10.2.2.10 `set_shunt_measurement_enable()`

```
void INA3221::set_shunt_measurement_enable ()
```

Enable shunt voltage measurements.

Definition at line 185 of file [INA3221.cpp](#).

Here is the call graph for this function:



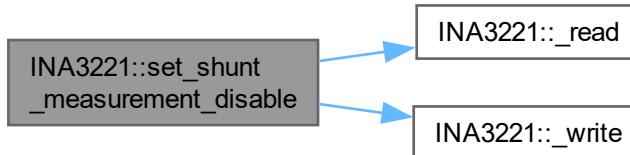
#### 6.10.2.2.11 `set_shunt_measurement_disable()`

```
void INA3221::set_shunt_measurement_disable ()
```

Disable shunt voltage measurements.

Definition at line 198 of file [INA3221.cpp](#).

Here is the call graph for this function:



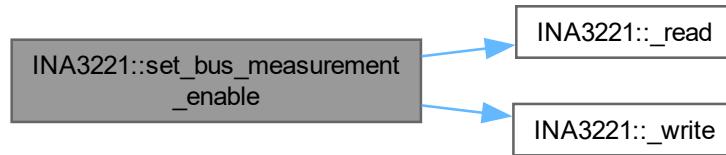
#### 6.10.2.2.12 `set_bus_measurement_enable()`

```
void INA3221::set_bus_measurement_enable ()
```

Enable bus voltage measurements.

Definition at line 211 of file [INA3221.cpp](#).

Here is the call graph for this function:



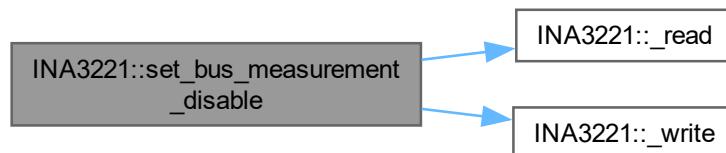
#### 6.10.2.2.13 `set_bus_measurement_disable()`

```
void INA3221::set_bus_measurement_disable ()
```

Disable bus voltage measurements.

Definition at line 224 of file [INA3221.cpp](#).

Here is the call graph for this function:



#### 6.10.2.2.14 `set_averaging_mode()`

```
void INA3221::set_averaging_mode (
    ina3221_avg_mode_t mode)
```

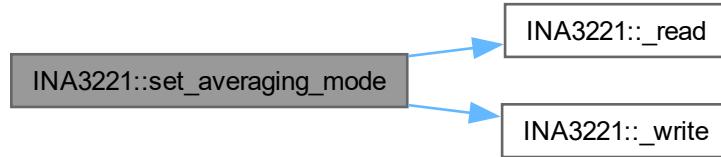
Set the averaging mode for measurements.

##### Parameters

<code>mode</code>	Number of samples to average
-------------------	------------------------------

Definition at line 238 of file [INA3221.cpp](#).

Here is the call graph for this function:



#### 6.10.2.2.15 set\_bus\_conversion\_time()

```
void INA3221::set_bus_conversion_time (
    ina3221_conv_time_t convTime)
```

Set bus voltage conversion time.

##### Parameters

<code>convTime</code>	Conversion time setting
-----------------------	-------------------------

Definition at line 252 of file [INA3221.cpp](#).

Here is the call graph for this function:



#### 6.10.2.2.16 set\_shunt\_conversion\_time()

```
void INA3221::set_shunt_conversion_time (
    ina3221_conv_time_t convTime)
```

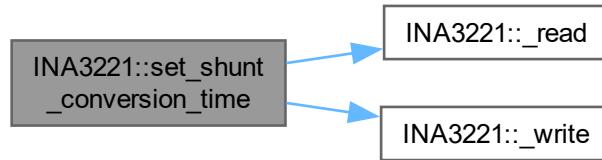
Set shunt voltage conversion time.

### Parameters

<code>convTime</code>	Conversion time setting
-----------------------	-------------------------

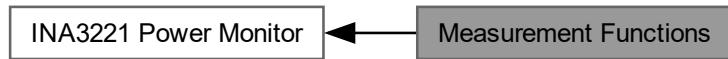
Definition at line 266 of file [INA3221.cpp](#).

Here is the call graph for this function:



### 6.10.3 Measurement Functions

Collaboration diagram for Measurement Functions:



### Functions

- `int32_t INA3221::get_shunt_voltage (ina3221_ch_t channel)`  
*Get shunt voltage for a specific channel.*
- `float INA3221::get_current_ma (ina3221_ch_t channel)`  
*Get current for a specific channel.*
- `float INA3221::get_voltage (ina3221_ch_t channel)`  
*Get bus voltage for a specific channel.*

#### 6.10.3.1 Detailed Description

Functions for reading voltage, current and power measurements

#### 6.10.3.2 Function Documentation

##### 6.10.3.2.1 `get_shunt_voltage()`

```
int32_t INA3221::get_shunt_voltage (
    ina3221_ch_t channel)
```

Get shunt voltage for a specific channel.

**Parameters**

<i>channel</i>	Channel number (1-3)
----------------	----------------------

**Returns**

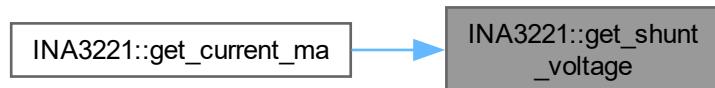
Shunt voltage in microvolts ( $\mu$ V)

Definition at line 282 of file [INA3221.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 6.10.3.2.2 `get_current_ma()`

```
float INA3221::get_current_ma (
    ina3221_ch_t channel)
```

Get current for a specific channel.

**Parameters**

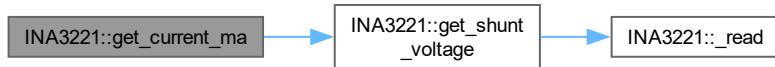
<i>channel</i>	Channel number (1-3)
----------------	----------------------

**Returns**

Current in millamps (mA)

Definition at line 314 of file [INA3221.cpp](#).

Here is the call graph for this function:



### 6.10.3.2.3 get\_voltage()

```
float INA3221::get_voltage (  
    ina3221_ch_t channel)
```

Get bus voltage for a specific channel.

**Parameters**

<i>channel</i>	Channel number (1-3)
----------------	----------------------

**Returns**

Voltage in volts (V)

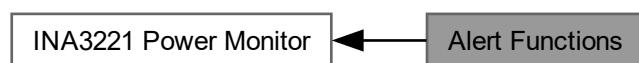
Definition at line 330 of file [INA3221.cpp](#).

Here is the call graph for this function:



## 6.10.4 Alert Functions

Collaboration diagram for Alert Functions:



## Functions

- void `INA3221::set_warn_alert_limit` (`ina3221_ch_t` channel, float `voltage_v`)  
*Set warning alert voltage threshold for a channel.*
- void `INA3221::set_crit_alert_limit` (`ina3221_ch_t` channel, float `voltage_v`)  
*Set critical alert voltage threshold for a channel.*
- void `INA3221::set_power_valid_limit` (float `voltage_upper_v`, float `voltage_lower_v`)  
*Set power valid voltage range.*
- void `INA3221::enable_alerts` ()  
*Enable all alert functions.*
- bool `INA3221::get_warn_alert` (`ina3221_ch_t` channel)  
*Get warning alert status for a channel.*
- bool `INA3221::get_crit_alert` (`ina3221_ch_t` channel)  
*Get critical alert status for a channel.*
- bool `INA3221::get_power_valid_alert` ()  
*Get power valid alert status.*
- void `INA3221::set_alert_latch` (bool enable)  
*Set alert latch mode.*

### 6.10.4.1 Detailed Description

Functions for configuring and reading alert conditions

### 6.10.4.2 Function Documentation

#### 6.10.4.2.1 `set_warn_alert_limit()`

```
void INA3221::set_warn_alert_limit (
    ina3221_ch_t channel,
    float voltage_v)
```

Set warning alert voltage threshold for a channel.

##### Parameters

<code>channel</code>	Channel number (1-3)
<code>voltage_v</code>	Voltage threshold in volts

Definition at line 360 of file `INA3221.cpp`.

Here is the call graph for this function:



#### 6.10.4.2.2 set\_crit\_alert\_limit()

```
void INA3221::set_crit_alert_limit (
    ina3221_ch_t channel,
    float voltage_v)
```

Set critical alert voltage threshold for a channel.

##### Parameters

<i>channel</i>	Channel number (1-3)
<i>voltage</i> ← _v	Voltage threshold in volts

Definition at line 385 of file [INA3221.cpp](#).

Here is the call graph for this function:



#### 6.10.4.2.3 set\_power\_valid\_limit()

```
void INA3221::set_power_valid_limit (
    float voltage_upper_v,
    float voltage_lower_v)
```

Set power valid voltage range.

##### Parameters

<i>voltage_upper</i> ← _v	Upper voltage threshold in volts
<i>voltage_lower</i> ← _v	Lower voltage threshold in volts

Definition at line 410 of file [INA3221.cpp](#).

Here is the call graph for this function:



#### 6.10.4.2.4 enable\_alerts()

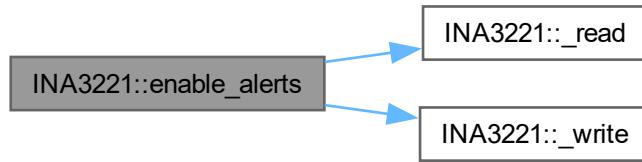
```
void INA3221::enable_alerts ()
```

Enable all alert functions.

Enables warning alerts, critical alerts, and power valid alerts for all channels

Definition at line 426 of file [INA3221.cpp](#).

Here is the call graph for this function:



#### 6.10.4.2.5 get\_warn\_alert()

```
bool INA3221::get_warn_alert (
    ina3221_ch_t channel)
```

Get warning alert status for a channel.

##### Parameters

<code>channel</code>	Channel number (1-3)
----------------------	----------------------

##### Returns

true if warning alert is active, false otherwise

Definition at line 448 of file [INA3221.cpp](#).

Here is the call graph for this function:



#### 6.10.4.2.6 `get_crit_alert()`

```
bool INA3221::get_crit_alert (
    ina3221_ch_t channel)
```

Get critical alert status for a channel.

**Parameters**

<i>channel</i>	Channel number (1-3)
----------------	----------------------

**Returns**

true if critical alert is active, false otherwise

Definition at line 467 of file [INA3221.cpp](#).

Here is the call graph for this function:

**6.10.4.2.7 get\_power\_valid\_alert()**

```
bool INA3221::get_power_valid_alert ()
```

Get power valid alert status.

**Returns**

true if power valid alert is active, false otherwise

Definition at line 485 of file [INA3221.cpp](#).

Here is the call graph for this function:

**6.10.4.2.8 set\_alert\_latch()**

```
void INA3221::set_alert_latch (
    bool enable)
```

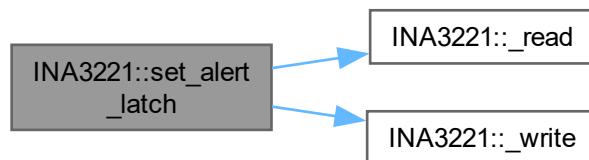
Set alert latch mode.

**Parameters**

<code>enable</code>	true to enable alert latching, false for transparent alerts
---------------------	---

Definition at line 497 of file [INA3221.cpp](#).

Here is the call graph for this function:



# Chapter 7

## Class Documentation

### 7.1 BH1750 Class Reference

```
#include <BH1750.h>
```

#### Public Types

- enum class `Mode` : `uint8_t` {  
    `UNCONFIGURED_POWER_DOWN` = 0x00 , `POWER_ON` = 0x01 , `RESET` = 0x07 , `CONTINUOUS_HIGH_RES_MODE` = 0x10 ,  
    `CONTINUOUS_HIGH_RES_MODE_2` = 0x11 , `CONTINUOUS_LOW_RES_MODE` = 0x13 , `ONE_TIME_HIGH_RES_MODE` = 0x20 ,  
    `ONE_TIME_HIGH_RES_MODE_2` = 0x21 ,  
    `ONE_TIME_LOW_RES_MODE` = 0x23 }

#### Public Member Functions

- `BH1750` (`uint8_t` `addr`=0x23)
- bool `begin` (`Mode mode`=`Mode::CONTINUOUS_HIGH_RES_MODE`)
- void `configure` (`Mode mode`)
- float `get_light_level` ()

#### Private Member Functions

- void `write8` (`uint8_t data`)

#### Private Attributes

- `uint8_t _i2c_addr`

### 7.1.1 Detailed Description

Definition at line 12 of file `BH1750.h`.

### 7.1.2 Member Enumeration Documentation

#### 7.1.2.1 Mode

```
enum class BH1750::Mode : uint8_t [strong]
```

### Enumerator

UNCONFIGURED_POWER_DOWN	
POWER_ON	
RESET	
CONTINUOUS_HIGH_RES_MODE	
CONTINUOUS_HIGH_RES_MODE_2	
CONTINUOUS_LOW_RES_MODE	
ONE_TIME_HIGH_RES_MODE	
ONE_TIME_HIGH_RES_MODE_2	
ONE_TIME_LOW_RES_MODE	

Definition at line 15 of file [BH1750.h](#).

### 7.1.3 Constructor & Destructor Documentation

#### 7.1.3.1 BH1750()

```
BH1750::BH1750 (
    uint8_t addr = 0x23)
```

Definition at line 6 of file [BH1750.cpp](#).

### 7.1.4 Member Function Documentation

#### 7.1.4.1 begin()

```
bool BH1750::begin (
    Mode mode = Mode::CONTINUOUS_HIGH_RES_MODE)
```

Definition at line 8 of file [BH1750.cpp](#).

Here is the call graph for this function:



### 7.1.4.2 configure()

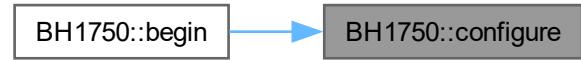
```
void BH1750::configure (
    Mode mode)
```

Definition at line 22 of file [BH1750.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 7.1.4.3 get\_light\_level()

```
float BH1750::get_light_level ()
```

Definition at line 40 of file [BH1750.cpp](#).

### 7.1.4.4 write8()

```
void BH1750::write8 (
    uint8_t data) [private]
```

Definition at line 49 of file [BH1750.cpp](#).

Here is the caller graph for this function:



## 7.1.5 Member Data Documentation

### 7.1.5.1 \_i2c\_addr

```
uint8_t BH1750::_i2c_addr [private]
```

Definition at line 34 of file [BH1750.h](#).

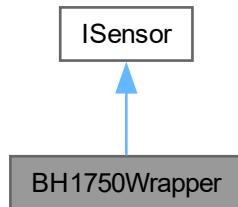
The documentation for this class was generated from the following files:

- lib/sensors/BH1750/[BH1750.h](#)
- lib/sensors/BH1750/[BH1750.cpp](#)

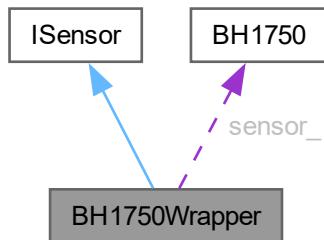
## 7.2 BH1750Wrapper Class Reference

```
#include <BH1750_WRAPPER.h>
```

Inheritance diagram for BH1750Wrapper:



Collaboration diagram for BH1750Wrapper:



## Public Member Functions

- `BH1750Wrapper ()`
- `int get_i2c_addr ()`
- `bool init () override`
- `float read_data (SensorDataTypelIdentifier type) override`
- `bool is_initialized () const override`
- `SensorType get_type () const override`
- `bool configure (const std::map< std::string, std::string > &config)`

## Public Member Functions inherited from `ISensor`

- `virtual ~ISensor ()=default`

## Private Attributes

- `BH1750 sensor_`
- `bool initialized_ = false`

### 7.2.1 Detailed Description

Definition at line 9 of file `BH1750_WRAPPER.h`.

### 7.2.2 Constructor & Destructor Documentation

#### 7.2.2.1 `BH1750Wrapper()`

```
BH1750Wrapper::BH1750Wrapper ()
```

Definition at line 6 of file `BH1750_WRAPPER.cpp`.

### 7.2.3 Member Function Documentation

#### 7.2.3.1 `get_i2c_addr()`

```
int BH1750Wrapper::get_i2c_addr ()
```

#### 7.2.3.2 `init()`

```
bool BH1750Wrapper::init () [override], [virtual]
```

Implements `ISensor`.

Definition at line 10 of file `BH1750_WRAPPER.cpp`.

### 7.2.3.3 `read_data()`

```
float BH1750Wrapper::read_data (
    SensorDataTypeIdentifier type) [override], [virtual]
```

Implements [ISensor](#).

Definition at line 15 of file [BH1750\\_WRAPPER.cpp](#).

### 7.2.3.4 `is_initialized()`

```
bool BH1750Wrapper::is_initialized () const [override], [virtual]
```

Implements [ISensor](#).

Definition at line 22 of file [BH1750\\_WRAPPER.cpp](#).

### 7.2.3.5 `get_type()`

```
SensorType BH1750Wrapper::get_type () const [override], [virtual]
```

Implements [ISensor](#).

Definition at line 26 of file [BH1750\\_WRAPPER.cpp](#).

### 7.2.3.6 `configure()`

```
bool BH1750Wrapper::configure (
    const std::map< std::string, std::string > & config) [virtual]
```

Implements [ISensor](#).

Definition at line 30 of file [BH1750\\_WRAPPER.cpp](#).

## 7.2.4 Member Data Documentation

### 7.2.4.1 `sensor_`

```
BH1750 BH1750Wrapper::sensor_ [private]
```

Definition at line 11 of file [BH1750\\_WRAPPER.h](#).

### 7.2.4.2 `initialized_`

```
bool BH1750Wrapper::initialized_ = false [private]
```

Definition at line 12 of file [BH1750\\_WRAPPER.h](#).

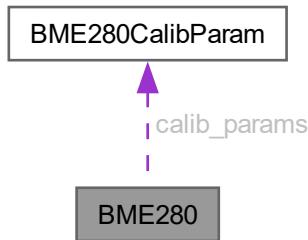
The documentation for this class was generated from the following files:

- lib/sensors/BH1750/[BH1750\\_WRAPPER.h](#)
- lib/sensors/BH1750/[BH1750\\_WRAPPER.cpp](#)

## 7.3 BME280 Class Reference

```
#include <BME280.h>
```

Collaboration diagram for BME280:



### Public Member Functions

- `BME280 (i2c_inst_t *i2cPort, uint8_t address=ADDR_SDO_LOW)`
- `bool init ()`
- `void reset ()`
- `bool read_raw_all (int32_t *temperature, int32_t *pressure, int32_t *humidity)`
- `float convert_temperature (int32_t temp_raw) const`
- `float convert_pressure (int32_t pressure_raw) const`
- `float convert_humidity (int32_t humidity_raw) const`

### Static Public Attributes

- `static constexpr uint8_t ADDR_SDO_LOW = 0x76`
- `static constexpr uint8_t ADDR_SDO_HIGH = 0x77`

### Private Member Functions

- `bool configure_sensor ()`
- `bool get_calibration_parameters ()`

### Private Attributes

- `i2c_inst_t * i2c_port`
- `uint8_t device_addr`
- `BME280CalibParam calib_params`
- `bool initialized_`
- `int32_t t_fine`

### Static Private Attributes

- static constexpr uint8\_t `REG_CONFIG` = 0xF5
- static constexpr uint8\_t `REG_CTRL_MEAS` = 0xF4
- static constexpr uint8\_t `REG_CTRL_HUM` = 0xF2
- static constexpr uint8\_t `REG_RESET` = 0xE0
- static constexpr uint8\_t `REG_PRESSURE_MSB` = 0xF7
- static constexpr uint8\_t `REG_TEMPERATURE_MSB` = 0xFA
- static constexpr uint8\_t `REG_HUMIDITY_MSB` = 0xFD
- static constexpr uint8\_t `REG_DIG_T1_LSB` = 0x88
- static constexpr uint8\_t `REG_DIG_T1_MSB` = 0x89
- static constexpr uint8\_t `REG_DIG_T2_LSB` = 0x8A
- static constexpr uint8\_t `REG_DIG_T2_MSB` = 0x8B
- static constexpr uint8\_t `REG_DIG_T3_LSB` = 0x8C
- static constexpr uint8\_t `REG_DIG_T3_MSB` = 0x8D
- static constexpr uint8\_t `REG_DIG_P1_LSB` = 0x8E
- static constexpr uint8\_t `REG_DIG_P1_MSB` = 0x8F
- static constexpr uint8\_t `REG_DIG_P2_LSB` = 0x90
- static constexpr uint8\_t `REG_DIG_P2_MSB` = 0x91
- static constexpr uint8\_t `REG_DIG_P3_LSB` = 0x92
- static constexpr uint8\_t `REG_DIG_P3_MSB` = 0x93
- static constexpr uint8\_t `REG_DIG_P4_LSB` = 0x94
- static constexpr uint8\_t `REG_DIG_P4_MSB` = 0x95
- static constexpr uint8\_t `REG_DIG_P5_LSB` = 0x96
- static constexpr uint8\_t `REG_DIG_P5_MSB` = 0x97
- static constexpr uint8\_t `REG_DIG_P6_LSB` = 0x98
- static constexpr uint8\_t `REG_DIG_P6_MSB` = 0x99
- static constexpr uint8\_t `REG_DIG_P7_LSB` = 0x9A
- static constexpr uint8\_t `REG_DIG_P7_MSB` = 0x9B
- static constexpr uint8\_t `REG_DIG_P8_LSB` = 0x9C
- static constexpr uint8\_t `REG_DIG_P8_MSB` = 0x9D
- static constexpr uint8\_t `REG_DIG_P9_LSB` = 0x9E
- static constexpr uint8\_t `REG_DIG_P9_MSB` = 0x9F
- static constexpr uint8\_t `REG_DIG_H1` = 0xA1
- static constexpr uint8\_t `REG_DIG_H2` = 0xE1
- static constexpr uint8\_t `REG_DIG_H3` = 0xE3
- static constexpr uint8\_t `REG_DIG_H4` = 0xE4
- static constexpr uint8\_t `REG_DIG_H5` = 0xE5
- static constexpr uint8\_t `REG_DIG_H6` = 0xE7
- static constexpr size\_t `NUM_CALIB_PARAMS` = 24

### 7.3.1 Detailed Description

Definition at line 38 of file [BME280.h](#).

### 7.3.2 Constructor & Destructor Documentation

#### 7.3.2.1 BME280()

```
BME280::BME280 (
    i2c_inst_t * i2cPort,
    uint8_t address = ADDR_SDO_LOW)
```

Definition at line 14 of file [BME280.cpp](#).

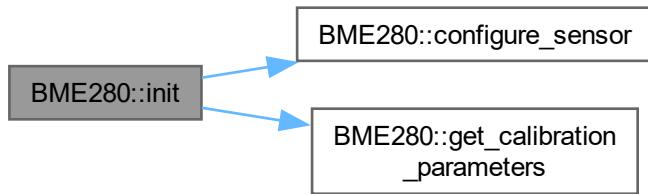
### 7.3.3 Member Function Documentation

#### 7.3.3.1 init()

```
bool BME280::init ()
```

Definition at line 18 of file [BME280.cpp](#).

Here is the call graph for this function:



#### 7.3.3.2 reset()

```
void BME280::reset ()
```

Definition at line 59 of file [BME280.cpp](#).

#### 7.3.3.3 read\_raw\_all()

```
bool BME280::read_raw_all (
    int32_t * temperature,
    int32_t * pressure,
    int32_t * humidity)
```

Definition at line 68 of file [BME280.cpp](#).

#### 7.3.3.4 convert\_temperature()

```
float BME280::convert_temperature (
    int32_t temp_raw) const
```

Definition at line 101 of file [BME280.cpp](#).

#### 7.3.3.5 convert\_pressure()

```
float BME280::convert_pressure (
    int32_t pressure_raw) const
```

Definition at line 110 of file [BME280.cpp](#).

### 7.3.3.6 convert\_humidity()

```
float BME280::convert_humidity (
    int32_t humidity_raw) const
```

Definition at line 131 of file [BME280.cpp](#).

### 7.3.3.7 configure\_sensor()

```
bool BME280::configure_sensor () [private]
```

Definition at line 201 of file [BME280.cpp](#).

Here is the caller graph for this function:



### 7.3.3.8 get\_calibration\_parameters()

```
bool BME280::get_calibration_parameters () [private]
```

Definition at line 143 of file [BME280.cpp](#).

Here is the caller graph for this function:



## 7.3.4 Member Data Documentation

### 7.3.4.1 ADDR\_SDO\_LOW

```
uint8_t BME280::ADDR_SDO_LOW = 0x76 [static], [constexpr]
```

Definition at line 41 of file [BME280.h](#).

#### 7.3.4.2 ADDR\_SDO\_HIGH

```
uint8_t BME280::ADDR_SDO_HIGH = 0x77 [static], [constexpr]
```

Definition at line 42 of file [BME280.h](#).

#### 7.3.4.3 i2c\_port

```
i2c_inst_t* BME280::i2c_port [private]
```

Definition at line 69 of file [BME280.h](#).

#### 7.3.4.4 device\_addr

```
uint8_t BME280::device_addr [private]
```

Definition at line 70 of file [BME280.h](#).

#### 7.3.4.5 calib\_params

```
BME280CalibParam BME280::calib_params [private]
```

Definition at line 73 of file [BME280.h](#).

#### 7.3.4.6 initialized\_

```
bool BME280::initialized_ [private]
```

Definition at line 76 of file [BME280.h](#).

#### 7.3.4.7 t\_fine

```
int32_t BME280::t_fine [mutable], [private]
```

Definition at line 79 of file [BME280.h](#).

#### 7.3.4.8 REG\_CONFIG

```
uint8_t BME280::REG_CONFIG = 0xF5 [static], [constexpr], [private]
```

Definition at line 82 of file [BME280.h](#).

#### 7.3.4.9 REG\_CTRL\_MEAS

```
uint8_t BME280::REG_CTRL_MEAS = 0xF4 [static], [constexpr], [private]
```

Definition at line 83 of file [BME280.h](#).

### 7.3.4.10 REG\_CTRL\_HUM

```
uint8_t BME280::REG_CTRL_HUM = 0xF2 [static], [constexpr], [private]
```

Definition at line 84 of file [BME280.h](#).

### 7.3.4.11 REG\_RESET

```
uint8_t BME280::REG_RESET = 0xE0 [static], [constexpr], [private]
```

Definition at line 85 of file [BME280.h](#).

### 7.3.4.12 REG\_PRESSURE\_MSB

```
uint8_t BME280::REG_PRESSURE_MSB = 0xF7 [static], [constexpr], [private]
```

Definition at line 87 of file [BME280.h](#).

### 7.3.4.13 REG\_TEMPERATURE\_MSB

```
uint8_t BME280::REG_TEMPERATURE_MSB = 0xFA [static], [constexpr], [private]
```

Definition at line 88 of file [BME280.h](#).

### 7.3.4.14 REG\_HUMIDITY\_MSB

```
uint8_t BME280::REG_HUMIDITY_MSB = 0xFD [static], [constexpr], [private]
```

Definition at line 89 of file [BME280.h](#).

### 7.3.4.15 REG\_DIG\_T1\_LSB

```
uint8_t BME280::REG_DIG_T1_LSB = 0x88 [static], [constexpr], [private]
```

Definition at line 92 of file [BME280.h](#).

### 7.3.4.16 REG\_DIG\_T1\_MSB

```
uint8_t BME280::REG_DIG_T1_MSB = 0x89 [static], [constexpr], [private]
```

Definition at line 93 of file [BME280.h](#).

### 7.3.4.17 REG\_DIG\_T2\_LSB

```
uint8_t BME280::REG_DIG_T2_LSB = 0x8A [static], [constexpr], [private]
```

Definition at line 94 of file [BME280.h](#).

#### 7.3.4.18 REG\_DIG\_T2\_MSB

```
uint8_t BME280::REG_DIG_T2_MSB = 0x8B [static], [constexpr], [private]
```

Definition at line 95 of file [BME280.h](#).

#### 7.3.4.19 REG\_DIG\_T3\_LSB

```
uint8_t BME280::REG_DIG_T3_LSB = 0x8C [static], [constexpr], [private]
```

Definition at line 96 of file [BME280.h](#).

#### 7.3.4.20 REG\_DIG\_T3\_MSB

```
uint8_t BME280::REG_DIG_T3_MSB = 0x8D [static], [constexpr], [private]
```

Definition at line 97 of file [BME280.h](#).

#### 7.3.4.21 REG\_DIG\_P1\_LSB

```
uint8_t BME280::REG_DIG_P1_LSB = 0x8E [static], [constexpr], [private]
```

Definition at line 99 of file [BME280.h](#).

#### 7.3.4.22 REG\_DIG\_P1\_MSB

```
uint8_t BME280::REG_DIG_P1_MSB = 0x8F [static], [constexpr], [private]
```

Definition at line 100 of file [BME280.h](#).

#### 7.3.4.23 REG\_DIG\_P2\_LSB

```
uint8_t BME280::REG_DIG_P2_LSB = 0x90 [static], [constexpr], [private]
```

Definition at line 101 of file [BME280.h](#).

#### 7.3.4.24 REG\_DIG\_P2\_MSB

```
uint8_t BME280::REG_DIG_P2_MSB = 0x91 [static], [constexpr], [private]
```

Definition at line 102 of file [BME280.h](#).

#### 7.3.4.25 REG\_DIG\_P3\_LSB

```
uint8_t BME280::REG_DIG_P3_LSB = 0x92 [static], [constexpr], [private]
```

Definition at line 103 of file [BME280.h](#).

### 7.3.4.26 REG\_DIG\_P3\_MSB

```
uint8_t BME280::REG_DIG_P3_MSB = 0x93 [static], [constexpr], [private]
```

Definition at line 104 of file [BME280.h](#).

### 7.3.4.27 REG\_DIG\_P4\_LSB

```
uint8_t BME280::REG_DIG_P4_LSB = 0x94 [static], [constexpr], [private]
```

Definition at line 105 of file [BME280.h](#).

### 7.3.4.28 REG\_DIG\_P4\_MSB

```
uint8_t BME280::REG_DIG_P4_MSB = 0x95 [static], [constexpr], [private]
```

Definition at line 106 of file [BME280.h](#).

### 7.3.4.29 REG\_DIG\_P5\_LSB

```
uint8_t BME280::REG_DIG_P5_LSB = 0x96 [static], [constexpr], [private]
```

Definition at line 107 of file [BME280.h](#).

### 7.3.4.30 REG\_DIG\_P5\_MSB

```
uint8_t BME280::REG_DIG_P5_MSB = 0x97 [static], [constexpr], [private]
```

Definition at line 108 of file [BME280.h](#).

### 7.3.4.31 REG\_DIG\_P6\_LSB

```
uint8_t BME280::REG_DIG_P6_LSB = 0x98 [static], [constexpr], [private]
```

Definition at line 109 of file [BME280.h](#).

### 7.3.4.32 REG\_DIG\_P6\_MSB

```
uint8_t BME280::REG_DIG_P6_MSB = 0x99 [static], [constexpr], [private]
```

Definition at line 110 of file [BME280.h](#).

### 7.3.4.33 REG\_DIG\_P7\_LSB

```
uint8_t BME280::REG_DIG_P7_LSB = 0x9A [static], [constexpr], [private]
```

Definition at line 111 of file [BME280.h](#).

#### 7.3.4.34 REG\_DIG\_P7\_MSB

```
uint8_t BME280::REG_DIG_P7_MSB = 0x9B [static], [constexpr], [private]
```

Definition at line 112 of file [BME280.h](#).

#### 7.3.4.35 REG\_DIG\_P8\_LSB

```
uint8_t BME280::REG_DIG_P8_LSB = 0x9C [static], [constexpr], [private]
```

Definition at line 113 of file [BME280.h](#).

#### 7.3.4.36 REG\_DIG\_P8\_MSB

```
uint8_t BME280::REG_DIG_P8_MSB = 0x9D [static], [constexpr], [private]
```

Definition at line 114 of file [BME280.h](#).

#### 7.3.4.37 REG\_DIG\_P9\_LSB

```
uint8_t BME280::REG_DIG_P9_LSB = 0x9E [static], [constexpr], [private]
```

Definition at line 115 of file [BME280.h](#).

#### 7.3.4.38 REG\_DIG\_P9\_MSB

```
uint8_t BME280::REG_DIG_P9_MSB = 0x9F [static], [constexpr], [private]
```

Definition at line 116 of file [BME280.h](#).

#### 7.3.4.39 REG\_DIG\_H1

```
uint8_t BME280::REG_DIG_H1 = 0xA1 [static], [constexpr], [private]
```

Definition at line 119 of file [BME280.h](#).

#### 7.3.4.40 REG\_DIG\_H2

```
uint8_t BME280::REG_DIG_H2 = 0xE1 [static], [constexpr], [private]
```

Definition at line 120 of file [BME280.h](#).

#### 7.3.4.41 REG\_DIG\_H3

```
uint8_t BME280::REG_DIG_H3 = 0xE3 [static], [constexpr], [private]
```

Definition at line 121 of file [BME280.h](#).

### 7.3.4.42 REG\_DIG\_H4

```
uint8_t BME280::REG_DIG_H4 = 0xE4 [static], [constexpr], [private]
```

Definition at line 122 of file [BME280.h](#).

### 7.3.4.43 REG\_DIG\_H5

```
uint8_t BME280::REG_DIG_H5 = 0xE5 [static], [constexpr], [private]
```

Definition at line 123 of file [BME280.h](#).

### 7.3.4.44 REG\_DIG\_H6

```
uint8_t BME280::REG_DIG_H6 = 0xE7 [static], [constexpr], [private]
```

Definition at line 124 of file [BME280.h](#).

### 7.3.4.45 NUM\_CALIB\_PARAMS

```
size_t BME280::NUM_CALIB_PARAMS = 24 [static], [constexpr], [private]
```

Definition at line 127 of file [BME280.h](#).

The documentation for this class was generated from the following files:

- lib/sensors/BME280/[BME280.h](#)
- lib/sensors/BME280/[BME280.cpp](#)

## 7.4 BME280CalibParam Struct Reference

```
#include <BME280.h>
```

### Public Attributes

- `uint16_t dig_t1`
- `int16_t dig_t2`
- `int16_t dig_t3`
- `uint16_t dig_p1`
- `int16_t dig_p2`
- `int16_t dig_p3`
- `int16_t dig_p4`
- `int16_t dig_p5`
- `int16_t dig_p6`
- `int16_t dig_p7`
- `int16_t dig_p8`
- `int16_t dig_p9`
- `uint8_t dig_h1`
- `int16_t dig_h2`
- `uint8_t dig_h3`
- `int16_t dig_h4`
- `int16_t dig_h5`
- `int8_t dig_h6`

### 7.4.1 Detailed Description

Definition at line 11 of file [BME280.h](#).

### 7.4.2 Member Data Documentation

#### 7.4.2.1 dig\_t1

```
uint16_t BME280CalibParam::dig_t1
```

Definition at line 13 of file [BME280.h](#).

#### 7.4.2.2 dig\_t2

```
int16_t BME280CalibParam::dig_t2
```

Definition at line 14 of file [BME280.h](#).

#### 7.4.2.3 dig\_t3

```
int16_t BME280CalibParam::dig_t3
```

Definition at line 15 of file [BME280.h](#).

#### 7.4.2.4 dig\_p1

```
uint16_t BME280CalibParam::dig_p1
```

Definition at line 18 of file [BME280.h](#).

#### 7.4.2.5 dig\_p2

```
int16_t BME280CalibParam::dig_p2
```

Definition at line 19 of file [BME280.h](#).

#### 7.4.2.6 dig\_p3

```
int16_t BME280CalibParam::dig_p3
```

Definition at line 20 of file [BME280.h](#).

#### 7.4.2.7 `dig_p4`

```
int16_t BME280CalibParam::dig_p4
```

Definition at line [21](#) of file [BME280.h](#).

#### 7.4.2.8 `dig_p5`

```
int16_t BME280CalibParam::dig_p5
```

Definition at line [22](#) of file [BME280.h](#).

#### 7.4.2.9 `dig_p6`

```
int16_t BME280CalibParam::dig_p6
```

Definition at line [23](#) of file [BME280.h](#).

#### 7.4.2.10 `dig_p7`

```
int16_t BME280CalibParam::dig_p7
```

Definition at line [24](#) of file [BME280.h](#).

#### 7.4.2.11 `dig_p8`

```
int16_t BME280CalibParam::dig_p8
```

Definition at line [25](#) of file [BME280.h](#).

#### 7.4.2.12 `dig_p9`

```
int16_t BME280CalibParam::dig_p9
```

Definition at line [26](#) of file [BME280.h](#).

#### 7.4.2.13 `dig_h1`

```
uint8_t BME280CalibParam::dig_h1
```

Definition at line [29](#) of file [BME280.h](#).

#### 7.4.2.14 `dig_h2`

```
int16_t BME280CalibParam::dig_h2
```

Definition at line [30](#) of file [BME280.h](#).

#### 7.4.2.15 dig\_h3

```
uint8_t BME280CalibParam::dig_h3
```

Definition at line 31 of file [BME280.h](#).

#### 7.4.2.16 dig\_h4

```
int16_t BME280CalibParam::dig_h4
```

Definition at line 32 of file [BME280.h](#).

#### 7.4.2.17 dig\_h5

```
int16_t BME280CalibParam::dig_h5
```

Definition at line 33 of file [BME280.h](#).

#### 7.4.2.18 dig\_h6

```
int8_t BME280CalibParam::dig_h6
```

Definition at line 34 of file [BME280.h](#).

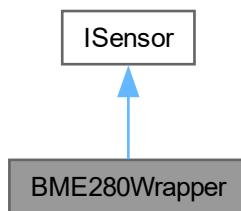
The documentation for this struct was generated from the following file:

- lib/sensors/BME280/[BME280.h](#)

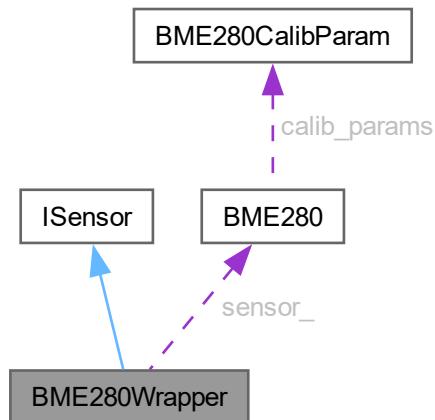
## 7.5 BME280Wrapper Class Reference

```
#include <BME280_WRAPPER.h>
```

Inheritance diagram for BME280Wrapper:



Collaboration diagram for BME280Wrapper:



### Public Member Functions

- [BME280Wrapper \(i2c\\_inst\\_t \\*i2c\)](#)
- bool [init \(\)](#) override
- float [read\\_data \(SensorDataTypelIdentifier type\)](#) override
- bool [is\\_initialized \(\)](#) const override
- [SensorType get\\_type \(\)](#) const override
- bool [configure \(const std::map< std::string, std::string > &config\)](#) override

### Public Member Functions inherited from [ISensor](#)

- virtual [~ISensor \(\)](#)=default

### Private Attributes

- [BME280 sensor\\_](#)
- bool [initialized\\_ = false](#)

### 7.5.1 Detailed Description

Definition at line 8 of file [BME280\\_WRAPPER.h](#).

### 7.5.2 Constructor & Destructor Documentation

#### 7.5.2.1 [BME280Wrapper\(\)](#)

```
BME280Wrapper::BME280Wrapper (
    i2c_inst_t * i2c)
```

Definition at line 3 of file [BME280\\_WRAPPER.cpp](#).

### 7.5.3 Member Function Documentation

#### 7.5.3.1 init()

```
bool BME280Wrapper::init () [override], [virtual]
```

Implements [ISensor](#).

Definition at line 5 of file [BME280\\_WRAPPER.cpp](#).

#### 7.5.3.2 read\_data()

```
float BME280Wrapper::read_data (
    SensorDataTypeIdentifier type) [override], [virtual]
```

Implements [ISensor](#).

Definition at line 10 of file [BME280\\_WRAPPER.cpp](#).

#### 7.5.3.3 is\_initialized()

```
bool BME280Wrapper::is_initialized () const [override], [virtual]
```

Implements [ISensor](#).

Definition at line 26 of file [BME280\\_WRAPPER.cpp](#).

#### 7.5.3.4 get\_type()

```
SensorType BME280Wrapper::get_type () const [override], [virtual]
```

Implements [ISensor](#).

Definition at line 30 of file [BME280\\_WRAPPER.cpp](#).

#### 7.5.3.5 configure()

```
bool BME280Wrapper::configure (
    const std::map< std::string, std::string > & config) [override], [virtual]
```

Implements [ISensor](#).

Definition at line 34 of file [BME280\\_WRAPPER.cpp](#).

### 7.5.4 Member Data Documentation

#### 7.5.4.1 sensor\_

```
BME280 BME280Wrapper::sensor_ [private]
```

Definition at line 10 of file [BME280\\_WRAPPER.h](#).

### 7.5.4.2 initialized\_

```
bool BME280Wrapper::initialized_ = false [private]
```

Definition at line 11 of file [BME280\\_WRAPPER.h](#).

The documentation for this class was generated from the following files:

- lib/sensors/BME280/[BME280\\_WRAPPER.h](#)
- lib/sensors/BME280/[BME280\\_WRAPPER.cpp](#)

## 7.6 INA3221::conf\_reg\_t Struct Reference

Configuration register bit fields.

### Public Attributes

- uint16\_t mode\_shunt\_en:1
- uint16\_t mode\_bus\_en:1
- uint16\_t mode\_continious\_en:1
- uint16\_t shunt\_conv\_time:3
- uint16\_t bus\_conv\_time:3
- uint16\_t avg\_mode:3
- uint16\_t ch3\_en:1
- uint16\_t ch2\_en:1
- uint16\_t ch1\_en:1
- uint16\_t reset:1

### 7.6.1 Detailed Description

Configuration register bit fields.

Definition at line 101 of file [INA3221.h](#).

### 7.6.2 Member Data Documentation

#### 7.6.2.1 mode\_shunt\_en

```
uint16_t INA3221::conf_reg_t::mode_shunt_en
```

Definition at line 102 of file [INA3221.h](#).

#### 7.6.2.2 mode\_bus\_en

```
uint16_t INA3221::conf_reg_t::mode_bus_en
```

Definition at line 103 of file [INA3221.h](#).

### 7.6.2.3 mode\_continious\_en

```
uint16_t INA3221::conf_reg_t::mode_continious_en
```

Definition at line 104 of file [INA3221.h](#).

### 7.6.2.4 shunt\_conv\_time

```
uint16_t INA3221::conf_reg_t::shunt_conv_time
```

Definition at line 105 of file [INA3221.h](#).

### 7.6.2.5 bus\_conv\_time

```
uint16_t INA3221::conf_reg_t::bus_conv_time
```

Definition at line 106 of file [INA3221.h](#).

### 7.6.2.6 avg\_mode

```
uint16_t INA3221::conf_reg_t::avg_mode
```

Definition at line 107 of file [INA3221.h](#).

### 7.6.2.7 ch3\_en

```
uint16_t INA3221::conf_reg_t::ch3_en
```

Definition at line 108 of file [INA3221.h](#).

### 7.6.2.8 ch2\_en

```
uint16_t INA3221::conf_reg_t::ch2_en
```

Definition at line 109 of file [INA3221.h](#).

### 7.6.2.9 ch1\_en

```
uint16_t INA3221::conf_reg_t::ch1_en
```

Definition at line 110 of file [INA3221.h](#).

### 7.6.2.10 reset

```
uint16_t INA3221::conf_reg_t::reset
```

Definition at line 111 of file [INA3221.h](#).

The documentation for this struct was generated from the following file:

- lib/powerman/INA3221/[INA3221.h](#)

## 7.7 DS3231 Class Reference

```
#include <DS3231.h>
```

### Public Member Functions

- [DS3231](#) (i2c\_inst\_t \*i2c\_instance)
- int [set\\_time](#) (ds3231\_data\_t \*data)
- int [get\\_time](#) (ds3231\_data\_t \*data)
- int [read\\_temperature](#) (float \*resolution)
- int [set\\_unix\\_time](#) (time\_t unix\_time)
- time\_t [get\\_unix\\_time](#) ()
- int [clock\\_enable](#) ()

### Private Member Functions

- int [i2c\\_read\\_reg](#) (uint8\_t reg\_addr, size\_t length, uint8\_t \*data)
 

*Library function to read a specific I2C register address.*
- int [i2c\\_write\\_reg](#) (uint8\_t reg\_addr, size\_t length, uint8\_t \*data)
 

*Library function to write to a specific I2C register address.*
- uint8\_t [bin\\_to\\_bcd](#) (const uint8\_t data)
 

*Library function that takes an 8-bit unsigned integer and converts it into a Binary Coded Decimal number that can be written to [DS3231](#) registers.*
- uint8\_t [bcd\\_to\\_bin](#) (const uint8\_t bcd)
 

*Library function that takes a BCD number and converts it to an unsigned 8-bit integer.*

### Private Attributes

- i2c\_inst\_t \* [i2c](#)
- uint8\_t [ds3231\\_addr](#)
- recursive\_mutex\_t [clock\\_mutex\\_](#)

### 7.7.1 Detailed Description

Definition at line 48 of file [DS3231.h](#).

## 7.7.2 Constructor & Destructor Documentation

### 7.7.2.1 DS3231()

```
DS3231::DS3231 (
    i2c_inst_t * i2c_instance)
```

Definition at line 6 of file [DS3231.cpp](#).

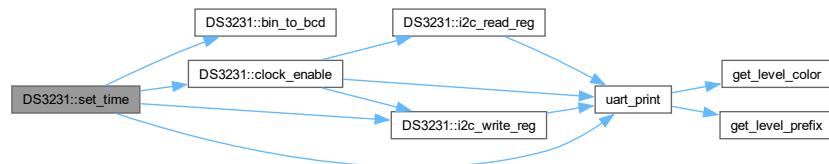
## 7.7.3 Member Function Documentation

### 7.7.3.1 set\_time()

```
int DS3231::set_time (
    ds3231_data_t * data)
```

Definition at line 11 of file [DS3231.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

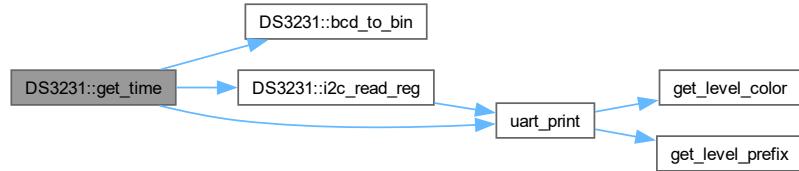


### 7.7.3.2 get\_time()

```
int DS3231::get_time (
    ds3231_data_t * data)
```

Definition at line 68 of file [DS3231.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

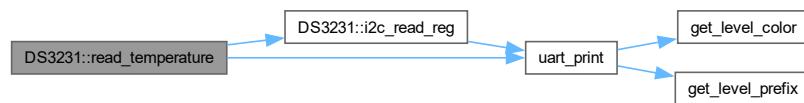


### 7.7.3.3 read\_temperature()

```
int DS3231::read_temperature (
    float * resolution)
```

Definition at line 110 of file [DS3231.cpp](#).

Here is the call graph for this function:

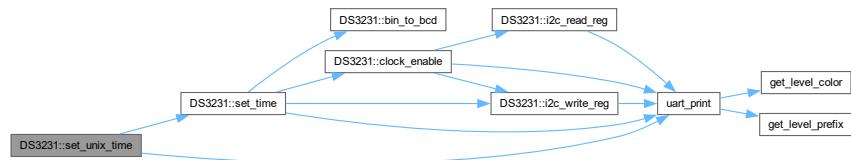


### 7.7.3.4 set\_unix\_time()

```
int DS3231::set_unix_time (
    time_t unix_time)
```

Definition at line 217 of file [DS3231.cpp](#).

Here is the call graph for this function:

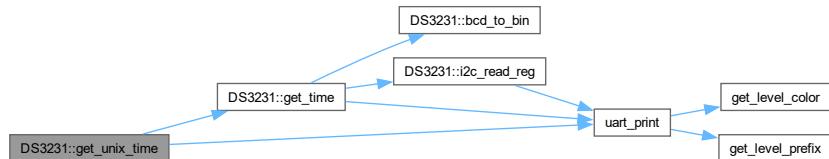


### 7.7.3.5 get\_unix\_time()

```
time_t DS3231::get_unix_time ()
```

Definition at line 237 of file [DS3231.cpp](#).

Here is the call graph for this function:

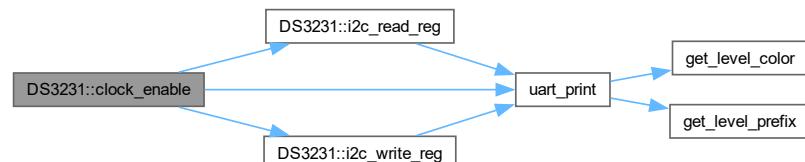


### 7.7.3.6 clock\_enable()

```
int DS3231::clock_enable ()
```

Definition at line 265 of file [DS3231.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 7.7.3.7 i2c\_read\_reg()

```
int DS3231::i2c_read_reg (
    uint8_t reg_addr,
    size_t length,
    uint8_t * data) [private]
```

Library function to read a specific I2C register address.

#### Parameters

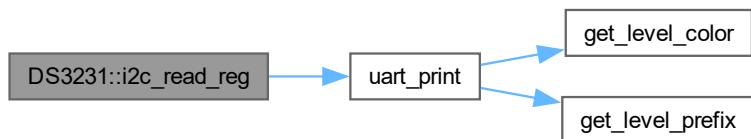
in	<i>reg_addr</i>	Register address to be read.
in	<i>length</i>	length of the data in bytes to be read.
out	<i>data</i>	Buffer to store the read data.

#### Returns

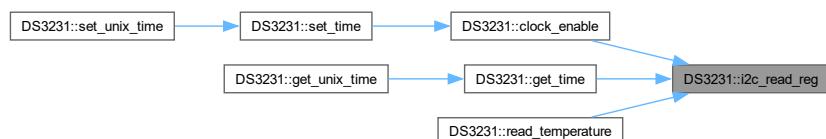
0 if successful, -1 if i2c failure.

Definition at line 136 of file [DS3231.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 7.7.3.8 i2c\_write\_reg()

```
int DS3231::i2c_write_reg (
    uint8_t reg_addr,
    size_t length,
    uint8_t * data) [private]
```

Library function to write to a specific I2C register address.

#### Parameters

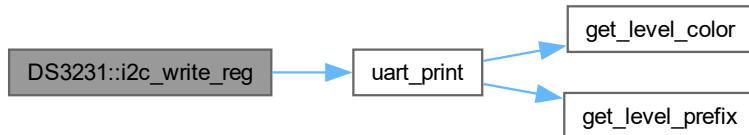
in	<i>reg_addr</i>	Register address to be written.
in	<i>length</i>	Length of the data to be written in bytes.
in	<i>data</i>	Pointer to the data buffer.

#### Returns

0 if successful, -1 if i2c failure.

Definition at line 171 of file [DS3231.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 7.7.3.9 bin\_to\_bcd()

```
uint8_t DS3231::bin_to_bcd (
    const uint8_t data) [private]
```

Library function that takes an 8-bit unsigned integer and converts it into a Binary Coded Decimal number that can be written to [DS3231](#) registers.

**Parameters**

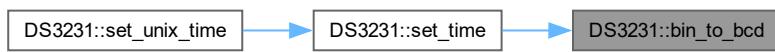
in	<i>data</i>	Number to be converted.
----	-------------	-------------------------

**Returns**

Number in BCD form.

Definition at line 199 of file [DS3231.cpp](#).

Here is the caller graph for this function:

**7.7.3.10 bcd\_to\_bin()**

```
uint8_t DS3231::bcd_to_bin (
    const uint8_t bcd) [private]
```

Library function that takes a BCD number and converts it to an unsigned 8-bit integer.

**Parameters**

in	<i>bcd</i>	BCD number to be converted.
----	------------	-----------------------------

**Returns**

Unsigned 8-bit integer.

Definition at line 211 of file [DS3231.cpp](#).

Here is the caller graph for this function:



## 7.7.4 Member Data Documentation

### 7.7.4.1 i2c

```
i2c_inst_t* DS3231::i2c [private]
```

Definition at line 61 of file [DS3231.h](#).

### 7.7.4.2 ds3231\_addr

```
uint8_t DS3231::ds3231_addr [private]
```

Definition at line 62 of file [DS3231.h](#).

### 7.7.4.3 clock\_mutex\_

```
recursive_mutex_t DS3231::clock_mutex_ [private]
```

Definition at line 70 of file [DS3231.h](#).

The documentation for this class was generated from the following files:

- lib/clock/[DS3231.h](#)
- lib/clock/[DS3231.cpp](#)

## 7.8 ds3231\_data\_t Struct Reference

```
#include <DS3231.h>
```

### Public Attributes

- `uint8_t seconds`
- `uint8_t minutes`
- `uint8_t hours`
- `uint8_t day`
- `uint8_t date`
- `uint8_t month`
- `uint8_t year`
- `bool century`

### 7.8.1 Detailed Description

Definition at line 37 of file [DS3231.h](#).

## 7.8.2 Member Data Documentation

### 7.8.2.1 seconds

```
uint8_t ds3231_data_t::seconds
```

Definition at line 38 of file [DS3231.h](#).

### 7.8.2.2 minutes

```
uint8_t ds3231_data_t::minutes
```

Definition at line 39 of file [DS3231.h](#).

### 7.8.2.3 hours

```
uint8_t ds3231_data_t::hours
```

Definition at line 40 of file [DS3231.h](#).

### 7.8.2.4 day

```
uint8_t ds3231_data_t::day
```

Definition at line 41 of file [DS3231.h](#).

### 7.8.2.5 date

```
uint8_t ds3231_data_t::date
```

Definition at line 42 of file [DS3231.h](#).

### 7.8.2.6 month

```
uint8_t ds3231_data_t::month
```

Definition at line 43 of file [DS3231.h](#).

### 7.8.2.7 year

```
uint8_t ds3231_data_t::year
```

Definition at line 44 of file [DS3231.h](#).

### 7.8.2.8 century

```
bool ds3231_data_t::century
```

Definition at line 45 of file [DS3231.h](#).

The documentation for this struct was generated from the following file:

- lib/clock/[DS3231.h](#)

## 7.9 EventEmitter Class Reference

Provides a static method for emitting events.

```
#include <event_manager.h>
```

### Static Public Member Functions

- template<typename T>  
static void [emit](#) ([EventGroup group](#), T event)  
*Emits an event.*

### 7.9.1 Detailed Description

Provides a static method for emitting events.

Definition at line 306 of file [event\\_manager.h](#).

### 7.9.2 Member Function Documentation

#### 7.9.2.1 emit()

```
template<typename T>
static void EventEmitter::emit (
    EventGroup group,
    T event) [inline], [static]
```

Emits an event.

#### Parameters

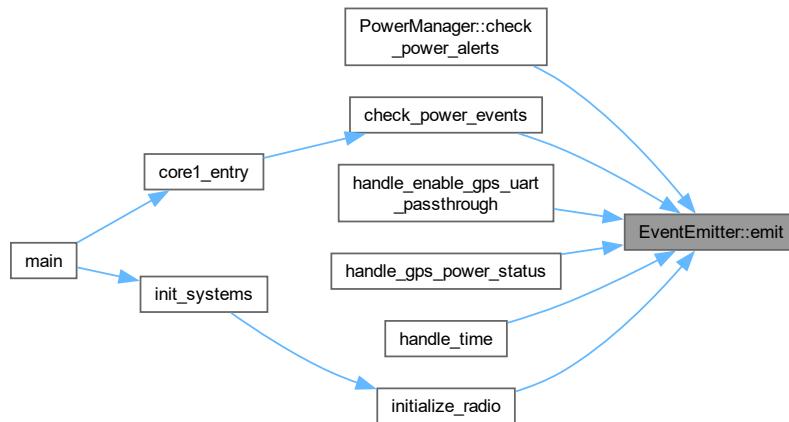
<i>group</i>	The event group.
<i>event</i>	The event identifier.

**Template Parameters**

<i>T</i>	The type of the event identifier.
----------	-----------------------------------

Definition at line 315 of file [event\\_manager.h](#).

Here is the caller graph for this function:



The documentation for this class was generated from the following file:

- lib/eventman/[event\\_manager.h](#)

## 7.10 EventLog Class Reference

Represents a single event log entry.

```
#include <event_manager.h>
```

### Public Member Functions

- std::string [to\\_string \(\) const](#)  
*Converts the EventLog to a string representation.*

### Public Attributes

- uint16\_t [id](#)  
*Sequence number.*
- uint32\_t [timestamp](#)  
*Unix timestamp or system time.*
- uint8\_t [group](#)  
*Event group identifier.*
- uint8\_t [event](#)  
*Specific event identifier.*

### 7.10.1 Detailed Description

Represents a single event log entry.

Definition at line 136 of file [event\\_manager.h](#).

### 7.10.2 Member Function Documentation

#### 7.10.2.1 `to_string()`

```
std::string EventLog::to_string () const [inline]
```

Converts the [EventLog](#) to a string representation.

##### Returns

A string representation of the [EventLog](#).

Definition at line 151 of file [event\\_manager.h](#).

Here is the caller graph for this function:



### 7.10.3 Member Data Documentation

#### 7.10.3.1 `id`

```
uint16_t EventLog::id
```

Sequence number.

Definition at line 139 of file [event\\_manager.h](#).

#### 7.10.3.2 `timestamp`

```
uint32_t EventLog::timestamp
```

Unix timestamp or system time.

Definition at line 141 of file [event\\_manager.h](#).

### 7.10.3.3 group

```
uint8_t EventLog::group
```

Event group identifier.

Definition at line 143 of file [event\\_manager.h](#).

### 7.10.3.4 event

```
uint8_t EventLog::event
```

Specific event identifier.

Definition at line 145 of file [event\\_manager.h](#).

The documentation for this class was generated from the following file:

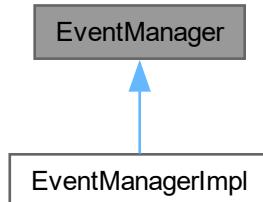
- lib/eventman/[event\\_manager.h](#)

## 7.11 EventManager Class Reference

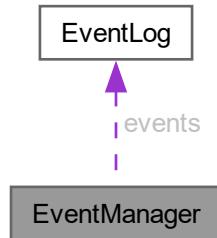
Manages the event logging system.

```
#include <event_manager.h>
```

Inheritance diagram for EventManager:



Collaboration diagram for EventManager:



## Public Member Functions

- **EventManager ()**  
*Constructor for the [EventManager](#).*
- **virtual ~EventManager ()=default**  
*Virtual destructor for the [EventManager](#).*
- **virtual void init ()**  
*Initializes the [EventManager](#).*
- **void log\_event (uint8\_t group, uint8\_t event)**  
*Logs an event.*
- **const EventLog & get\_event (size\_t index) const**  
*Retrieves an event from the event buffer.*
- **size\_t get\_event\_count () const**  
*Gets the number of events in the buffer.*
- **virtual bool save\_to\_storage ()=0**  
*Saves the events to storage.*
- **virtual bool load\_from\_storage ()=0**  
*Loads the events from storage.*

## Protected Attributes

- **EventLog events [EVENT\_BUFFER\_SIZE]**  
*Event buffer.*
- **size\_t eventCount**  
*Number of events in the buffer.*
- **size\_t writeIndex**  
*Index of the next event to be written.*
- **mutex\_t eventMutex**  
*Mutex for protecting the event buffer.*
- **volatile uint16\_t nextEventId**  
*Next event ID.*
- **bool needsPersistence**  
*Flag indicating whether the events need to be saved to storage.*

### 7.11.1 Detailed Description

Manages the event logging system.

Definition at line 165 of file [event\\_manager.h](#).

### 7.11.2 Constructor & Destructor Documentation

#### 7.11.2.1 EventManager()

```
EventManager::EventManager () [inline]
```

Constructor for the [EventManager](#).

Initializes the event buffer, mutex, and other internal variables.

Definition at line 171 of file [event\\_manager.h](#).

### 7.11.2.2 ~EventManager()

```
virtual EventManager::~EventManager () [virtual], [default]
```

Virtual destructor for the [EventManager](#).

## 7.11.3 Member Function Documentation

### 7.11.3.1 init()

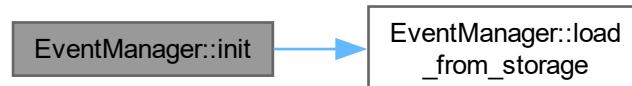
```
virtual void EventManager::init () [inline], [virtual]
```

Initializes the [EventManager](#).

Loads events from storage.

Definition at line 189 of file [event\\_manager.h](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 7.11.3.2 get\_event\_count()

```
size_t EventManager::get_event_count () const [inline]
```

Gets the number of events in the buffer.

#### Returns

The number of events in the buffer.

Definition at line 211 of file [event\\_manager.h](#).

### 7.11.3.3 `save_to_storage()`

```
virtual bool EventManager::save_to_storage () [pure virtual]
```

Saves the events to storage.

#### Returns

True if the events were successfully saved, false otherwise.

Implemented in [EventManagerImpl](#).

Here is the caller graph for this function:



### 7.11.3.4 `load_from_storage()`

```
virtual bool EventManager::load_from_storage () [pure virtual]
```

Loads the events from storage.

#### Returns

True if the events were successfully loaded, false otherwise.

Implemented in [EventManagerImpl](#).

Here is the caller graph for this function:



## 7.11.4 Member Data Documentation

### 7.11.4.1 `events`

```
EventLog EventManager::events [EVENT_BUFFER_SIZE] [protected]
```

Event buffer.

Definition at line 227 of file [event\\_manager.h](#).

#### 7.11.4.2 eventCount

```
size_t EventManager::eventCount [protected]
```

Number of events in the buffer.

Definition at line 229 of file [event\\_manager.h](#).

#### 7.11.4.3 writeIndex

```
size_t EventManager::writeIndex [protected]
```

Index of the next event to be written.

Definition at line 231 of file [event\\_manager.h](#).

#### 7.11.4.4 eventMutex

```
mutex_t EventManager::eventMutex [protected]
```

Mutex for protecting the event buffer.

Definition at line 233 of file [event\\_manager.h](#).

#### 7.11.4.5 nextEventId

```
volatile uint16_t EventManager::nextEventId [protected]
```

Next event ID.

Definition at line 235 of file [event\\_manager.h](#).

#### 7.11.4.6 needsPersistence

```
bool EventManager::needsPersistence [protected]
```

Flag indicating whether the events need to be saved to storage.

Definition at line 237 of file [event\\_manager.h](#).

The documentation for this class was generated from the following files:

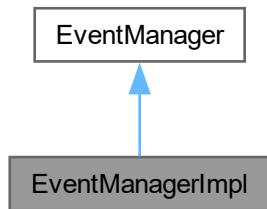
- lib/eventman/[event\\_manager.h](#)
- lib/eventman/[event\\_manager.cpp](#)

## 7.12 EventManagerImpl Class Reference

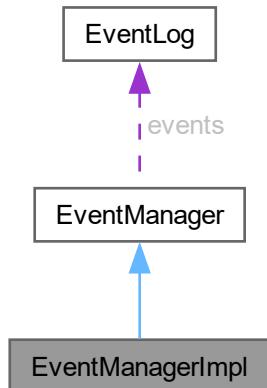
Implementation of the [EventManager](#) class.

```
#include <event_manager.h>
```

Inheritance diagram for EventManagerImpl:



Collaboration diagram for EventManagerImpl:



### Public Member Functions

- [EventManagerImpl \(\)](#)  
*Constructor for the `EventManagerImpl`.*
- [bool `save\_to\_storage \(\)` override](#)  
*Saves the events to storage.*
- [bool `load\_from\_storage \(\)` override](#)  
*Loads the events from storage.*

## Public Member Functions inherited from `EventManager`

- `EventManager ()`  
*Constructor for the `EventManager`.*
- `virtual ~EventManager ()=default`  
*Virtual destructor for the `EventManager`.*
- `virtual void init ()`  
*Initializes the `EventManager`.*
- `void log_event (uint8_t group, uint8_t event)`  
*Logs an event.*
- `const EventLog & get_event (size_t index) const`  
*Retrieves an event from the event buffer.*
- `size_t get_event_count () const`  
*Gets the number of events in the buffer.*

## Additional Inherited Members

### Protected Attributes inherited from `EventManager`

- `EventLog events [EVENT_BUFFER_SIZE]`  
*Event buffer.*
- `size_t eventCount`  
*Number of events in the buffer.*
- `size_t writeIndex`  
*Index of the next event to be written.*
- `mutex_t eventMutex`  
*Mutex for protecting the event buffer.*
- `volatile uint16_t nextEventId`  
*Next event ID.*
- `bool needsPersistence`  
*Flag indicating whether the events need to be saved to storage.*

### 7.12.1 Detailed Description

Implementation of the `EventManager` class.

Definition at line 245 of file `event_manager.h`.

### 7.12.2 Constructor & Destructor Documentation

#### 7.12.2.1 `EventManagerImpl()`

```
EventManagerImpl::EventManagerImpl () [inline]
```

Constructor for the `EventManagerImpl`.

Initializes the `EventManagerImpl` and calls the `init` method.

Definition at line 251 of file `event_manager.h`.

Here is the call graph for this function:



### 7.12.3 Member Function Documentation

#### 7.12.3.1 save\_to\_storage()

```
bool EventManagerImpl::save_to_storage () [inline], [override], [virtual]
```

Saves the events to storage.

##### Returns

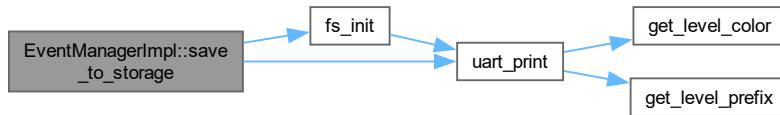
True if the events were successfully saved, false otherwise.

This method is not yet implemented.

Implements [EventManager](#).

Definition at line 260 of file [event\\_manager.h](#).

Here is the call graph for this function:



#### 7.12.3.2 load\_from\_storage()

```
bool EventManagerImpl::load_from_storage () [inline], [override], [virtual]
```

Loads the events from storage.

##### Returns

True if the events were successfully loaded, false otherwise.

This method is not yet implemented.

Implements [EventManager](#).

Definition at line 290 of file [event\\_manager.h](#).

The documentation for this class was generated from the following file:

- lib/eventman/[event\\_manager.h](#)

## 7.13 FileHandle Struct Reference

```
#include <storage.h>
```

### Public Attributes

- int [fd](#)
- bool [is\\_open](#)

### 7.13.1 Detailed Description

Definition at line [19](#) of file [storage.h](#).

### 7.13.2 Member Data Documentation

#### 7.13.2.1 fd

```
int FileHandle::fd
```

Definition at line [20](#) of file [storage.h](#).

#### 7.13.2.2 is\_open

```
bool FileHandle::is_open
```

Definition at line [21](#) of file [storage.h](#).

The documentation for this struct was generated from the following file:

- lib/storage/[storage.h](#)

## 7.14 Frame Struct Reference

Represents a communication frame used for data exchange.

```
#include <protocol.h>
```

### Public Attributes

- std::string [header](#)
- uint8\_t [direction](#)
- [OperationType](#) [operationType](#)
- uint8\_t [group](#)
- uint8\_t [command](#)
- std::string [value](#)
- std::string [unit](#)
- std::string [footer](#)

### 7.14.1 Detailed Description

Represents a communication frame used for data exchange.

This structure encapsulates the different components of a communication frame, including the header, direction, operation type, group ID, command ID, payload value, unit, and footer. It is used for both encoding and decoding messages.

#### Note

- The `header` and `footer` fields are used to mark the beginning and end of the frame, respectively.
- The `direction` field indicates the direction of the communication (0 = ground->sat, 1 = sat->ground).
- The `operationType` field specifies the type of operation being performed (e.g., GET, SET, ANS, ERR, INF).
- The `group` and `command` fields identify the specific command being executed.
- The `value` field contains the payload data.
- The `unit` field specifies the unit of measurement for the payload data.

#### Example Usage:

```
// Creating a Frame instance
Frame myFrame;
myFrame.header = FRAME_BEGIN;
myFrame.direction = 1;
myFrame.operationType = OperationType::ANS;
myFrame.group = 2;
myFrame.command = 5;
myFrame.value = "25.5";
myFrame.unit = "VOLT";
myFrame.footer = FRAME_END;

// Encoding the Frame to a string
std::string encodedFrame = frame_encode(myFrame);
```

#### Example Instances:

```
// Example of a GET command
Frame getCommand;
getCommand.header = FRAME_BEGIN;
getCommand.direction = 0;
getCommand.operationType = OperationType::GET;
getCommand.group = 1;
getCommand.command = 10;
getCommand.value = "";
getCommand.unit = "";
getCommand.footer = FRAME_END;

// Example of an ANSWER command
Frame answerCommand;
answerCommand.header = FRAME_BEGIN;
answerCommand.direction = 1;
answerCommand.operationType = OperationType::ANS;
answerCommand.group = 1;
answerCommand.command = 10;
answerCommand.value = "OK";
answerCommand.unit = "";
answerCommand.footer = FRAME_END;
```

#### Example of Encoded Frames:

```
// Encoded GET command example:
// KBST;0;GET;1;10;;TSBK

// Encoded SET command example:
// KBST;0;SET;2;5;25.5;VOLT;TSBK

// Encoded ANSWER command example:
// KBST;1;ANS;1;10;OK;;TSBK

// Encoded ERROR command example:
// KBST;1;ERR;3;1;Invalid Parameter;;TSBK

// Encoded INFO command example:
// KBST;1;INF;4;2;System Booted;;TSBK
```

Definition at line 221 of file [protocol.h](#).

## 7.14.2 Member Data Documentation

### 7.14.2.1 header

```
std::string Frame::header
```

Definition at line [222](#) of file [protocol.h](#).

### 7.14.2.2 direction

```
uint8_t Frame::direction
```

Definition at line [223](#) of file [protocol.h](#).

### 7.14.2.3 operationType

```
OperationType Frame::operationType
```

Definition at line [224](#) of file [protocol.h](#).

### 7.14.2.4 group

```
uint8_t Frame::group
```

Definition at line [225](#) of file [protocol.h](#).

### 7.14.2.5 command

```
uint8_t Frame::command
```

Definition at line [226](#) of file [protocol.h](#).

### 7.14.2.6 value

```
std::string Frame::value
```

Definition at line [227](#) of file [protocol.h](#).

### 7.14.2.7 unit

```
std::string Frame::unit
```

Definition at line [228](#) of file [protocol.h](#).

### 7.14.2.8 footer

```
std::string Frame::footer
```

Definition at line 229 of file [protocol.h](#).

The documentation for this struct was generated from the following file:

- lib/comms/[protocol.h](#)

## 7.15 HMC5883L Class Reference

```
#include <HMC5883L.h>
```

### Public Member Functions

- [HMC5883L](#) (*i2c\_inst\_t* \**i2c*, *uint8\_t* *address*=0x0D)
- bool [init](#) ()
- bool [read](#) (*int16\_t* &*x*, *int16\_t* &*y*, *int16\_t* &*z*)

### Private Member Functions

- bool [write\\_register](#) (*uint8\_t* *reg*, *uint8\_t* *value*)
- bool [read\\_register](#) (*uint8\_t* *reg*, *uint8\_t* \**buffer*, *size\_t* *length*)

### Private Attributes

- *i2c\_inst\_t* \* *i2c*
- *uint8\_t* *address*

### 7.15.1 Detailed Description

Definition at line 6 of file [HMC5883L.h](#).

### 7.15.2 Constructor & Destructor Documentation

#### 7.15.2.1 HMC5883L()

```
HMC5883L::HMC5883L (
    i2c_inst_t * i2c,
    uint8_t address = 0x0D)
```

Definition at line 3 of file [HMC5883L.cpp](#).

### 7.15.3 Member Function Documentation

#### 7.15.3.1 init()

```
bool HMC5883L::init ()
```

Definition at line 5 of file [HMC5883L.cpp](#).

Here is the call graph for this function:



#### 7.15.3.2 read()

```
bool HMC5883L::read (
    int16_t & x,
    int16_t & y,
    int16_t & z)
```

Definition at line 13 of file [HMC5883L.cpp](#).

Here is the call graph for this function:



#### 7.15.3.3 write\_register()

```
bool HMC5883L::write_register (
    uint8_t reg,
    uint8_t value) [private]
```

Definition at line 28 of file [HMC5883L.cpp](#).

Here is the caller graph for this function:



#### 7.15.3.4 `read_register()`

```
bool HMC5883L::read_register (
    uint8_t reg,
    uint8_t * buffer,
    size_t length) [private]
```

Definition at line 33 of file [HMC5883L.cpp](#).

Here is the caller graph for this function:



### 7.15.4 Member Data Documentation

#### 7.15.4.1 `i2c`

```
i2c_inst_t* HMC5883L::i2c [private]
```

Definition at line 13 of file [HMC5883L.h](#).

#### 7.15.4.2 `address`

```
uint8_t HMC5883L::address [private]
```

Definition at line 14 of file [HMC5883L.h](#).

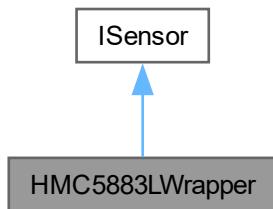
The documentation for this class was generated from the following files:

- lib/sensors/HMC5883L/[HMC5883L.h](#)
- lib/sensors/HMC5883L/[HMC5883L.cpp](#)

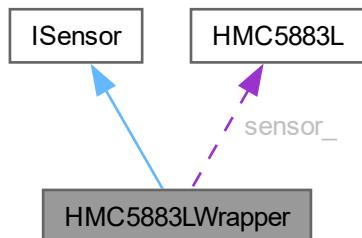
## 7.16 HMC5883LWrapper Class Reference

```
#include <HMC5883L_WRAPPER.h>
```

Inheritance diagram for HMC5883LWrapper:



Collaboration diagram for HMC5883LWrapper:



### Public Member Functions

- [HMC5883LWrapper \(i2c\\_inst\\_t \\*i2c\)](#)
- bool [init \(\)](#) override
- float [read\\_data \(SensorDataTypelIdentifier type\)](#) override
- bool [is\\_initialized \(\)](#) const override
- [SensorType get\\_type \(\)](#) const override
- bool [configure \(const std::map< std::string, std::string > &config\)](#) override

### Public Member Functions inherited from [ISensor](#)

- virtual [~ISensor \(\)=default](#)

### Private Attributes

- `HMC5883L sensor_`
- `bool initialized_`

## 7.16.1 Detailed Description

Definition at line 7 of file [HMC5883L\\_WRAPPER.h](#).

## 7.16.2 Constructor & Destructor Documentation

### 7.16.2.1 HMC5883LWrapper()

```
HMC5883LWrapper::HMC5883LWrapper (
    i2c_inst_t * i2c)
```

Definition at line 5 of file [HMC5883L\\_WRAPPER.cpp](#).

## 7.16.3 Member Function Documentation

### 7.16.3.1 init()

```
bool HMC5883LWrapper::init () [override], [virtual]
```

Implements [ISensor](#).

Definition at line 7 of file [HMC5883L\\_WRAPPER.cpp](#).

### 7.16.3.2 read\_data()

```
float HMC5883LWrapper::read_data (
    SensorDataTypeIdentifier type) [override], [virtual]
```

Implements [ISensor](#).

Definition at line 12 of file [HMC5883L\\_WRAPPER.cpp](#).

### 7.16.3.3 is\_initialized()

```
bool HMC5883LWrapper::is_initialized () const [override], [virtual]
```

Implements [ISensor](#).

Definition at line 35 of file [HMC5883L\\_WRAPPER.cpp](#).

#### 7.16.3.4 `get_type()`

```
SensorType HMC5883LWrapper::get_type () const [override], [virtual]
```

Implements [ISensor](#).

Definition at line 39 of file [HMC5883L\\_WRAPPER.cpp](#).

#### 7.16.3.5 `configure()`

```
bool HMC5883LWrapper::configure (
    const std::map< std::string, std::string > & config) [override], [virtual]
```

Implements [ISensor](#).

Definition at line 43 of file [HMC5883L\\_WRAPPER.cpp](#).

### 7.16.4 Member Data Documentation

#### 7.16.4.1 `sensor_`

```
HMC5883L HMC5883LWrapper::sensor_ [private]
```

Definition at line 17 of file [HMC5883L\\_WRAPPER.h](#).

#### 7.16.4.2 `initialized_`

```
bool HMC5883LWrapper::initialized_ [private]
```

Definition at line 18 of file [HMC5883L\\_WRAPPER.h](#).

The documentation for this class was generated from the following files:

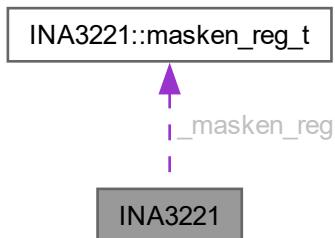
- lib/sensors/HMC5883L/[HMC5883L\\_WRAPPER.h](#)
- lib/sensors/HMC5883L/[HMC5883L\\_WRAPPER.cpp](#)

### 7.17 INA3221 Class Reference

[INA3221](#) Triple-Channel Power Monitor driver class.

```
#include <INA3221.h>
```

Collaboration diagram for INA3221:



## Classes

- struct `conf_reg_t`  
*Configuration register bit fields.*
- struct `masken_reg_t`  
*Mask/Enable register bit fields.*

## Public Member Functions

- `INA3221 (ina3221_addr_t addr, i2c_inst_t *i2c)`  
*Constructor for `INA3221` class.*
- `bool begin ()`  
*Initialize the `INA3221` device.*
- `uint16_t read_register (ina3221_reg_t reg)`  
*Read a register from the device.*
- `void reset ()`  
*Reset the `INA3221` to default settings.*
- `void set_mode_power_down ()`  
*Set device to power-down mode.*
- `void set_mode_continuous ()`  
*Set device to continuous measurement mode.*
- `void set_mode_triggered ()`  
*Set device to triggered measurement mode.*
- `void set_shunt_measurement_enable ()`  
*Enable shunt voltage measurements.*
- `void set_shunt_measurement_disable ()`  
*Disable shunt voltage measurements.*
- `void set_bus_measurement_enable ()`  
*Enable bus voltage measurements.*
- `void set_bus_measurement_disable ()`  
*Disable bus voltage measurements.*
- `void set_averaging_mode (ina3221_avg_mode_t mode)`  
*Set the averaging mode for measurements.*
- `void set_bus_conversion_time (ina3221_conv_time_t convTime)`  
*Set bus voltage conversion time.*
- `void set_shunt_conversion_time (ina3221_conv_time_t convTime)`  
*Set shunt voltage conversion time.*
- `uint16_t get_manufacturer_id ()`  
*Get the manufacturer ID of the device.*
- `uint16_t get_die_id ()`  
*Get the die ID of the device.*
- `int32_t get_shunt_voltage (ina3221_ch_t channel)`  
*Get shunt voltage for a specific channel.*
- `float get_current (ina3221_ch_t channel)`
- `float get_current_ma (ina3221_ch_t channel)`  
*Get current for a specific channel.*
- `float get_voltage (ina3221_ch_t channel)`  
*Get bus voltage for a specific channel.*
- `void set_warn_alert_limit (ina3221_ch_t channel, float voltage_v)`  
*Set warning alert voltage threshold for a channel.*

- void `set_crit_alert_limit` (`ina3221_ch_t` channel, float voltage\_v)  
*Set critical alert voltage threshold for a channel.*
- void `set_power_valid_limit` (float voltage\_upper\_v, float voltage\_lower\_v)  
*Set power valid voltage range.*
- void `enable_alerts` ()  
*Enable all alert functions.*
- bool `get_warn_alert` (`ina3221_ch_t` channel)  
*Get warning alert status for a channel.*
- bool `get_crit_alert` (`ina3221_ch_t` channel)  
*Get critical alert status for a channel.*
- bool `get_power_valid_alert` ()  
*Get power valid alert status.*
- void `set_alert_latch` (bool enable)  
*Set alert latch mode.*

### Private Member Functions

- void `_read` (`ina3221_reg_t` reg, `uint16_t` \*val)  
*Read a 16-bit register from the device.*
- void `_write` (`ina3221_reg_t` reg, `uint16_t` \*val)  
*Write a 16-bit value to a register.*

### Private Attributes

- `i2c_inst_t` \* `_i2c`
- `ina3221_addr_t` `_i2c_addr`
- `uint32_t` `_shuntRes` [`INA3221_CH_NUM`]
- `uint32_t` `_filterRes` [`INA3221_CH_NUM`]
- `masken_reg_t` `_masken_reg`

## 7.17.1 Detailed Description

[INA3221](#) Triple-Channel Power Monitor driver class.

Provides functionality for voltage, current, and power monitoring with configurable alerts and power valid monitoring

Definition at line 96 of file [INA3221.h](#).

## 7.17.2 Member Function Documentation

### 7.17.2.1 `_read()`

```
void INA3221::_read (
    ina3221_reg_t reg,
    uint16_t * val) [private]
```

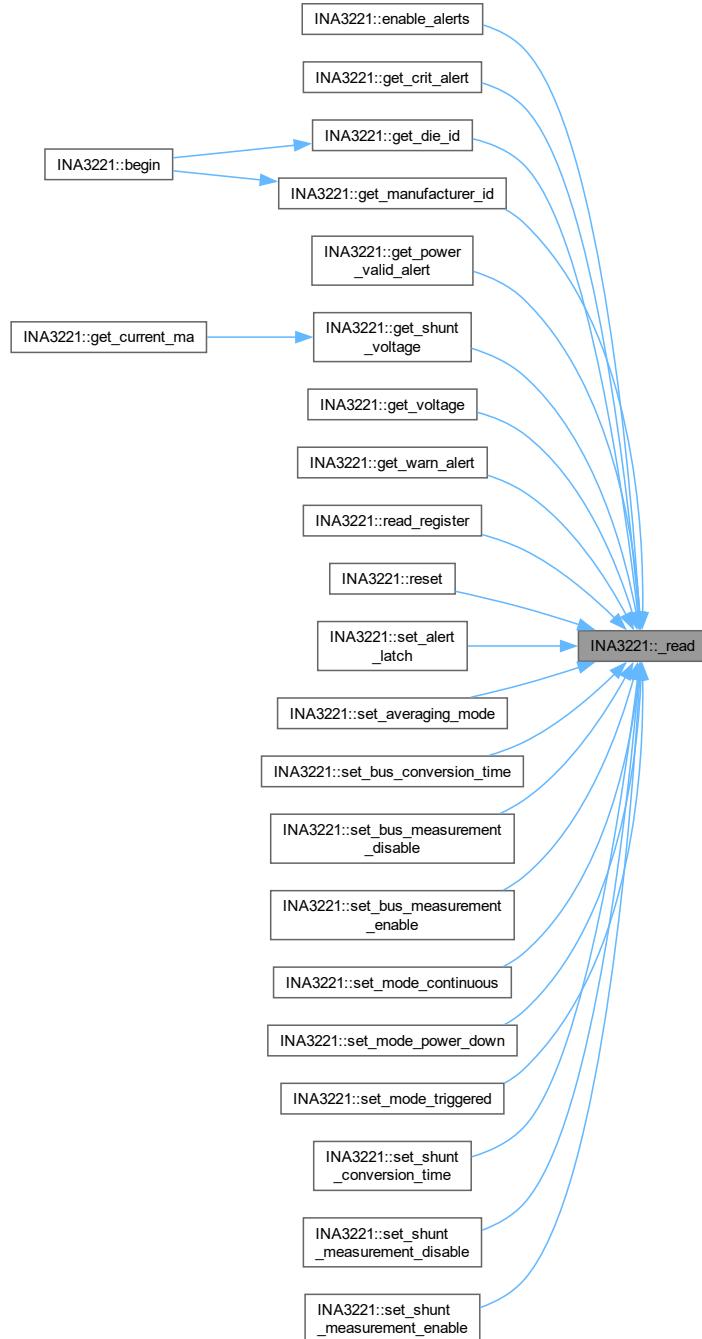
Read a 16-bit register from the device.

**Parameters**

<i>reg</i>	Register address
<i>val</i>	Pointer to store the read value

Definition at line 513 of file [INA3221.cpp](#).

Here is the caller graph for this function:



### 7.17.2.2 `_write()`

```
void INA3221::_write (
    ina3221_reg_t reg,
    uint16_t * val) [private]
```

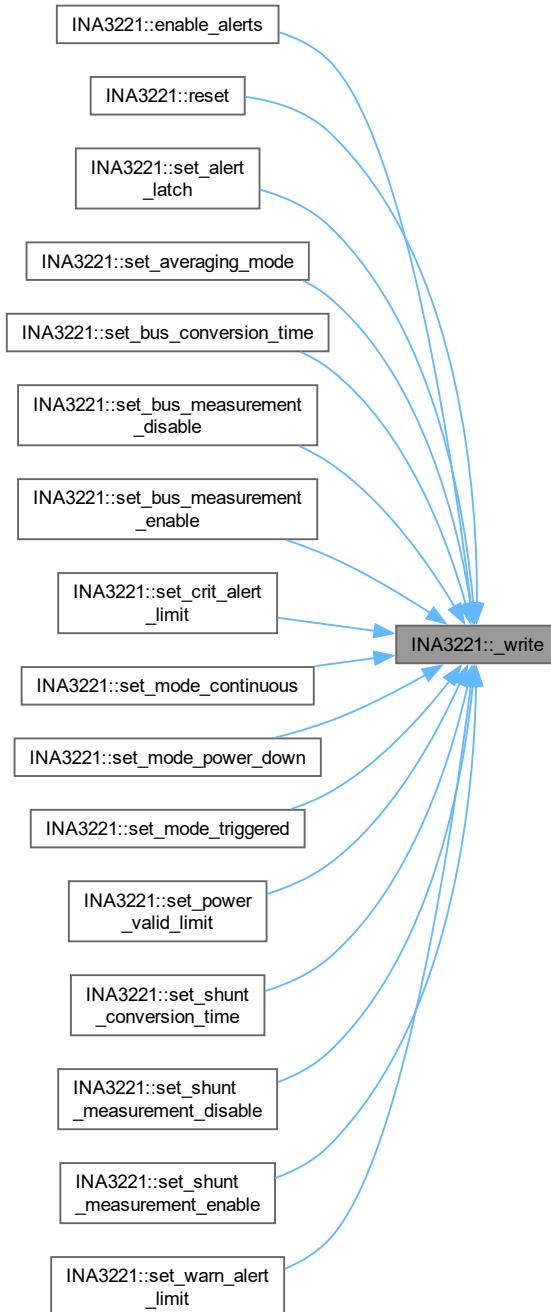
Write a 16-bit value to a register.

#### Parameters

<i>reg</i>	Register address
<i>val</i>	Pointer to the value to write

Definition at line 539 of file [INA3221.cpp](#).

Here is the caller graph for this function:



### 7.17.2.3 get\_current()

```
float INA3221::get_current (
    ina3221_ch_t channel)
```

### 7.17.3 Member Data Documentation

#### 7.17.3.1 \_i2c

```
i2c_inst_t* INA3221::_i2c [private]
```

Definition at line 136 of file [INA3221.h](#).

#### 7.17.3.2 \_i2c\_addr

```
ina3221_addr_t INA3221::_i2c_addr [private]
```

Definition at line 138 of file [INA3221.h](#).

#### 7.17.3.3 \_shuntRes

```
uint32_t INA3221::_shuntRes[INA3221_CH_NUM] [private]
```

Definition at line 141 of file [INA3221.h](#).

#### 7.17.3.4 \_filterRes

```
uint32_t INA3221::_filterRes[INA3221_CH_NUM] [private]
```

Definition at line 144 of file [INA3221.h](#).

#### 7.17.3.5 \_masken\_reg

```
masken_reg_t INA3221::_masken_reg [private]
```

Definition at line 147 of file [INA3221.h](#).

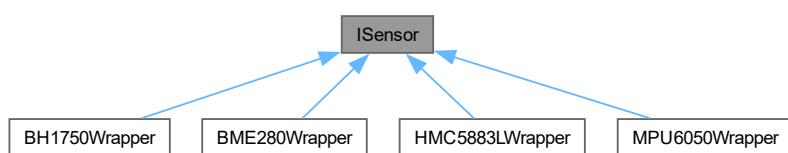
The documentation for this class was generated from the following files:

- lib/powerman/INA3221/[INA3221.h](#)
- lib/powerman/INA3221/[INA3221.cpp](#)

## 7.18 ISensor Class Reference

```
#include <ISensor.h>
```

Inheritance diagram for ISensor:



## Public Member Functions

- virtual `~ISensor ()=default`
- virtual bool `init ()=0`
- virtual float `read_data (SensorDataTypeIdentifier type)=0`
- virtual bool `is_initialized () const =0`
- virtual `SensorType get_type () const =0`
- virtual bool `configure (const std::map< std::string, std::string > &config)=0`

### 7.18.1 Detailed Description

Definition at line 33 of file [ISensor.h](#).

### 7.18.2 Constructor & Destructor Documentation

#### 7.18.2.1 `~ISensor()`

```
virtual ISensor::~ISensor () [virtual], [default]
```

### 7.18.3 Member Function Documentation

#### 7.18.3.1 `init()`

```
virtual bool ISensor::init () [pure virtual]
```

Implemented in [BH1750Wrapper](#), [BME280Wrapper](#), [HMC5883LWrapper](#), and [MPU6050Wrapper](#).

#### 7.18.3.2 `read_data()`

```
virtual float ISensor::read_data (
    SensorDataTypeIdentifier type) [pure virtual]
```

Implemented in [BH1750Wrapper](#), [BME280Wrapper](#), [HMC5883LWrapper](#), and [MPU6050Wrapper](#).

#### 7.18.3.3 `is_initialized()`

```
virtual bool ISensor::is_initialized () const [pure virtual]
```

Implemented in [BH1750Wrapper](#), [BME280Wrapper](#), [HMC5883LWrapper](#), and [MPU6050Wrapper](#).

#### 7.18.3.4 `get_type()`

```
virtual SensorType ISensor::get_type () const [pure virtual]
```

Implemented in [BH1750Wrapper](#), [BME280Wrapper](#), [HMC5883LWrapper](#), and [MPU6050Wrapper](#).

### 7.18.3.5 `configure()`

```
virtual bool ISensor::configure (
    const std::map< std::string, std::string > & config) [pure virtual]
```

Implemented in [BH1750Wrapper](#), [BME280Wrapper](#), [HMC5883LWrapper](#), and [MPU6050Wrapper](#).

The documentation for this class was generated from the following file:

- lib/sensors/[ISensor.h](#)

## 7.19 `INA3221::masken_reg_t` Struct Reference

Mask/Enable register bit fields.

### Public Attributes

- `uint16_t conv_ready:1`
- `uint16_t timing_ctrl_alert:1`
- `uint16_t pwr_valid_alert:1`
- `uint16_t warn_alert_ch3:1`
- `uint16_t warn_alert_ch2:1`
- `uint16_t warn_alert_ch1:1`
- `uint16_t shunt_sum_alert:1`
- `uint16_t crit_alert_ch3:1`
- `uint16_t crit_alert_ch2:1`
- `uint16_t crit_alert_ch1:1`
- `uint16_t crit_alert_latch_en:1`
- `uint16_t warn_alert_latch_en:1`
- `uint16_t shunt_sum_en_ch3:1`
- `uint16_t shunt_sum_en_ch2:1`
- `uint16_t shunt_sum_en_ch1:1`
- `uint16_t reserved:1`

### 7.19.1 Detailed Description

Mask/Enable register bit fields.

Definition at line [117](#) of file [INA3221.h](#).

### 7.19.2 Member Data Documentation

#### 7.19.2.1 `conv_ready`

```
uint16_t INA3221::masken_reg_t::conv_ready
```

Definition at line [118](#) of file [INA3221.h](#).

### 7.19.2.2 timing\_ctrl\_alert

```
uint16_t INA3221::masken_reg_t::timing_ctrl_alert
```

Definition at line 119 of file [INA3221.h](#).

### 7.19.2.3 pwr\_valid\_alert

```
uint16_t INA3221::masken_reg_t::pwr_valid_alert
```

Definition at line 120 of file [INA3221.h](#).

### 7.19.2.4 warn\_alert\_ch3

```
uint16_t INA3221::masken_reg_t::warn_alert_ch3
```

Definition at line 121 of file [INA3221.h](#).

### 7.19.2.5 warn\_alert\_ch2

```
uint16_t INA3221::masken_reg_t::warn_alert_ch2
```

Definition at line 122 of file [INA3221.h](#).

### 7.19.2.6 warn\_alert\_ch1

```
uint16_t INA3221::masken_reg_t::warn_alert_ch1
```

Definition at line 123 of file [INA3221.h](#).

### 7.19.2.7 shunt\_sum\_alert

```
uint16_t INA3221::masken_reg_t::shunt_sum_alert
```

Definition at line 124 of file [INA3221.h](#).

### 7.19.2.8 crit\_alert\_ch3

```
uint16_t INA3221::masken_reg_t::crit_alert_ch3
```

Definition at line 125 of file [INA3221.h](#).

### 7.19.2.9 crit\_alert\_ch2

```
uint16_t INA3221::masken_reg_t::crit_alert_ch2
```

Definition at line 126 of file [INA3221.h](#).

### 7.19.2.10 crit\_alert\_ch1

```
uint16_t INA3221::masken_reg_t::crit_alert_ch1
```

Definition at line 127 of file [INA3221.h](#).

### 7.19.2.11 crit\_alert\_latch\_en

```
uint16_t INA3221::masken_reg_t::crit_alert_latch_en
```

Definition at line 128 of file [INA3221.h](#).

### 7.19.2.12 warn\_alert\_latch\_en

```
uint16_t INA3221::masken_reg_t::warn_alert_latch_en
```

Definition at line 129 of file [INA3221.h](#).

### 7.19.2.13 shunt\_sum\_en\_ch3

```
uint16_t INA3221::masken_reg_t::shunt_sum_en_ch3
```

Definition at line 130 of file [INA3221.h](#).

### 7.19.2.14 shunt\_sum\_en\_ch2

```
uint16_t INA3221::masken_reg_t::shunt_sum_en_ch2
```

Definition at line 131 of file [INA3221.h](#).

### 7.19.2.15 shunt\_sum\_en\_ch1

```
uint16_t INA3221::masken_reg_t::shunt_sum_en_ch1
```

Definition at line 132 of file [INA3221.h](#).

### 7.19.2.16 reserved

```
uint16_t INA3221::masken_reg_t::reserved
```

Definition at line 133 of file [INA3221.h](#).

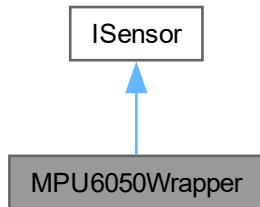
The documentation for this struct was generated from the following file:

- lib/powerman/INA3221/[INA3221.h](#)

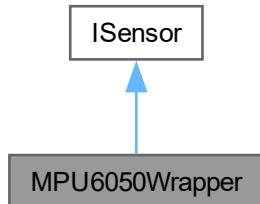
## 7.20 MPU6050Wrapper Class Reference

```
#include <MPU6050_WRAPPER.h>
```

Inheritance diagram for MPU6050Wrapper:



Collaboration diagram for MPU6050Wrapper:



### Public Member Functions

- [MPU6050Wrapper \(\)](#)
- bool [init \(\)](#) override
- float [read\\_data \(SensorDataTypIdentifier type\)](#) override
- bool [is\\_initialized \(\)](#) const override
- [SensorType get\\_type \(\)](#) const override
- bool [configure \(const std::map< std::string, std::string > &config\)](#)

### Public Member Functions inherited from [ISensor](#)

- virtual [~ISensor \(\)=default](#)

### Private Attributes

- MPU6050 `sensor_`
- bool `initialized_` = false

### 7.20.1 Detailed Description

Definition at line 9 of file [MPU6050\\_WRAPPER.h](#).

### 7.20.2 Constructor & Destructor Documentation

#### 7.20.2.1 `MPU6050Wrapper()`

```
MPU6050Wrapper::MPU6050Wrapper ()
```

### 7.20.3 Member Function Documentation

#### 7.20.3.1 `init()`

```
bool MPU6050Wrapper::init () [override], [virtual]
```

Implements [ISensor](#).

#### 7.20.3.2 `read_data()`

```
float MPU6050Wrapper::read_data (
    SensorDataTypeIdentifier type) [override], [virtual]
```

Implements [ISensor](#).

#### 7.20.3.3 `is_initialized()`

```
bool MPU6050Wrapper::is_initialized () const [override], [virtual]
```

Implements [ISensor](#).

#### 7.20.3.4 `get_type()`

```
SensorType MPU6050Wrapper::get_type () const [override], [virtual]
```

Implements [ISensor](#).

### 7.20.3.5 configure()

```
bool MPU6050Wrapper::configure (
    const std::map< std::string, std::string > & config) [virtual]
```

Implements [ISensor](#).

## 7.20.4 Member Data Documentation

### 7.20.4.1 sensor\_

```
MPU6050 MPU6050Wrapper::sensor_ [private]
```

Definition at line 11 of file [MPU6050\\_WRAPPER.h](#).

### 7.20.4.2 initialized\_

```
bool MPU6050Wrapper::initialized_ = false [private]
```

Definition at line 12 of file [MPU6050\\_WRAPPER.h](#).

The documentation for this class was generated from the following file:

- lib/sensors/MPU6050/[MPU6050\\_WRAPPER.h](#)

## 7.21 NMEAData Class Reference

```
#include <NMEA_data.h>
```

### Public Member Functions

- [NMEAData \(\)](#)
- void [update\\_rmc\\_tokens](#) (const std::vector< std::string > &tokens)
- void [update\\_gga\\_tokens](#) (const std::vector< std::string > &tokens)
- std::vector< std::string > [get\\_rmc\\_tokens](#) () const
- std::vector< std::string > [get\\_gga\\_tokens](#) () const

### Private Attributes

- std::vector< std::string > [rmc\\_tokens\\_](#)
- std::vector< std::string > [gga\\_tokens\\_](#)
- mutex\_t [rmc\\_mutex\\_](#)
- mutex\_t [gga\\_mutex\\_](#)

### 7.21.1 Detailed Description

Definition at line 9 of file [NMEA\\_data.h](#).

## 7.21.2 Constructor & Destructor Documentation

### 7.21.2.1 NMEAData()

```
NMEAData::NMEAData ()
```

Definition at line 5 of file [NMEA\\_data.cpp](#).

## 7.21.3 Member Function Documentation

### 7.21.3.1 update\_rmc\_tokens()

```
void NMEAData::update_rmc_tokens (
    const std::vector< std::string > & tokens)
```

Definition at line 10 of file [NMEA\\_data.cpp](#).

### 7.21.3.2 update\_gga\_tokens()

```
void NMEAData::update_gga_tokens (
    const std::vector< std::string > & tokens)
```

Definition at line 16 of file [NMEA\\_data.cpp](#).

### 7.21.3.3 get\_rmc\_tokens()

```
std::vector< std::string > NMEAData::get_rmc_tokens () const
```

Definition at line 22 of file [NMEA\\_data.cpp](#).

### 7.21.3.4 get\_gga\_tokens()

```
std::vector< std::string > NMEAData::get_gga_tokens () const
```

Definition at line 29 of file [NMEA\\_data.cpp](#).

## 7.21.4 Member Data Documentation

### 7.21.4.1 rmc\_tokens\_

```
std::vector<std::string> NMEAData::rmc_tokens_ [private]
```

Definition at line 19 of file [NMEA\\_data.h](#).

#### 7.21.4.2 gga\_tokens\_

```
std::vector<std::string> NMEAData::gga_tokens_ [private]
```

Definition at line 20 of file [NMEA\\_data.h](#).

#### 7.21.4.3 rmc\_mutex\_

```
mutex_t NMEAData::rmc_mutex_ [private]
```

Definition at line 21 of file [NMEA\\_data.h](#).

#### 7.21.4.4 gga\_mutex\_

```
mutex_t NMEAData::gga_mutex_ [private]
```

Definition at line 22 of file [NMEA\\_data.h](#).

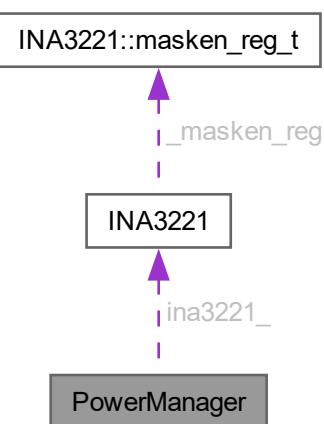
The documentation for this class was generated from the following files:

- lib/location/NMEA/[NMEA\\_data.h](#)
- lib/location/NMEA/[NMEA\\_data.cpp](#)

## 7.22 PowerManager Class Reference

```
#include <PowerManager.h>
```

Collaboration diagram for PowerManager:



## Public Member Functions

- `PowerManager (i2c_inst_t *i2c)`
- `bool initialize ()`
- `std::string read_device_ids ()`
- `float get_current_charge_solar ()`
- `float get_current_charge_usb ()`
- `float get_current_charge_total ()`
- `float get_current_draw ()`
- `float get_voltage_battery ()`
- `float get_voltage_5v ()`
- `void configure (const std::map< std::string, std::string > &config)`
- `bool is_charging_solar ()`
- `bool is_charging_usb ()`
- `bool check_power_alerts ()`

## Static Public Attributes

- `static constexpr float SOLAR_CURRENT_THRESHOLD = 50.0f`
- `static constexpr float USB_CURRENT_THRESHOLD = 50.0f`
- `static constexpr float VOLTAGE_LOW_THRESHOLD = 4.7f`
- `static constexpr float VOLTAGE_OVERCHARGE_THRESHOLD = 5.3f`
- `static constexpr float FALL_RATE_THRESHOLD = -0.02f`
- `static constexpr int FALLING_TREND_REQUIRED = 3`

## Private Attributes

- `INA3221 ina3221_`
- `bool initialized_`
- `recursive_mutex_t powerman_mutex_`
- `bool charging_solar_active_ = false`
- `bool charging_usb_active_ = false`

### 7.22.1 Detailed Description

Definition at line 11 of file [PowerManager.h](#).

### 7.22.2 Constructor & Destructor Documentation

#### 7.22.2.1 PowerManager()

```
PowerManager::PowerManager (
    i2c_inst_t * i2c)
```

Definition at line 5 of file [PowerManager.cpp](#).

### 7.22.3 Member Function Documentation

#### 7.22.3.1 initialize()

```
bool PowerManager::initialize ()
```

Definition at line 10 of file [PowerManager.cpp](#).

#### 7.22.3.2 read\_device\_ids()

```
std::string PowerManager::read_device_ids ()
```

Definition at line 27 of file [PowerManager.cpp](#).

#### 7.22.3.3 get\_current\_charge\_solar()

```
float PowerManager::get_current_charge_solar ()
```

Definition at line 68 of file [PowerManager.cpp](#).

Here is the caller graph for this function:



#### 7.22.3.4 get\_current\_charge\_usb()

```
float PowerManager::get_current_charge_usb ()
```

Definition at line 52 of file [PowerManager.cpp](#).

Here is the caller graph for this function:



#### 7.22.3.5 get\_current\_charge\_total()

```
float PowerManager::get_current_charge_total ()
```

Definition at line 76 of file [PowerManager.cpp](#).

### 7.22.3.6 `get_current_draw()`

```
float PowerManager::get_current_draw ()
```

Definition at line 60 of file [PowerManager.cpp](#).

### 7.22.3.7 `get_voltage_battery()`

```
float PowerManager::get_voltage_battery ()
```

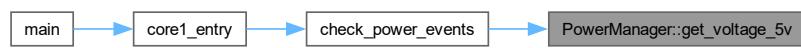
Definition at line 36 of file [PowerManager.cpp](#).

### 7.22.3.8 `get_voltage_5v()`

```
float PowerManager::get_voltage_5v ()
```

Definition at line 44 of file [PowerManager.cpp](#).

Here is the caller graph for this function:



### 7.22.3.9 `configure()`

```
void PowerManager::configure (
    const std::map< std::string, std::string > & config)
```

Definition at line 84 of file [PowerManager.cpp](#).

### 7.22.3.10 `is_charging_solar()`

```
bool PowerManager::is_charging_solar ()
```

Definition at line 113 of file [PowerManager.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



#### 7.22.3.11 is\_charging\_usb()

```
bool PowerManager::is_charging_usb ()
```

Definition at line 121 of file [PowerManager.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



#### 7.22.3.12 check\_power\_alerts()

```
bool PowerManager::check_power_alerts ()
```

Definition at line 129 of file [PowerManager.cpp](#).

Here is the call graph for this function:



## 7.22.4 Member Data Documentation

### 7.22.4.1 SOLAR\_CURRENT\_THRESHOLD

```
float PowerManager::SOLAR_CURRENT_THRESHOLD = 50.0f [static], [constexpr]
```

Definition at line [28](#) of file [PowerManager.h](#).

### 7.22.4.2 USB\_CURRENT\_THRESHOLD

```
float PowerManager::USB_CURRENT_THRESHOLD = 50.0f [static], [constexpr]
```

Definition at line [29](#) of file [PowerManager.h](#).

### 7.22.4.3 VOLTAGE\_LOW\_THRESHOLD

```
float PowerManager::VOLTAGE_LOW_THRESHOLD = 4.7f [static], [constexpr]
```

Definition at line [30](#) of file [PowerManager.h](#).

### 7.22.4.4 VOLTAGE\_OVERCHARGE\_THRESHOLD

```
float PowerManager::VOLTAGE_OVERCHARGE_THRESHOLD = 5.3f [static], [constexpr]
```

Definition at line [31](#) of file [PowerManager.h](#).

### 7.22.4.5 FALL\_RATE\_THRESHOLD

```
float PowerManager::FALL_RATE_THRESHOLD = -0.02f [static], [constexpr]
```

Definition at line [32](#) of file [PowerManager.h](#).

### 7.22.4.6 FALLING\_TREND\_REQUIRED

```
int PowerManager::FALLING_TREND_REQUIRED = 3 [static], [constexpr]
```

Definition at line [33](#) of file [PowerManager.h](#).

### 7.22.4.7 ina3221\_

```
INA3221 PowerManager::ina3221_ [private]
```

Definition at line [36](#) of file [PowerManager.h](#).

#### 7.22.4.8 initialized\_

```
bool PowerManager::initialized_ [private]
```

Definition at line 37 of file [PowerManager.h](#).

#### 7.22.4.9 powerman\_mutex\_

```
recursive_mutex_t PowerManager::powerman_mutex_ [private]
```

Definition at line 38 of file [PowerManager.h](#).

#### 7.22.4.10 charging\_solar\_active\_

```
bool PowerManager::charging_solar_active_ = false [private]
```

Definition at line 39 of file [PowerManager.h](#).

#### 7.22.4.11 charging\_usb\_active\_

```
bool PowerManager::charging_usb_active_ = false [private]
```

Definition at line 40 of file [PowerManager.h](#).

The documentation for this class was generated from the following files:

- lib/powerman/[PowerManager.h](#)
- lib/powerman/[PowerManager.cpp](#)

## 7.23 SensorWrapper Class Reference

Manages different sensor types and provides a unified interface for accessing sensor data.

```
#include <ISensor.h>
```

### Public Member Functions

- bool [sensor\\_init](#) ([SensorType](#) type, [i2c\\_inst\\_t](#) \*i2c=nullptr)  
*Initializes a given sensor type on the specified I2C bus.*
- bool [sensor\\_configure](#) ([SensorType](#) type, const std::map< std::string, std::string > &config)  
*Configures an already initialized sensor with supplied settings.*
- float [sensor\\_read\\_data](#) ([SensorType](#) sensorType, [SensorDataTypelIdentifier](#) dataType)  
*Reads a specific data type (e.g., temperature, humidity) from a sensor.*

## Static Public Member Functions

- static [SensorWrapper & get\\_instance \(\)](#)  
*Provides a global instance of SensorWrapper.*

## Private Member Functions

- [SensorWrapper \(\)](#)  
*Default constructor for SensorWrapper.*

## Private Attributes

- std::map< [SensorType](#), [ISensor \\* >](#) sensors

### 7.23.1 Detailed Description

Manages different sensor types and provides a unified interface for accessing sensor data.

Definition at line 43 of file [ISensor.h](#).

### 7.23.2 Constructor & Destructor Documentation

#### 7.23.2.1 SensorWrapper()

```
SensorWrapper::SensorWrapper () [private], [default]
```

Default constructor for [SensorWrapper](#).

Here is the caller graph for this function:



### 7.23.3 Member Function Documentation

#### 7.23.3.1 get\_instance()

```
SensorWrapper & SensorWrapper::get_instance () [static]
```

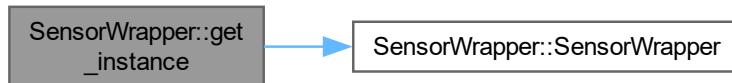
Provides a global instance of [SensorWrapper](#).

##### Returns

A reference to the single [SensorWrapper](#) instance.

Definition at line 23 of file [ISensor.cpp](#).

Here is the call graph for this function:



#### 7.23.3.2 sensor\_init()

```
bool SensorWrapper::sensor_init (
    SensorType type,
    i2c_inst_t * i2c = nullptr)
```

Initializes a given sensor type on the specified I2C bus.

##### Parameters

<code>type</code>	The sensor type (LIGHT, ENVIRONMENT, etc.).
<code>i2c</code>	The I2C interface pointer.

##### Returns

True if initialization succeeded, otherwise false.

Definition at line 39 of file [ISensor.cpp](#).

#### 7.23.3.3 sensor\_configure()

```
bool SensorWrapper::sensor_configure (
    SensorType type,
    const std::map< std::string, std::string > & config)
```

Configures an already initialized sensor with supplied settings.

**Parameters**

<i>type</i>	The sensor type.
<i>config</i>	Key-value pairs for sensor configuration.

**Returns**

True if the sensor was successfully configured, otherwise false.

Definition at line 63 of file [ISensor.cpp](#).

**7.23.3.4 sensor\_read\_data()**

```
float SensorWrapper::sensor_read_data (
    SensorType sensorType,
    SensorDataTypeIdentifier dataType)
```

Reads a specific data type (e.g., temperature, humidity) from a sensor.

**Parameters**

<i>sensorType</i>	The sensor type.
<i>dataType</i>	The type of data to read (light level, temperature, etc.).

**Returns**

The requested measurement. Returns 0.0f if sensor not found or uninitialized.

Definition at line 78 of file [ISensor.cpp](#).

**7.23.4 Member Data Documentation****7.23.4.1 sensors**

```
std::map<SensorType, ISensor*> SensorWrapper::sensors [private]
```

Definition at line 51 of file [ISensor.h](#).

The documentation for this class was generated from the following files:

- lib/sensors/[ISensor.h](#)
- lib/sensors/[ISensor.cpp](#)

# Chapter 8

# File Documentation

## 8.1 build\_number.h File Reference

This graph shows which files directly or indirectly include this file:



### Macros

- `#define BUILD_NUMBER 359`

#### 8.1.1 Macro Definition Documentation

##### 8.1.1.1 BUILD\_NUMBER

```
#define BUILD_NUMBER 359
```

Definition at line 6 of file [build\\_number.h](#).

## 8.2 build\_number.h

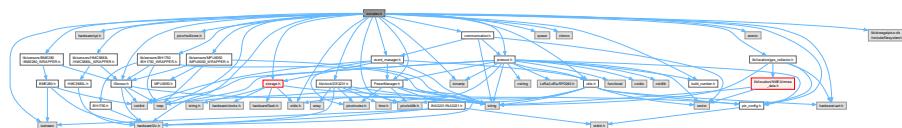
[Go to the documentation of this file.](#)

```
00001 //This file is automatically generated by build_number.cmake
00002
00003 #ifndef CMAKE_BUILD_NUMBER_HEADER
00004 #define CMAKE_BUILD_NUMBER_HEADER
00005
00006 #define BUILD_NUMBER 359
00007
00008 #endif
```

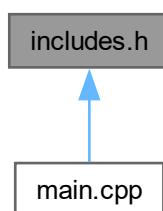
### 8.3 includes.h File Reference

```
#include <stdio.h>
#include "pico/stl.h"
#include "hardware/spi.h"
#include "hardware/i2c.h"
#include "hardware/uart.h"
#include "pico/multicore.h"
#include "event_manager.h"
#include "lib/powerman/PowerManager.h"
#include "ISensor.h"
#include "lib/sensors/BH1750/BH1750_WRAPPER.h"
#include "lib/sensors/BME280/BME280_WRAPPER.h"
#include "lib/sensors/HMC5883L/HMC5883L_WRAPPER.h"
#include "lib/sensors/MPU6050/MPU6050_WRAPPER.h"
#include "lib/clock/DS3231.h"
#include <iostream>
#include <iomanip>
#include <queue>
#include <chrono>
#include "protocol.h"
#include <atomic>
#include <map>
#include "pin_config.h"
#include "utils.h"
#include "communication.h"
#include "build_number.h"
#include "lib/location/gps_collector.h"
#include "lib/storage/storage.h"
#include "lib/storage/pico-vfs/include/filesystem/vfs.h"
```

Include dependency graph for includes.h:



This graph shows which files directly or indirectly include this file:



## 8.4 includes.h

[Go to the documentation of this file.](#)

```

00001 #ifndef INCLUDES_H
00002 #define INCLUDES_H
00003
00004 #include <stdio.h>
00005 #include "pico/stl.h"
00006 #include "hardware/spi.h"
00007 #include "hardware/i2c.h"
00008 #include "hardware/uart.h"
00009 #include "pico/multicore.h"
00010 #include "event_manager.h"
00011 #include "lib/powerman/PowerManager.h" // Corrected path
00012
00013 #include "ISensor.h"
00014 #include "lib/sensors/BH1750/BH1750_WRAPPER.h" // Corrected path
00015 #include "lib/sensors/BME280/BME280_WRAPPER.h" // Corrected path
00016 #include "lib/sensors/HMC5883L/HMC5883L_WRAPPER.h" // Corrected path
00017 #include "lib/sensors/MPU6050/MPU6050_WRAPPER.h" // Corrected path
00018 #include "lib/clock/DS3231.h" // Corrected path
00019 #include <iostream>
00020 #include <iomanip>
00021 #include <queue>
00022 #include <chrono>
00023 #include "protocol.h"
00024 #include <atomic>
00025 #include <iostream>
00026 #include <map>
00027 #include "pin_config.h"
00028 #include "utils.h"
00029 #include "communication.h"
00030 #include "build_number.h"
00031 #include "lib/location/gps_collector.h"
00032 #include "lib/storage/storage.h" // Corrected path
00033 #include "lib/storage/pico-vfs/include/filesystem/vfs.h" // Corrected path
00034
00035 #endif

```

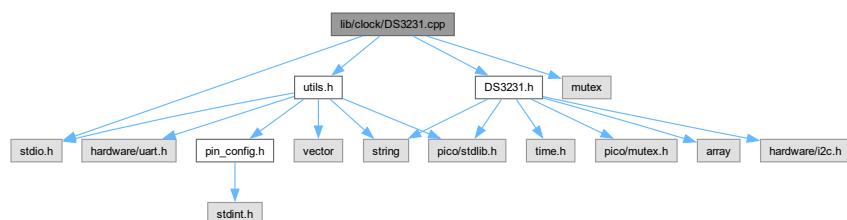
## 8.5 lib/clock/DS3231.cpp File Reference

```

#include "DS3231.h"
#include "utils.h"
#include <stdio.h>
#include <mutex>

```

Include dependency graph for DS3231.cpp:



## 8.6 DS3231.cpp

[Go to the documentation of this file.](#)

```

00001 #include "DS3231.h"
00002 #include "utils.h"
00003 #include <stdio.h> // Include for printf

```

```

00004 #include <mutex> // Include for mutex
00005
00006 DS3231::DS3231(i2c_inst_t *i2c_instance) : i2c(i2c_instance), ds3231_addr(DS3231_DEVICE_ADDRESS) {
00007     // Initialize mutex (assuming you have a mutex member variable)
00008     recursive_mutex_init(&clock_mutex_);
00009 }
0010
0011 int DS3231::set_time(ds3231_data_t *data) {
0012     uint8_t temp[7] = {0};
0013
0014     // Enable oscillator
0015     if (clock_enable() != 0) {
0016         uart_print("Failed to enable clock oscillator", VerbosityLevel::ERROR);
0017         return -1;
0018     }
0019
0020     if (data->seconds > 59)
0021         data->seconds = 59;
0022     if (data->minutes > 59)
0023         data->minutes = 59;
0024     if (data->hours > 23)
0025         data->hours = 23;
0026     if (data->day > 7)
0027         data->day = 7;
0028     else if (data->day < 1)
0029         data->day = 1;
0030     if (data->date > 31)
0031         data->date = 31;
0032     else if (data->date < 1)
0033         data->date = 1;
0034     if (data->month > 12)
0035         data->month = 12;
0036     else if (data->month < 1)
0037         data->month = 1;
0038     if (data->year > 99)
0039         data->year = 99;
0040
0041     temp[0] = bin_to_bcd(data->seconds);
0042     temp[1] = bin_to_bcd(data->minutes);
0043     temp[2] = bin_to_bcd(data->hours);
0044     temp[2] &= ~(0x01 « 6); // Clear 12/24 hour bit
0045     temp[3] = bin_to_bcd(data->day);
0046     temp[4] = bin_to_bcd(data->date);
0047     temp[5] = bin_to_bcd(data->month);
0048     if (data->century)
0049         temp[5] |= (0x01 « 7);
0050     temp[6] = bin_to_bcd(data->year);
0051
0052     std::string status = "BCD values to be written to DS3231: " + std::to_string(temp[0]) + " " +
0053             std::to_string(temp[1]) + " " + std::to_string(temp[2]) + " " +
0054             std::to_string(temp[3]) + " " + std::to_string(temp[4]) + " " +
0055             std::to_string(temp[5]) + " " + std::to_string(temp[6]);
0056
0057     uart_print(status, VerbosityLevel::DEBUG);
0058
0059     int result = i2c_write_reg(DS3231_SECONDS_REG, 7, temp);
0060     if (result != 0) {
0061         uart_print("i2c write failed", VerbosityLevel::ERROR);
0062         return -1;
0063     }
0064
0065     return 0;
0066 }
0067
0068 int DS3231::get_time(ds3231_data_t *data) {
0069     std::string status;
0070     uint8_t raw_data[7];
0071     int result = i2c_read_reg(DS3231_SECONDS_REG, 7, raw_data);
0072     if (result != 0) {
0073         status = "Failed to read time from DS3231";
0074         uart_print(status, VerbosityLevel::ERROR);
0075         return -1;
0076     }
0077
0078     status = "Raw BCD values read from DS3231: " + std::to_string(raw_data[0]) + " " +
0079             std::to_string(raw_data[1]) + " " + std::to_string(raw_data[2]) + " " +
0080             std::to_string(raw_data[3]) + " " + std::to_string(raw_data[4]) + " " +
0081             std::to_string(raw_data[5]) + " " + std::to_string(raw_data[6]);
0082     uart_print(status, VerbosityLevel::DEBUG);
0083
0084     data->seconds = bcd_to_bin(raw_data[0] & 0x7F); // Masking for CH bit (clock halt)
0085     data->minutes = bcd_to_bin(raw_data[1] & 0x7F);
0086     data->hours = bcd_to_bin(raw_data[2] & 0x3F); // Masking for 12/24 hour mode bit
0087     data->day = raw_data[3] & 0x07; // Day of week (1-7)
0088     data->date = bcd_to_bin(raw_data[4] & 0x3F);
0089     data->month = bcd_to_bin(raw_data[5] & 0x1F); // Masking for century bit
0090     data->century = (raw_data[5] & 0x80) » 7;

```

```
00091     data->year = bcd_to_bin(raw_data[6]);
00092
00093     // Data validation
00094     if (data->seconds > 59 || data->minutes > 59 || data->hours > 23 ||
00095         data->day < 1 || data->day > 7 || data->date < 1 || data->date > 31 ||
00096         data->month < 1 || data->month > 12 || data->year > 99) {
00097         uart_print("Invalid data read from DS3231", VerbosityLevel::ERROR);
00098         return -1;
00099     }
00100
00101     uart_print("Reading time from DS3231", VerbosityLevel::DEBUG);
00102     std::string timeStr = "Time: " + std::to_string(data->hours) + ":" + std::to_string(data->minutes)
00103     + ":" + std::to_string(data->seconds);
00104     uart_print(timeStr, VerbosityLevel::DEBUG);
00105     std::string dateStr = "Date: " + std::to_string(data->date) + "/" + std::to_string(data->month) +
00106     "/" + std::to_string(data->year);
00107     uart_print(dateStr, VerbosityLevel::DEBUG);
00108
00109     return 0;
00110 }
00111
00112 int DS3231::read_temperature(float *resolution) {
00113     std::string status;
00114     uint8_t temp[2];
00115     int result = i2c_read_reg(DS3231_TEMPERATURE_MSB_REG, 2, temp);
00116     if (result != 0) {
00117         status = "Failed to read temperature from DS3231";
00118         uart_print(status, VerbosityLevel::ERROR);
00119         return -1;
00120     }
00121
00122     int8_t temperature_msb = (int8_t)temp[0]; // Signed for negative temperatures
00123     uint8_t temperature_lsb = temp[1] >> 6; // Only the 2 MSB are valid
00124
00125     *resolution = temperature_msb + (temperature_lsb * 0.25f); // 0.25 degree resolution
00126
00127     return 0;
00128 }
00129
00130 int DS3231::i2c_read_reg(uint8_t reg_addr, size_t length, uint8_t *data) {
00131     if (!length)
00132         return -1;
00133
00134     std::string status = "Reading register " + std::to_string(reg_addr) + " from DS3231";
00135     uart_print(status, VerbosityLevel::DEBUG);
00136     recursive_mutex_enter_blocking(&clock_mutex_);
00137     uint8_t reg = reg_addr;
00138     int write_result = i2c_write_blocking(i2c, ds3231_addr, &reg, 1, true);
00139     if (write_result == PICO_ERROR_GENERIC) {
00140         status = "Failed to write register address to DS3231";
00141         uart_print(status, VerbosityLevel::ERROR);
00142         recursive_mutex_exit(&clock_mutex_);
00143         return -1;
00144     }
00145     int read_result = i2c_read_blocking(i2c, ds3231_addr, data, length, false);
00146     if (read_result == PICO_ERROR_GENERIC) {
00147         status = "Failed to read register data from DS3231";
00148         uart_print(status, VerbosityLevel::ERROR);
00149         recursive_mutex_exit(&clock_mutex_);
00150         return -1;
00151     }
00152     recursive_mutex_exit(&clock_mutex_);
00153
00154     return 0;
00155 }
00156
00157
00158
00159
00160
00161 }
00162
00163 int DS3231::i2c_write_reg(uint8_t reg_addr, size_t length, uint8_t *data) {
00164     if (!length)
00165         return -1;
00166
00167     recursive_mutex_enter_blocking(&clock_mutex_);
00168     uint8_t message[length + 1];
00169     message[0] = reg_addr;
00170     for (int i = 0; i < length; i++) {
00171         message[i + 1] = data[i];
00172     }
00173     int write_result = i2c_write_blocking(i2c, ds3231_addr, message, (length + 1), false);
00174     if (write_result == PICO_ERROR_GENERIC) {
00175         uart_print("Error: i2c_write_blocking failed in i2c_write_reg", VerbosityLevel::ERROR);
00176         recursive_mutex_exit(&clock_mutex_);
00177         return -1;
00178     }
00179     recursive_mutex_exit(&clock_mutex_);
00180
00181     return 0;
00182 }
```

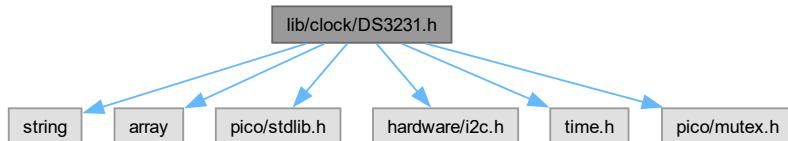
```

00199 uint8_t DS3231::bin_to_bcd(const uint8_t data) {
00200     uint8_t ones_digit = (uint8_t)(data % 10);
00201     uint8_t tens_digit = (uint8_t)(data - ones_digit) / 10;
00202     return ((tens_digit << 4) + ones_digit);
00203 }
00204
00211 uint8_t DS3231::bcd_to_bin(const uint8_t bcd) {
00212     uint8_t ones_digit = (uint8_t)(bcd & 0x0F);
00213     uint8_t tens_digit = (uint8_t)(bcd >> 4);
00214     return (tens_digit * 10 + ones_digit);
00215 }
00216
00217 int DS3231::set_unix_time(time_t unix_time) {
00218     struct tm *timeinfo = gmtime(&unix_time);
00219     if (timeinfo == NULL) {
00220         uart_print("Error: gmtime() failed", VerbosityLevel::ERROR);
00221         return -1;
00222     }
00223
00224     ds3231_data_t data;
00225     data.seconds = timeinfo->tm_sec;
00226     data.minutes = timeinfo->tm_min;
00227     data.hours = timeinfo->tm_hour;
00228     data.day = timeinfo->tm_wday == 0 ? 7 : timeinfo->tm_wday; // Sunday is 0 in tm struct, but 1 in
00229     DS3231
00230     data.date = timeinfo->tm_mday;
00231     data.month = timeinfo->tm_mon + 1; // Month is 0-11 in tm struct, but 1-12 in DS3231
00232     data.year = timeinfo->tm_year - 100; // Year is since 1900, we want the last two digits
00233     data.century = timeinfo->tm_year >= 2000;
00234
00235     return set_time(&data);
00236 }
00237 time_t DS3231::get_unix_time() {
00238     ds3231_data_t data;
00239     if (get_time(&data)) {
00240         return -1; // Indicate error
00241     }
00242
00243     struct tm timeinfo;
00244     timeinfo.tm_sec = data.seconds;
00245     timeinfo.tm_min = data.minutes;
00246     timeinfo.tm_hour = data.hours;
00247     timeinfo.tm_mday = data.date;
00248     timeinfo.tm_mon = data.month - 1; // Month is 0-11 in tm struct, but 1-12 in DS3231
00249     timeinfo.tm_year = data.year + 100; // Year is since 1900
00250
00251     // mktime assumes that tm_wday and tm_yday are uninitialized
00252     timeinfo.tm_wday = 0;
00253     timeinfo.tm_yday = 0;
00254     timeinfo.tm_isdst = 0; // Set to 0 to use UTC
00255
00256     time_t timestamp = mktime(&timeinfo);
00257     if (timestamp == (time_t)(-1)) {
00258         uart_print("Error: mktime() failed", VerbosityLevel::ERROR);
00259         return -1;
00260     }
00261
00262     return timestamp;
00263 }
00264
00265 int DS3231::clock_enable() {
00266     std::string status;
00267     uint8_t control_reg = 0;
00268     int result = i2c_read_reg(DS3231_CONTROL_REG, 1, &control_reg);
00269     if (result != 0) {
00270         status = "Failed to read control register";
00271         uart_print(status, VerbosityLevel::ERROR);
00272         return -1;
00273     }
00274
00275     // Clear the EOSC bit to enable the oscillator
00276     control_reg &= ~(1 << 7);
00277
00278     result = i2c_write_reg(DS3231_CONTROL_REG, 1, &control_reg);
00279     if (result != 0) {
00280         status = "Failed to write control register";
00281         uart_print(status, VerbosityLevel::ERROR);
00282         return -1;
00283     }
00284
00285     return 0;
00286 }

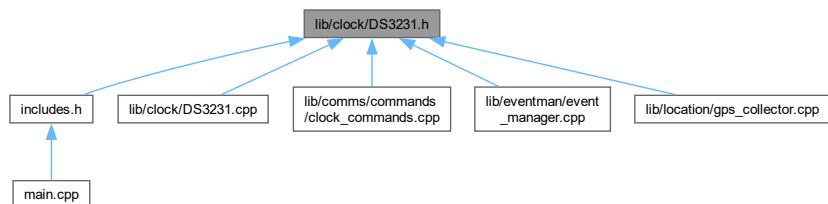
```

## 8.7 lib/clock/DS3231.h File Reference

```
#include <string>
#include <array>
#include "pico/stdlib.h"
#include "hardware/i2c.h"
#include <time.h>
#include "pico/mutex.h"
Include dependency graph for DS3231.h:
```



This graph shows which files directly or indirectly include this file:



### Classes

- struct `ds3231_data_t`
- class `DS3231`

### Macros

- `#define DS3231_DEVICE_ADDRESS 0x68`
- `#define DS3231_SECONDS_REG 0x00`
- `#define DS3231_MINUTES_REG 0x01`
- `#define DS3231_HOURS_REG 0x02`
- `#define DS3231_DAY_REG 0x03`
- `#define DS3231_DATE_REG 0x04`
- `#define DS3231_MONTH_REG 0x05`
- `#define DS3231_YEAR_REG 0x06`
- `#define DS3231_CONTROL_REG 0x0E`
- `#define DS3231_CONTROL_STATUS_REG 0x0F`
- `#define DS3231_TEMPERATURE_MSB_REG 0x11`
- `#define DS3231_TEMPERATURE_LSB_REG 0x12`

## Enumerations

- enum days\_of\_week {  
  MONDAY = 1 , TUESDAY , WEDNESDAY , THURSDAY ,  
  FRIDAY , SATURDAY , SUNDAY }

### 8.7.1 Macro Definition Documentation

#### 8.7.1.1 DS3231\_DEVICE\_ADDRESS

```
#define DS3231_DEVICE_ADDRESS 0x68
```

Definition at line 11 of file [DS3231.h](#).

#### 8.7.1.2 DS3231\_SECONDS\_REG

```
#define DS3231_SECONDS_REG 0x00
```

Definition at line 13 of file [DS3231.h](#).

#### 8.7.1.3 DS3231\_MINUTES\_REG

```
#define DS3231_MINUTES_REG 0x01
```

Definition at line 14 of file [DS3231.h](#).

#### 8.7.1.4 DS3231\_HOURS\_REG

```
#define DS3231_HOURS_REG 0x02
```

Definition at line 15 of file [DS3231.h](#).

#### 8.7.1.5 DS3231\_DAY\_REG

```
#define DS3231_DAY_REG 0x03
```

Definition at line 16 of file [DS3231.h](#).

#### 8.7.1.6 DS3231\_DATE\_REG

```
#define DS3231_DATE_REG 0x04
```

Definition at line 17 of file [DS3231.h](#).

### 8.7.1.7 DS3231\_MONTH\_REG

```
#define DS3231_MONTH_REG 0x05
```

Definition at line 18 of file [DS3231.h](#).

### 8.7.1.8 DS3231\_YEAR\_REG

```
#define DS3231_YEAR_REG 0x06
```

Definition at line 19 of file [DS3231.h](#).

### 8.7.1.9 DS3231\_CONTROL\_REG

```
#define DS3231_CONTROL_REG 0x0E
```

Definition at line 21 of file [DS3231.h](#).

### 8.7.1.10 DS3231\_CONTROL\_STATUS\_REG

```
#define DS3231_CONTROL_STATUS_REG 0x0F
```

Definition at line 22 of file [DS3231.h](#).

### 8.7.1.11 DS3231\_TEMPERATURE\_MSB\_REG

```
#define DS3231_TEMPERATURE_MSB_REG 0x11
```

Definition at line 24 of file [DS3231.h](#).

### 8.7.1.12 DS3231\_TEMPERATURE\_LSB\_REG

```
#define DS3231_TEMPERATURE_LSB_REG 0x12
```

Definition at line 25 of file [DS3231.h](#).

## 8.7.2 Enumeration Type Documentation

### 8.7.2.1 days\_of\_week

```
enum days_of_week
```

Enumerator

MONDAY	
TUESDAY	
WEDNESDAY	
THURSDAY	
FRIDAY	
SATURDAY	
SUNDAY	

Definition at line 27 of file [DS3231.h](#).

## 8.8 DS3231.h

[Go to the documentation of this file.](#)

```

00001 #ifndef DS3231_H
00002 #define DS3231_H
00003
00004 #include <string>
00005 #include <array>
00006 #include "pico/stdlib.h"
00007 #include "hardware/i2c.h"
00008 #include <time.h>
00009 #include "pico/mutex.h"
00010
00011 #define DS3231_DEVICE_ADDRESS 0x68
00012
00013 #define DS3231_SECONDS_REG 0x00
00014 #define DS3231_MINUTES_REG 0x01
00015 #define DS3231_HOURS_REG 0x02
00016 #define DS3231_DAY_REG 0x03
00017 #define DS3231_DATE_REG 0x04
00018 #define DS3231_MONTH_REG 0x05
00019 #define DS3231_YEAR_REG 0x06
00020
00021 #define DS3231_CONTROL_REG 0x0E
00022 #define DS3231_CONTROL_STATUS_REG 0x0F
00023
00024 #define DS3231_TEMPERATURE_MSB_REG 0x11
00025 #define DS3231_TEMPERATURE_LSB_REG 0x12
00026
00027 enum days_of_week {
00028     MONDAY = 1,
00029     TUESDAY,
00030     WEDNESDAY,
00031     THURSDAY,
00032     FRIDAY,
00033     SATURDAY,
00034     SUNDAY
00035 };
00036
00037 typedef struct {
00038     uint8_t seconds;
00039     uint8_t minutes;
00040     uint8_t hours;
00041     uint8_t day;
00042     uint8_t date;
00043     uint8_t month;
00044     uint8_t year;
00045     bool century;
00046 } ds3231_data_t;
00047
00048 class DS3231 {
00049 public:
00050     DS3231(i2c_inst_t *i2c_instance);
00051
00052     int set_time(ds3231_data_t *data);
00053     int get_time(ds3231_data_t *data);
00054     int read_temperature(float *resolution);
00055
00056     int set_unix_time(time_t unix_time);
00057     time_t get_unix_time();
00058     int clock_enable();
00059
00060 private:
00061     i2c_inst_t *i2c;
00062     uint8_t ds3231_addr;
00063
00064     int i2c_read_reg(uint8_t reg_addr, size_t length, uint8_t *data);
00065     int i2c_write_reg(uint8_t reg_addr, size_t length, uint8_t *data);
00066
00067     uint8_t bin_to_bcd(const uint8_t data);
00068     uint8_t bcd_to_bin(const uint8_t bcd);
00069
00070     recursive_mutex_t clock_mutex; // Mutex for I2C access
00071 };
00072
00073 #endif

```

## 8.9 lib/comms/commands/clock\_commands.cpp File Reference

```
#include "communication.h"
#include <time.h>
```

```
#include "DS3231.h"
```

Include dependency graph for clock\_commands.cpp:



## Macros

- #define CLOCK\_GROUP 3
- #define TIME 0
- #define TIMEZONE\_OFFSET 1
- #define CLOCK\_SYNC\_INTERVAL 2
- #define LAST\_SYNC\_TIME 3

## Functions

- Frame handle\_time (const std::string &param, OperationType operationType)  
*Handler for getting and setting system time.*
- Frame handle\_timezone\_offset (const std::string &param, OperationType operationType)  
*Handler for getting and setting timezone offset.*
- Frame handle\_clock\_sync\_interval (const std::string &param, OperationType operationType)  
*Handler for getting and setting clock synchronization interval.*
- Frame handle\_get\_last\_sync\_time (const std::string &param, OperationType operationType)  
*Handler for getting last clock sync time.*

## Variables

- DS3231 systemClock

### 8.9.1 Macro Definition Documentation

#### 8.9.1.1 CLOCK\_GROUP

```
#define CLOCK_GROUP 3
```

Definition at line 5 of file [clock\\_commands.cpp](#).

#### 8.9.1.2 TIME

```
#define TIME 0
```

Definition at line 6 of file [clock\\_commands.cpp](#).

### 8.9.1.3 TIMEZONE\_OFFSET

```
#define TIMEZONE_OFFSET 1
```

Definition at line 7 of file [clock\\_commands.cpp](#).

### 8.9.1.4 CLOCK\_SYNC\_INTERVAL

```
#define CLOCK_SYNC_INTERVAL 2
```

Definition at line 8 of file [clock\\_commands.cpp](#).

### 8.9.1.5 LAST\_SYNC\_TIME

```
#define LAST_SYNC_TIME 3
```

Definition at line 9 of file [clock\\_commands.cpp](#).

## 8.10 `clock_commands.cpp`

[Go to the documentation of this file.](#)

```
00001 #include "communication.h"
00002 #include <time.h>
00003 #include "DS3231.h" // Include the DS3231 header
00004
00005 #define CLOCK_GROUP 3
00006 #define TIME 0
00007 #define TIMEZONE_OFFSET 1
00008 #define CLOCK_SYNC_INTERVAL 2
00009 #define LAST_SYNC_TIME 3
00010
00016
00017 extern DS3231 systemClock;
00018
00032 Frame handle_time(const std::string& param, OperationType operationType) {
00033     // Validate operation type and parameter
00034     if (operationType == OperationType::SET) {
00035         if (param.empty()) return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIME, "PARAM REQUIRED");
00036         try {
00037             time_t newTime = std::stoll(param);
00038             if (newTime <= 0) return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIME, "TIME MUST BE POSITIVE");
00039             if (systemClock.set_unix_time(newTime) != 0) return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIME, "FAILED TO SET TIME");
00041             EventEmitter::emit(EventGroup::CLOCK, ClockEvent::CHANGED);
00042             return frame_build(ExecutionResult::SUCCESS, CLOCK_GROUP, TIME, std::to_string(systemClock.get_unix_time()));
00044         } catch (...) {
00046             return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIME, "INVALID TIME FORMAT");
00047         }
00048     } else if (operationType == OperationType::GET) {
00049         if (!param.empty()) return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIME, "PARAM UNNECESSARY");
00050         uint32_t timeUnix = systemClock.get_unix_time();
00052         if (timeUnix == 0) return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIME, "FAILED TO GET TIME");
00053         return frame_build(ExecutionResult::SUCCESS, CLOCK_GROUP, TIME, std::to_string(timeUnix));
00055     }
00056
00057     return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIME, "INVALID OPERATION");
00058 }
```

```

00059
00060
00071 Frame handle_timezone_offset(const std::string& param, OperationType operationType) {
00072     if (!(operationType == OperationType::GET || operationType == OperationType::SET)) {
00073         return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIMEZONE_OFFSET, "INVALID OPERATION");
00074     }
00075
00076     if (operationType == OperationType::GET) {
00077         if (!param.empty()) {
00078             return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIMEZONE_OFFSET, "PARAM
UNNECESSARY");
00079         }
00080
00081         std::string timezoneOffset = "60";
00082         return frame_build(ExecutionResult::SUCCESS, CLOCK_GROUP, TIMEZONE_OFFSET, timezoneOffset);
00083     }
00084
00085     if (operationType == OperationType::SET) {
00086         if (param.empty()) {
00087             return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIMEZONE_OFFSET, "PARAM
REQUIRED");
00088         }
00089         try {
00090             int16_t offset = std::stoi(param);
00091             if (offset < -720 || offset > 720) { // ±12 hours in minutes
00092                 return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIMEZONE_OFFSET, "INVALID
OFFSET");
00093             }
00094
00095             // set offset
00096             return frame_build(ExecutionResult::SUCCESS, CLOCK_GROUP, TIMEZONE_OFFSET, param);
00097         } catch (...) {
00098             return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIMEZONE_OFFSET, "INVALID
PARAMETER");
00099         }
00100     }
00101     return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, TIMEZONE_OFFSET, "UNKNOWN ERROR");
00102 }
00103
00104
00115 Frame handle_clock_sync_interval(const std::string& param, OperationType operationType) {
00116     if (!(operationType == OperationType::GET || operationType == OperationType::SET)) {
00117         return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, CLOCK_SYNC_INTERVAL, "INVALID
OPERATION");
00118     }
00119
00120     if (operationType == OperationType::GET) {
00121         if (!param.empty()) {
00122             return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, CLOCK_SYNC_INTERVAL, "PARAM
UNNECESSARY");
00123         }
00124
00125         std::string clockSyncInterval = "1440";
00126         return frame_build(ExecutionResult::SUCCESS, CLOCK_GROUP, CLOCK_SYNC_INTERVAL,
clockSyncInterval);
00127     }
00128
00129     if (operationType == OperationType::SET) {
00130         if (param.empty()) {
00131             return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, CLOCK_SYNC_INTERVAL, "PARAM
REQUIRED");
00132         }
00133         try {
00134             uint32_t interval = std::stoul(param);
00135
00136             //set sync interval
00137
00138             return frame_build(ExecutionResult::SUCCESS, CLOCK_GROUP, CLOCK_SYNC_INTERVAL, param);
00139         } catch (...) {
00140             return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, CLOCK_SYNC_INTERVAL, "INVALID
PARAMETER");
00141         }
00142     }
00143     return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, CLOCK_SYNC_INTERVAL, "UNKNOWN ERROR");
00144 }
00145
00155 Frame handle_get_last_sync_time(const std::string& param, OperationType operationType) {
00156     if (operationType != OperationType::GET || !param.empty()) {
00157         return frame_build(ExecutionResult::ERROR, CLOCK_GROUP, LAST_SYNC_TIME, "INVALID REQUEST");
00158     }
00159     std::string lastSyncTime = "none";
00160     return frame_build(ExecutionResult::SUCCESS, CLOCK_GROUP, LAST_SYNC_TIME, lastSyncTime);
00161 } // end of ClockCommands group

```

## 8.11 lib/comms/commands/commands.cpp File Reference

```
#include "commands.h"
#include "communication.h"
Include dependency graph for commands.cpp:
```



### TypeDefs

- using `CommandHandler` = std::function<`Frame`(const std::string&, `OperationType`)>  
*Function type for command handlers.*
- using `CommandMap` = std::map<uint32\_t, `CommandHandler`>  
*Map type for storing command handlers.*

### Functions

- `Frame execute_command` (uint32\_t commandKey, const std::string &param, `OperationType` operationType)  
*Executes a command based on its key.*

### Variables

- `CommandMap commandHandlers`  
*Global map of all command handlers.*

## 8.12 commands.cpp

Go to the documentation of this file.

```
00001 // commands/commands.cpp
00002 #include "commands.h"
00003 #include "communication.h"
00004
00010
00015 using CommandHandler = std::function<Frame(const std::string&, OperationType)>;
00016
00021 using CommandMap = std::map<uint32_t, CommandHandler>;
00022
00027 CommandMap commandHandlers = {
00028     {((static_cast<uint32_t>(1) << 8) | static_cast<uint32_t>(0)), handle_get_commands_list},
    // Group 1, Command 0
00029     {((static_cast<uint32_t>(1) << 8) | static_cast<uint32_t>(1)), handle_get_build_version},
    // Group 1, Command 1
00030     {((static_cast<uint32_t>(1) << 8) | static_cast<uint32_t>(8)), handle_verbosity},
    // Group 1, Command 9
00031     {((static_cast<uint32_t>(1) << 8) | static_cast<uint32_t>(9)), handle_enter_bootloader_mode},
    // Group 1, Command 9
00032     {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(0)), handle_get_power_manager_ids},
    // Group 2, Command 0
00033     {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(2)), handle_get_voltage_battery},
    // Group 2, Command 2
00034     {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(3)), handle_get_voltage_5v},
    // Group 2, Command 3
00035     {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(4)), handle_get_current_charge_usb},
    // Group 2, Command 4
```

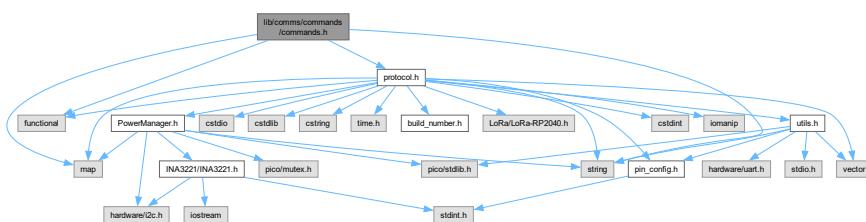
```

00036     {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(5)), handle_get_current_charge_solar},
00037     // Group 2, Command 5
00038     {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(6)), handle_get_current_charge_total},
00039     // Group 2, Command 6
00040     {((static_cast<uint32_t>(2) << 8) | static_cast<uint32_t>(7)), handle_get_current_draw},
00041     // Group 2, Command 7
00042     {((static_cast<uint32_t>(3) << 8) | static_cast<uint32_t>(0)), handle_time},
00043     // Group 3, Command 0
00044     {((static_cast<uint32_t>(3) << 8) | static_cast<uint32_t>(1)), handle_timezone_offset},
00045     // Group 3, Command 1
00046     {((static_cast<uint32_t>(3) << 8) | static_cast<uint32_t>(2)), handle_clock_sync_interval},
00047     // Group 3, Command 2
00048     {((static_cast<uint32_t>(3) << 8) | static_cast<uint32_t>(3)), handle_get_last_sync_time},
00049     // Group 3, Command 3
00050     {((static_cast<uint32_t>(5) << 8) | static_cast<uint32_t>(1)), handle_get_last_events},
00051     // Group 5, Command 1
00052     {((static_cast<uint32_t>(5) << 8) | static_cast<uint32_t>(2)), handle_get_event_count},
00053     // Group 5, Command 2
00054     {((static_cast<uint32_t>(6) << 8) | static_cast<uint32_t>(0)), handle_list_files},
00055     // Group 6, Command 0
00056     {((static_cast<uint32_t>(6) << 8) | static_cast<uint32_t>(1)), handle_file_download},
00057     // Group 6, Command 1
00058     {((static_cast<uint32_t>(6) << 8) | static_cast<uint32_t>(4)), handle_mount},
00059     // Group 7, Command 1
00060     {((static_cast<uint32_t>(7) << 8) | static_cast<uint32_t>(1)), handle_gps_power_status},
00061     // Group 7, Command 3
00062     {((static_cast<uint32_t>(7) << 8) | static_cast<uint32_t>(3)), handle_get_rmc_data},
00063     // Group 7, Command 4
00064 };
00065
00066 Frame execute_command(uint32_t commandKey, const std::string& param, OperationType operationType) {
00067     auto it = commandHandlers.find(commandKey);
00068     if (it != commandHandlers.end()) {
00069         CommandHandler handler = it->second;
00070         return handler(param, operationType);
00071     }
00072 } // end of CommandSystem group

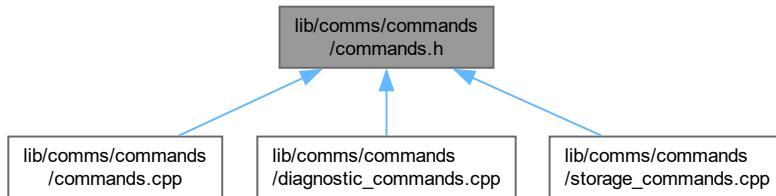
```

## 8.13 lib/comms/commands/commands.h File Reference

```
#include <string>
#include <functional>
#include <map>
#include "protocol.h"
Include dependency graph for commands.h:
```



This graph shows which files directly or indirectly include this file:



## Functions

- `Frame handle_time` (const std::string &param, `OperationType` operationType)  
*Handler for getting and setting system time.*
- `Frame handle_timezone_offset` (const std::string &param, `OperationType` operationType)  
*Handler for getting and setting timezone offset.*
- `Frame handle_clock_sync_interval` (const std::string &param, `OperationType` operationType)  
*Handler for getting and setting clock synchronization interval.*
- `Frame handle_get_last_sync_time` (const std::string &param, `OperationType` operationType)  
*Handler for getting last clock sync time.*
- `Frame handle_get_commands_list` (const std::string &param, `OperationType` operationType)  
*Handler for listing all available commands on UART.*
- `Frame handle_get_build_version` (const std::string &param, `OperationType` operationType)  
*Get firmware build version.*
- `Frame handle_verbosity` (const std::string &param, `OperationType` operationType)  
*Handles setting or getting the UART verbosity level.*
- `Frame handle_enter_bootloader_mode` (const std::string &param, `OperationType` operationType)  
*Reboot system to USB firmware loader.*
- `Frame handle_gps_power_status` (const std::string &param, `OperationType` operationType)  
*Handler for controlling GPS module power state.*
- `Frame handle_enable_gps_uart_passthrough` (const std::string &param, `OperationType` operationType)  
*Handler for enabling GPS transparent mode (UART pass-through)*
- `Frame handle_get_rmc_data` (const std::string &param, `OperationType` operationType)  
*Handler for retrieving GPS RMC (Recommended Minimum Navigation) data.*
- `Frame handle_get_gga_data` (const std::string &param, `OperationType` operationType)  
*Handler for retrieving GPS GGA (Global Positioning System Fix Data) data.*
- `Frame handle_get_power_manager_ids` (const std::string &param, `OperationType` operationType)  
*Handler for retrieving Power Manager IDs.*
- `Frame handle_get_voltage_battery` (const std::string &param, `OperationType` operationType)  
*Handler for getting battery voltage.*
- `Frame handle_get_voltage_5v` (const std::string &param, `OperationType` operationType)  
*Handler for getting 5V rail voltage.*
- `Frame handle_get_current_charge_usb` (const std::string &param, `OperationType` operationType)  
*Handler for getting USB charge current.*
- `Frame handle_get_current_charge_solar` (const std::string &param, `OperationType` operationType)  
*Handler for getting solar panel charge current.*
- `Frame handle_get_current_charge_total` (const std::string &param, `OperationType` operationType)

- Frame handle\_get\_current\_draw (const std::string &param, OperationType operationType)
 

*Handler for getting total charge current.*
- Frame handle\_get\_system\_current\_draw (const std::string &param, OperationType operationType)
 

*Handler for getting system current draw.*
- Frame handle\_get\_last\_events (const std::string &param, OperationType operationType)
 

*Handler for retrieving last N events from the event log.*
- Frame handle\_get\_event\_count (const std::string &param, OperationType operationType)
 

*Handler for getting total number of events in the log.*
- Frame handle\_list\_files (const std::string &param, OperationType operationType)
 

*Handles the list files command.*
- Frame handle\_file\_download (const std::string &param, OperationType operationType)
 

*Handles the file download command.*
- Frame handle\_mount (const std::string &param, OperationType operationType)
 

*Handles the SD card mount/unmount command.*
- Frame execute\_command (uint32\_t commandKey, const std::string &param, OperationType operationType)
 

*Executes a command based on its key.*

## Variables

- std::map< uint32\_t, std::function< Frame(const std::string &, OperationType)> > commandHandlers
 

*Global map of all command handlers.*

## 8.14 commands.h

Go to the documentation of this file.

```

00001 // commands/commands.h
00002 #ifndef COMMANDS_H
00003 #define COMMANDS_H
00004
00005 #include <string>
00006 #include <functional>
00007 #include <map>
00008 #include "protocol.h"
00009
00010 // CLOCK
00011 Frame handle_time(const std::string& param, OperationType operationType);
00012 Frame handle_timezone_offset(const std::string& param, OperationType operationType);
00013 Frame handle_clock_sync_interval(const std::string& param, OperationType operationType);
00014 Frame handle_get_last_sync_time(const std::string& param, OperationType operationType);
00015
00016 // DIAG
00017 Frame handle_get_commands_list(const std::string& param, OperationType operationType);
00018 Frame handle_get_build_version(const std::string& param, OperationType operationType);
00019 Frame handle_verbosity(const std::string& param, OperationType operationType);
00020 Frame handle_enter_bootloader_mode(const std::string& param, OperationType operationType);
00021
00022 // GPS
00023 Frame handle_gps_power_status(const std::string& param, OperationType operationType);
00024 Frame handle_enable_gps_uart_passthrough(const std::string& param, OperationType operationType);
00025 Frame handle_get_rmc_data(const std::string& param, OperationType operationType);
00026 Frame handle_get_gga_data(const std::string& param, OperationType operationType);
00027
00028 // POWER
00029 Frame handle_get_power_manager_ids(const std::string& param, OperationType operationType);
00030 Frame handle_get_voltage_battery(const std::string& param, OperationType operationType);
00031 Frame handle_get_voltage_5v(const std::string& param, OperationType operationType);
00032 Frame handle_get_current_charge_usb(const std::string& param, OperationType operationType);
00033 Frame handle_get_current_charge_solar(const std::string& param, OperationType operationType);
00034 Frame handle_get_current_charge_total(const std::string& param, OperationType operationType);
00035 Frame handle_get_current_draw(const std::string& param, OperationType operationType);
00036
00037 // EVENT
00038 Frame handle_get_last_events(const std::string& param, OperationType operationType);
00039 Frame handle_get_event_count(const std::string& param, OperationType operationType);
00040
00041
00042 //STORAGE

```

```

00043 Frame handle_list_files(const std::string& param, OperationType operationType);
00044 Frame handle_file_download(const std::string& param, OperationType operationType);
00045 Frame handle_mount(const std::string& param, OperationType operationType);
00046
00047 Frame execute_command(uint32_t commandKey, const std::string& param, OperationType operationType);
00048 extern std::map<uint32_t, std::function<Frame(const std::string&, OperationType)>> commandHandlers;
00049
00050 #endif

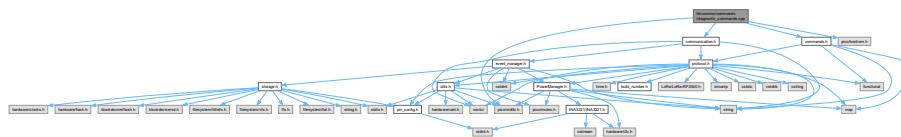
```

## 8.15 lib/comms/commands/diagnostic\_commands.cpp File Reference

```

#include "communication.h"
#include "commands.h"
#include "pico/stdlib.h"
#include "pico/bootrom.h"
Include dependency graph for diagnostic_commands.cpp:

```



### Functions

- [Frame handle\\_get\\_commands\\_list](#) (const std::string &param, OperationType operationType)  
*Handler for listing all available commands on UART.*
- [Frame handle\\_get\\_build\\_version](#) (const std::string &param, OperationType operationType)  
*Get firmware build version.*
- [Frame handle\\_verbosity](#) (const std::string &param, OperationType operationType)  
*Handles setting or getting the UART verbosity level.*
- [Frame handle\\_enter\\_bootloader\\_mode](#) (const std::string &param, OperationType operationType)  
*Reboot system to USB firmware loader.*

## 8.16 diagnostic\_commands.cpp

[Go to the documentation of this file.](#)

```

00001 #include "communication.h"
00002 #include "commands.h"
00003 #include "pico/stdlib.h"
00004 #include "pico/bootrom.h"
00005
00010
00021 Frame handle_get_commands_list(const std::string& param, OperationType operationType) {
00022     if (!param.empty()) {
00023         return frame_build(ExecutionResult::ERROR, 1, 0, "PARAM UNNECESSARY");
00024     }
00025
00026     if (!(operationType == OperationType::GET)) {
00027         return frame_build(ExecutionResult::ERROR, 1, 0, "INVALID OPERATION");
00028     }
00029
00030     std::stringstream ss;
00031     for (const auto& entry : commandHandlers) {
00032         uint32_t commandKey = entry.first;
00033         uint8_t group = (commandKey >> 8) & 0xFF;
00034         uint8_t command = commandKey & 0xFF;
00035
00036         ss << "Group: " << static_cast<int>(group)

```

```

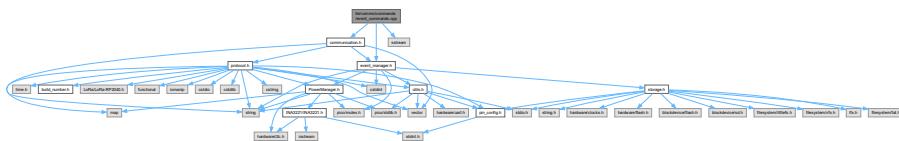
00037         << ", Command: " << static_cast<int>(command) << "\n";
00038     }
00039
00040     std::string commandList = ss.str();
00041     uart_print(commandList, VerbosityLevel::INFO); // Print to UART
00042
00043     return frame_build(ExecutionResult::SUCCESS, 1, 0, "Commands listed on UART");
00044 }
00045
00056 Frame handle_get_build_version(const std::string& param, OperationType operationType) {
00057     if (!param.empty()) {
00058         return frame_build(ExecutionResult::ERROR, 1, 1, "PARAM UNECESSARY");
00059     }
00060     if (operationType == OperationType::GET) {
00061         return frame_build(ExecutionResult::SUCCESS, 1, 1, std::to_string(BUILD_NUMBER));
00062     }
00063     return frame_build(ExecutionResult::ERROR, 1, 1, "INVALID OPERATION");
00064 }
00065
00066
00088 Frame handle_verbosity(const std::string& param, OperationType operationType) {
00089     if (param.empty()) {
00090         uart_print("Current verbosity level: " + std::to_string(static_cast<int>(g_uart_verbosity)),
00091             VerbosityLevel::INFO);
00092         return frame_build(ExecutionResult::SUCCESS, 1, 8,
00093                             std::to_string(static_cast<int>(g_uart_verbosity)));
00094     }
00095     try {
00096         int level = std::stoi(param);
00097         if (level < 0 || level > 5) {
00098             return frame_build(ExecutionResult::ERROR, 1, 8, "INVALID LEVEL (0-5)");
00099         }
00100         g_uart_verbosity = static_cast<VerbosityLevel>(level);
00101         return frame_build(ExecutionResult::SUCCESS, 1, 8, "LEVEL SET");
00102     } catch (...) {
00103         return frame_build(ExecutionResult::ERROR, 1, 8, "INVALID FORMAT");
00104     }
00105 }
00106
00117 Frame handle_enter_bootloader_mode(const std::string& param, OperationType operationType) {
00118     if (!param.empty()) {
00119         return frame_build(ExecutionResult::ERROR, 1, 9, "PARAM UNNECESSARY");
00120     }
00121
00122     if (operationType != OperationType::SET) {
00123         return frame_build(ExecutionResult::ERROR, 1, 9, "INVALID OPERATION");
00124     }
00125
00126     // Build the success frame *before* resetting
00127     Frame successFrame = frame_build(ExecutionResult::SUCCESS, 1, 9, "REBOOT BOOTSEL");
00128
00129     // Send the success frame
00130     uart_print("Sending BOOTSEL confirmation...");
00131     send_frame(successFrame); // Assuming you have a sendFrame function
00132
00133     // Delay to ensure the frame is sent
00134     sleep_ms(100);
00135
00136     uart_print("Entering BOOTSEL mode...", VerbosityLevel::WARNING);
00137     reset_usb_boot(0, 0); // Trigger BOOTSEL mode
00138
00139     // The code will never reach here because the Pico will reset
00140     return frame_build(ExecutionResult::SUCCESS, 1, 9, "Entering BOOTSEL mode");
00141 }
00142

```

## 8.17 lib/comms/commands/event\_commands.cpp File Reference

```
#include "communication.h"
#include "event_manager.h"
#include <iostream>
```

Include dependency graph for event\_commands.cpp:



## Functions

- **Frame handle\_get\_last\_events (const std::string &param, OperationType operationType)**  
*Handler for retrieving last N events from the event log.*
- **Frame handle\_get\_event\_count (const std::string &param, OperationType operationType)**  
*Handler for getting total number of events in the log.*

## 8.18 event\_commands.cpp

Go to the documentation of this file.

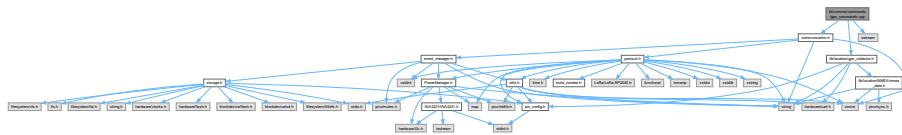
```

00001 #include "communication.h"
00002 #include "event_manager.h"
00003 #include <iostream>
00004
00005
00011
00029 Frame handle_get_last_events(const std::string& param, OperationType operationType) {
00030     if (operationType != OperationType::GET) {
00031         return frame_build(ExecutionResult::ERROR, 5, 1, "INVALID OPERATION");
00032     }
00033
00034     size_t count = 10; // Default number of events to return
00035     if (!param.empty()) {
00036         try {
00037             count = std::stoul(param);
00038             if (count == 0 || count > EVENT_BUFFER_SIZE) {
00039                 return frame_build(ExecutionResult::ERROR, 5, 1, "INVALID COUNT");
00040             }
00041         } catch (...) {
00042             return frame_build(ExecutionResult::ERROR, 5, 1, "INVALID PARAMETER");
00043         }
00044     }
00045
00046     std::stringstream ss;
00047     ss << std::hex << std::uppercase << std::setfill('0');
00048
00049     size_t available = eventManager.get_event_count();
00050     size_t toReturn = std::min(count, available);
00051
00052     // Start from the most recent event
00053     for (size_t i = 0; i < toReturn; i++) {
00054         const EventLog& event = eventManager.get_event(available - 1 - i);
00055         // Format: IIIITTTTTTGEE
00056         // IIII: 16-bit ID (4 hex chars)
00057         // TTTTTT: 32-bit timestamp (8 hex chars)
00058         // GG: 8-bit group (2 hex chars)
00059         // EE: 8-bit event (2 hex chars)
00060         ss << std::setw(4) << event.id
00061             << std::setw(8) << event.timestamp
00062             << std::setw(2) << static_cast<int>(event.group)
00063             << std::setw(2) << static_cast<int>(event.event);
00064         if (i < toReturn - 1) ss << "-";
00065     }
00066
00067     return frame_build(ExecutionResult::SUCCESS, 5, 1, ss.str());
00068 }
00069
00070
00083 Frame handle_get_event_count(const std::string& param, OperationType operationType) {
00084     if (operationType != OperationType::GET || !param.empty()) {
00085         return frame_build(ExecutionResult::ERROR, 5, 2, "INVALID REQUEST");
00086     }
00087
00088     return frame_build(ExecutionResult::SUCCESS, 5, 2,
00089                         std::to_string(eventManager.get_event_count()));
00090 } // end of EventCommands group

```

## 8.19 lib/comms/commands/gps\_commands.cpp File Reference

```
#include "communication.h"
#include "lib/location/gps_collector.h"
#include <sstream>
Include dependency graph for gps_commands.cpp:
```



### Functions

- **Frame handle\_gps\_power\_status** (const std::string &param, OperationType operationType)  
*Handler for controlling GPS module power state.*
- **Frame handle\_enable\_gps\_uart\_passthrough** (const std::string &param, OperationType operationType)  
*Handler for enabling GPS transparent mode (UART pass-through)*
- **Frame handle\_get\_rmc\_data** (const std::string &param, OperationType operationType)  
*Handler for retrieving GPS RMC (Recommended Minimum Navigation) data.*
- **Frame handle\_get\_gga\_data** (const std::string &param, OperationType operationType)  
*Handler for retrieving GPS GGA (Global Positioning System Fix Data) data.*

## 8.20 gps\_commands.cpp

[Go to the documentation of this file.](#)

```
00001 #include "communication.h"
00002 #include "lib/location/gps_collector.h"
00003 #include <sstream> // Include for stringstream
00004
00010
00026 Frame handle_gps_power_status(const std::string& param, OperationType operationType) {
00027     if (!(operationType == OperationType::GET || operationType == OperationType::SET)) {
00028         return frame_build(ExecutionResult::ERROR, 7, 1, "INVALID OPERATION");
00029     }
00030
00031     if (operationType == OperationType::SET) {
00032         if (param.empty()) {
00033             return frame_build(ExecutionResult::ERROR, 7, 1, "PARAM REQUIRED");
00034         }
00035
00036         try {
00037             int powerStatus = std::stoi(param);
00038             if (powerStatus != 0 && powerStatus != 1) {
00039                 return frame_build(ExecutionResult::ERROR, 7, 1, "INVALID VALUE. USE 0 OR 1");
00040             }
00041             gpio_put(GPS_POWER_ENABLE_PIN, powerStatus);
00042             EventEmitter::emit(EventGroup::GPS, powerStatus ? GPSEvent::POWER_ON :
00043             GPSEvent::POWER_OFF);
00044             return frame_build(ExecutionResult::SUCCESS, 7, 1, std::to_string(powerStatus));
00045         } catch (...) {
00046             return frame_build(ExecutionResult::ERROR, 7, 1, "INVALID PARAMETER FORMAT");
00047         }
00048
00049     // GET operation
00050     if (!param.empty()) {
00051         return frame_build(ExecutionResult::ERROR, 7, 1, "PARAM UNNECESSARY");
00052     }
00053
00054     bool powerStatus = gpio_get(GPS_POWER_ENABLE_PIN);
00055     return frame_build(ExecutionResult::SUCCESS, 7, 1, std::to_string(powerStatus));
```

```

00056 }
00057
00058
00074 Frame handle_enable_gps_uart_passthrough(const std::string& param, OperationType operationType) {
00075     // Validate operation type
00076     if (!(operationType == OperationType::SET)) {
00077         return frame_build(ExecutionResult::ERROR, 7, 2, "NOT ALLOWED");
00078     }
00079
00080     // Parse and validate timeout parameter
00081     uint32_t timeoutMs;
00082     try {
00083         timeoutMs = param.empty() ? 60000u : std::stoul(param) * 1000;
00084     } catch (...) {
00085         return frame_build(ExecutionResult::ERROR, 7, 2, "INVALID TIMEOUT FORMAT");
00086     }
00087
00088     // Setup UART parameters and exit sequence
00089     const std::string EXIT_SEQUENCE = "##EXIT##";
00090     std::string inputBuffer;
00091     bool exitRequested = false;
00092     uint32_t originalBaudRate = DEBUG_UART_BAUD_RATE;
00093     uint32_t gpsBaudRate = GPS_UART_BAUD_RATE;
00094     uint32_t startTime = to_ms_since_boot(get_absolute_time());
00095
00096     // Log start of transparent mode
00097     EventEmitter::emit(EventGroup::GPS, GPSEvent::PASS_THROUGH_START);
00098
00099     // Print startup message
00100     std::string message = "Entering GPS Serial Pass-Through Mode @" +
00101             std::to_string(gpsBaudRate) + " for " +
00102             std::to_string(timeoutMs/1000) + "s\r\n" +
00103             "Send " + EXIT_SEQUENCE + " to exit";
00104     uart_print(message, VerbosityLevel::INFO);
00105
00106     // Allow time for message to be sent before baudrate change
00107     sleep_ms(10);
00108
00109     // Switch to GPS baudrate
00110     uart_set_baudrate(DEBUG_UART_PORT, gpsBaudRate);
00111
00112     // Main transparent mode loop
00113     while (!exitRequested) {
00114         while (uart_is_readable(DEBUG_UART_PORT)) {
00115             char ch = uart_getc(DEBUG_UART_PORT);
00116
00117             inputBuffer += ch;
00118             if (inputBuffer.length() > EXIT_SEQUENCE.length()) {
00119                 inputBuffer = inputBuffer.substr(1);
00120             }
00121
00122             if (inputBuffer == EXIT_SEQUENCE) {
00123                 exitRequested = true;
00124                 break;
00125             }
00126
00127             if (inputBuffer != EXIT_SEQUENCE.substr(0, inputBuffer.length())) {
00128                 uart_write_blocking(GPS_UART_PORT,
00129                     reinterpret_cast<const uint8_t*>(&ch), 1);
00130             }
00131         }
00132
00133         while (uart_is_readable(GPS_UART_PORT)) {
00134             char gpsByte = uart_getc(GPS_UART_PORT);
00135             uart_write_blocking(DEBUG_UART_PORT,
00136                 reinterpret_cast<const uint8_t*>(&gpsByte), 1);
00137         }
00138
00139         if (to_ms_since_boot(get_absolute_time()) - startTime >= timeoutMs) {
00140             break;
00141         }
00142     }
00143
00144     uart_set_baudrate(DEBUG_UART_PORT, originalBaudRate);
00145
00146     sleep_ms(10);
00147
00148     EventEmitter::emit(EventGroup::GPS, GPSEvent::PASS_THROUGH_END);
00149
00150     std::string exitReason = exitRequested ? "USER_EXIT" : "TIMEOUT";
00151     std::string response = "GPS UART BRIDGE EXIT: " + exitReason;
00152     uart_print(response, VerbosityLevel::INFO);
00153
00154     return frame_build(ExecutionResult::SUCCESS, 7, 2, response);
00155 }
00156
00157

```

```

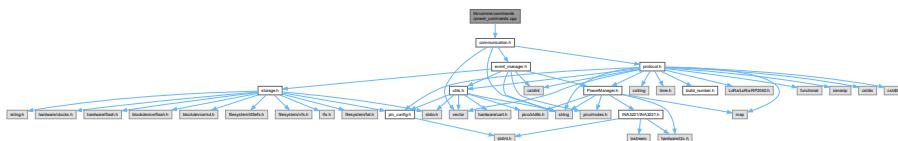
00170 Frame handle_get_rmc_data(const std::string& param, OperationType operationType) {
00171     if (operationType != OperationType::GET) {
00172         return frame_build(ExecutionResult::ERROR, 7, 3, "INVALID OPERATION");
00173     }
00174
00175     if (!param.empty()) {
00176         return frame_build(ExecutionResult::ERROR, 7, 3, "PARAM UNNECESSARY");
00177     }
00178
00179     std::vector<std::string> tokens = nmea_data.get_rmc_tokens();
00180     if (tokens.empty()) {
00181         return frame_build(ExecutionResult::ERROR, 7, 3, "NO RMC DATA");
00182     }
00183
00184     // Join tokens with commas to create the response
00185     std::stringstream ss;
00186     for (size_t i = 0; i < tokens.size(); ++i) {
00187         ss << tokens[i];
00188         if (i < tokens.size() - 1) {
00189             ss << ",";
00190         }
00191     }
00192
00193     return frame_build(ExecutionResult::SUCCESS, 7, 3, ss.str());
00194 }
00195
00196
00197 00209 Frame handle_get_gga_data(const std::string& param, OperationType operationType) {
00210     if (operationType != OperationType::GET) {
00211         return frame_build(ExecutionResult::ERROR, 7, 4, "INVALID OPERATION");
00212     }
00213
00214     if (!param.empty()) {
00215         return frame_build(ExecutionResult::ERROR, 7, 4, "PARAM UNNECESSARY");
00216     }
00217
00218     std::vector<std::string> tokens = nmea_data.get_gga_tokens();
00219     if (tokens.empty()) {
00220         return frame_build(ExecutionResult::ERROR, 7, 4, "NO GGA DATA");
00221     }
00222
00223     // Join tokens with commas to create the response
00224     std::stringstream ss;
00225     for (size_t i = 0; i < tokens.size(); ++i) {
00226         ss << tokens[i];
00227         if (i < tokens.size() - 1) {
00228             ss << ",";
00229         }
00230     }
00231
00232     return frame_build(ExecutionResult::SUCCESS, 7, 4, ss.str());
00233 } // end of GPSCommands group

```

## 8.21 lib/comms/commands/power\_commands.cpp File Reference

#include "communication.h"

Include dependency graph for power\_commands.cpp:



## Functions

- Frame handle\_get\_power\_manager\_ids (const std::string &param, OperationType operationType)  
Handler for retrieving Power Manager IDs.
- Frame handle\_get\_voltage\_battery (const std::string &param, OperationType operationType)  
Handler for getting battery voltage.

- Frame `handle_get_voltage_5v` (const std::string &param, OperationType operationType)  
*Handler for getting 5V rail voltage.*
- Frame `handle_get_current_charge_usb` (const std::string &param, OperationType operationType)  
*Handler for getting USB charge current.*
- Frame `handle_get_current_charge_solar` (const std::string &param, OperationType operationType)  
*Handler for getting solar panel charge current.*
- Frame `handle_get_current_charge_total` (const std::string &param, OperationType operationType)  
*Handler for getting total charge current.*
- Frame `handle_get_current_draw` (const std::string &param, OperationType operationType)  
*Handler for getting system current draw.*

## 8.22 power\_commands.cpp

[Go to the documentation of this file.](#)

```

00001 #include "communication.h"
00002
00003
00004
00005
00006
00007
00008
00009
00010 Frame handle_get_power_manager_ids(const std::string& param, OperationType operationType) {
00011     if (!param.empty()) {
00012         return frame_build(ExecutionResult::ERROR, 2, 0, "PARAM UNNECESSARY");
00013     }
00014
00015     if (!(operationType == OperationType::GET)) {
00016         return frame_build(ExecutionResult::ERROR, 2, 0, "INVALID OPERATION");
00017     }
00018
00019     extern PowerManager powerManager;
00020     std::string powerManagerIDS = powerManager.read_device_ids();
00021     return frame_build(ExecutionResult::SUCCESS, 2, 0, powerManagerIDS);
00022 }
00023
00024
00025
00026
00027
00028
00029
00030
00031
00032
00033
00034
00035
00036
00037
00038
00039 Frame handle_get_voltage_battery(const std::string& param, OperationType operationType) {
00040     if (!param.empty()) {
00041         return frame_build(ExecutionResult::ERROR, 2, 2, "PARAM UNNECESSARY");
00042     }
00043
00044     if (!(operationType == OperationType::GET)) {
00045         return frame_build(ExecutionResult::ERROR, 2, 2, "NOT ALLOWED");
00046     }
00047
00048     extern PowerManager powerManager;
00049     float voltage = powerManager.get_voltage_battery();
00050     return frame_build(ExecutionResult::SUCCESS, 2, 2, std::to_string(voltage), ValueUnit::VOLT);
00051 }
00052
00053
00054
00055
00056
00057
00058
00059
00060
00061
00062
00063
00064
00065
00066
00067 Frame handle_get_voltage_5v(const std::string& param, OperationType operationType) {
00068     if (!param.empty()) {
00069         return frame_build(ExecutionResult::ERROR, 2, 3, "PARAM UNNECESSARY");
00070     }
00071
00072     if (!(operationType == OperationType::GET)) {
00073         return frame_build(ExecutionResult::ERROR, 2, 3, "NOT ALLOWED");
00074     }
00075
00076     extern PowerManager powerManager;
00077     float voltage = powerManager.get_voltage_5v();
00078     return frame_build(ExecutionResult::SUCCESS, 2, 3, std::to_string(voltage), ValueUnit::VOLT);
00079 }
00080
00081
00082
00083
00084
00085
00086
00087
00088
00089
00090
00091
00092
00093 Frame handle_get_current_charge_usb(const std::string& param, OperationType operationType) {
00094     if (!param.empty()) {
00095         return frame_build(ExecutionResult::ERROR, 2, 4, "PARAM UNNECESSARY");
00096     }
00097
00098     if (!(operationType == OperationType::GET)) {
00099         return frame_build(ExecutionResult::ERROR, 2, 4, "NOT ALLOWED");
00100     }
00101
00102     extern PowerManager powerManager;
00103     float chargeCurrent = powerManager.get_current_charge_usb();
00104 }
```

```

00114     return frame_build(ExecutionResult::SUCCESS, 2, 4, std::to_string(chargeCurrent),
00115     ValueUnit::MILIAMP);
00116
00117
00118 Frame handle_get_current_charge_solar(const std::string& param, OperationType operationType) {
00119     if (!param.empty()) {
00120         return frame_build(ExecutionResult::ERROR, 2, 5, "PARAM UNNECESSARY");
00121     }
00122
00123     if (!(operationType == OperationType::GET)) {
00124         return frame_build(ExecutionResult::ERROR, 2, 5, "NOT ALLOWED");
00125     }
00126
00127     extern PowerManager powerManager;
00128     float chargeCurrent = powerManager.get_current_charge_solar();
00129     return frame_build(ExecutionResult::SUCCESS, 2, 5, std::to_string(chargeCurrent),
00130     ValueUnit::MILIAMP);
00131 }
00132
00133
00134
00135 Frame handle_get_current_charge_total(const std::string& param, OperationType operationType) {
00136     if (!param.empty()) {
00137         return frame_build(ExecutionResult::ERROR, 2, 6, "PARAM UNNECESSARY");
00138     }
00139
00140     if (!(operationType == OperationType::GET)) {
00141         return frame_build(ExecutionResult::ERROR, 2, 6, "NOT ALLOWED");
00142     }
00143
00144
00145 Frame handle_get_current_draw(const std::string& param, OperationType operationType) {
00146     if (!param.empty()) {
00147         return frame_build(ExecutionResult::ERROR, 2, 7, "PARAM UNNECESSARY");
00148     }
00149
00150
00151
00152     if (!(operationType == OperationType::GET)) {
00153         return frame_build(ExecutionResult::ERROR, 2, 7, "NOT ALLOWED");
00154     }
00155
00156     extern PowerManager powerManager;
00157     float currentDraw = powerManager.get_current_draw();
00158     return frame_build(ExecutionResult::SUCCESS, 2, 7, std::to_string(currentDraw),
00159     ValueUnit::MILIAMP);
00160 }
00161
00162
00163
00164
00165
00166
00167
00168
00169
00170
00171
00172
00173
00174
00175
00176
00177
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00180
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00182
00183
00184
00185
00186
00187
00188
00189
00190
00191
00192
00193
00194
00195
00196
00197 } // end of PowerCommands group

```

## 8.23 lib/comms/commands/storage\_commands.cpp File Reference

```

#include "commands.h"
#include "communication.h"
#include "storage.h"
#include "filesystem/vfs.h"
#include "filesystem/littlefs.h"
#include <sys/stat.h>
#include <errno.h>
#include "storage_commands_utils.h"
#include "dirent.h"

```

Include dependency graph for storage\_commands.cpp:



## Macros

- #define MAX\_BLOCK\_SIZE 250
- #define STORAGE\_GROUP 6
- #define START\_COMMAND 1
- #define DATA\_COMMAND 2
- #define END\_COMMAND 3
- #define LIST\_FILES\_COMMAND 0
- #define MOUNT\_COMMAND 4

## Functions

- Frame handle\_file\_download (const std::string &param, OperationType operationType)  
*Handles the file download command.*
- Frame handle\_list\_files (const std::string &param, OperationType operationType)  
*Handles the list files command.*
- Frame handle\_mount (const std::string &param, OperationType operationType)  
*Handles the SD card mount/unmount command.*

### 8.23.1 Macro Definition Documentation

#### 8.23.1.1 MAX\_BLOCK\_SIZE

```
#define MAX_BLOCK_SIZE 250
```

Definition at line 11 of file [storage\\_commands.cpp](#).

#### 8.23.1.2 STORAGE\_GROUP

```
#define STORAGE_GROUP 6
```

Definition at line 12 of file [storage\\_commands.cpp](#).

#### 8.23.1.3 START\_COMMAND

```
#define START_COMMAND 1
```

Definition at line 13 of file [storage\\_commands.cpp](#).

#### 8.23.1.4 DATA\_COMMAND

```
#define DATA_COMMAND 2
```

Definition at line 14 of file [storage\\_commands.cpp](#).

### 8.23.1.5 END\_COMMAND

```
#define END_COMMAND 3
```

Definition at line 15 of file [storage\\_commands.cpp](#).

### 8.23.1.6 LIST\_FILES\_COMMAND

```
#define LIST_FILES_COMMAND 0
```

Definition at line 16 of file [storage\\_commands.cpp](#).

### 8.23.1.7 MOUNT\_COMMAND

```
#define MOUNT_COMMAND 4
```

Definition at line 17 of file [storage\\_commands.cpp](#).

## 8.24 storage\_commands.cpp

[Go to the documentation of this file.](#)

```
00001 #include "commands.h"
00002 #include "communication.h"
00003 #include "storage.h"
00004 #include "filesystem/vfs.h"
00005 #include "filesystem/littlefs.h"
00006 #include <sys/stat.h>
00007 #include <errno.h>
00008 #include "storage_commands_utils.h"
00009 #include "dirent.h"
0010
0011 #define MAX_BLOCK_SIZE 250
0012 #define STORAGE_GROUP 6
0013 #define START_COMMAND 1
0014 #define DATA_COMMAND 2
0015 #define END_COMMAND 3
0016 #define LIST_FILES_COMMAND 0
0017 #define MOUNT_COMMAND 4
0023
0043 Frame handle_file_download(const std::string& param, OperationType operationType) {
0044     if (operationType != OperationType::GET) {
0045         return frame_build(ExecutionResult::ERROR, STORAGE_GROUP, START_COMMAND, "Invalid operation
type");
0046     }
0047
0048     const char* filename = param.c_str();
0049     FILE* file = fopen(filename, "rb");
0050
0051     if (!file) {
0052         return frame_build(ExecutionResult::ERROR, STORAGE_GROUP, START_COMMAND, "File not found");
0053     }
0054
0055     // Get file size
0056     fseek(file, 0, SEEK_END);
0057     size_t fileSize = ftell(file);
0058     fseek(file, 0, SEEK_SET);
0059
0060     // Send file size to ground station
0061     Frame sizeFrame = frame_build(ExecutionResult::INFO, STORAGE_GROUP, START_COMMAND,
std::to_string(fileSize));
0062     send_frame(sizeFrame);
0063
0064     size_t block_size = MAX_BLOCK_SIZE;
0065     size_t block_count = (fileSize + block_size - 1) / block_size;
0066
0067     // Send block size and count
```

```

00068     Frame blockSizeFrame = frame_build(ExecutionResult::INFO, STORAGE_GROUP, START_COMMAND,
00069         std::to_string(block_size));
00070     send_frame(blockSizeFrame);
00071     Frame blockCountFrame = frame_build(ExecutionResult::INFO, STORAGE_GROUP, START_COMMAND,
00072         std::to_string(block_count));
00073     send_frame(blockCountFrame);
00074     uint8_t buffer[MAX_BLOCK_SIZE];
00075     size_t bytesRead;
00076     uint32_t totalChecksum = 0;
00077     size_t blockIndex = 0;
00078     while ((bytesRead = fread(buffer, 1, MAX_BLOCK_SIZE, file)) > 0) {
00079         // Send data block
00080         send_data_block(buffer, bytesRead);
00081         totalChecksum = calculate_checksum(buffer, bytesRead);
00082         // Wait for ACK
00083         if (!receive_ack()) {
00084             fclose(file);
00085             return frame_build(ExecutionResult::ERROR, STORAGE_GROUP, DATA_COMMAND, "ACK timeout");
00086         }
00087         blockIndex++;
00088     }
00089 }
00090 fclose(file);
00091 // Send end frame with checksum
00092 std::stringstream ss;
00093 ss << std::hex << totalChecksum;
00094 Frame endFrame = frame_build(ExecutionResult::SUCCESS, STORAGE_GROUP, END_COMMAND, ss.str());
00095 send_frame(endFrame);
00096 return frame_build(ExecutionResult::SUCCESS, STORAGE_GROUP, END_COMMAND, "File download
complete");
00100 }
00101
00102 Frame handle_list_files(const std::string& param, OperationType operationType) {
00103     if (operationType != OperationType::GET) {
00104         return frame_build(ExecutionResult::ERROR, STORAGE_GROUP, LIST_FILES_COMMAND, "Invalid
operation type");
00105     }
00106     DIR *dir;
00107     struct dirent *ent;
00108     if ((dir = opendir("/")) != NULL) {
00109         while ((ent = readdir(dir)) != NULL) {
00110             const char* filename = ent->d_name;
00111             // Skip "." and ".." directories
00112             if (strcmp(filename, ".") == 0 || strcmp(filename, "..") == 0) {
00113                 continue;
00114             }
00115             // Get file size
00116             char filepath[256];
00117             snprintf(filepath, sizeof(filepath), "/%s", filename);
00118             FILE* file = fopen(filepath, "rb");
00119             size_t fileSize = 0;
00120             if (file != NULL) {
00121                 fseek(file, 0, SEEK_END);
00122                 fileSize = ftell(file);
00123                 fclose(file);
00124             }
00125             // Create and send frame with filename and size
00126             char fileInfo[512];
00127             snprintf(fileInfo, sizeof(fileInfo), "%s:%zu", filename, fileSize);
00128             Frame fileFrame = frame_build(ExecutionResult::INFO, STORAGE_GROUP, LIST_FILES_COMMAND,
00129                 fileInfo);
00130             uart_print(fileInfo, VerboseLevel::INFO);
00131             send_frame(fileFrame);
00132         }
00133         closedir(dir);
00134     }
00135     return frame_build(ExecutionResult::SUCCESS, STORAGE_GROUP, LIST_FILES_COMMAND, "File listing
complete");
00136 } else {
00137     return frame_build(ExecutionResult::ERROR, STORAGE_GROUP, LIST_FILES_COMMAND, "Could not open
directory");
00138 }
00139
00140 Frame handle_mount(const std::string& param, OperationType operationType) {

```

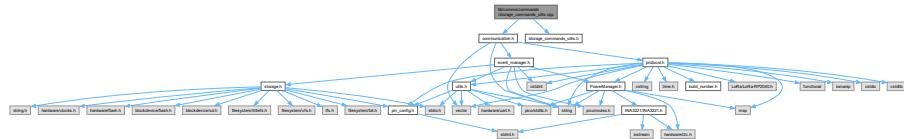
```

00181     if (operationType != OperationType::SET) {
00182         return frame_build(ExecutionResult::ERROR, STORAGE_GROUP, MOUNT_COMMAND, "Invalid operation
00183             type");
00184
00185     if (param == "1") {
00186         if (fs_init()) {
00187             return frame_build(ExecutionResult::SUCCESS, STORAGE_GROUP, MOUNT_COMMAND, "SD card
00188                 mounted");
00189         } else {
00190             return frame_build(ExecutionResult::ERROR, STORAGE_GROUP, MOUNT_COMMAND, "Mount failed");
00191         }
00192     } else if (param == "0") {
00193         if (fs_unmount("/") == 0) {
00194             sd_card_mounted = false;
00195             return frame_build(ExecutionResult::SUCCESS, STORAGE_GROUP, MOUNT_COMMAND, "SD card
00196                 unmounted");
00197         } else {
00198             return frame_build(ExecutionResult::ERROR, STORAGE_GROUP, MOUNT_COMMAND, "Unmount
00199                 failed");
00200         }
00201     }
00202 } // StorageCommands

```

## 8.25 lib/comms/commands/storage\_commands\_utils.cpp File Reference

```
#include "communication.h"
#include "storage_commands_utils.h"
Include dependency graph for storage_commands_utils.cpp:
```



### Functions

- uint32\_t **calculate\_checksum** (const uint8\_t \*data, size\_t length)
- void **send\_data\_block** (const uint8\_t \*data, size\_t length)
- bool **receive\_ack** ()

#### 8.25.1 Function Documentation

##### 8.25.1.1 calculate\_checksum()

```
uint32_t calculate_checksum (
    const uint8_t * data,
    size_t length)
```

Definition at line 5 of file [storage\\_commands\\_utils.cpp](#).

Here is the caller graph for this function:



### 8.25.1.2 send\_data\_block()

```
void send_data_block (
    const uint8_t * data,
    size_t length)
```

Definition at line 14 of file [storage\\_commands\\_utils.cpp](#).

Here is the caller graph for this function:



### 8.25.1.3 receive\_ack()

```
bool receive_ack ()
```

Definition at line 21 of file [storage\\_commands\\_utils.cpp](#).

Here is the caller graph for this function:



## 8.26 storage\_commands\_utils.cpp

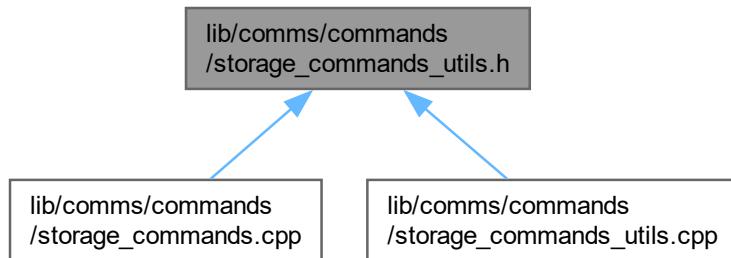
[Go to the documentation of this file.](#)

```

00001 #include "communication.h"
00002 #include "storage_commands_utils.h"
00003
00004 // Helper function to calculate checksum (simple XOR)
00005 uint32_t calculate_checksum(const uint8_t* data, size_t length) {
00006     uint32_t checksum = 0;
00007     for (size_t i = 0; i < length; ++i) {
00008         checksum ^= data[i];
00009     }
00010     return checksum;
00011 }
00012
00013
00014 void send_data_block(const uint8_t* data, size_t length) {
00015     LoRa.beginPacket();
00016     LoRa.write(data, length);
00017     LoRa.endPacket();
00018 }
00019
00020 // Receiving an ACK (simplified)
00021 bool receive_ack() {
00022     // Implement logic to receive an ACK frame from the ground station
00023     // Return true if ACK received, false otherwise
00024     // This is a placeholder, replace with your actual ACK receiving logic
00025     return true; // Placeholder: Always return true for now
00026 }
```

## 8.27 lib/comms/commands/storage\_commands\_utils.h File Reference

This graph shows which files directly or indirectly include this file:



### Functions

- `uint32_t calculate_checksum (const uint8_t *data, size_t length)`
- `void send_data_block (const uint8_t *data, size_t length)`
- `bool receive_ack ()`

## 8.27.1 Function Documentation

### 8.27.1.1 calculate\_checksum()

```
uint32_t calculate_checksum (
    const uint8_t * data,
    size_t length)
```

Definition at line 5 of file [storage\\_commands\\_utils.cpp](#).

Here is the caller graph for this function:



### 8.27.1.2 send\_data\_block()

```
void send_data_block (
    const uint8_t * data,
    size_t length)
```

Definition at line 14 of file [storage\\_commands\\_utils.cpp](#).

Here is the caller graph for this function:



### 8.27.1.3 receive\_ack()

```
bool receive_ack ()
```

Definition at line 21 of file [storage\\_commands\\_utils.cpp](#).

Here is the caller graph for this function:



## 8.28 storage\_commands\_utils.h

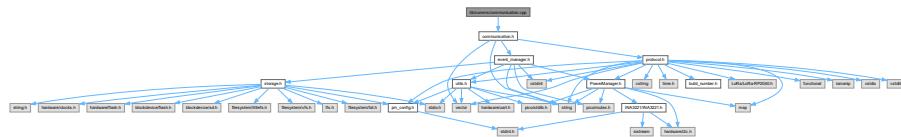
[Go to the documentation of this file.](#)

```
00001 uint32_t calculate_checksum(const uint8_t* data, size_t length);
00002 void send_data_block(const uint8_t* data, size_t length);
00003 bool receive_ack();
```

## 8.29 lib/comms/communication.cpp File Reference

```
#include "communication.h"
```

Include dependency graph for communication.cpp:



### Functions

- `bool initialize_radio ()`  
*Initializes the LoRa radio module.*

### Variables

- `string outgoing`
- `uint8_t msgCount = 0`
- `long lastSendTime = 0`
- `long lastReceiveTime = 0`
- `long lastPrintTime = 0`
- `unsigned long interval = 0`

### 8.29.1 Function Documentation

#### 8.29.1.1 initialize\_radio()

```
bool initialize_radio ()
```

Initializes the LoRa radio module.

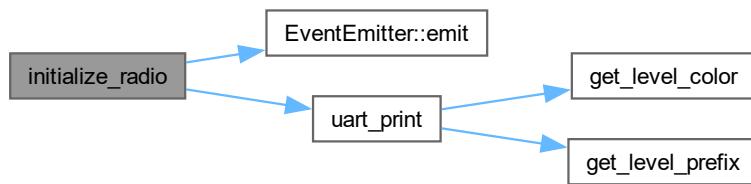
**Returns**

True if initialization was successful, false otherwise.

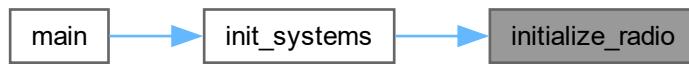
Sets the LoRa pins and attempts to begin LoRa communication at a specified frequency. Emits a [CommsEvent::RADIO\\_INIT](#) event on success or a [CommsEvent::RADIO\\_ERROR](#) event on failure.

Definition at line 17 of file [communication.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



## 8.29.2 Variable Documentation

### 8.29.2.1 outgoing

```
string outgoing
```

Definition at line 3 of file [communication.cpp](#).

### 8.29.2.2 msgCount

```
uint8_t msgCount = 0
```

Definition at line 4 of file [communication.cpp](#).

### 8.29.2.3 lastSendTime

```
long lastSendTime = 0
```

Definition at line 5 of file [communication.cpp](#).

### 8.29.2.4 lastReceiveTime

```
long lastReceiveTime = 0
```

Definition at line 6 of file [communication.cpp](#).

### 8.29.2.5 lastPrintTime

```
long lastPrintTime = 0
```

Definition at line 7 of file [communication.cpp](#).

### 8.29.2.6 interval

```
unsigned long interval = 0
```

Definition at line 8 of file [communication.cpp](#).

## 8.30 communication.cpp

[Go to the documentation of this file.](#)

```
00001 #include "communication.h"
00002
00003 string outgoing;
00004 uint8_t msgCount = 0;
00005 long lastSendTime = 0;
00006 long lastReceiveTime = 0;
00007 long lastPrintTime = 0;
00008 unsigned long interval = 0;
00009
00010
00011 bool initialize_radio() {
00012     LoRa.set_pins(lora_cs_pin, lora_reset_pin, lora_irq_pin);
00013     long frequency = 433E6;
00014     bool initStatus = false;
00015     if (!LoRa.begin(frequency))
00016     {
00017         uart_print("LoRa init failed. Check your connections.", VerbosityLevel::WARNING);
00018         initStatus = false;
00019     } else {
00020         uart_print("LoRa initialized with frequency " + std::to_string(frequency),
00021             VerbosityLevel::INFO);
00022         initStatus = true;
00023     }
00024     EventEmitter::emit(EventGroup::COMMS, initStatus ? CommsEvent::RADIO_INIT :
00025         CommsEvent::RADIO_ERROR);
00026     return initStatus;
00027 }
00028
00029
00030
00031
00032
00033 }
```

## 8.31 lib/comms/communication.h File Reference

```
#include <string>
#include <vector>
#include "protocol.h"
#include "event_manager.h"
Include dependency graph for communication.h:
```



This graph shows which files directly or indirectly include this file:



### Functions

- `bool initialize_radio ()`  
*Initializes the LoRa radio module.*
- `void on_receive (int packetSize)`  
*Callback function for handling received LoRa packets.*
- `void handle_uart_input ()`  
*Handles UART input.*
- `void send_message (std::string outgoing)`
- `void send_frame (const Frame &frame)`
- `void send_frame_uart (const Frame &frame)`
- `void send_frame_lora (const Frame &frame)`
- `void split_and_send_message (const uint8_t *data, size_t length)`  
*Sends a large packet using LoRa.*
- `Frame execute_command (uint32_t commandKey, const std::string &param, OperationType operationType)`  
*Executes a command based on its key.*
- `void frame_process (const std::string &data, Interface interface)`  
*Executes a command based on the command key and the parameter.*
- `std::string frame_encode (const Frame &frame)`  
*Encodes a `Frame` instance into a string.*
- `Frame frame_decode (const std::string &data)`  
*Decodes a string into a `Frame` instance.*
- `Frame frame_build (ExecutionResult result, uint8_t group, uint8_t command, const std::string &value, const ValueUnit unitType=ValueUnit::UNDEFINED)`  
*Builds a `Frame` instance based on the execution result, group, command, value, and unit.*
- `std::string determine_unit (uint8_t group, uint8_t command)`

### 8.31.1 Function Documentation

#### 8.31.1.1 initialize\_radio()

```
bool initialize_radio ()
```

Initializes the LoRa radio module.

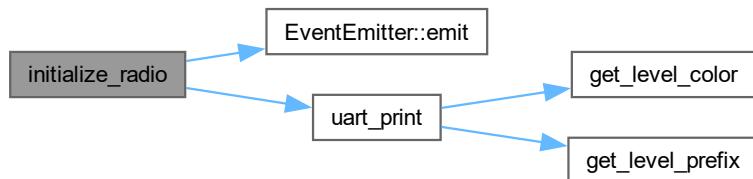
##### Returns

True if initialization was successful, false otherwise.

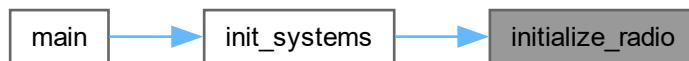
Sets the LoRa pins and attempts to begin LoRa communication at a specified frequency. Emits a [CommsEvent::RADIO\\_INIT](#) event on success or a [CommsEvent::RADIO\\_ERROR](#) event on failure.

Definition at line 17 of file [communication.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



#### 8.31.1.2 on\_receive()

```
void on_receive (
    int packetSize)
```

Callback function for handling received LoRa packets.

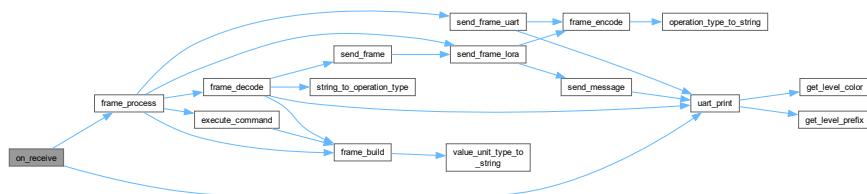
### Parameters

<code>packetSize</code>	The size of the received packet.
-------------------------	----------------------------------

Reads the received LoRa packet, extracts metadata, validates the lora\_address\_remote and local addresses, extracts the frame data, and processes it. Prints raw hex values for debugging.

Definition at line 15 of file [receive.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 8.31.1.3 handle\_uart\_input()

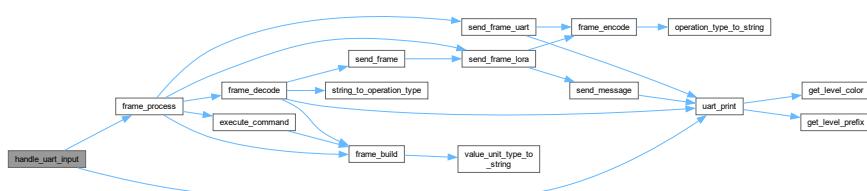
```
void handle_uart_input ()
```

Handles UART input.

Reads characters from the UART port, appends them to a buffer, and processes the buffer when a newline character is received.

Definition at line 76 of file [receive.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



#### 8.31.1.4 send\_message()

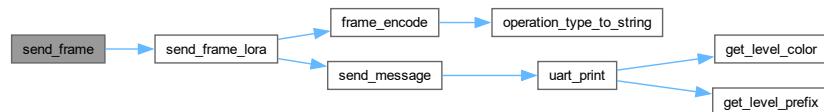
```
void send_message (
    std::string outgoing)
```

#### 8.31.1.5 send\_frame()

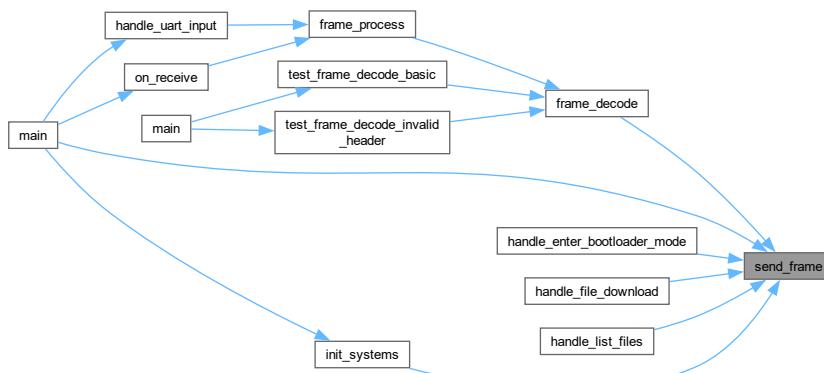
```
void send_frame (
    const Frame & frame)
```

Definition at line 48 of file [send.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

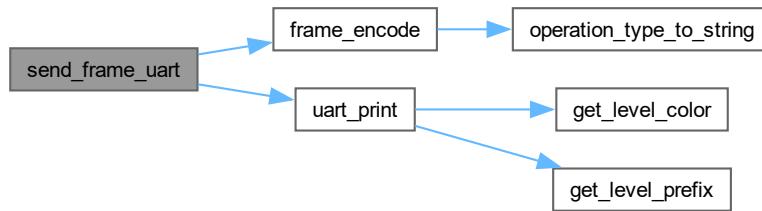


### 8.31.1.6 send\_frame\_uart()

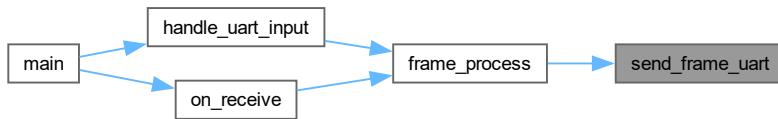
```
void send_frame_uart (
    const Frame & frame)
```

Definition at line 42 of file [send.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

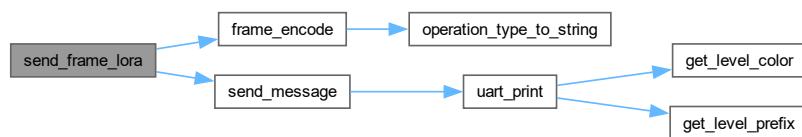


### 8.31.1.7 send\_frame\_lora()

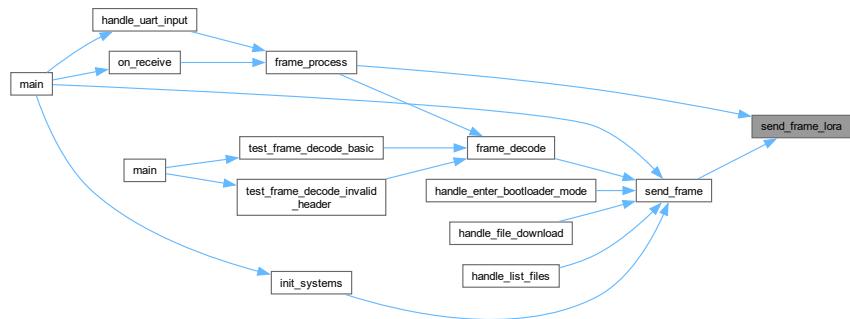
```
void send_frame_lora (
    const Frame & frame)
```

Definition at line 37 of file [send.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 8.31.1.8 split\_and\_send\_message()

```
void split_and_send_message (
    const uint8_t * data,
    size_t length)
```

Sends a large packet using LoRa.

#### Parameters

<i>data</i>	The data to send.
<i>length</i>	The length of the data.

Splits the data into chunks of MAX\_PKT\_SIZE and sends each chunk as a separate LoRa packet.

Definition at line 59 of file [send.cpp](#).

### 8.31.1.9 determine\_unit()

```
std::string determine_unit (
    uint8_t group,
    uint8_t command)
```

## 8.32 communication.h

[Go to the documentation of this file.](#)

```
00001 #ifndef COMMUNICATION_H
00002 #define COMMUNICATION_H
00003
00004 #include <string>
00005 #include <vector>
00006 #include "protocol.h"
00007 #include "event_manager.h"
00008
00009 bool initialize_radio();
00010 void on_receive(int packetSize);
00011 void handle_uart_input();
```

```

00012 void send_message(std::string outgoing);
00013 void send_frame(const Frame& frame);
00014 void send_frame_uart(const Frame& frame);
00015 void send_frame_lora(const Frame& frame);
00016
00017 void split_and_send_message(const uint8_t* data, size_t length);
00018
00019 Frame execute_command(uint32_t commandKey, const std::string& param, OperationType operationType);
00020
00021 void frame_process(const std::string& data, Interface interface);
00022 std::string frame_encode(const Frame& frame);
00023 Frame frame_decode(const std::string& data);
00024 Frame frame_build(ExecutionResult result, uint8_t group, uint8_t command, const std::string& value,
    const ValueUnit unitType = ValueUnit::UNDEFINED);
00025
00026 std::string determine_unit(uint8_t group, uint8_t command);
00027
00028 #endif

```

## 8.33 lib/comms/frame.cpp File Reference

Implements functions for encoding, decoding, building, and processing Frames.

```
#include "communication.h"
```

Include dependency graph for frame.cpp:



### Typedefs

- using **CommandHandler** = std::function<std::string(const std::string&, OperationType)>

### Functions

- std::string **frame\_encode** (const Frame &frame)
 

*Encodes a **Frame** instance into a string.*
- Frame **frame\_decode** (const std::string &data)
 

*Decodes a string into a **Frame** instance.*
- void **frame\_process** (const std::string &data, Interface interface)
 

*Executes a command based on the command key and the parameter.*
- Frame **frame\_build** (ExecutionResult result, uint8\_t group, uint8\_t command, const std::string &value, const ValueUnit unitType)
 

*Builds a **Frame** instance based on the execution result, group, command, value, and unit.*

### Variables

- std::map< uint32\_t, CommandHandler > **commandHandlers**

*Global map of all command handlers.*
- volatile uint16\_t **eventRegister**

### 8.33.1 Detailed Description

Implements functions for encoding, decoding, building, and processing Frames.

Definition in file [frame.cpp](#).

### 8.33.2 Typedef Documentation

#### 8.33.2.1 CommandHandler

```
using CommandHandler = std::function<std::string(const std::string&, OperationType)>
```

Definition at line 3 of file [frame.cpp](#).

### 8.33.3 Variable Documentation

#### 8.33.3.1 eventRegister

```
volatile uint16_t eventRegister [extern]
```

## 8.34 frame.cpp

[Go to the documentation of this file.](#)

```
00001 #include "communication.h"
00002
00003 using CommandHandler = std::function<std::string(const std::string&, OperationType)>;
00004 extern std::map<uint32_t, CommandHandler> commandHandlers;
00005 extern volatile uint16_t eventRegister;
00006
00014
00037 std::string frame_encode(const Frame& frame) {
00038     std::stringstream ss;
00039     ss << static_cast<int>(frame.direction) << DELIMITER
00040         << operation_type_to_string(frame.operationType) << DELIMITER
00041         << static_cast<int>(frame.group) << DELIMITER
00042         << static_cast<int>(frame.command) << DELIMITER
00043         << frame.value;
00044
00045     if (!frame.unit.empty()) {
00046         ss << DELIMITER << frame.unit;
00047     }
00048
00049     return FRAME_BEGIN + DELIMITER + ss.str() + DELIMITER + FRAME_END;
00050 }
00051
00052
00062 Frame frame_decode(const std::string& data) {
00063     try {
00064         Frame frame;
00065         std::stringstream ss(data);
00066         std::string token;
00067
00068         std::getline(ss, token, DELIMITER);
00069         if (token != FRAME_BEGIN)
00070             throw std::runtime_error("Invalid frame header");
00071         frame.header = token;
00072
00073         std::string decodedFrameData;
00074         while (std::getline(ss, token, DELIMITER)) {
00075             if (token == FRAME_END) break;
00076             decodedFrameData += token + DELIMITER;
00077         }
00078         if (!decodedFrameData.empty())
00079             decodedFrameData.pop_back();
```

```

00080         }
00081
00082         std::stringstream frameDataStream(decodedFrameData);
00083
00084         std::getline(frameDataStream, token, DELIMITER);
00085         frame.direction = std::stoi(token);
00086
00087         std::getline(frameDataStream, token, DELIMITER);
00088         frame.operationType = string_to_operation_type(token);
00089
00090         std::getline(frameDataStream, token, DELIMITER);
00091         frame.group = std::stoi(token);
00092
00093         std::getline(frameDataStream, token, DELIMITER);
00094         frame.command = std::stoi(token);
00095
00096         std::getline(frameDataStream, token, DELIMITER);
00097         frame.value = token;
00098
00099         std::getline(frameDataStream, token, DELIMITER);
00100         frame.unit = token;
00101
00102         return frame;
00103     } catch (const std::exception& e) {
00104         uart_print("Frame error: " + std::string(e.what()), VerbosityLevel::ERROR);
00105         Frame errorFrame = frame_build(ExecutionResult::ERROR, 0, 0, e.what());
00106         send_frame(errorFrame);
00107         throw;
00108     }
00109 }
00110
00111
00118 void frame_process(const std::string& data, Interface interface) {
00119     try {
00120         Frame frame = frame_decode(data);
00121         uint32_t commandKey = (static_cast<uint32_t>(frame.group) << 8) |
00122             static_cast<uint32_t>(frame.command);
00123
00124         Frame responseFrame = execute_command(commandKey, frame.value, frame.operationType);
00125
00126         // Send response through the same interface that received the command
00127         if (interface == Interface::UART) {
00128             send_frame_uart(responseFrame);
00129         } else if (interface == Interface::LORA) {
00130             send_frame_lora(responseFrame);
00131         }
00132     } catch (const std::exception& e) {
00133         Frame errorFrame = frame_build(ExecutionResult::ERROR, 0, 0, e.what());
00134
00135         // Send error through the same interface
00136         if (interface == Interface::UART) {
00137             send_frame_uart(errorFrame);
00138         } else if (interface == Interface::LORA) {
00139             send_frame_lora(errorFrame);
00140         }
00141     }
00152 Frame frame_build(ExecutionResult result, uint8_t group, uint8_t command,
00153                      const std::string& value, const ValueUnit unitType) {
00154     Frame frame;
00155     frame.header = FRAME_BEGIN;
00156     frame.footer = FRAME_END;
00157
00158     switch (result) {
00159         case ExecutionResult::SUCCESS:
00160             frame.direction = 1;
00161             frame.operationType = OperationType::ANS;
00162             frame.value = value;
00163             frame.unit = value_unit_type_to_string(unitType);
00164             break;
00165
00166         case ExecutionResult::ERROR:
00167             frame.direction = 1;
00168             frame.operationType = OperationType::ERR;
00169             frame.value = value;
00170             frame.unit = value_unit_type_to_string(ValueUnit::UNDEFINED);
00171             break;
00172
00173         case ExecutionResult::INFO:
00174             frame.direction = 1;
00175             frame.operationType = OperationType::INF;
00176             frame.value = value;
00177             frame.unit = value_unit_type_to_string(ValueUnit::UNDEFINED);
00178             break;
00179     }
00180     frame.group = group;

```

```

00182     frame.command = command;
00183
00184     return frame;
00185 }
00186 // end of FrameHandling group

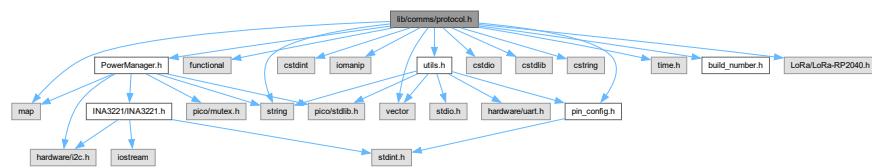
```

## 8.35 lib/comms/protocol.h File Reference

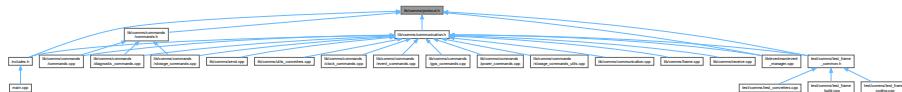
```

#include <string>
#include <map>
#include <functional>
#include <vector>
#include <cstdint>
#include <iomanip>
#include "pin_config.h"
#include "PowerManager.h"
#include <cstdio>
#include <cstdlib>
#include <cstring>
#include "utils.h"
#include "time.h"
#include "build_number.h"
#include "LoRa/LoRa-RP2040.h"
Include dependency graph for protocol.h:

```



This graph shows which files directly or indirectly include this file:



### Classes

- struct [Frame](#)  
*Represents a communication frame used for data exchange.*

### Enumerations

- enum class [ExecutionResult](#) { [SUCCESS](#) , [ERROR](#) , [INFO](#) }  
*Represents the result of a command execution.*
- enum class [OperationType](#) {  
[GET](#) , [SET](#) , [ANS](#) , [ERR](#) ,  
[INF](#) }

- enum class `CommandAccessLevel` { `NONE` , `READ_ONLY` , `WRITE_ONLY` , `READ_WRITE` }
 

*Represents the type of operation being performed.*
- enum class `ValueUnit` {
 `UNDEFINED` , `SECOND` , `VOLT` , `BOOL` ,
 `DATETIME` , `TEXT` , `MILIAMP` }
 

*Represents the access level required to execute a command.*
- enum class `ExceptionType` {
 `NONE` , `NOT_ALLOWED` , `INVALID_PARAM` , `INVALID_OPERATION` ,
 `PARAM_UNNECESSARY` }
 

*Represents the unit of measurement for a payload value.*
- enum class `Interface` { `UART` , `LORA` }
 

*Represents the type of exception that occurred during command execution.*
- enum class `Interface` { `UART` , `LORA` }
 

*Represents the communication interface being used.*

## Functions

- std::string `exception_type_to_string` (`ExceptionType` type)
 

*Converts an `ExceptionType` to a string.*
- std::string `operation_type_to_string` (`OperationType` type)
 

*Converts an `OperationType` to a string.*
- `OperationType string_to_operation_type` (const std::string &str)
 

*Converts a string to an `OperationType`.*
- std::vector< uint8\_t > `hex_string_to_bytes` (const std::string &hexString)
 

*Converts a hex string to a vector of bytes.*
- std::string `value_unit_type_to_string` (`ValueUnit` unit)
 

*Converts a `ValueUnit` to a string.*

## Variables

- const std::string `FRAME_BEGIN` = "KBST"
- const std::string `FRAME_END` = "TSBK"
- const char `DELIMITER` = ':'

## 8.35.1 Enumeration Type Documentation

### 8.35.1.1 ExecutionResult

```
enum class ExecutionResult [strong]
```

Represents the result of a command execution.

#### Enumerator

<code>SUCCESS</code>	Command executed successfully.
<code>ERROR</code>	Command execution resulted in an error.
<code>INFO</code>	Command execution provided informational output.

Definition at line 45 of file `protocol.h`.

### 8.35.1.2 OperationType

```
enum class OperationType [strong]
```

Represents the type of operation being performed.

**Enumerator**

GET	Get data.
SET	Set data.
ANS	Answer to a command.
ERR	Error occurred during command execution.
INF	Informational message.

Definition at line 60 of file [protocol.h](#).

**8.35.1.3 CommandAccessLevel**

```
enum class CommandAccessLevel [strong]
```

Represents the access level required to execute a command.

**Enumerator**

NONE	No access allowed.
READ_ONLY	Read-only access.
WRITE_ONLY	Write-only access.
READ_WRITE	Read and write access.

Definition at line 79 of file [protocol.h](#).

**8.35.1.4 ValueUnit**

```
enum class ValueUnit [strong]
```

Represents the unit of measurement for a payload value.

**Enumerator**

UNDEFINED	Unit is undefined.
SECOND	Unit is seconds.
VOLT	Unit is volts.
BOOL	Unit is boolean.
DATETIME	Unit is date and time.
TEXT	Unit is text.
MILIAMP	Unit is milliamperes.

Definition at line 96 of file [protocol.h](#).

**8.35.1.5 ExceptionType**

```
enum class ExceptionType [strong]
```

Represents the type of exception that occurred during command execution.

**Enumerator**

NONE	No exception.
NOT_ALLOWED	Operation not allowed.
INVALID_PARAM	Invalid parameter provided.
INVALID_OPERATION	Invalid operation requested.
PARAM_UNNECESSARY	Parameter is unnecessary for the operation.

Definition at line 119 of file [protocol.h](#).

**8.35.1.6 Interface**

```
enum class Interface [strong]
```

Represents the communication interface being used.

**Enumerator**

UART	UART interface.
LORA	LoRa interface.

Definition at line 138 of file [protocol.h](#).

**8.35.2 Function Documentation****8.35.2.1 exception\_type\_to\_string()**

```
std::string exception_type_to_string (
    ExceptionType type)
```

Converts an [ExceptionType](#) to a string.

**Parameters**

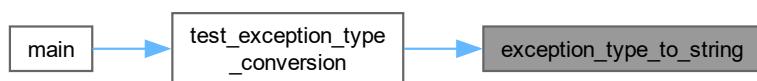
type	The <a href="#">ExceptionType</a> to convert.
------	---

**Returns**

The string representation of the [ExceptionType](#).

Definition at line 14 of file [utils\\_converters.cpp](#).

Here is the caller graph for this function:



### 8.35.2.2 operation\_type\_to\_string()

```
std::string operation_type_to_string (
    OperationType type)
```

Converts an [OperationType](#) to a string.

#### Parameters

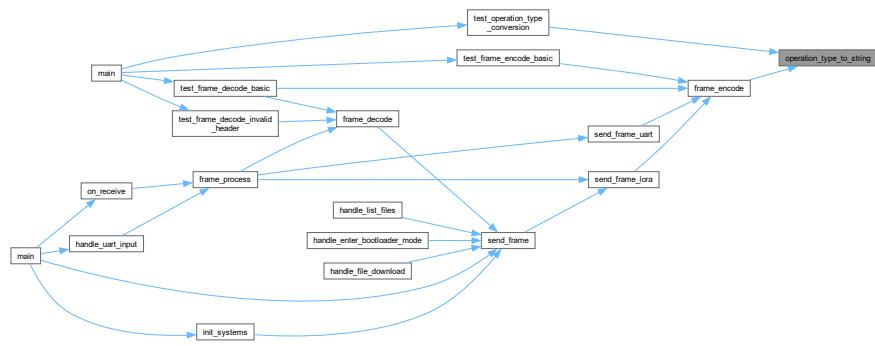
<code>type</code>	The <a href="#">OperationType</a> to convert.
-------------------	---

#### Returns

The string representation of the [OperationType](#).

Definition at line 50 of file [utils\\_converters.cpp](#).

Here is the caller graph for this function:



### 8.35.2.3 string\_to\_operation\_type()

```
OperationType string_to_operation_type (
    const std::string & str)
```

Converts a string to an [OperationType](#).

#### Parameters

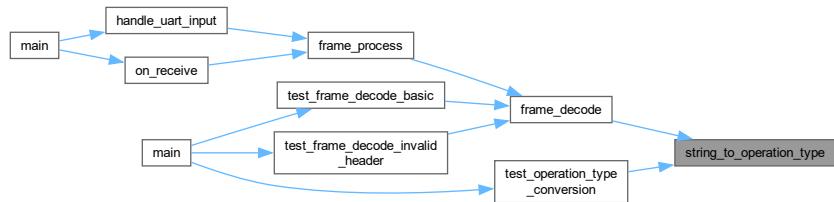
<code>str</code>	The string to convert.
------------------	------------------------

**Returns**

The [OperationType](#) corresponding to the string. Defaults to GET if the string is not recognized.

Definition at line 67 of file [utils\\_converters.cpp](#).

Here is the caller graph for this function:

**8.35.2.4 hex\_string\_to\_bytes()**

```
std::vector< uint8_t > hex_string_to_bytes (
    const std::string & hexString)
```

Converts a hex string to a vector of bytes.

**Parameters**

<i>hexString</i>	The hex string to convert.
------------------	----------------------------

**Returns**

A vector of bytes representing the hex string.

Definition at line 81 of file [utils\\_converters.cpp](#).

Here is the caller graph for this function:

**8.35.2.5 value\_unit\_type\_to\_string()**

```
std::string value_unit_type_to_string (
    ValueUnit unit)
```

Converts a [ValueUnit](#) to a string.

**Parameters**

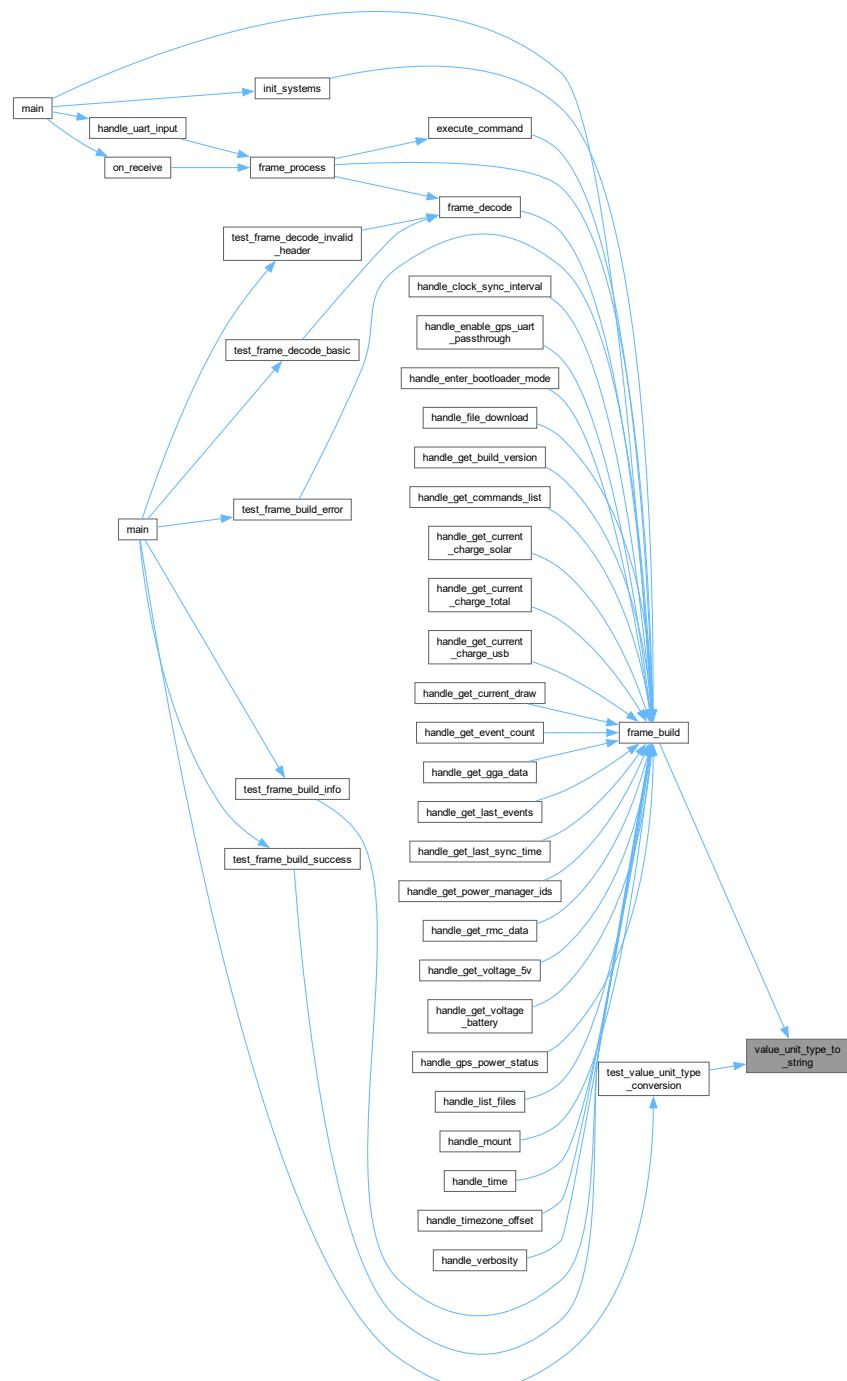
<i>unit</i>	The <a href="#">ValueUnit</a> to convert.
-------------	---

**Returns**

The string representation of the [ValueUnit](#).

Definition at line 31 of file [utils\\_converters.cpp](#).

Here is the caller graph for this function:



### 8.35.3 Variable Documentation

#### 8.35.3.1 FRAME\_BEGIN

```
const std::string FRAME_BEGIN = "KBST"
```

Definition at line 26 of file [protocol.h](#).

#### 8.35.3.2 FRAME\_END

```
const std::string FRAME_END = "TSBK"
```

Definition at line 32 of file [protocol.h](#).

#### 8.35.3.3 DELIMITER

```
const char DELIMITER = ';'
```

Definition at line 38 of file [protocol.h](#).

## 8.36 protocol.h

[Go to the documentation of this file.](#)

```
00001 // protocol.h
00002 #ifndef PROTOCOL_H
00003 #define PROTOCOL_H
00004
00005 #include <string>
00006 #include <map>
00007 #include <functional>
00008 #include <vector>
00009 #include <cstdint>
00010 #include <iomanip>
00011 #include "pin_config.h"
00012 #include "PowerManager.h"
00013 #include <cstdio>
00014 #include <cstdlib>
00015 #include <map>
00016 #include <cstring>
00017 #include "utils.h"
00018 #include "time.h"
00019 #include "build_number.h"
00020 #include "LoRa/LoRa-RP2040.h"
00021
00026 const std::string FRAME_BEGIN = "KBST";
00027
00032 const std::string FRAME_END = "TSBK";
00033
00038 const char DELIMITER = ';';
00039
00040
00045 enum class ExecutionResult {
00047     SUCCESS,
00049     ERROR,
00051     INFO
00052 };
00053
00054
00055
00060 enum class OperationType {
00062     GET,
00064     SET,
00066     ANS,
00068     ERR,
00070     INF
```

```

00071 };
00072
00073
00074
00079 enum class CommandAccessLevel {
00081     NONE,
00083     READ_ONLY,
00085     WRITE_ONLY,
00087     READ_WRITE
00088 };
00089
00090
00091
00096 enum class ValueUnit {
00098     UNDEFINED,
00100     SECOND,
00102     VOLT,
00104     BOOL,
00106     DATETIME,
00108     TEXT,
00110     MILIAMP,
00111 };
00112
00113
00114
00119 enum class ExceptionType {
00121     NONE,
00123     NOT_ALLOWED,
00125     INVALID_PARAM,
00127     INVALID_OPERATION,
00129     PARAM_UNNECESSARY
00130 };
00131
00132
00133
00138 enum class Interface {
00140     UART,
00142     LORA
00143 };
00144
00145
00221 struct Frame {
00222     std::string header;           // Start marker
00223     uint8_t direction;          // 0 = ground->sat, 1 = sat->ground
00224     OperationType operationType;
00225     uint8_t group;               // Group ID
00226     uint8_t command;             // Command ID within group
00227     std::string value;            // Payload value
00228     std::string unit;              // Payload unit
00229     std::string footer;           // End marker
00230 };
00231
00232 std::string exception_type_to_string(ExceptionType type);
00233 std::string operation_type_to_string(OperationType type);
00234 OperationType string_to_operation_type(const std::string& str);
00235 std::vector<uint8_t> hex_string_to_bytes(const std::string& hexString);
00236 std::string value_unit_type_to_string(ValueUnit unit);
00237
00238 #endif

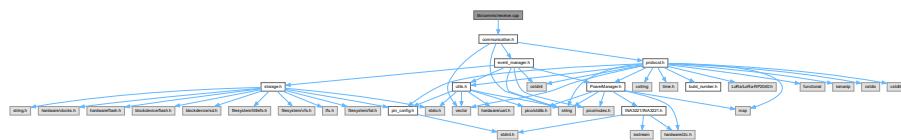
```

## 8.37 lib/comms/receive.cpp File Reference

Implements functions for receiving and processing data, including LoRa and UART input.

```
#include "communication.h"
```

Include dependency graph for receive.cpp:



## Functions

- void `on_receive` (int packetSize)  
*Callback function for handling received LoRa packets.*
- void `handle_uart_input` ()  
*Handles UART input.*

### 8.37.1 Detailed Description

Implements functions for receiving and processing data, including LoRa and UART input.

Definition in file [receive.cpp](#).

### 8.37.2 Function Documentation

#### 8.37.2.1 `on_receive()`

```
void on_receive (
    int packetSize)
```

Callback function for handling received LoRa packets.

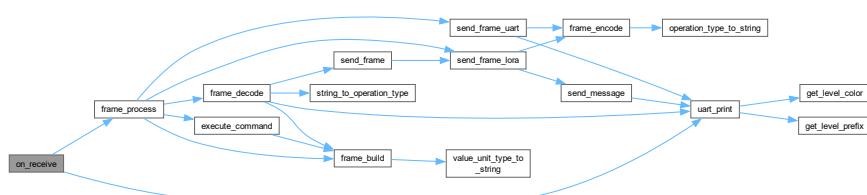
Parameters

<code>packetSize</code>	The size of the received packet.
-------------------------	----------------------------------

Reads the received LoRa packet, extracts metadata, validates the lora\_address\_remote and local addresses, extracts the frame data, and processes it. Prints raw hex values for debugging.

Definition at line 15 of file [receive.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 8.37.2.2 handle\_uart\_input()

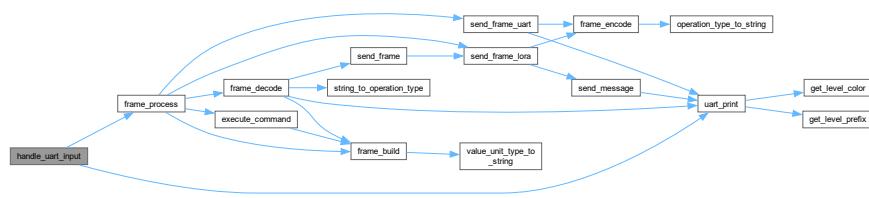
```
void handle_uart_input ()
```

Handles UART input.

Reads characters from the UART port, appends them to a buffer, and processes the buffer when a newline character is received.

Definition at line 76 of file [receive.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



## 8.38 receive.cpp

[Go to the documentation of this file.](#)

```

00001 #include "communication.h"
00002
00003
00008
00015 void on_receive(int packetSize) {
00016     if (packetSize == 0) return;
00017
00018     uint8_t buffer[256];
00019     int bytesRead = 0;
00020
00021     while (LoRa.available() && bytesRead < packetSize) {
00022         buffer[bytesRead++] = LoRa.read();
00023     }
00024
00025     // Extract LoRa metadata
00026     uint8_t receivedDestination = buffer[0];
00027     uint8_t receivedLocalAddress = buffer[1];
00028
00029     // Validate metadata (optional, for security)
00030     if (receivedDestination != lora_address_local) {
00031         uart_print("Error: Destination address mismatch!", VerbosityLevel::ERROR);
00032         return;
00033     }
00034 }
```

```

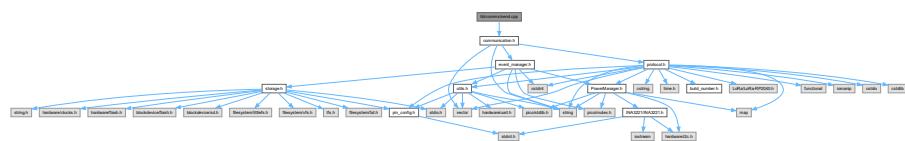
00035     if (receivedLocalAddress != lora_address_remote) {
00036         uart_print("Error: Local address mismatch!", VerbosityLevel::ERROR);
00037         return;
00038     }
00039
00040     // Find the starting index of the actual frame data
00041     int startIndex = 2; // Start after the metadata
00042
00043     // Extract the frame data
00044     std::string received = std::string(reinterpret_cast<char*>(buffer + startIndex), bytesRead -
00045     startIndex);
00046
00047     if (received.empty()) return;
00048
00049     // Debug: Print raw hex values
00050     std::stringstream hexDump;
00051     hexDump << "Raw bytes: ";
00052     for (int i = 0; i < bytesRead; i++) {
00053         hexDump << std::hex << std::setfill('0') << std::setw(2)
00054             << static_cast<int>(buffer[i]) << " ";
00055     }
00056     uart_print(hexDump.str(), VerbosityLevel::DEBUG);
00057
00058     // Find frame boundaries
00059     size_t headerPos = received.find(FRAME_BEGIN);
00060     size_t footerPos = received.find(FRAME_END);
00061
00062     if (headerPos != std::string::npos && footerPos != std::string::npos && footerPos > headerPos) {
00063         std::string frameData = received.substr(headerPos, footerPos + FRAME_END.length() -
00064         headerPos);
00065         uart_print("Extracted frame (length=" + std::to_string(frameData.length()) + "): " +
00066         frameData, VerbosityLevel::DEBUG);
00067         frame_process(frameData, Interface::LORA);
00068     } else {
00069         uart_print("No valid frame found in received data", VerbosityLevel::WARNING);
00070     }
00071 }
00072
00073 void handle_uart_input() {
00074     static std::string uartBuffer;
00075
00076     while (uart_is_readable(DEBUG_UART_PORT)) {
00077         char c = uart_getc(DEBUG_UART_PORT);
00078
00079         if (c == '\r' || c == '\n') {
00080             uart_print("Received UART string: " + uartBuffer, VerbosityLevel::DEBUG);
00081             frame_process(uartBuffer, Interface::UART);
00082             uartBuffer.clear();
00083         } else {
00084             uartBuffer += c;
00085         }
00086     }
00087 }
00088
00089 }
00090 }

```

## 8.39 lib/comms/send.cpp File Reference

Implements functions for sending data, including LoRa messages and Frames.

```
#include "communication.h"
Include dependency graph for send.cpp:
```



## Functions

- void **send\_message** (string *outgoing*)

- Sends a message using LoRa.*
- void [send\\_frame\\_lora](#) (const [Frame](#) &frame)
  - void [send\\_frame\\_uart](#) (const [Frame](#) &frame)
  - void [send\\_frame](#) (const [Frame](#) &frame)
  - void [split\\_and\\_send\\_message](#) (const uint8\_t \*data, size\_t length)

*Sends a large packet using LoRa.*

### 8.39.1 Detailed Description

Implements functions for sending data, including LoRa messages and Frames.

Definition in file [send.cpp](#).

### 8.39.2 Function Documentation

#### 8.39.2.1 send\_message()

```
void send_message (
    string outgoing)
```

Sends a message using LoRa.

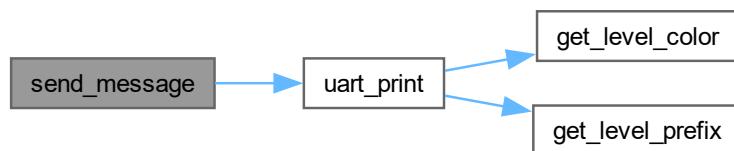
Parameters

<i>outgoing</i>	The message to send.
-----------------	----------------------

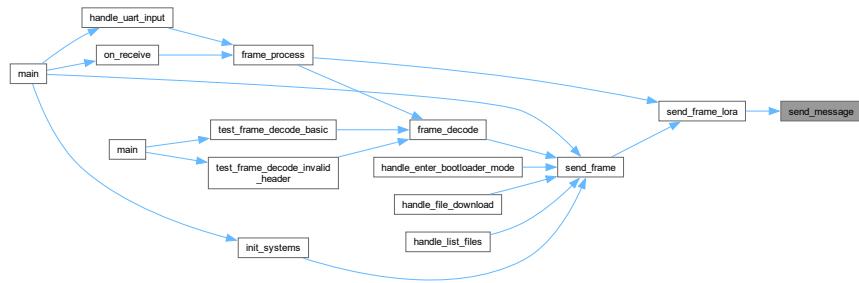
Converts the outgoing string to a C-style string, adds destination and local addresses, and sends the message using LoRa. Prints a log message to the UART.

Definition at line 15 of file [send.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

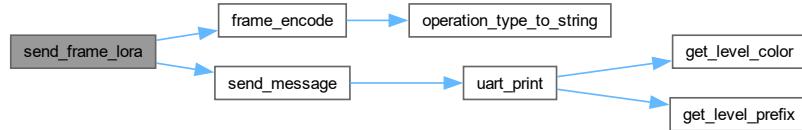


### 8.39.2.2 send\_frame\_lora()

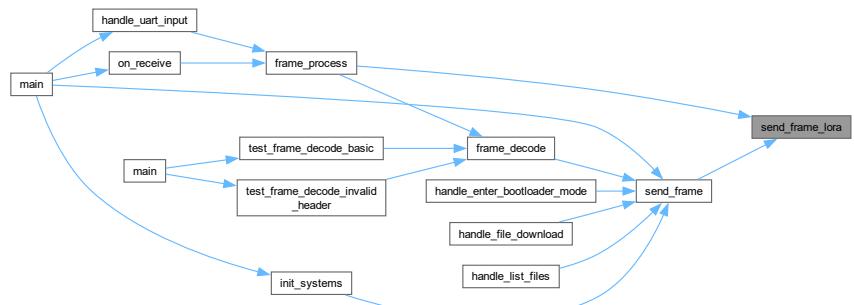
```
void send_frame_lora (
    const Frame & frame)
```

Definition at line 37 of file [send.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

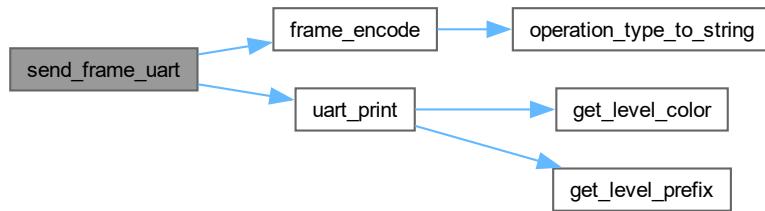


### 8.39.2.3 send\_frame\_uart()

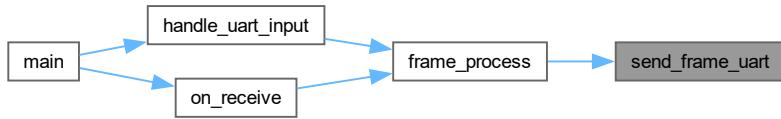
```
void send_frame_uart (
    const Frame & frame)
```

Definition at line 42 of file [send.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

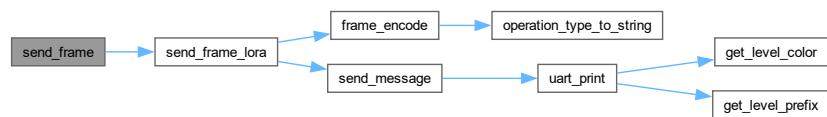


### 8.39.2.4 send\_frame()

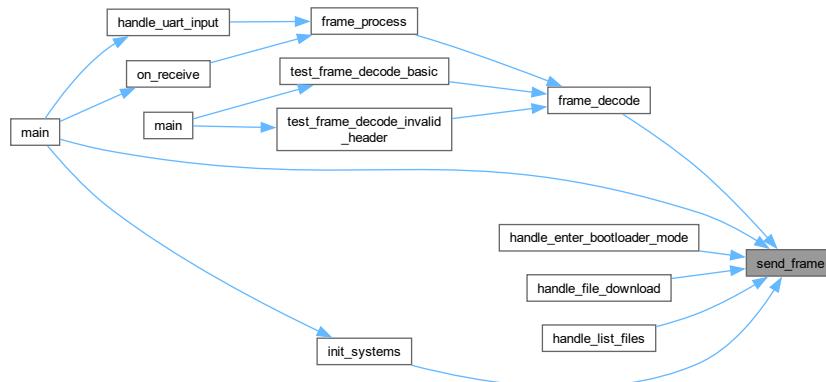
```
void send_frame (
    const Frame & frame)
```

Definition at line 48 of file [send.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 8.39.2.5 split\_and\_send\_message()

```
void split_and_send_message (
    const uint8_t * data,
    size_t length)
```

Sends a large packet using LoRa.

#### Parameters

<i>data</i>	The data to send.
<i>length</i>	The length of the data.

Splits the data into chunks of MAX\_PKT\_SIZE and sends each chunk as a separate LoRa packet.

Definition at line 59 of file [send.cpp](#).

## 8.40 send.cpp

[Go to the documentation of this file.](#)

```
00001 #include "communication.h"
00002
00003
00008
00015 void send_message(string outgoing)
00016 {
00017     int n = outgoing.length();
00018     char send[n + 1];
00019     strcpy(send, outgoing.c_str());
00020
00021     LoRa.beginPacket();      // start packet
00022     LoRa.write(lora_address_remote); // add destination address
00023     LoRa.write(lora_address_local); // add sender address
00024     LoRa.print(send);        // add payload
00025     LoRa.endPacket(false);   // finish packet and send it
00026
00027     std::string messageToLog = "Sent message of size " + std::to_string(n);
00028     messageToLog += " to 0x" + std::to_string(lora_address_remote);
```

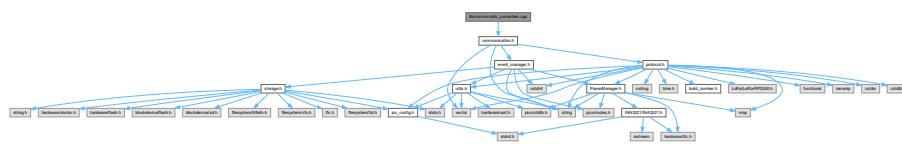
```

00029     messageToLog += " containing: " + string(send);
00030
00031     uart_print(messageToLog, VerbosityLevel::DEBUG);
00032
00033     LoRa.flush();
00034 }
00035
00036
00037 void send_frame_lora(const Frame& frame) {
00038     std::string encodedFrame = frame_encode(frame);
00039     send_message(encodedFrame);
00040 }
00041
00042 void send_frame_uart(const Frame& frame) {
00043     std::string encodedFrame = frame_encode(frame);
00044     uart_print(encodedFrame);
00045 }
00046
00047 [[deprecated("Use send_frame_lora or send_frame_uart instead")]]
00048 void send_frame(const Frame& frame) {
00049     send_frame_lora(frame);
00050 }
00051
00052
00053 void split_and_send_message(const uint8_t* data, size_t length)
00054 {
00055     const size_t MAX_PKT_SIZE = 255;
00056     size_t offset = 0;
00057     while (offset < length)
00058     {
00059         size_t chunkSize = ((length - offset) < MAX_PKT_SIZE) ? (length - offset) : MAX_PKT_SIZE;
00060         LoRa.beginPacket();
00061         LoRa.write(data[offset], chunkSize);
00062         LoRa.endPacket();
00063         offset += chunkSize;
00064         sleep_ms(100);
00065     }
00066 }
00067
00068 }
```

## 8.41 lib/comms/utils\_converters.cpp File Reference

Implements utility functions for converting between different data types.

```
#include "communication.h"
Include dependency graph for utils_converters.cpp:
```



### Functions

- `std::string exception_type_to_string (ExceptionType type)`  
*Converts an `ExceptionType` to a string.*
- `std::string value_unit_type_to_string (ValueUnit unit)`  
*Converts a `ValueUnit` to a string.*
- `std::string operation_type_to_string (OperationType type)`  
*Converts an `OperationType` to a string.*
- `OperationType string_to_operation_type (const std::string &str)`  
*Converts a string to an `OperationType`.*
- `std::vector< uint8_t > hex_string_to_bytes (const std::string &hexString)`  
*Converts a hex string to a vector of bytes.*

### 8.41.1 Detailed Description

Implements utility functions for converting between different data types.

Definition in file [utils\\_converters.cpp](#).

### 8.41.2 Function Documentation

#### 8.41.2.1 exception\_type\_to\_string()

```
std::string exception_type_to_string (
    ExceptionType type)
```

Converts an [ExceptionType](#) to a string.

##### Parameters

<i>type</i>	The <a href="#">ExceptionType</a> to convert.
-------------	---

##### Returns

The string representation of the [ExceptionType](#).

Definition at line 14 of file [utils\\_converters.cpp](#).

Here is the caller graph for this function:



#### 8.41.2.2 value\_unit\_type\_to\_string()

```
std::string value_unit_type_to_string (
    ValueUnit unit)
```

Converts a [ValueUnit](#) to a string.

##### Parameters

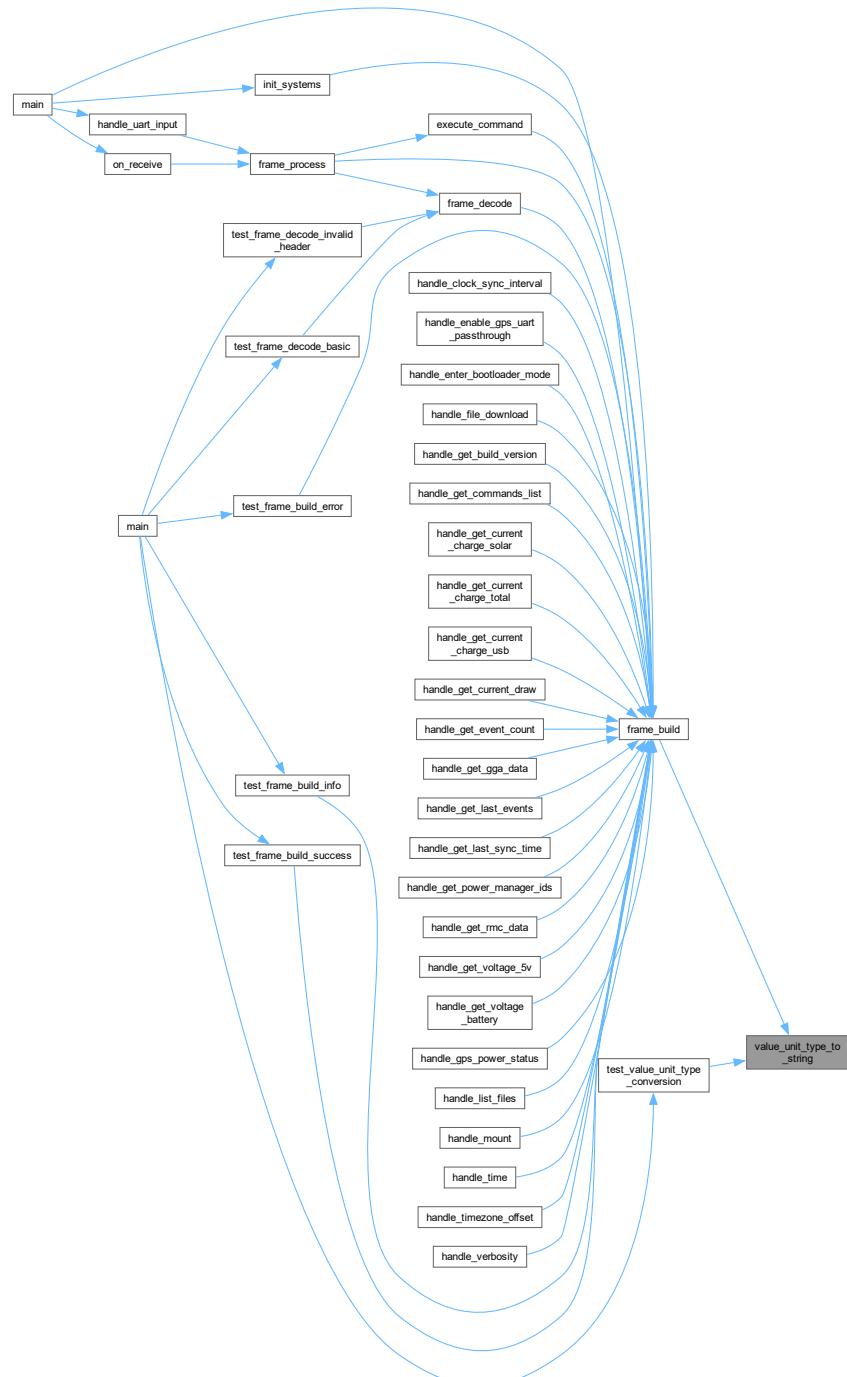
<i>unit</i>	The <a href="#">ValueUnit</a> to convert.
-------------	---

**Returns**

The string representation of the [ValueUnit](#).

Definition at line 31 of file [utils\\_converters.cpp](#).

Here is the caller graph for this function:



### 8.41.2.3 operation\_type\_to\_string()

```
std::string operation_type_to_string (
    OperationType type)
```

Converts an [OperationType](#) to a string.

#### Parameters

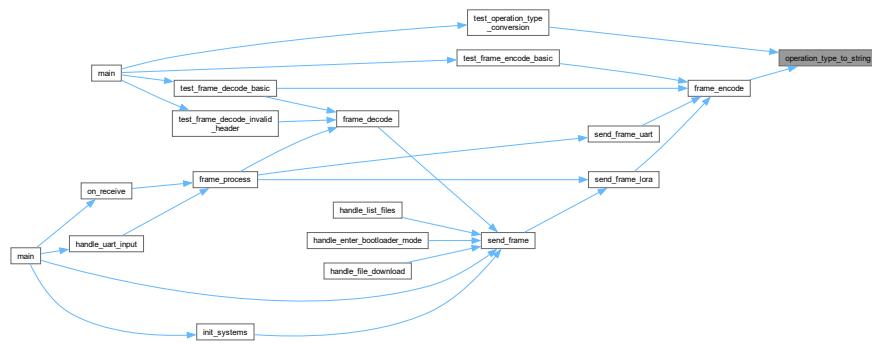
<code>type</code>	The <a href="#">OperationType</a> to convert.
-------------------	---

#### Returns

The string representation of the [OperationType](#).

Definition at line 50 of file [utils\\_converters.cpp](#).

Here is the caller graph for this function:



### 8.41.2.4 string\_to\_operation\_type()

```
OperationType string_to_operation_type (
    const std::string & str)
```

Converts a string to an [OperationType](#).

#### Parameters

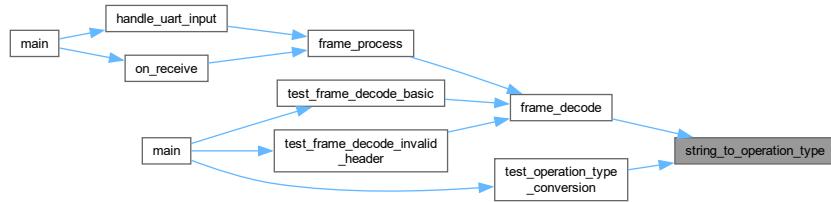
<code>str</code>	The string to convert.
------------------	------------------------

**Returns**

The `OperationType` corresponding to the string. Defaults to GET if the string is not recognized.

Definition at line 67 of file [utils\\_converters.cpp](#).

Here is the caller graph for this function:

**8.41.2.5 hex\_string\_to\_bytes()**

```
std::vector< uint8_t > hex_string_to_bytes (
    const std::string & hexString)
```

Converts a hex string to a vector of bytes.

**Parameters**

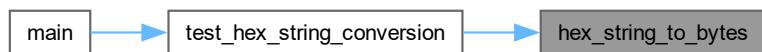
<i>hexString</i>	The hex string to convert.
------------------	----------------------------

**Returns**

A vector of bytes representing the hex string.

Definition at line 81 of file [utils\\_converters.cpp](#).

Here is the caller graph for this function:



## 8.42 utils\_converters.cpp

[Go to the documentation of this file.](#)

```

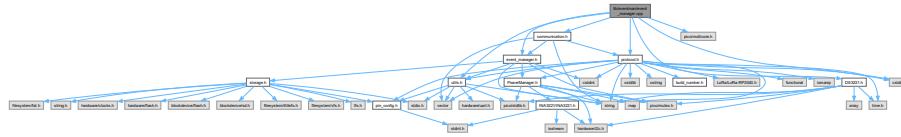
00001 #include "communication.h"
00002
00003
00008
00014 std::string exception_type_to_string(ExceptionType type) {
00015     switch (type) {
00016         case ExceptionType::NOT_ALLOWED:      return "NOT ALLOWED";
00017         case ExceptionType::INVALID_PARAM:    return "INVALID PARAM";
00018         case ExceptionType::INVALID_OPERATION: return "INVALID OPERATION";
00019         case ExceptionType::PARAM_UNNECESSARY: return "PARAM UNECESSARY";
00020         case ExceptionType::NONE:             return "NONE";
00021         default:                           return "UNKNOWN EXCEPTION";
00022     }
00023 }
00024
00025
00031 std::string value_unit_type_to_string(ValueUnit unit) {
00032     switch (unit) {
00033         case ValueUnit::UNDEFINED:   return "";
00034         case ValueUnit::SECOND:     return "s";
00035         case ValueUnit::VOLT:       return "V";
00036         case ValueUnit::BOOL:       return "";
00037         case ValueUnit::DATETIME:   return "";
00038         case ValueUnit::TEXT:       return "";
00039         case ValueUnit::MILLIAMP:   return "mA";
00040         default:                  return "";
00041     }
00042 }
00043
00044
00050 std::string operation_type_to_string(OperationType type) {
00051     switch (type) {
00052         case OperationType::GET:   return "GET";
00053         case OperationType::SET:   return "SET";
00054         case OperationType::ANS:   return "ANS";
00055         case OperationType::ERR:   return "ERR";
00056         case OperationType::INF:   return "INF";
00057         default:                 return "UNKNOWN";
00058     }
00059 }
00060
00061
00067 OperationType string_to_operation_type(const std::string& str) {
00068     if (str == "GET") return OperationType::GET;
00069     if (str == "SET") return OperationType::SET;
00070     if (str == "ANS") return OperationType::ANS;
00071     if (str == "ERR") return OperationType::ERR;
00072     if (str == "INF") return OperationType::INF;
00073     return OperationType::GET; // Default to GET
00074 }
00075
00081 std::vector<uint8_t> hex_string_to_bytes(const std::string& hexString) {
00082     std::vector<uint8_t> bytes;
00083     for (size_t i = 0; i < hexString.length(); i += 2) {
00084         std::string byteString = hexString.substr(i, 2);
00085         unsigned int byte;
00086         std::stringstream ss;
00087         ss << std::hex << byteString;
00088         ss >> byte;
00089         bytes.push_back(static_cast<uint8_t>(byte));
00090     }
00091     return bytes;
00092 }
```

## 8.43 lib/eventman/event\_manager.cpp File Reference

Implements the event management system for the Kabisat firmware.

```
#include "event_manager.h"
#include <cstdio>
#include "protocol.h"
#include "pico/multicore.h"
```

```
#include "communication.h"
#include "utils.h"
#include "DS3231.h"
Include dependency graph for event_manager.cpp:
```



## Functions

- void [check\\_power\\_events \(PowerManager &pm\)](#)  
*Checks power statuses and triggers events based on voltage trends.*

## Variables

- volatile uint16\_t [eventLogId](#) = 0  
*Global event log ID counter.*
- static PowerEvent [lastPowerState](#) = PowerEvent::LOW\_BATTERY  
*Stores the last known power state.*
- static constexpr float [FALL\\_RATE\\_THRESHOLD](#) = -0.02f  
*Threshold for detecting a falling voltage rate.*
- static constexpr int [FALLING\\_TREND\\_REQUIRED](#) = 3  
*Number of consecutive falling voltage readings required to trigger a power falling event.*
- static constexpr float [VOLTAGE\\_LOW\\_THRESHOLD](#) = 4.7f  
*Voltage threshold for detecting a low battery condition.*
- static constexpr float [VOLTAGE\\_OVERCHARGE\\_THRESHOLD](#) = 5.3f  
*Voltage threshold for detecting an overcharge condition.*
- static int [fallingTrendCount](#) = 0  
*Counter for consecutive falling voltage readings.*
- bool [lastSolarState](#) = false  
*Stores the last known solar charging state.*
- bool [lastUSBState](#) = false  
*Stores the last known USB connection state.*
- DS3231 [systemClock](#)  
*External declaration of the system clock.*
- EventManagerImpl [eventManager](#)  
*Global instance of the [EventManager](#) implementation.*

### 8.43.1 Detailed Description

Implements the event management system for the Kabisat firmware.

This file contains the implementation for logging events, managing event storage, and checking for specific events such as power status changes.

Definition in file [event\\_manager.cpp](#).

## 8.44 event\_manager.cpp

[Go to the documentation of this file.](#)

```

00001 #include "event_manager.h"
00002 #include <cstdio>
00003 #include "protocol.h"
00004 #include "pico/multicore.h"
00005 #include "communication.h"
00006 #include "utils.h"
00007 #include "DS3231.h"
00008
00016
00017
00022 volatile uint16_t eventLogId = 0;
00023
00028 static PowerEvent lastPowerState = PowerEvent::LOW_BATTERY;
00029
00034 static constexpr float FALL_RATE_THRESHOLD = -0.02f;
00035
00040 static constexpr int FALLING_TREND_REQUIRED = 3;
00041
00046 static constexpr float VOLTAGE_LOW_THRESHOLD = 4.7f;
00047
00052 static constexpr float VOLTAGE_OVERCHARGE_THRESHOLD = 5.3f;
00053
00058 static int fallingTrendCount = 0;
00059
00064 bool lastSolarState = false;
00065
00070 bool lastUSBState = false;
00071
00076 extern DS3231 systemClock;
00077
00082 EventManagerImpl eventManager;
00083
00084
00093 void EventManager::log_event(uint8_t group, uint8_t event) {
00094     mutex_enter_blocking(&eventMutex);
00095
00096     EventLog& log = events[writeIndex];
00097     log.id = nextEventId++;
00098     log.timestamp = systemClock.get_unix_time();
00099     log.group = group;
00100     log.event = event;
00101
00102     // Print event immediately
00103     uart_print(log.to_string(), VerbosityLevel::EVENT);
00104
00105     writeIndex = (writeIndex + 1) % EVENT_BUFFER_SIZE;
00106     if (eventCount < EVENT_BUFFER_SIZE) {
00107         eventCount++;
00108     }
00109
00110     // Set persistence flag on buffer full or power events
00111     if (eventCount == EVENT_BUFFER_SIZE ||
00112         (group == static_cast<uint8_t>(EventGroup::POWER) &&
00113          event == static_cast<uint8_t>(PowerEvent::POWER_FALLING))) {
00114         needsPersistence = true;
00115         save_to_storage();
00116     }
00117
00118     mutex_exit(&eventMutex);
00119 }
00120
00121
00128 const EventLog& EventManager::get_event(size_t index) const {
00129     static const EventLog emptyEvent = {0, 0, 0, 0}; // Initialize {id, timestamp, group, event}
00130     if (index >= eventCount) {
00131         return emptyEvent;
00132     }
00133
00134     // Calculate actual index in circular buffer
00135     size_t actualIndex;
00136     if (eventCount == EVENT_BUFFER_SIZE) {
00137         actualIndex = (writeIndex + index) % EVENT_BUFFER_SIZE;
00138     } else {
00139         actualIndex = index;
00140     }
00141
00142     return events[actualIndex];
00143 }
00144
00145
00154 void check_power_events(PowerManager& pm) {
00155     float currentVoltage = pm.get_voltage_5v();

```

```

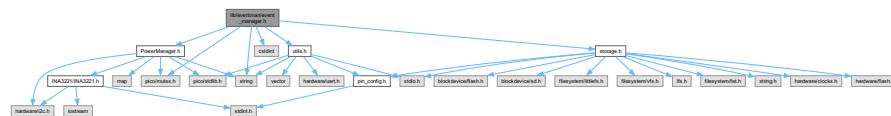
00156     static float previousVoltage = 0.0f;
00157     float delta = currentVoltage - previousVoltage;
00158     previousVoltage = currentVoltage;
00159
00160     if (delta < FALL_RATE_THRESHOLD) {
00161         fallingTrendCount++;
00162     } else {
00163         fallingTrendCount = 0;
00164     }
00165
00166     if (fallingTrendCount >= FALLING_TREND_REQUIRED) {
00167         lastPowerState = PowerEvent::POWER_FALLING;
00168         EventEmitter::emit(EventGroup::POWER, PowerEvent::POWER_FALLING);
00169     }
00170
00171     if (currentVoltage < PowerManager::VOLTAGE_LOW_THRESHOLD &&
00172         lastPowerState != PowerEvent::LOW_BATTERY) {
00173         lastPowerState = PowerEvent::LOW_BATTERY;
00174         EventEmitter::emit(EventGroup::POWER, PowerEvent::LOW_BATTERY);
00175     }
00176     else if (currentVoltage > PowerManager::VOLTAGE_OVERCHARGE_THRESHOLD &&
00177             lastPowerState != PowerEvent::OVERCHARGE) {
00178         lastPowerState = PowerEvent::OVERCHARGE;
00179         EventEmitter::emit(EventGroup::POWER, PowerEvent::OVERCHARGE);
00180     }
00181     else if (currentVoltage >= PowerManager::VOLTAGE_LOW_THRESHOLD &&
00182             currentVoltage <= PowerManager::VOLTAGE_OVERCHARGE_THRESHOLD &&
00183             lastPowerState != PowerEvent::POWER_NORMAL) {
00184         lastPowerState = PowerEvent::POWER_NORMAL;
00185         EventEmitter::emit(EventGroup::POWER, PowerEvent::POWER_NORMAL);
00186     }
00187
00188     // Check solar charging state
00189     bool currentSolarState = pm.is_charging_solar();
00190     if (currentSolarState != lastSolarState) {
00191         if (currentSolarState) {
00192             EventEmitter::emit(EventGroup::POWER, PowerEvent::SOLAR_ACTIVE);
00193         } else {
00194             EventEmitter::emit(EventGroup::POWER, PowerEvent::SOLAR_INACTIVE);
00195         }
00196         lastSolarState = currentSolarState;
00197     }
00198
00199     // Check USB connection state
00200     bool currentUSBState = pm.is_charging_usb();
00201     if (currentUSBState != lastUSBState) {
00202         if (currentUSBState) {
00203             EventEmitter::emit(EventGroup::POWER, PowerEvent::USB_CONNECTED);
00204         } else {
00205             EventEmitter::emit(EventGroup::POWER, PowerEvent::USB_DISCONNECTED);
00206         }
00207         lastUSBState = currentUSBState;
00208     }
00209 }
```

## 8.45 lib/eventman/event\_manager.h File Reference

Manages the event logging system for the Kubisat firmware.

```
#include "PowerManager.h"
#include <cstdint>
#include <string>
#include "pico/mutex.h"
#include "storage.h"
#include "utils.h"

Include dependency graph for event_manager.h:
```



This graph shows which files directly or indirectly include this file:



## Classes

- class [EventLog](#)  
*Represents a single event log entry.*
- class [EventManager](#)  
*Manages the event logging system.*
- class [EventManagerImpl](#)  
*Implementation of the [EventManager](#) class.*
- class [EventEmitter](#)  
*Provides a static method for emitting events.*

## Macros

- #define [EVENT\\_BUFFER\\_SIZE](#) 10
- #define [EVENT\\_LOG\\_FILE](#) "/event\_log.csv"

## Enumerations

- enum class [EventGroup](#) : uint8\_t {  
    EventGroup::SYSTEM = 0x00 , EventGroup::POWER = 0x01 , EventGroup::COMMS = 0x02 ,  
    EventGroup::GPS = 0x03 ,  
    EventGroup::CLOCK = 0x04 }  
*Represents the group to which an event belongs.*
- enum class [SystemEvent](#) : uint8\_t {  
    SystemEvent::BOOT = 0x01 , SystemEvent::SHUTDOWN = 0x02 , SystemEvent::WATCHDOG\_RESET = 0x03 , SystemEvent::CORE1\_START = 0x04 ,  
    SystemEvent::CORE1\_STOP = 0x05 }  
*Represents specific system events.*
- enum class [PowerEvent](#) : uint8\_t {  
    PowerEvent::LOW\_BATTERY = 0x01 , PowerEvent::OVERCHARGE = 0x02 , PowerEvent::POWER\_FALLING = 0x03 , PowerEvent::POWER\_NORMAL = 0x04 ,  
    PowerEvent::SOLAR\_ACTIVE = 0x05 , PowerEvent::SOLAR\_INACTIVE = 0x06 , PowerEvent::USB\_CONNECTED = 0x07 , PowerEvent::USB\_DISCONNECTED = 0x08 }  
*Represents specific power-related events.*
- enum class [CommsEvent](#) : uint8\_t {  
    CommsEvent::RADIO\_INIT = 0x01 , CommsEvent::RADIO\_ERROR = 0x02 , CommsEvent::MSG\_RECEIVED = 0x03 , CommsEvent::MSG\_SENT = 0x04 ,  
    CommsEvent::UART\_ERROR = 0x06 }  
*Represents specific communication-related events.*
- enum class [GPSEvent](#) : uint8\_t {  
    GPSEvent::LOCK = 0x01 , GPSEvent::LOST = 0x02 , GPSEvent::ERROR = 0x03 , GPSEvent::POWER\_ON = 0x04 ,  
    GPSEvent::POWER\_OFF = 0x05 , GPSEvent::DATA\_READY = 0x06 , GPSEvent::PASS\_THROUGH\_START = 0x07 , GPSEvent::PASS\_THROUGH\_END = 0x08 }  
*Represents specific GPS-related events.*
- enum class [ClockEvent](#) : uint8\_t { ClockEvent::CHANGED = 0x01 , ClockEvent::GPS\_SYNC = 0x02 }  
*Represents specific clock-related events.*

## Functions

- class [EventLog \\_\\_attribute\\_\\_ \(\(packed\)\)](#)
- std::string [to\\_string \(\) const](#)

*Converts the `EventLog` to a string representation.*
- void [check\\_power\\_events \(PowerManager &pm\)](#)

*Checks power statuses and triggers events based on voltage trends.*

## Variables

- uint16\_t [id](#)

*Sequence number.*
- uint32\_t [timestamp](#)

*Unix timestamp or system time.*
- uint8\_t [group](#)

*Event group identifier.*
- uint8\_t [event](#)

*Specific event identifier.*
- class [EventManager \\_\\_attribute\\_\\_](#)
- [EventManagerImpl eventManager](#)

*Global instance of the `EventManagerImpl` class.*

### 8.45.1 Detailed Description

Manages the event logging system for the Kubisat firmware.

Definition in file [event\\_manager.h](#).

### 8.45.2 Macro Definition Documentation

#### 8.45.2.1 EVENT\_BUFFER\_SIZE

```
#define EVENT_BUFFER_SIZE 10
```

Definition at line 11 of file [event\\_manager.h](#).

#### 8.45.2.2 EVENT\_LOG\_FILE

```
#define EVENT_LOG_FILE "/event_log.csv"
```

Definition at line 12 of file [event\\_manager.h](#).

### 8.45.3 Function Documentation

#### 8.45.3.1 `to_string()`

```
std::string __attribute__::to_string () const
```

Converts the [EventLog](#) to a string representation.

##### Returns

A string representation of the [EventLog](#).

Definition at line 14 of file [event\\_manager.h](#).

### 8.45.4 Variable Documentation

#### 8.45.4.1 `id`

```
uint16_t id
```

Sequence number.

Definition at line 2 of file [event\\_manager.h](#).

#### 8.45.4.2 `timestamp`

```
uint32_t timestamp
```

Unix timestamp or system time.

Definition at line 4 of file [event\\_manager.h](#).

#### 8.45.4.3 `group`

```
uint8_t group
```

Event group identifier.

Definition at line 6 of file [event\\_manager.h](#).

#### 8.45.4.4 `event`

```
uint8_t event
```

Specific event identifier.

Definition at line 8 of file [event\\_manager.h](#).

## 8.46 event\_manager.h

Go to the documentation of this file.

```

00001 #ifndef EVENT_MANAGER_H
00002 #define EVENT_MANAGER_H
00003
00004 #include "PowerManager.h"
00005 #include <cstdint>
00006 #include <string>
00007 #include "pico/mutex.h"
00008 #include "storage.h"
00009 #include "utils.h"
0010
0011 #define EVENT_BUFFER_SIZE 10
0012 #define EVENT_LOG_FILE "/event_log.csv"
0020
0021
0026 enum class EventGroup : uint8_t {
0028     SYSTEM = 0x00,
0030     POWER = 0x01,
0032     COMMS = 0x02,
0034     GPS = 0x03,
0036     CLOCK = 0x04
0037 };
0038
0043 enum class SystemEvent : uint8_t {
0045     BOOT = 0x01,
0047     SHUTDOWN = 0x02,
0049     WATCHDOG_RESET = 0x03,
0051     CORE1_START = 0x04,
0053     CORE1_STOP = 0x05
0054 };
0055
0060 enum class PowerEvent : uint8_t {
0062     LOW_BATTERY = 0x01,
0064     OVERCHARGE = 0x02,
0066     POWER_FALLING = 0x03,
0068     POWER_NORMAL = 0x04,
0070     SOLAR_ACTIVE = 0x05,
0072     SOLAR_INACTIVE = 0x06,
0074     USB_CONNECTED = 0x07,
0076     USB_DISCONNECTED = 0x08
0077 };
0078
0083 enum class CommsEvent : uint8_t {
0085     RADIO_INIT = 0x01,
0087     RADIO_ERROR = 0x02,
0089     MSG_RECEIVED = 0x03,
0091     MSG_SENT = 0x04,
0093     UART_ERROR = 0x06
0094 };
0095
0100 enum class GPSEvent : uint8_t {
0102     LOCK = 0x01,
0104     LOST = 0x02,
0106     ERROR = 0x03,
0108     POWER_ON = 0x04,
0110     POWER_OFF = 0x05,
0112     DATA_READY = 0x06,
0114     PASS_THROUGH_START = 0x07,
0116     PASS_THROUGH_END = 0x08
0117 };
0118
0119
0124 enum class ClockEvent : uint8_t {
0126     CHANGED = 0x01,
0128     GPS_SYNC = 0x02
0129 };
0130
0131
0136 class EventLog {
0137     public:
0139         uint16_t id;
0141         uint32_t timestamp;
0143         uint8_t group;
0145         uint8_t event;
0146
0151         std::string to_string() const {
0152             char buffer[256];
0153             snprintf(buffer, sizeof(buffer),
0154                     "EventLog: id=%u, timestamp=%lu, group=%u, event=%u",
0155                     id, timestamp, group, event);
0156             return std::string(buffer);
0157         }
0158     } __attribute__((packed));

```

```

00159
00160
00165 class EventManager {
00166     public:
00171         EventManager()
00172             : eventCount(0)
00173             , writeIndex(0)
00174             , nextEventId(0)
00175             , needsPersistence(false)
00176     {
00177         mutex_init(&eventMutex);
00178     }
00179
00183     virtual ~EventManager() = default;
00184
00189     virtual void init() {
00190         load_from_storage();
00191     }
00192
00198     void log_event(uint8_t group, uint8_t event);
00199
00205     const EventLog& get_event(size_t index) const;
00206
00211     size_t get_event_count() const { return eventCount; }
00212
00217     virtual bool save_to_storage() = 0;
00218
00223     virtual bool load_from_storage() = 0;
00224
00225     protected:
00227         EventLog events[EVENT_BUFFER_SIZE];
00229         size_t eventCount;
00231         size_t writeIndex;
00233         mutex_t eventMutex;
00235         volatile uint16_t nextEventId;
00237         bool needsPersistence;
00238     };
00239
00240
00245 class EventManagerImpl : public EventManager {
00246     public:
00251         EventManagerImpl() {
00252             init(); // Safe to call virtual functions here
00253         }
00254
00260         bool save_to_storage() override {
00261             if(!sd_card_mounted) {
00262                 bool status = fs_init();
00263                 if(!status) {
00264                     return false;
00265                 }
00266             }
00267             FILE *file = fopen(EVENT_LOG_FILE, "a");
00268             if (file) {
00269                 for (size_t i = 0; i < eventCount; i++) {
00270                     fprintf(file, "%u;%lu;%u;%u\n",
00271                         events[i].id,
00272                         events[i].timestamp,
00273                         events[i].group,
00274                         events[i].event
00275                     );
00276                 }
00277                 fclose(file);
00278                 needsPersistence = false;
00279                 uart_print("Events saved to storage", VerboseLevel::INFO);
00280                 return true;
00281             }
00282             return false;
00283         }
00284
00290         bool load_from_storage() override {
00291             // TODO: Implement based on chosen storage (SD/EEPROM)
00292             return false;
00293         }
00294     };
00295
00296
00300 extern EventManagerImpl eventManager;
00301
00306 class EventEmitter {
00307     public:
00314     template<typename T>
00315     static void emit(EventGroup group, T event) {
00316         eventManager.log_event(
00317             static_cast<uint8_t>(group),
00318             static_cast<uint8_t>(event)
00319         );

```

```

00320      }
00321  };
00322
00323
00328 void check_power_events(PowerManager& pm);
00329
00330
00331 #endif // End of EventManagerGroup

```

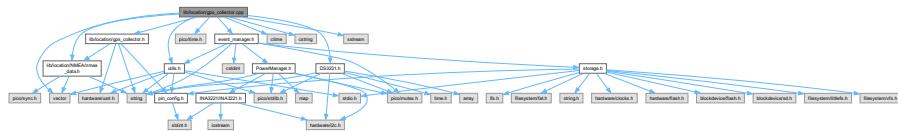
## 8.47 lib/location/gps\_collector.cpp File Reference

```

#include "lib/location/gps_collector.h"
#include "utils.h"
#include "pico/time.h"
#include "lib/location/NMEA/nmea_data.h"
#include "event_manager.h"
#include <vector>
#include <ctime>
#include <cstring>
#include "DS3231.h"
#include <sstream>

```

Include dependency graph for gps\_collector.cpp:



### Macros

- #define MAX\_RAW\_DATA\_LENGTH 1024

### Functions

- std::vector< std::string > splitString (const std::string &str, char delimiter)
- void collect\_gps\_data ()

### Variables

- NMEAData nmea\_data

#### 8.47.1 Macro Definition Documentation

##### 8.47.1.1 MAX\_RAW\_DATA\_LENGTH

```
#define MAX_RAW_DATA_LENGTH 1024
```

Definition at line 13 of file [gps\\_collector.cpp](#).

## 8.47.2 Function Documentation

### 8.47.2.1 splitString()

```
std::vector< std::string > splitString (
    const std::string & str,
    char delimiter)
```

Definition at line 17 of file [gps\\_collector.cpp](#).

Here is the caller graph for this function:



### 8.47.2.2 collect\_gps\_data()

```
void collect_gps_data ()
```

Definition at line 27 of file [gps\\_collector.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 8.47.3 Variable Documentation

#### 8.47.3.1 nmea\_data

```
NMEAData nmea_data [extern]
```

Definition at line 3 of file NMEA\_data.cpp.

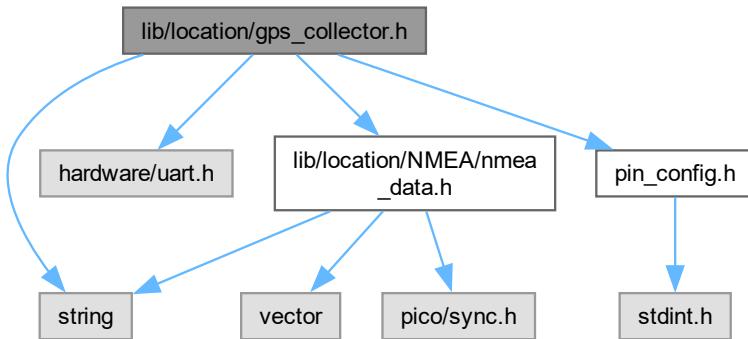
## 8.48 gps\_collector.cpp

[Go to the documentation of this file.](#)

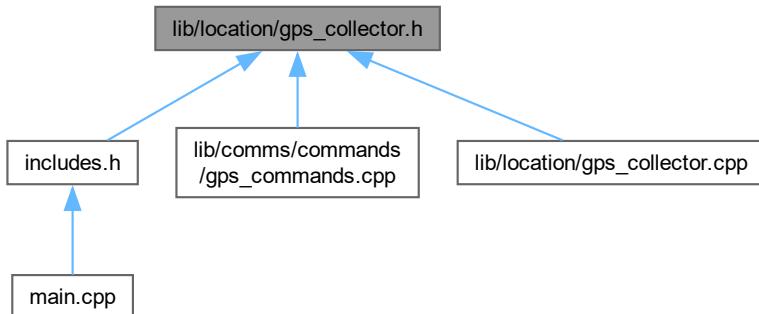
```
00001 // filepath: /c:/Users/Kuba/Desktop/inz/kubisat/software/kubisat_firmware/lib/GPS/gps_collector.cpp
00002 #include "lib/location/gps_collector.h"
00003 #include "utils.h"
00004 #include "pico/time.h"
00005 #include "lib/location/NMEA/nmea_data.h"
00006 #include "event_manager.h"
00007 #include <vector>
00008 #include <ctime>
00009 #include <cstring>
00010 #include "DS3231.h"
00011 #include <sstream>
00012
00013 #define MAX_RAW_DATA_LENGTH 1024
00014
00015 extern NMEAData nmea_data;
00016
00017 std::vector<std::string> splitString(const std::string& str, char delimiter) {
00018     std::vector<std::string> tokens;
00019     std::stringstream ss(str);
00020     std::string token;
00021     while (std::getline(ss, token, delimiter)) {
00022         tokens.push_back(token);
00023     }
00024     return tokens;
00025 }
00026
00027 void collect_gps_data() {
00028     static char raw_data_buffer[MAX_RAW_DATA_LENGTH];
00029     static int raw_data_index = 0;
00030
00031     while (uart_is_readable(GPS_UART_PORT)) {
00032         char c = uart_getc(GPS_UART_PORT);
00033
00034         if (c == '\r' || c == '\n') {
00035             // End of message
00036             if (raw_data_index > 0) {
00037                 raw_data_buffer[raw_data_index] = '\0';
00038                 std::string message(raw_data_buffer);
00039                 raw_data_index = 0;
00040
00041                 // Split the message into tokens
00042                 std::vector<std::string> tokens = splitString(message, ',');
00043
00044                 // Update the global vectors based on the sentence type
00045                 if (message.find("$GPRMC") == 0) {
00046                     nmea_data.update_rmc_tokens(tokens);
00047                 } else if (message.find("$GPGGA") == 0) {
00048                     nmea_data.update_gga_tokens(tokens);
00049                 }
00050             }
00051         } else {
00052             // Append to buffer
00053             if (raw_data_index < MAX_RAW_DATA_LENGTH - 1) {
00054                 raw_data_buffer[raw_data_index++] = c;
00055             } else {
00056                 raw_data_index = 0;
00057             }
00058         }
00059     }
00060 }
```

## 8.49 lib/location/gps\_collector.h File Reference

```
#include <string>
#include "hardware/uart.h"
#include "lib/location/NMEA/nmea_data.h"
#include "pin_config.h"
Include dependency graph for gps_collector.h:
```



This graph shows which files directly or indirectly include this file:



### Functions

- void [collect\\_gps\\_data\(\)](#)

#### 8.49.1 Function Documentation

##### 8.49.1.1 [collect\\_gps\\_data\(\)](#)

```
void collect_gps_data ()
```

Definition at line 27 of file [gps\\_collector.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



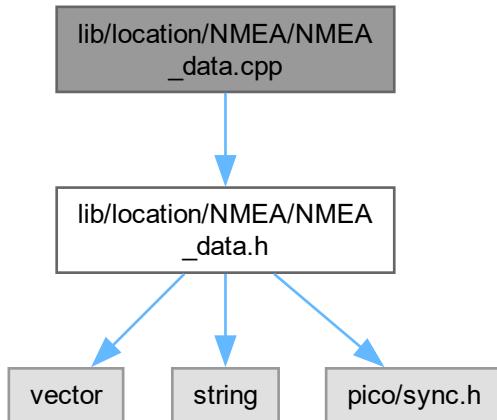
## 8.50 gps\_collector.h

[Go to the documentation of this file.](#)

```
00001 #ifndef GPS_COLLECTOR_H
00002 #define GPS_COLLECTOR_H
00003
00004 #include <string>
00005 #include "hardware/uart.h"
00006 #include "lib/location/NMEA/nmea_data.h" // Include the new header
00007 #include "pin_config.h"
00008
00009 // Function to collect GPS data from the UART
00010 void collect_gps_data();
00011
00012 #endif
```

## 8.51 lib/location/NMEA/NMEA\_data.cpp File Reference

```
#include "lib/location/NMEA/NMEA_data.h"
Include dependency graph for NMEA_data.cpp:
```



### Variables

- [NMEAData nmea\\_data](#)

#### 8.51.1 Variable Documentation

##### 8.51.1.1 [nmea\\_data](#)

[NMEAData nmea\\_data](#)

Definition at line 3 of file [NMEA\\_data.cpp](#).

## 8.52 NMEA\_data.cpp

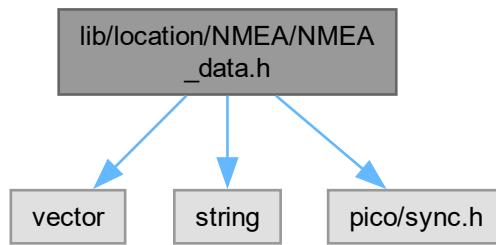
[Go to the documentation of this file.](#)

```
00001 #include "lib/location/NMEA/NMEA_data.h"
00002
00003 NMEAData nmea_data; // Define the global instance
00004
00005 NMEAData::NMEAData() {
00006     mutex_init(&rmc_mutex_);
00007     mutex_init(&gga_mutex_);
00008 }
00009
00010 void NMEAData::update_rmc_tokens(const std::vector<std::string>& tokens) {
00011     mutex_enter_blocking(&rmc_mutex_);
00012     rmc_tokens_ = tokens;
00013     mutex_exit(&rmc_mutex_);
00014 }
```

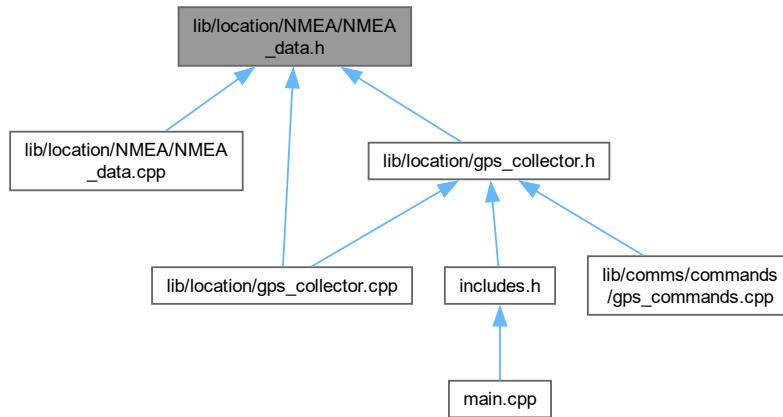
```
00015
00016 void NMEAData::update_gga_tokens(const std::vector<std::string>& tokens) {
00017     mutex_enter_blocking(&gga_mutex_);
00018     gga_tokens_ = tokens;
00019     mutex_exit(&gga_mutex_);
00020 }
00021
00022 std::vector<std::string> NMEAData::get_rmc_tokens() const {
00023     mutex_enter_blocking(const_cast<mutex_t*>(&rmc_mutex_));
00024     std::vector<std::string> copy = rmc_tokens_;
00025     mutex_exit(const_cast<mutex_t*>(&rmc_mutex_));
00026     return copy;
00027 }
00028
00029 std::vector<std::string> NMEAData::get_gga_tokens() const {
00030     mutex_enter_blocking(const_cast<mutex_t*>(&gga_mutex_));
00031     std::vector<std::string> copy = gga_tokens_;
00032     mutex_exit(const_cast<mutex_t*>(&gga_mutex_));
00033     return copy;
00034 }
```

## 8.53 lib/location/NMEA/NMEA\_data.h File Reference

```
#include <vector>
#include <string>
#include "pico/sync.h"
Include dependency graph for NMEA_data.h:
```



This graph shows which files directly or indirectly include this file:



## Classes

- class [NMEAData](#)

## Variables

- [NMEAData nmea\\_data](#)

### 8.53.1 Variable Documentation

#### 8.53.1.1 nmea\_data

`NMEAData nmea_data [extern]`

Definition at line 3 of file [NMEA\\_data.cpp](#).

## 8.54 NMEA\_data.h

[Go to the documentation of this file.](#)

```

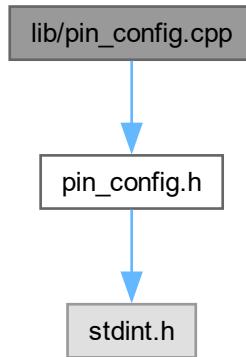
00001 // filepath: /c:/Users/Kuba/Desktop/inz/kubisat/software/kubisat_firmware/lib/GPS/nmea_data.h
00002 #ifndef NMEA_DATA_H
00003 #define NMEA_DATA_H
00004
00005 #include <vector>
00006 #include <string>
00007 #include "pico/sync.h"
00008
00009 class NMEAData {
00010 public:
00011     NMEAData();
00012     void update_rmc_tokens(const std::vector<std::string>& tokens);
00013     void update_gga_tokens(const std::vector<std::string>& tokens);
00014     std::vector<std::string> get_rmc_tokens() const;
  
```

```
00016     std::vector<std::string> get_gga_tokens() const;
00017
00018 private:
00019     std::vector<std::string> rmc_tokens_;
00020     std::vector<std::string> gga_tokens_;
00021     mutex_t rmc_mutex_;
00022     mutex_t gga_mutex_;
00023 };
00024
00025 extern NMEAData nmea_data;
00026
00027 #endif
```

## 8.55 lib/pin\_config.cpp File Reference

```
#include "pin_config.h"
```

Include dependency graph for pin\_config.cpp:



### Variables

- const int lora\_cs\_pin = 17
- const int lora\_reset\_pin = 22
- const int lora\_irq\_pin = 28
- uint8\_t lora\_address\_local = 37
- uint8\_t lora\_address\_remote = 21

### 8.55.1 Variable Documentation

#### 8.55.1.1 lora\_cs\_pin

```
const int lora_cs_pin = 17
```

Definition at line 4 of file [pin\\_config.cpp](#).

### 8.55.1.2 lora\_reset\_pin

```
const int lora_reset_pin = 22
```

Definition at line [5](#) of file [pin\\_config.cpp](#).

### 8.55.1.3 lora\_irq\_pin

```
const int lora_irq_pin = 28
```

Definition at line [6](#) of file [pin\\_config.cpp](#).

### 8.55.1.4 lora\_address\_local

```
uint8_t lora_address_local = 37
```

Definition at line [8](#) of file [pin\\_config.cpp](#).

### 8.55.1.5 lora\_address\_remote

```
uint8_t lora_address_remote = 21
```

Definition at line [9](#) of file [pin\\_config.cpp](#).

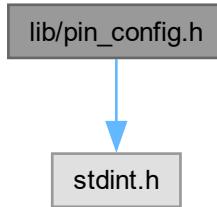
## 8.56 pin\_config.cpp

[Go to the documentation of this file.](#)

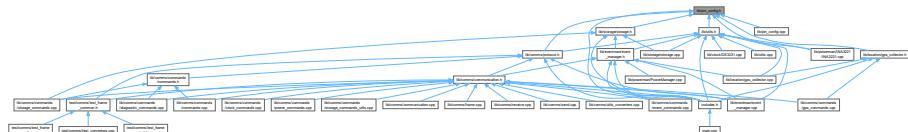
```
00001 #include "pin_config.h"
00002
00003 // LoRa constants
00004 const int lora_cs_pin = 17;           // LoRa radio chip select
00005 const int lora_reset_pin = 22;        // LoRa radio reset
00006 const int lora_irq_pin = 28;          // LoRa hardware interrupt pin
00007
00008 uint8_t lora_address_local = 37;      // address of this device
00009 uint8_t lora_address_remote = 21;
```

## 8.57 lib/pin\_config.h File Reference

```
#include <stdint.h>
Include dependency graph for pin_config.h:
```



This graph shows which files directly or indirectly include this file:



### Macros

- `#define DEBUG_UART_PORT uart0`
- `#define DEBUG_UART_BAUD_RATE 115200`
- `#define DEBUG_UART_TX_PIN 0`
- `#define DEBUG_UART_RX_PIN 1`
- `#define MAIN_I2C_PORT i2c1`
- `#define MAIN_I2C_SDA_PIN 6`
- `#define MAIN_I2C_SCL_PIN 7`
- `#define GPS_UART_PORT uart1`
- `#define GPS_UART_BAUD_RATE 9600`
- `#define GPS_UART_TX_PIN 8`
- `#define GPS_UART_RX_PIN 9`
- `#define GPS_POWER_ENABLE_PIN 14`
- `#define BUFFER_SIZE 85`
- `#define SD_SPI_PORT spi1`
- `#define SD_MISO_PIN 12`
- `#define SD_MOSI_PIN 11`
- `#define SD_SCK_PIN 10`
- `#define SD_CS_PIN 13`
- `#define SD_CARD_DETECT_PIN 28`
- `#define SX1278_MISO 16`
- `#define SX1278_CS 17`
- `#define SX1278_SCK 18`
- `#define SX1278_MOSI 19`

- #define SPI\_PORT spi0
- #define READ\_BIT 0x80
- #define LORA\_DEFAULT\_SPI spi0
- #define LORA\_DEFAULT\_SPI\_FREQUENCY 8E6
- #define LORA\_DEFAULT\_SS\_PIN 17
- #define LORA\_DEFAULT\_RESET\_PIN 22
- #define LORA\_DEFAULT\_DIO0\_PIN 20
- #define PA\_OUTPUT\_RFO\_PIN 11
- #define PA\_OUTPUT\_PA\_BOOST\_PIN 12

## Variables

- const int lora\_cs\_pin
- const int lora\_reset\_pin
- const int lora\_irq\_pin
- uint8\_t lora\_address\_local
- uint8\_t lora\_address\_remote

## 8.57.1 Macro Definition Documentation

### 8.57.1.1 DEBUG\_UART\_PORT

```
#define DEBUG_UART_PORT uart0
```

Definition at line 8 of file [pin\\_config.h](#).

### 8.57.1.2 DEBUG\_UART\_BAUD\_RATE

```
#define DEBUG_UART_BAUD_RATE 115200
```

Definition at line 9 of file [pin\\_config.h](#).

### 8.57.1.3 DEBUG\_UART\_TX\_PIN

```
#define DEBUG_UART_TX_PIN 0
```

Definition at line 11 of file [pin\\_config.h](#).

### 8.57.1.4 DEBUG\_UART\_RX\_PIN

```
#define DEBUG_UART_RX_PIN 1
```

Definition at line 12 of file [pin\\_config.h](#).

### 8.57.1.5 MAIN\_I2C\_PORT

```
#define MAIN_I2C_PORT i2c1
```

Definition at line 14 of file [pin\\_config.h](#).

### 8.57.1.6 MAIN\_I2C\_SDA\_PIN

```
#define MAIN_I2C_SDA_PIN 6
```

Definition at line 15 of file [pin\\_config.h](#).

### 8.57.1.7 MAIN\_I2C\_SCL\_PIN

```
#define MAIN_I2C_SCL_PIN 7
```

Definition at line 16 of file [pin\\_config.h](#).

### 8.57.1.8 GPS\_UART\_PORT

```
#define GPS_UART_PORT uart1
```

Definition at line 19 of file [pin\\_config.h](#).

### 8.57.1.9 GPS\_UART\_BAUD\_RATE

```
#define GPS_UART_BAUD_RATE 9600
```

Definition at line 20 of file [pin\\_config.h](#).

### 8.57.1.10 GPS\_UART\_TX\_PIN

```
#define GPS_UART_TX_PIN 8
```

Definition at line 21 of file [pin\\_config.h](#).

### 8.57.1.11 GPS\_UART\_RX\_PIN

```
#define GPS_UART_RX_PIN 9
```

Definition at line 22 of file [pin\\_config.h](#).

### 8.57.1.12 GPS\_POWER\_ENABLE\_PIN

```
#define GPS_POWER_ENABLE_PIN 14
```

Definition at line 23 of file [pin\\_config.h](#).

### 8.57.1.13 BUFFER\_SIZE

```
#define BUFFER_SIZE 85
```

Definition at line 25 of file [pin\\_config.h](#).

### 8.57.1.14 SD\_SPI\_PORT

```
#define SD_SPI_PORT spil
```

Definition at line 28 of file [pin\\_config.h](#).

### 8.57.1.15 SD\_MISO\_PIN

```
#define SD_MISO_PIN 12
```

Definition at line 29 of file [pin\\_config.h](#).

### 8.57.1.16 SD\_MOSI\_PIN

```
#define SD_MOSI_PIN 11
```

Definition at line 30 of file [pin\\_config.h](#).

### 8.57.1.17 SD\_SCK\_PIN

```
#define SD_SCK_PIN 10
```

Definition at line 31 of file [pin\\_config.h](#).

### 8.57.1.18 SD\_CS\_PIN

```
#define SD_CS_PIN 13
```

Definition at line 32 of file [pin\\_config.h](#).

### 8.57.1.19 SD\_CARD\_DETECT\_PIN

```
#define SD_CARD_DETECT_PIN 28
```

Definition at line 33 of file [pin\\_config.h](#).

### 8.57.1.20 SX1278\_MISO

```
#define SX1278_MISO 16
```

Definition at line 35 of file [pin\\_config.h](#).

### 8.57.1.21 SX1278\_CS

```
#define SX1278_CS 17
```

Definition at line 36 of file [pin\\_config.h](#).

### 8.57.1.22 SX1278\_SCK

```
#define SX1278_SCK 18
```

Definition at line [37](#) of file [pin\\_config.h](#).

### 8.57.1.23 SX1278\_MOSI

```
#define SX1278_MOSI 19
```

Definition at line [38](#) of file [pin\\_config.h](#).

### 8.57.1.24 SPI\_PORT

```
#define SPI_PORT spio
```

Definition at line [40](#) of file [pin\\_config.h](#).

### 8.57.1.25 READ\_BIT

```
#define READ_BIT 0x80
```

Definition at line [41](#) of file [pin\\_config.h](#).

### 8.57.1.26 LORA\_DEFAULT\_SPI

```
#define LORA_DEFAULT_SPI spio
```

Definition at line [43](#) of file [pin\\_config.h](#).

### 8.57.1.27 LORA\_DEFAULT\_SPI\_FREQUENCY

```
#define LORA_DEFAULT_SPI_FREQUENCY 8E6
```

Definition at line [44](#) of file [pin\\_config.h](#).

### 8.57.1.28 LORA\_DEFAULT\_SS\_PIN

```
#define LORA_DEFAULT_SS_PIN 17
```

Definition at line [45](#) of file [pin\\_config.h](#).

### 8.57.1.29 LORA\_DEFAULT\_RESET\_PIN

```
#define LORA_DEFAULT_RESET_PIN 22
```

Definition at line [46](#) of file [pin\\_config.h](#).

### 8.57.1.30 LORA\_DEFAULT\_DIO0\_PIN

```
#define LORA_DEFAULT_DIO0_PIN 20
```

Definition at line 47 of file [pin\\_config.h](#).

### 8.57.1.31 PA\_OUTPUT\_RFO\_PIN

```
#define PA_OUTPUT_RFO_PIN 11
```

Definition at line 49 of file [pin\\_config.h](#).

### 8.57.1.32 PA\_OUTPUT\_PA\_BOOST\_PIN

```
#define PA_OUTPUT_PA_BOOST_PIN 12
```

Definition at line 50 of file [pin\\_config.h](#).

## 8.57.2 Variable Documentation

### 8.57.2.1 lora\_cs\_pin

```
const int lora_cs_pin [extern]
```

Definition at line 4 of file [pin\\_config.cpp](#).

### 8.57.2.2 lora\_reset\_pin

```
const int lora_reset_pin [extern]
```

Definition at line 5 of file [pin\\_config.cpp](#).

### 8.57.2.3 lora\_irq\_pin

```
const int lora_irq_pin [extern]
```

Definition at line 6 of file [pin\\_config.cpp](#).

### 8.57.2.4 lora\_address\_local

```
uint8_t lora_address_local [extern]
```

Definition at line 8 of file [pin\\_config.cpp](#).

### 8.57.2.5 lora\_address\_remote

```
uint8_t lora_address_remote [extern]
```

Definition at line 9 of file [pin\\_config.cpp](#).

## 8.58 pin\_config.h

[Go to the documentation of this file.](#)

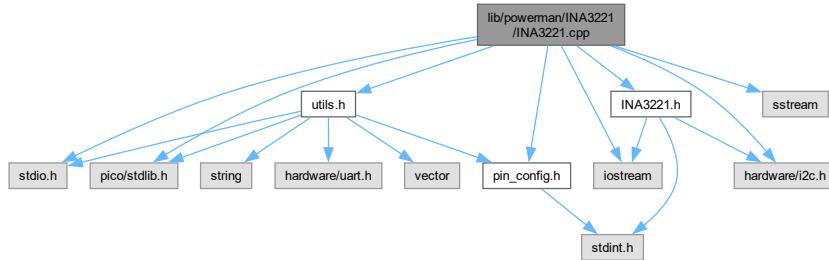
```
00001 // pin_config.h
00002 #include <stdint.h>
00003
00004 #ifndef PIN_CONFIG_H
00005 #define PIN_CONFIG_H
00006
00007 //DEBUG uart
00008 #define DEBUG_UART_PORT uart0
00009 #define DEBUG_UART_BAUD_RATE 115200
00010
00011 #define DEBUG_UART_TX_PIN 0
00012 #define DEBUG_UART_RX_PIN 1
00013
00014 #define MAIN_I2C_PORT i2c1
00015 #define MAIN_I2C_SDA_PIN 6
00016 #define MAIN_I2C_SCL_PIN 7
00017
00018 // GPS configuration
00019 #define GPS_UART_PORT uart1
00020 #define GPS_UART_BAUD_RATE 9600
00021 #define GPS_UART_TX_PIN 8
00022 #define GPS_UART_RX_PIN 9
00023 #define GPS_POWER_ENABLE_PIN 14
00024
00025 #define BUFFER_SIZE 85 // NMEA sentences are usually under 85 chars
00026
00027 // SPI configuration for SD card
00028 #define SD_SPI_PORT spi1
00029 #define SD_MISO_PIN 12
00030 #define SD_MOSI_PIN 11
00031 #define SD_SCK_PIN 10
00032 #define SD_CS_PIN 13
00033 #define SD_CARD_DETECT_PIN 28
00034
00035 #define SX1278_MISO 16
00036 #define SX1278_CS 17
00037 #define SX1278_SCK 18
00038 #define SX1278_MOSI 19
00039
00040 #define SPI_PORT spi0
00041 #define READ_BIT 0x80
00042
00043 #define LORA_DEFAULT_SPI spi0
00044 #define LORA_DEFAULT_SPI_FREQUENCY 8E6
00045 #define LORA_DEFAULT_SS_PIN 17
00046 #define LORA_DEFAULT_RESET_PIN 22
00047 #define LORA_DEFAULT_DIO0_PIN 20
00048
00049 #define PA_OUTPUT_RFO_PIN 11
00050 #define PA_OUTPUT_PA_BOOST_PIN 12
00051
00052
00053
00054 // LoRa constants - declare as extern
00055 extern const int lora_cs_pin; // LoRa radio chip select
00056 extern const int lora_reset_pin; // LoRa radio reset
00057 extern const int lora_irq_pin; // LoRa hardware interrupt pin
00058 extern uint8_t lora_address_local; // address of this device
00059 extern uint8_t lora_address_remote; // destination to send to
00060
00061
00062 #endif // PIN_CONFIG_H
```

## 8.59 lib/powerman/INA3221/INA3221.cpp File Reference

Implementation of the [INA3221](#) power monitor driver.

```
#include "INA3221.h"
#include <stdio.h>
#include "pico/stdlib.h"
#include "hardware/i2c.h"
#include <iostream>
#include "pin_config.h"
#include "utils.h"
#include <sstream>
```

Include dependency graph for INA3221.cpp:



### 8.59.1 Detailed Description

Implementation of the [INA3221](#) power monitor driver.

This file contains the implementation for the [INA3221](#) triple-channel power monitor, providing functionality for voltage, current, and power monitoring with alert capabilities.

Definition in file [INA3221.cpp](#).

## 8.60 INA3221.cpp

[Go to the documentation of this file.](#)

```

00001 #include "INA3221.h"
00002 #include <stdio.h>
00003 #include "pico/stdlib.h"
00004 #include "hardware/i2c.h"
00005 #include <iostream>
00006 #include "pin_config.h"
00007 #include "utils.h"
00008 #include <sstream>
00009
00010
00017
00018
00038
00039
00046 INA3221::INA3221(in3221_addr_t addr, i2c_inst_t* i2c)
00047     : _i2c_addr(addr), _i2c(i2c) {}
00048
00049
00056 bool INA3221::begin() {
00057     uart_print("INA3221 initializing...", VerboseLevel::DEBUG);
  
```

```
00058
00059     _shuntRes[0] = 10;
00060     _shuntRes[1] = 10;
00061     _shuntRes[2] = 10;
00062
00063     _filterRes[0] = 10;
00064     _filterRes[1] = 10;
00065     _filterRes[2] = 10;
00066
00067     uint16_t manuf_id = get_manufacturer_id();
00068     uint16_t die_id = get_die_id();
00069     std::stringstream ss;
00070     ss << "INA3221 Manufacturer ID: 0x" << std::hex << manuf_id
00071             << ", Die ID: 0x" << die_id << std::endl;
00072     uart_print(ss.str(), VerbosityLevel::INFO);
00073
00074     if (manuf_id == 0x5449 && die_id == 0x3220) {
00075         uart_print("INA3221 found and initialized.", VerbosityLevel::INFO);
00076         return true;
00077     } else {
00078         uart_print("INA3221 initialization failed. Incorrect IDs.", VerbosityLevel::ERROR);
00079         return false;
00080     }
00081
00082 }
00083
00084
00085 00090 void INA3221::reset(){
00086     conf_reg_t conf_reg;
00087
00088     _read(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00089     conf_reg.reset = 1;
00090     _write(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00091 }
00092
00093
00094
00095 00104 uint16_t INA3221::get_manufacturer_id() {
00096     uint16_t id = 0;
00097     _read(INA3221_REG_MANUF_ID, &id);
00098     return id;
00099 }
00100
00101
00102 00116 uint16_t INA3221::get_die_id() {
00103     uint16_t id = 0;
00104     _read(INA3221_REG_DIE_ID, &id);
00105     return id;
00106 }
00107
00108
00109
00110
00111
00112
00113
00114
00115
00116
00117
00118
00119
00120
00121
00122
00123
00124
00125
00126
00127
00128
00129
00130
00131
00132
00133
00134
00135
00136 //configure
00137
00138
00139
00140
00141
00142
00143
00144
00145
00146
00147
00148
00149
00150
00151
00152
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00168
00169
00170
00171
00172
00173
00174
00175
00176
00177
00178
00179
00180
```

```

00185 void INA3221::set_shunt_measurement_enable() {
00186     conf_reg_t conf_reg;
00187
00188     _read(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00189     conf_reg.mode_shunt_en = 1;
00190     _write(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00191 }
00192
00193
00198 void INA3221::set_shunt_measurement_disable() {
00199     conf_reg_t conf_reg;
00200
00201     _read(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00202     conf_reg.mode_shunt_en = 0;
00203     _write(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00204 }
00205
00206
00211 void INA3221::set_bus_measurement_enable() {
00212     conf_reg_t conf_reg;
00213
00214     _read(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00215     conf_reg.mode_bus_en = 1;
00216     _write(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00217 }
00218
00219
00224 void INA3221::set_bus_measurement_disable() {
00225     conf_reg_t conf_reg;
00226
00227     _read(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00228     conf_reg.mode_bus_en = 0;
00229     _write(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00230 }
00231
00232
00238 void INA3221::set_averaging_mode(ina3221_avg_mode_t mode) {
00239     conf_reg_t conf_reg;
00240
00241     _read(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00242     conf_reg.avg_mode = mode;
00243     _write(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00244 }
00245
00246
00252 void INA3221::set_bus_conversion_time(ina3221_conv_time_t convTime) {
00253     conf_reg_t conf_reg;
00254
00255     _read(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00256     conf_reg.bus_conv_time = convTime;
00257     _write(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00258 }
00259
00260
00266 void INA3221::set_shunt_conversion_time(ina3221_conv_time_t convTime) {
00267     conf_reg_t conf_reg;
00268
00269     _read(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00270     conf_reg.shunt_conv_time = convTime;
00271     _write(INA3221_REG_CONF, (uint16_t*)&conf_reg);
00272 }
00273
00274
00275 //get measurement
00282 int32_t INA3221::get_shunt_voltage(ina3221_ch_t channel) {
00283     int32_t res;
00284     ina3221_reg_t reg;
00285     uint16_t val_raw = 0;
00286
00287     switch(channel){
00288         case INA3221_CH1:
00289             reg = INA3221_REG_CH1_SHUNTV;
00290             break;
00291         case INA3221_CH2:
00292             reg = INA3221_REG_CH2_SHUNTV;
00293             break;
00294         case INA3221_CH3:
00295             reg = INA3221_REG_CH3_SHUNTV;
00296             break;
00297     }
00298
00299     _read(reg, &val_raw);
00300
00301     res = (int16_t) (val_raw >> 3);
00302     res *= SHUNT_VOLTAGE_LSB_UV;
00303
00304     return res;

```

```
00305 }
00306
00307
00314 float INA3221::get_current_ma(ina3221_ch_t channel) {
00315     int32_t shunt_uV = 0;
00316     float current_A = 0;
00317
00318     shunt_uV = get_shunt_voltage(channel);
00319     current_A = shunt_uV / (int32_t)_shuntRes[channel] / 1000.0;;
00320     return current_A;
00321 }
00322
00323
00330 float INA3221::get_voltage(ina3221_ch_t channel) {
00331     float voltage_V = 0.0;
00332     ina3221_reg_t reg;
00333     uint16_t val_raw = 0;
00334
00335     switch(channel){
00336         case INA3221_CH1:
00337             reg = INA3221_REG_CH1_BUSV;
00338             break;
00339         case INA3221_CH2:
00340             reg = INA3221_REG_CH2_BUSV;
00341             break;
00342         case INA3221_CH3:
00343             reg = INA3221_REG_CH3_BUSV;
00344             break;
00345     }
00346
00347     _read(reg, &val_raw);
00348     voltage_V = val_raw / 1000.0;
00349     return voltage_V;
00350 }
00351
00352
00353 // alerts
00360 void INA3221::set_warn_alert_limit(ina3221_ch_t channel, float voltage_v) {
00361     ina3221_reg_t reg;
00362     uint16_t val = (uint16_t)(voltage_v * 1000); // Convert V to mV
00363
00364     switch(channel) {
00365         case INA3221_CH1:
00366             reg = INA3221_REG_CH1_WARNING_ALERT_LIM;
00367             break;
00368         case INA3221_CH2:
00369             reg = INA3221_REG_CH2_WARNING_ALERT_LIM;
00370             break;
00371         case INA3221_CH3:
00372             reg = INA3221_REG_CH3_WARNING_ALERT_LIM;
00373             break;
00374     }
00375     _write(reg, &val);
00376 }
00377
00378
00385 void INA3221::set_crit_alert_limit(ina3221_ch_t channel, float voltage_v) {
00386     ina3221_reg_t reg;
00387     uint16_t val = (uint16_t)(voltage_v * 1000); // Convert V to mV
00388
00389     switch(channel) {
00390         case INA3221_CH1:
00391             reg = INA3221_REG_CH1_CRIT_ALERT_LIM;
00392             break;
00393         case INA3221_CH2:
00394             reg = INA3221_REG_CH2_CRIT_ALERT_LIM;
00395             break;
00396         case INA3221_CH3:
00397             reg = INA3221_REG_CH3_CRIT_ALERT_LIM;
00398             break;
00399     }
00400     _write(reg, &val);
00401 }
00402
00403
00410 void INA3221::set_power_valid_limit(float voltage_upper_v, float voltage_lower_v) {
00411     uint16_t val;
00412
00413     val = (uint16_t)(voltage_upper_v * 1000);
00414     _write(INA3221_REG_PWR_VALID_HI_LIM, &val);
00415
00416     val = (uint16_t)(voltage_lower_v * 1000);
00417     _write(INA3221_REG_PWR_VALID_LO_LIM, &val);
00418 }
00419
00420
00426 void INA3221::enable_alerts() {
```

```

00427     masken_reg_t masken;
00428     _read(INA3221_REG_MASK_ENABLE, (uint16_t*)&masken);
00429
00430     masken.warn_alert_ch1 = 1;
00431     masken.warn_alert_ch2 = 1;
00432     masken.warn_alert_ch3 = 1;
00433     masken.crit_alert_ch1 = 1;
00434     masken.crit_alert_ch2 = 1;
00435     masken.crit_alert_ch3 = 1;
00436     masken.pwr_valid_alert = 1;
00437
00438     _write(INA3221_REG_MASK_ENABLE, (uint16_t*)&masken);
00439 }
00440
00441
00442 bool INA3221::get_warn_alert(ina3221_ch_t channel) {
00443     masken_reg_t masken;
00444     _read(INA3221_REG_MASK_ENABLE, (uint16_t*)&masken);
00445
00446     switch(channel) {
00447         case INA3221_CH1: return masken.warn_alert_ch1;
00448         case INA3221_CH2: return masken.warn_alert_ch2;
00449         case INA3221_CH3: return masken.warn_alert_ch3;
00450         default: return false;
00451     }
00452 }
00453
00454
00455 bool INA3221::get_crit_alert(ina3221_ch_t channel) {
00456     masken_reg_t masken;
00457     _read(INA3221_REG_MASK_ENABLE, (uint16_t*)&masken);
00458
00459     switch(channel) {
00460         case INA3221_CH1: return masken.crit_alert_ch1;
00461         case INA3221_CH2: return masken.crit_alert_ch2;
00462         case INA3221_CH3: return masken.crit_alert_ch3;
00463         default: return false;
00464     }
00465 }
00466
00467
00468 bool INA3221::get_power_valid_alert() {
00469     masken_reg_t masken;
00470     _read(INA3221_REG_MASK_ENABLE, (uint16_t*)&masken);
00471     return masken.pwr_valid_alert;
00472 }
00473
00474
00475 void INA3221::set_alert_latch(bool enable) {
00476     masken_reg_t masken;
00477     _read(INA3221_REG_MASK_ENABLE, (uint16_t*)&masken);
00478     masken.warn_alert_latch_en = enable;
00479     masken.crit_alert_latch_en = enable;
00480     _write(INA3221_REG_MASK_ENABLE, (uint16_t*)&masken);
00481 }
00482
00483
00484 // private
00485 void INA3221::_read(ina3221_reg_t reg, uint16_t *val) {
00486     uint8_t reg_buf = reg;
00487     uint8_t data[2];
00488
00489     int ret = i2c_write_blocking(MAIN_I2C_PORT, _i2c_addr, &reg_buf, 1, true);
00490     if (ret != 1) {
00491         std::cerr << "Failed to write register address to I2C device." << std::endl;
00492         return;
00493     }
00494
00495     ret = i2c_read_blocking(MAIN_I2C_PORT, _i2c_addr, data, 2, false);
00496     if (ret != 2) {
00497         std::cerr << "Failed to read data from I2C device." << std::endl;
00498         return;
00499     }
00500
00501     *val = (data[0] << 8) | data[1];
00502 }
00503
00504
00505 void INA3221::_write(ina3221_reg_t reg, uint16_t *val) {
00506     uint8_t buf[3];
00507     buf[0] = reg;
00508     buf[1] = (*val >> 8) & 0xFF; // MSB
00509     buf[2] = (*val) & 0xFF; // LSB
00510
00511     int ret = i2c_write_blocking(MAIN_I2C_PORT, _i2c_addr, buf, 3, false);
00512     if (ret != 3) {
00513         std::cerr << "Failed to write data to I2C device." << std::endl;
00514     }
00515 }
```

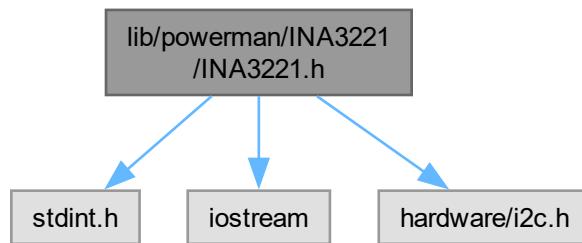
```
00548 }
00549 }
```

## 8.61 lib/powerman/INA3221/INA3221.h File Reference

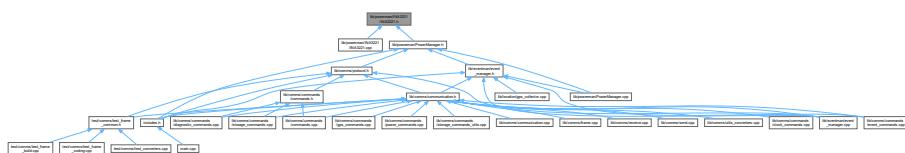
Header file for the [INA3221](#) triple-channel power monitor driver.

```
#include <stdint.h>
#include <iostream>
#include <hardware/i2c.h>
```

Include dependency graph for INA3221.h:



This graph shows which files directly or indirectly include this file:



### Classes

- class [INA3221](#)  
*INA3221 Triple-Channel Power Monitor driver class.*
- struct [INA3221::conf\\_reg\\_t](#)  
*Configuration register bit fields.*
- struct [INA3221::masken\\_reg\\_t](#)  
*Mask/Enable register bit fields.*

## Enumerations

- enum `ina3221_addr_t` { `INA3221_ADDR40_GND` = 0b1000000 , `INA3221_ADDR41_VCC` = 0b1000001 , `INA3221_ADDR42_SDA` = 0b1000010 , `INA3221_ADDR43_SCL` = 0b1000011 }
- enum `ina3221_ch_t` { `INA3221_CH1` = 0 , `INA3221_CH2` , `INA3221_CH3` }
- enum `ina3221_reg_t`
  - `INA3221_REG_CONF` = 0 , `INA3221_REG_CH1_SHUNTV` , `INA3221_REG_CH1_BUSV` , `INA3221_REG_CH2_SHUNTV` ,  
`INA3221_REG_CH2_BUSV` , `INA3221_REG_CH3_SHUNTV` , `INA3221_REG_CH3_BUSV` , `INA3221_REG_CH1_CRIT_ALEP` ,  
`INA3221_REG_CH1_WARNING_ALERT_LIM` , `INA3221_REG_CH2_CRIT_ALERT_LIM` , `INA3221_REG_CH2_WARNING_A` ,  
`INA3221_REG_CH3_CRIT_ALERT_LIM` , `INA3221_REG_SHUNTV_SUM` , `INA3221_REG_SHUNTV_SUM_LIM` ,  
`INA3221_REG_MASK_ENABLE` ,  
`INA3221_REG_PWR_VALID_HI_LIM` , `INA3221_REG_PWR_VALID_LO_LIM` , `INA3221_REG_MANUF_ID` = 0xFE , `INA3221_REG_DIE_ID` = 0xFF }

*Register addresses for `INA3221`.*
- enum `ina3221_conv_time_t`
  - `INA3221_REG_CONF_CT_140US` = 0 , `INA3221_REG_CONF_CT_204US` , `INA3221_REG_CONF_CT_332US` ,  
`INA3221_REG_CONF_CT_588US` ,  
`INA3221_REG_CONF_CT_1100US` , `INA3221_REG_CONF_CT_2116US` , `INA3221_REG_CONF_CT_4156US` ,  
`INA3221_REG_CONF_CT_8244US` }

*Conversion time settings.*
- enum `ina3221_avg_mode_t`
  - `INA3221_REG_CONF_AVG_1` = 0 , `INA3221_REG_CONF_AVG_4` , `INA3221_REG_CONF_AVG_16` ,  
`INA3221_REG_CONF_AVG_64` ,  
`INA3221_REG_CONF_AVG_128` , `INA3221_REG_CONF_AVG_256` , `INA3221_REG_CONF_AVG_512` ,  
`INA3221_REG_CONF_AVG_1024` }

*Averaging mode settings.*

## Variables

- const int `INA3221_CH_NUM` = 3  
*Number of channels in `INA3221`.*
- const int `SHUNT_VOLTAGE_LSB_UV` = 5  
*LSB value for shunt voltage measurements in microvolts.*

### 8.61.1 Detailed Description

Header file for the `INA3221` triple-channel power monitor driver.

Definition in file `INA3221.h`.

### 8.61.2 Enumeration Type Documentation

#### 8.61.2.1 `ina3221_addr_t`

```
enum ina3221_addr_t
```

Enumerator

INA3221_ADDR40_GND	
INA3221_ADDR41_VCC	
INA3221_ADDR42_SDA	
INA3221_ADDR43_SCL	

Definition at line 12 of file [INA3221.h](#).

### 8.61.2.2 ina3221\_ch\_t

```
enum ina3221_ch_t
```

Enumerator

INA3221_CH1	
INA3221_CH2	
INA3221_CH3	

Definition at line 23 of file [INA3221.h](#).

### 8.61.2.3 ina3221\_reg\_t

```
enum ina3221_reg_t
```

Register addresses for [INA3221](#).

Enumerator

INA3221_REG_CONF	
INA3221_REG_CH1_SHUNTV	
INA3221_REG_CH1_BUSV	
INA3221_REG_CH2_SHUNTV	
INA3221_REG_CH2_BUSV	
INA3221_REG_CH3_SHUNTV	
INA3221_REG_CH3_BUSV	
INA3221_REG_CH1_CRIT_ALERT_LIM	
INA3221_REG_CH1_WARNING_ALERT_LIM	
INA3221_REG_CH2_CRIT_ALERT_LIM	
INA3221_REG_CH2_WARNING_ALERT_LIM	
INA3221_REG_CH3_CRIT_ALERT_LIM	
INA3221_REG_CH3_WARNING_ALERT_LIM	
INA3221_REG_SHUNTV_SUM	
INA3221_REG_SHUNTV_SUM_LIM	
INA3221_REG_MASK_ENABLE	
INA3221_REG_PWR_VALID_HI_LIM	
INA3221_REG_PWR_VALID_LO_LIM	
INA3221_REG_MANUF_ID	
INA3221_REG_DIE_ID	

Definition at line 38 of file [INA3221.h](#).

#### 8.61.2.4 ina3221\_conv\_time\_t

enum [ina3221\\_conv\\_time\\_t](#)

Conversion time settings.

Time taken for each measurement conversion

Enumerator

INA3221_REG_CONF_CT_140US
INA3221_REG_CONF_CT_204US
INA3221_REG_CONF_CT_332US
INA3221_REG_CONF_CT_588US
INA3221_REG_CONF_CT_1100US
INA3221_REG_CONF_CT_2116US
INA3221_REG_CONF_CT_4156US
INA3221_REG_CONF_CT_8244US

Definition at line [65](#) of file [INA3221.h](#).

#### 8.61.2.5 ina3221\_avg\_mode\_t

enum [ina3221\\_avg\\_mode\\_t](#)

Averaging mode settings.

Number of samples to average for each measurement

Enumerator

INA3221_REG_CONF_AVG_1
INA3221_REG_CONF_AVG_4
INA3221_REG_CONF_AVG_16
INA3221_REG_CONF_AVG_64
INA3221_REG_CONF_AVG_128
INA3221_REG_CONF_AVG_256
INA3221_REG_CONF_AVG_512
INA3221_REG_CONF_AVG_1024

Definition at line [80](#) of file [INA3221.h](#).

### 8.61.3 Variable Documentation

#### 8.61.3.1 INA3221\_CH\_NUM

const int INA3221\_CH\_NUM = 3

Number of channels in [INA3221](#).

Definition at line [30](#) of file [INA3221.h](#).

### 8.61.3.2 SHUNT\_VOLTAGE\_LSB\_UV

```
const int SHUNT_VOLTAGE_LSB_UV = 5
```

LSB value for shunt voltage measurements in microvolts.

Definition at line 32 of file [INA3221.h](#).

## 8.62 INA3221.h

[Go to the documentation of this file.](#)

```
00001 #ifndef BEASTDEVICES_INA3221_H
00002 #define BEASTDEVICES_INA3221_H
00003
00004 #include <stdint.h>
00005 #include <iostream>
00006 #include <hardware/i2c.h>
00007
00012 typedef enum {
00013     INA3221_ADDR40_GND = 0b1000000, // A0 pin -> GND
00014     INA3221_ADDR41_VCC = 0b1000001, // A0 pin -> VCC
00015     INA3221_ADDR42_SDA = 0b1000010, // A0 pin -> SDA
00016     INA3221_ADDR43_SCL = 0b1000011 // A0 pin -> SCL
00017 } ina3221_addr_t;
00018
00023 typedef enum {
00024     INA3221_CH1 = 0,
00025     INA3221_CH2,
00026     INA3221_CH3,
00027 } ina3221_ch_t;
00028
00030 const int INA3221_CH_NUM = 3;
00032 const int SHUNT_VOLTAGE_LSB_UV = 5;
00033
00034
00038 typedef enum {
00039     INA3221_REG_CONF = 0,
00040     INA3221_REG_CH1_SHUNTV,
00041     INA3221_REG_CH1_BUSV,
00042     INA3221_REG_CH2_SHUNTV,
00043     INA3221_REG_CH2_BUSV,
00044     INA3221_REG_CH3_SHUNTV,
00045     INA3221_REG_CH3_BUSV,
00046     INA3221_REG_CH1_CRIT_ALERT_LIM,
00047     INA3221_REG_CH1_WARNING_ALERT_LIM,
00048     INA3221_REG_CH2_CRIT_ALERT_LIM,
00049     INA3221_REG_CH2_WARNING_ALERT_LIM,
00050     INA3221_REG_CH3_CRIT_ALERT_LIM,
00051     INA3221_REG_CH3_WARNING_ALERT_LIM,
00052     INA3221_REG_SHUNTV_SUM,
00053     INA3221_REG_SHUNTV_SUM_LIM,
00054     INA3221_REG_MASK_ENABLE,
00055     INA3221_REG_PWR_VALID_HI_LIM,
00056     INA3221_REG_PWR_VALID_LO_LIM,
00057     INA3221_REG_MANUF_ID = 0xFE,
00058     INA3221_REG_DIE_ID = 0xFF
00059 } ina3221_reg_t;
00060
00065 typedef enum {
00066     INA3221_REG_CONF_CT_140US = 0,
00067     INA3221_REG_CONF_CT_204US,
00068     INA3221_REG_CONF_CT_332US,
00069     INA3221_REG_CONF_CT_588US,
00070     INA3221_REG_CONF_CT_1100US,
00071     INA3221_REG_CONF_CT_2116US,
00072     INA3221_REG_CONF_CT_4156US,
00073     INA3221_REG_CONF_CT_8244US
00074 } ina3221_conv_time_t;
00075
00080 typedef enum {
00081     INA3221_REG_CONF_AVG_1 = 0,
00082     INA3221_REG_CONF_AVG_4,
00083     INA3221_REG_CONF_AVG_16,
00084     INA3221_REG_CONF_AVG_64,
00085     INA3221_REG_CONF_AVG_128,
00086     INA3221_REG_CONF_AVG_256,
00087     INA3221_REG_CONF_AVG_512,
```

```

00088     INA3221_REG_CONF_AVG_1024
00089 } ina3221_avg_mode_t;
00090
00096 class INA3221 {
00097
00101     typedef struct {
00102         uint16_t mode_shunt_en:1;
00103         uint16_t mode_bus_en:1;
00104         uint16_t mode_continious_en:1;
00105         uint16_t shunt_conv_time:3;
00106         uint16_t bus_conv_time:3;
00107         uint16_t avg_mode:3;
00108         uint16_t ch3_en:1;
00109         uint16_t ch2_en:1;
00110         uint16_t ch1_en:1;
00111         uint16_t reset:1;
00112     } conf_reg_t;
00113
00117     typedef struct {
00118         uint16_t conv_ready:1;
00119         uint16_t timing_ctrl_alert:1;
00120         uint16_t pwr_valid_alert:1;
00121         uint16_t warn_alert_ch3:1;
00122         uint16_t warn_alert_ch2:1;
00123         uint16_t warn_alert_ch1:1;
00124         uint16_t shunt_sum_alert:1;
00125         uint16_t crit_alert_ch3:1;
00126         uint16_t crit_alert_ch2:1;
00127         uint16_t crit_alert_ch1:1;
00128         uint16_t crit_alert_latch_en:1;
00129         uint16_t warn_alert_latch_en:1;
00130         uint16_t shunt_sum_en_ch3:1;
00131         uint16_t shunt_sum_en_ch2:1;
00132         uint16_t shunt_sum_en_ch1:1;
00133         uint16_t reserved:1;
00134     } masken_reg_t;
00135
00136     i2c_inst_t* _i2c;
00137     // I2C address
00138     ina3221_addr_t _i2c_addr;
00139
00140     // Shunt resistance in mOhm
00141     uint32_t _shuntRes[INA3221_CH_NUM];
00142
00143     // Series filter resistance in Ohm
00144     uint32_t _filterRes[INA3221_CH_NUM];
00145
00146     // Value of Mask/Enable register.
00147     masken_reg_t _masken_reg;
00148
00149     // Reads 16 bytes from a register.
00150     void _read(ina3221_reg_t reg, uint16_t *val);
00151
00152     // Writes 16 bytes to a register.
00153     void _write(ina3221_reg_t reg, uint16_t *val);
00154
00155 public:
00156
00157     INA3221(ina3221_addr_t addr, i2c_inst_t* i2c);
00158     // Initializes INA3221
00159     bool begin();
00160
00161     // Gets a register value.
00162     uint16_t read_register(ina3221_reg_t reg);
00163
00164     // Resets INA3221
00165     void reset();
00166
00167     // Sets operating mode to power-down
00168     void set_mode_power_down();
00169
00170     // Sets operating mode to continious
00171     void set_mode_continious();
00172
00173     // Sets operating mode to triggered (single-shot)
00174     void set_mode_triggered();
00175
00176     // Enables shunt-voltage measurement
00177     void set_shunt_measurement_enable();
00178
00179     // Disables shunt-voltage mesurement
00180     void set_shunt_measurement_disable();
00181
00182     // Enables bus-voltage measurement
00183     void set_bus_measurement_enable();
00184
00185     // Disables bus-voltage measureement

```

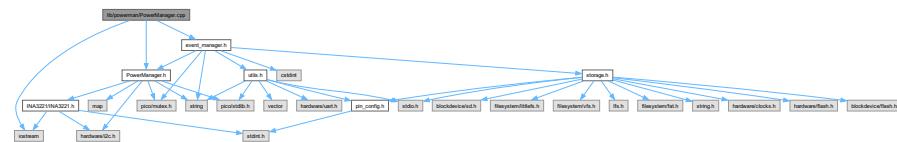
```

00186     void set_bus_measurement_disable();
00187
00188     // Sets averaging mode. Sets number of samples that are collected
00189     // and averaged together.
00190     void set_averaging_mode(ina3221_avg_mode_t mode);
00191
00192     // Sets bus-voltage conversion time.
00193     void set_bus_conversion_time(ina3221_conv_time_t convTime);
00194
00195     // Sets shunt-voltage conversion time.
00196     void set_shunt_conversion_time(ina3221_conv_time_t convTime);
00197
00198     // Gets manufacturer ID.
00199     // Should read 0x5449.
00200     uint16_t get_manufacturer_id();
00201
00202     // Gets die ID.
00203     // Should read 0x3220.
00204     uint16_t get_die_id();
00205
00206     // Gets shunt voltage in uV.
00207     int32_t get_shunt_voltage(ina3221_ch_t channel);
00208
00209     // Gets current in A.
00210     float get_current(ina3221_ch_t channel);
00211
00212     float get_current_ma(ina3221_ch_t channel);
00213
00214     // Gets bus voltage in V.
00215     float get_voltage(ina3221_ch_t channel);
00216
00217     void set_warn_alert_limit(ina3221_ch_t channel, float voltage_v);
00218     void set_crit_alert_limit(ina3221_ch_t channel, float voltage_v);
00219     void set_power_valid_limit(float voltage_upper_v, float voltage_lower_v);
00220     void enable_alerts();
00221     bool get_warn_alert(ina3221_ch_t channel);
00222     bool get_crit_alert(ina3221_ch_t channel);
00223     bool get_power_valid_alert();
00224     void set_alertLatch(bool enable);
00225 };
00226
00227 #endif

```

## 8.63 lib/powerman/PowerManager.cpp File Reference

```
#include "PowerManager.h"
#include <iostream>
#include "event_manager.h"
Include dependency graph for PowerManager.cpp:
```



## 8.64 PowerManager.cpp

Go to the documentation of this file.

```

00001 #include "PowerManager.h"
00002 #include <iostream>
00003 #include "event_manager.h"
00004
00005 PowerManager::PowerManager(i2c_inst_t* i2c)
00006     : ina3221_(INA3221_ADDR40_GND, i2c) {
00007         recursive_mutex_init(&powerman_mutex_);
00008     };
00009

```

```

00010     bool PowerManager::initialize() {
00011         recursive_mutex_enter_blocking(&powerman_mutex_);
00012         initialized_ = ina3221_.begin();
00013
00014         if (initialized_) {
00015             // Set up alerts
00016             ina3221_.set_warn_alert_limit(INA3221_CH2, VOLTAGE_LOW_THRESHOLD);
00017             ina3221_.set_crit_alert_limit(INA3221_CH2, VOLTAGE_OVERCHARGE_THRESHOLD);
00018             ina3221_.set_power_valid_limit(VOLTAGE_OVERCHARGE_THRESHOLD, VOLTAGE_LOW_THRESHOLD);
00019             ina3221_.enable_alerts();
00020             ina3221_.set_alert_latch(true);
00021         }
00022
00023         recursive_mutex_exit(&powerman_mutex_);
00024         return initialized_;
00025     }
00026
00027     std::string PowerManager::read_device_ids() {
00028         if (!initialized_) return "noinit";
00029         recursive_mutex_enter_blocking(&powerman_mutex_);
00030         std::string MAN = "MAN " + std::to_string(ina3221_.get_manufacturer_id());
00031         std::string DIE = "DIE " + std::to_string(ina3221_.get_die_id());
00032         recursive_mutex_exit(&powerman_mutex_);
00033         return MAN + " - " + DIE;
00034     }
00035
00036     float PowerManager::get_voltage_battery() {
00037         if (!initialized_) return 0.0f;
00038         recursive_mutex_enter_blocking(&powerman_mutex_);
00039         float voltage = ina3221_.get_voltage(INA3221_CH1);
00040         recursive_mutex_exit(&powerman_mutex_);
00041         return voltage;
00042     }
00043
00044     float PowerManager::get_voltage_5v() {
00045         if (!initialized_) return 0.0f;
00046         recursive_mutex_enter_blocking(&powerman_mutex_);
00047         float voltage = ina3221_.get_voltage(INA3221_CH2);
00048         recursive_mutex_exit(&powerman_mutex_);
00049         return voltage;
00050     }
00051
00052     float PowerManager::get_current_charge_usb() {
00053         if (!initialized_) return 0.0f;
00054         recursive_mutex_enter_blocking(&powerman_mutex_);
00055         float current = ina3221_.get_current_ma(INA3221_CH1);
00056         recursive_mutex_exit(&powerman_mutex_);
00057         return current;
00058     }
00059
00060     float PowerManager::get_current_draw() {
00061         if (!initialized_) return 0.0f;
00062         recursive_mutex_enter_blocking(&powerman_mutex_);
00063         float current = ina3221_.get_current_ma(INA3221_CH2);
00064         recursive_mutex_exit(&powerman_mutex_);
00065         return current;
00066     }
00067
00068     float PowerManager::get_current_charge_solar() {
00069         if (!initialized_) return 0.0f;
00070         recursive_mutex_enter_blocking(&powerman_mutex_);
00071         float current = ina3221_.get_current_ma(INA3221_CH3);
00072         recursive_mutex_exit(&powerman_mutex_);
00073         return current;
00074     }
00075
00076     float PowerManager::get_current_charge_total() {
00077         if (!initialized_) return 0.0f;
00078         recursive_mutex_enter_blocking(&powerman_mutex_);
00079         float current = ina3221_.get_current_ma(INA3221_CH1) + ina3221_.get_current_ma(INA3221_CH3);
00080         recursive_mutex_exit(&powerman_mutex_);
00081         return current;
00082     }
00083
00084     void PowerManager::configure(const std::map<std::string, std::string>& config) {
00085         if (!initialized_) return;
00086         recursive_mutex_enter_blocking(&powerman_mutex_);
00087
00088         if (config.find("operating_mode") != config.end()) {
00089             if (config.at("operating_mode") == "continuous") {
00090                 ina3221_.set_mode_continuous();
00091             }
00092         }
00093
00094         if (config.find("averaging_mode") != config.end()) {
00095             int avg_mode = std::stoi(config.at("averaging_mode"));
00096             switch(avg_mode) {

```

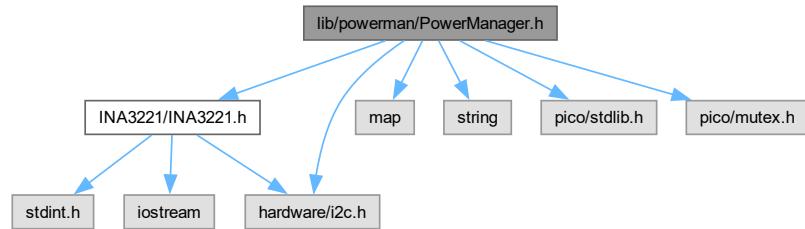
```

00097     case 1:
00098         ina3221_.set_averaging_mode(INA3221_REG_CONF_AVG_1);
00099         break;
00100     case 4:
00101         ina3221_.set_averaging_mode(INA3221_REG_CONF_AVG_4);
00102         break;
00103     case 16:
00104         ina3221_.set_averaging_mode(INA3221_REG_CONF_AVG_16);
00105         break;
00106     default:
00107         ina3221_.set_averaging_mode(INA3221_REG_CONF_AVG_16);
00108     }
00109 }
00110 recursive_mutex_exit(&powerman_mutex_);
00111 }
00112
00113 bool PowerManager::is_charging_solar() {
00114     if (!initialized_) return false;
00115     recursive_mutex_enter_blocking(&powerman_mutex_);
00116     bool active = get_current_charge_solar() > SOLAR_CURRENT_THRESHOLD;
00117     recursive_mutex_exit(&powerman_mutex_);
00118     return active;
00119 }
00120
00121 bool PowerManager::is_charging_usb() {
00122     if (!initialized_) return false;
00123     recursive_mutex_enter_blocking(&powerman_mutex_);
00124     bool connected = get_current_charge_usb() > USB_CURRENT_THRESHOLD;
00125     recursive_mutex_exit(&powerman_mutex_);
00126     return connected;
00127 }
00128
00129 bool PowerManager::check_power_alerts() {
00130     if (!initialized_) return false;
00131
00132     recursive_mutex_enter_blocking(&powerman_mutex_);
00133
00134     bool status_changed = false;
00135
00136     // Check warning alert (low battery)
00137     if (ina3221_.get_warn_alert(INA3221_CH2)) {
00138         EventEmitter::emit(EventGroup::POWER, PowerEvent::LOW_BATTERY);
00139         status_changed = true;
00140     }
00141
00142     // Check critical alert (overcharge)
00143     if (ina3221_.get_crit_alert(INA3221_CH2)) {
00144         EventEmitter::emit(EventGroup::POWER, PowerEvent::OVERCHARGE);
00145         status_changed = true;
00146     }
00147
00148     // Check power valid alert
00149     if (ina3221_.get_power_valid_alert()) {
00150         EventEmitter::emit(EventGroup::POWER, PowerEvent::POWER_NORMAL);
00151         status_changed = true;
00152     }
00153
00154     recursive_mutex_exit(&powerman_mutex_);
00155     return status_changed;
00156 }
```

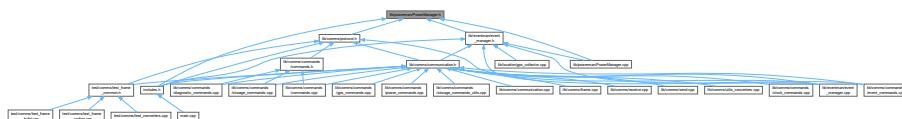
## 8.65 lib/powerman/PowerManager.h File Reference

```
#include "INA3221/INA3221.h"
#include <map>
#include <string>
#include <hardware/i2c.h>
#include "pico/stdlib.h"
#include "pico/mutex.h"
```

Include dependency graph for PowerManager.h:



This graph shows which files directly or indirectly include this file:



## Classes

- class [PowerManager](#)

## 8.66 PowerManager.h

[Go to the documentation of this file.](#)

```

00001 #ifndef POWER_MANAGER_H
00002 #define POWER_MANAGER_H
00003
00004 #include "INA3221/INA3221.h"
00005 #include <map>
00006 #include <string>
00007 #include <hardware/i2c.h>
00008 #include "pico/stdlib.h"
00009 #include "pico/mutex.h"
00010
00011 class PowerManager {
00012 public:
00013     PowerManager(i2c_inst_t* i2c);
00014     bool initialize();
00015     std::string read_device_ids();
00016     float get_current_charge_solar();
00017     float get_current_charge_usb();
00018     float get_current_charge_total();
00019     float get_current_draw();
00020     float get_voltage_battery();
00021     float get_voltage_5v();
00022     void configure(const std::map<std::string, std::string>& config);
00023     bool is_charging_solar();
00024     bool is_charging_usb();
00025     bool check_power_alerts();
00026
00027     static constexpr float SOLAR_CURRENT_THRESHOLD = 50.0f; // mA
00028     static constexpr float USB_CURRENT_THRESHOLD = 50.0f; // mA
00029     static constexpr float VOLTAGE_LOW_THRESHOLD = 4.7f; // V
00030     static constexpr float VOLTAGE_OVERCHARGE_THRESHOLD = 5.3f; // V
00031     static constexpr float FALL_RATE_THRESHOLD = -0.02f; // V/sample
00032     static constexpr int FALLING_TREND_REQUIRED = 3; // samples
00033
00034
  
```

```

00035 private:
00036     INA3221 ina3221_;
00037     bool initialized_;
00038     recursive_mutex_t powerman_mutex_;
00039     bool charging_solar_active_ = false;
00040     bool charging_usb_active_ = false;
00041 };
00042
00043 #endif // POWER_MANAGER_H

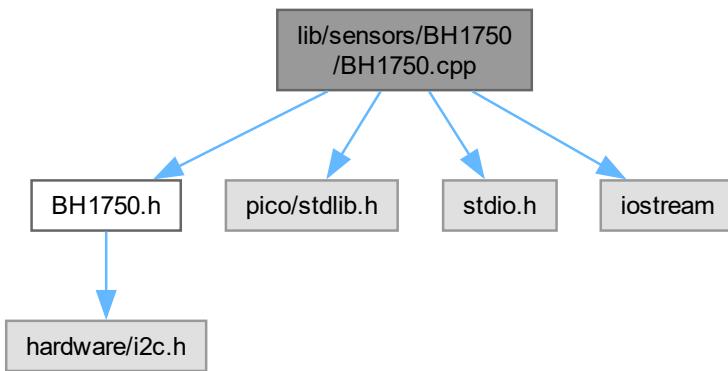
```

## 8.67 lib/sensors/BH1750/BH1750.cpp File Reference

```

#include "BH1750.h"
#include "pico/stl.h"
#include <stdio.h>
#include <iostream>
Include dependency graph for BH1750.cpp:

```



## 8.68 BH1750.cpp

[Go to the documentation of this file.](#)

```

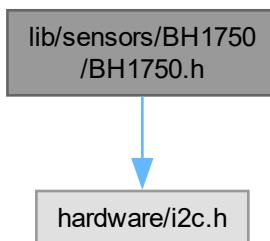
00001 #include "BH1750.h"
00002 #include "pico/stl.h"
00003 #include <stdio.h>
00004 #include <iostream>
00005
00006 BH1750::BH1750(uint8_t addr) : _i2c_addr(addr) {}
00007
00008 bool BH1750::begin(Mode mode) {
00009     write8(static_cast<uint8_t>(Mode::POWER_ON));
00010     write8(static_cast<uint8_t>(Mode::RESET));
00011     configure(mode);
00012     configure(BH1750::Mode::POWER_ON);
00013     uint8_t check = 0;
00014     uint8_t cmd = 0x10; // Continuously H-Resolution Mode
00015     if (i2c_write_blocking(i2c1, _i2c_addr, &cmd, 1, false) == 1) {
00016         std::cout << "BH1750 sensor found at 0x" << std::hex << (int)_i2c_addr << std::endl;
00017         return true;
00018     }
00019     return false;
00020 }
00021
00022 void BH1750::configure(Mode mode) {

```

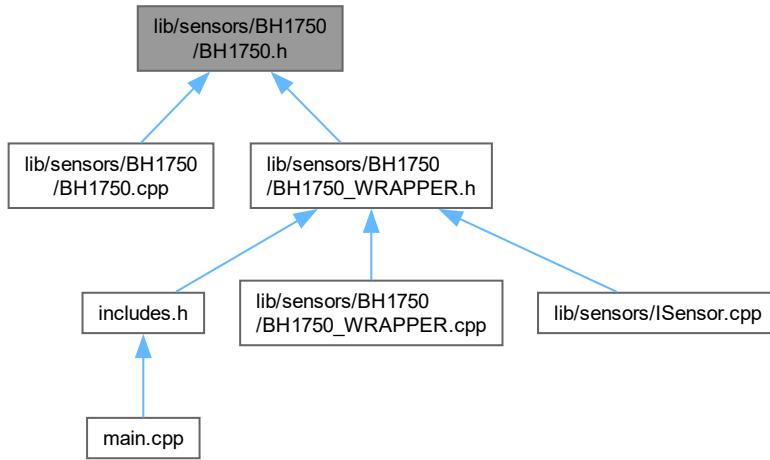
```
00023     uint8_t modeVal = static_cast<uint8_t>(mode);
00024     switch (mode) {
00025         case Mode::CONTINUOUS_HIGH_RES_MODE:
00026         case Mode::CONTINUOUS_HIGH_RES_MODE_2:
00027         case Mode::CONTINUOUS_LOW_RES_MODE:
00028         case Mode::ONE_TIME_HIGH_RES_MODE:
00029         case Mode::ONE_TIME_HIGH_RES_MODE_2:
00030         case Mode::ONE_TIME_LOW_RES_MODE:
00031             write8(modeVal);
00032             sleep_ms(10);
00033             break;
00034     default:
00035         printf("Invalid measurement mode\n");
00036         break;
00037     }
00038 }
00039
00040 float BH1750::get_light_level() {
00041     uint8_t buffer[2];
00042     i2c_read_blocking(i2c_default, _i2c_addr, buffer, 2, false);
00043     uint16_t level = (buffer[0] << 8) | buffer[1];
00044
00045     float lux = static_cast<float>(level) / 1.2f;
00046     return lux;
00047 }
00048
00049 void BH1750::write8(uint8_t data) {
00050     uint8_t buf[1] = {data};
00051     i2c_write_blocking(i2c_default, _i2c_addr, buf, 1, false);
00052 }
```

## 8.69 lib/sensors/BH1750/BH1750.h File Reference

```
#include "hardware/i2c.h"
Include dependency graph for BH1750.h:
```



This graph shows which files directly or indirectly include this file:



## Classes

- class [BH1750](#)

## Macros

- `#define _BH1750_DEVICE_ID 0xE1`
- `#define _BH1750_MTREG_MIN 31`
- `#define _BH1750_MTREG_MAX 254`
- `#define _BH1750_DEFAULT_MTREG 69`

### 8.69.1 Macro Definition Documentation

#### 8.69.1.1 `_BH1750_DEVICE_ID`

```
#define _BH1750_DEVICE_ID 0xE1
```

Definition at line [7](#) of file [BH1750.h](#).

#### 8.69.1.2 `_BH1750_MTREG_MIN`

```
#define _BH1750_MTREG_MIN 31
```

Definition at line [8](#) of file [BH1750.h](#).

### 8.69.1.3 \_BH1750\_MTREG\_MAX

```
#define _BH1750_MTREG_MAX 254
```

Definition at line 9 of file [BH1750.h](#).

### 8.69.1.4 \_BH1750\_DEFAULT\_MTREG

```
#define _BH1750_DEFAULT_MTREG 69
```

Definition at line 10 of file [BH1750.h](#).

## 8.70 BH1750.h

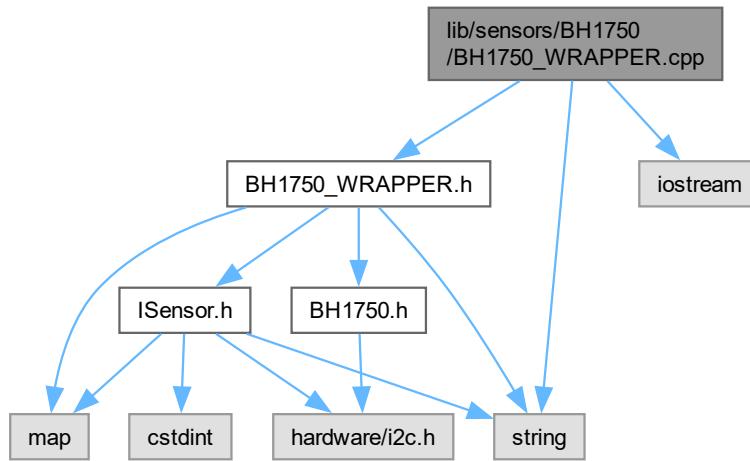
[Go to the documentation of this file.](#)

```
00001 #ifndef __BH1750_H__
00002 #define __BH1750_H__
00003
00004 #include "hardware/i2c.h"
00005
00006 // Define constants
00007 #define _BH1750_DEVICE_ID 0xE1 // Correct content of WHO_AM_I register
00008 #define _BH1750_MTREG_MIN 31
00009 #define _BH1750_MTREG_MAX 254
00010 #define _BH1750_DEFAULT_MTREG 69
00011
00012 class BH1750 {
00013 public:
00014     // Scoped enum for measurement modes
00015     enum class Mode : uint8_t {
00016         UNCONFIGURED_POWER_DOWN = 0x00,
00017         POWER_ON = 0x01,
00018         RESET = 0x07,
00019         CONTINUOUS_HIGH_RES_MODE = 0x10,
00020         CONTINUOUS_HIGH_RES_MODE_2 = 0x11,
00021         CONTINUOUS_LOW_RES_MODE = 0x13,
00022         ONE_TIME_HIGH_RES_MODE = 0x20,
00023         ONE_TIME_HIGH_RES_MODE_2 = 0x21,
00024         ONE_TIME_LOW_RES_MODE = 0x23
00025     };
00026
00027     BH1750(uint8_t addr = 0x23);
00028     bool begin(Mode mode = Mode::CONTINUOUS_HIGH_RES_MODE);
00029     void configure(Mode mode);
00030     float get_light_level();
00031
00032 private:
00033     void write8(uint8_t data);
00034     uint8_t _i2c_addr;
00035 };
00036
00037 #endif // __BH1750_H__
```

## 8.71 lib/sensors/BH1750/BH1750\_WRAPPER.cpp File Reference

```
#include "BH1750_WRAPPER.h"
#include <string>
```

```
#include <iostream>
Include dependency graph for BH1750_WRAPPER.cpp:
```



## 8.72 BH1750\_WRAPPER.cpp

[Go to the documentation of this file.](#)

```

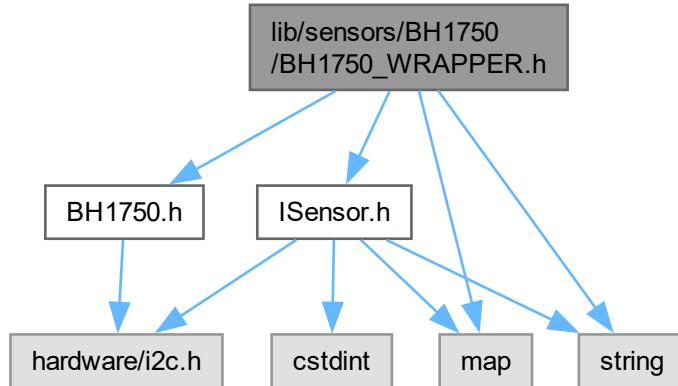
00001 // BH1750Wrapper.cpp
00002 #include "BH1750_WRAPPER.h"
00003 #include <string>
00004 #include <iostream>
00005
00006 BH1750Wrapper::BH1750Wrapper() {
00007     sensor_.configure(BH1750::Mode::CONTINUOUS_HIGH_RES_MODE);
00008 }
00009
00010 bool BH1750Wrapper::init() {
00011     initialized_ = sensor_.begin();
00012     return initialized_;
00013 }
00014
00015 float BH1750Wrapper::read_data(SensorDataTypeIdentifier type) {
00016     if (type == SensorDataTypeIdentifier::LIGHT_LEVEL) {
00017         return sensor_.get_light_level();
00018     }
00019     return 0.0f;
00020 }
00021
00022 bool BH1750Wrapper::is_initialized() const {
00023     return initialized_;
00024 }
00025
00026 SensorType BH1750Wrapper::get_type() const {
00027     return SensorType::LIGHT;
00028 }
00029
00030 bool BH1750Wrapper::configure(const std::map<std::string, std::string>& config) {
00031     for (const auto& [key, value] : config) {
00032         if (key == "measurement_mode") {
00033             if (value == "continuously_high_resolution") {
00034                 sensor_.configure(BH1750::Mode::CONTINUOUS_HIGH_RES_MODE);
00035             }
00036             else if (value == "continuously_high_resolution_2") {
00037                 sensor_.configure(BH1750::Mode::CONTINUOUS_HIGH_RES_MODE_2);
00038             }
00039             else if (value == "continuously_low_resolution") {
00040                 sensor_.configure(BH1750::Mode::CONTINUOUS_LOW_RES_MODE);
00041             }
00042         }
00043     }
00044 }
```

```

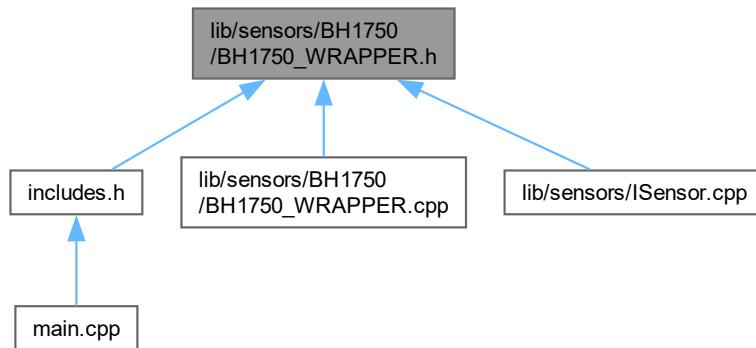
00042     else if (value == "one_time_high_resolution") {
00043         sensor_.configure(BH1750::Mode::ONE_TIME_HIGH_RES_MODE);
00044     }
00045     else if (value == "one_time_high_resolution_2") {
00046         sensor_.configure(BH1750::Mode::ONE_TIME_HIGH_RES_MODE_2);
00047     }
00048     else if (value == "one_time_low_resolution") {
00049         sensor_.configure(BH1750::Mode::ONE_TIME_LOW_RES_MODE);
00050     }
00051     else {
00052         std::cerr << "[BH1750Wrapper] Unknown measurement_mode value: " << value << std::endl;
00053         return false;
00054     }
00055 }
00056 // Handle additional configuration keys here
00057 else {
00058     std::cerr << "[BH1750Wrapper] Unknown configuration key: " << key << std::endl;
00059     return false;
00060 }
00061 }
00062 return true;
00063 }
```

## 8.73 lib/sensors/BH1750/BH1750\_WRAPPER.h File Reference

```
#include "ISensor.h"
#include "BH1750.h"
#include <map>
#include <string>
Include dependency graph for BH1750_WRAPPER.h:
```



This graph shows which files directly or indirectly include this file:



## Classes

- class [BH1750Wrapper](#)

## 8.74 BH1750\_WRAPPER.h

[Go to the documentation of this file.](#)

```

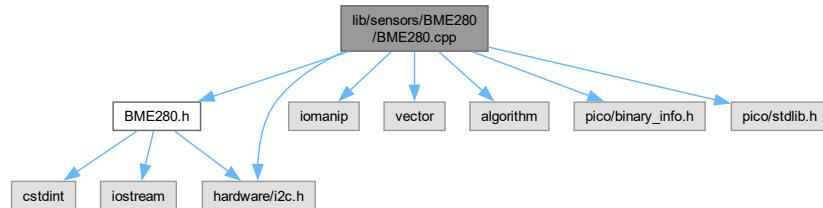
00001 #ifndef BH1750_WRAPPER_H
00002 #define BH1750_WRAPPER_H
00003
00004 #include "ISensor.h"
00005 #include "BH1750.h"
00006 #include <map>
00007 #include <string>
00008
00009 class BH1750Wrapper : public ISensor {
00010 private:
00011     BH1750 sensor_;
00012     bool initialized_ = false;
00013
00014 public:
00015     BH1750Wrapper();
00016     int get_i2c_addr();
00017     bool init() override;
00018     float read_data(SensorDataTypeIdentifier type) override;
00019     bool is_initialized() const override;
00020     SensorType get_type() const override;
00021
00022     bool configure(const std::map<std::string, std::string>& config);
00023
00024 };
00025
00026 #endif // BH1750_WRAPPER_H
  
```

## 8.75 lib/sensors/BME280/BME280.cpp File Reference

```

#include "BME280.h"
#include <iomanip>
#include <vector>
#include <algorithm>
  
```

```
#include "hardware/i2c.h"
#include "pico/binary_info.h"
#include "pico/stdlib.h"
Include dependency graph for BME280.cpp:
```



## 8.76 BME280.cpp

[Go to the documentation of this file.](#)

```

00001 // BME280.cpp
00002
00003 #include "BME280.h"
00004
00005 #include <iomanip>
00006 #include <vector>
00007 #include <algorithm>
00008 #include "hardware/i2c.h"
00009 #include "pico/binary_info.h"
00010 #include "pico/stdlib.h"
00011
00012 // BME280 (BME280) Class Implementation
00013
00014 BME280::BME280(i2c_inst_t* i2cPort, uint8_t address)
00015     : i2c_port(i2cPort), device_addr(address), calib_params{}, initialized_(false), t_fine(0) {
00016 }
00017
00018 bool BME280::init() {
00019     if (!i2c_port) {
00020         std::cerr << "Invalid I2C port.\n";
00021         return false;
00022     }
00023
00024     // Check device ID to confirm it's a BME280
00025     uint8_t reg = 0xD0; // Chip ID register
00026     uint8_t chip_id = 0;
00027     int ret = i2c_write_blocking(i2c_port, device_addr, &reg, 1, true);
00028     if (ret != 1) {
00029         std::cerr << "Failed to write to BME280.\n";
00030         return false;
00031     }
00032     ret = i2c_read_blocking(i2c_port, device_addr, &chip_id, 1, false);
00033     if (ret != 1) {
00034         std::cerr << "Failed to read chip ID from BME280.\n";
00035         return false;
00036     }
00037     if (chip_id != 0x60) {
00038         std::cerr << "Device is not a BME280.\n";
00039         return false;
00040     }
00041
00042     // Configure sensor
00043     if (!configure_sensor()) {
00044         std::cerr << "Failed to configure BME280 sensor.\n";
00045         return false;
00046     }
00047
00048     // Retrieve calibration parameters
00049     if (!get_calibration_parameters()) {
00050         std::cerr << "Failed to retrieve calibration parameters.\n";
00051         return false;
00052     }
00053

```

```

00054     initialized_ = true;
00055     std::cout << "BME280 sensor initialized_ successfully.\n";
00056     return true;
00057 }
00058
00059 void BME280::reset() {
00060     uint8_t buf[2] = { REG_RESET, 0xB6 };
00061     int ret = i2c_write_blocking(i2c_port, device_addr, buf, 2, false);
00062     if (ret != 2) {
00063         std::cerr << "Failed to reset BME280 sensor.\n";
00064     }
00065     sleep_ms(10); // Wait for reset to complete
00066 }
00067
00068 bool BME280::read_raw_all(int32_t* temperature, int32_t* pressure, int32_t* humidity) {
00069     if (!initialized_) {
00070         std::cerr << "BME280 not initialized_.\n";
00071         return false;
00072     }
00073
00074     // Define the starting register address
00075     uint8_t start_reg = REG_PRESSURE_MSB;
00076     // Total bytes to read: 3 (pressure) + 3 (temperature) + 2 (humidity) = 8
00077     uint8_t buf[8] = {0};
00078
00079     // Write the starting register address
00080     int ret = i2c_write_blocking(i2c_port, device_addr, &start_reg, 1, true);
00081     if (ret != 1) {
00082         std::cerr << "Failed to write starting register address to BME280.\n";
00083         return false;
00084     }
00085
00086     // Read data
00087     ret = i2c_read_blocking(i2c_port, device_addr, buf, 8, false);
00088     if (ret != 8) {
00089         std::cerr << "Failed to read data from BME280.\n";
00090         return false;
00091     }
00092
00093     // Combine bytes to form raw values
00094     *pressure = ((int32_t)buf[0] << 12) | ((int32_t)buf[1] << 4) | ((int32_t)(buf[2] >> 4));
00095     *temperature = ((int32_t)buf[3] << 12) | ((int32_t)buf[4] << 4) | ((int32_t)(buf[5] >> 4));
00096     *humidity = ((int32_t)buf[6] << 8) | (int32_t)buf[7];
00097
00098     return true;
00099 }
00100
00101 float BME280::convert_temperature(int32_t temp_raw) const {
00102     int32_t var1, var2;
00103     var1 = (((temp_raw >> 3) - ((int32_t)calib_params.dig_t1 << 1))) * ((int32_t)calib_params.dig_t2)
00104     » 11;
00105     var2 = (((((temp_raw >> 4) - ((int32_t)calib_params.dig_t1)) * ((temp_raw >> 4) -
00106     ((int32_t)calib_params.dig_t1)) » 12) * ((int32_t)calib_params.dig_t3)) » 14;
00107     t_fine = var1 + var2;
00108     float T = (t_fine * 5 + 128) » 8;
00109     return T / 100.0f;
00110 }
00111
00112 float BME280::convert_pressure(int32_t pressure_raw) const {
00113     int64_t var1, var2, p;
00114     var1 = ((int64_t)t_fine) - 128000;
00115     var2 = var1 * var1 * (int64_t)calib_params.dig_p6;
00116     var2 = var2 + ((var1 * (int64_t)calib_params.dig_p5) » 17);
00117     var2 = var2 + (((int64_t)calib_params.dig_p4) » 35);
00118     var1 = ((var1 * var1 * (int64_t)calib_params.dig_p3) » 8) + ((var1 * (int64_t)calib_params.dig_p2)
00119     » 12);
00120     var1 = (((int64_t)1 << 47) + var1) * ((int64_t)calib_params.dig_p1) » 33;
00121
00122     if (var1 == 0) {
00123         return 0.0f; // avoid exception caused by division by zero
00124     }
00125     p = 1048576 - pressure_raw;
00126     p = (((p << 31) - var2) * 3125) / var1;
00127     var1 = (((int64_t)calib_params.dig_p9) * (p » 13) * (p » 13)) » 25;
00128     var2 = (((int64_t)calib_params.dig_p8) * p) » 19;
00129
00130     p = ((p + var1 + var2) » 8) + (((int64_t)calib_params.dig_p7) » 4);
00131     return (float)p / 25600.0f; // in hPa
00132 }
00133
00134 float BME280::convert_humidity(int32_t humidity_raw) const {
00135     int32_t v_x1_u32r;
00136     v_x1_u32r = t_fine - 76800;
00137     v_x1_u32r = (((((humidity_raw << 14) - ((int32_t)calib_params.dig_h4 << 20) -
00138     ((int32_t)calib_params.dig_h5 * v_x1_u32r) + 16384) » 15) *
00139     (((((v_x1_u32r * (int32_t)calib_params.dig_h6) » 10) * (((v_x1_u32r *
00140     (int32_t)calib_params.dig_h3) » 11) + 32768)) » 10) + 2097152) *

```

```

00136             (int32_t)calib_params.dig_h2 + 8192) » 14));
00137     v_xl_u32r = std::max(v_xl_u32r, (int32_t)0);
00138     v_xl_u32r = std::min(v_xl_u32r, (int32_t)419430400);
00139     float h = v_xl_u32r » 12;
00140     return h / 1024.0f;
00141 }
00142
00143 bool BME280::get_calibration_parameters() {
00144     // Read temperature and pressure calibration data (0x88 to 0xA1)
00145     uint8_t calib_data[26];
00146     uint8_t reg = REG_DIG_T1_LSB;
00147     int ret = i2c_write_blocking(i2c_port, device_addr, &reg, 1, true);
00148     if (ret != 1) {
00149         std::cerr « "Failed to write to BME280.\n";
00150         return false;
00151     }
00152     ret = i2c_read_blocking(i2c_port, device_addr, calib_data, 26, false);
00153     if (ret != 26) {
00154         std::cerr « "Failed to read calibration data from BME280.\n";
00155         return false;
00156     }
00157
00158     // Parse temperature calibration data
00159     calib_params.dig_t1 = (uint16_t)(calib_data[1] « 8 | calib_data[0]);
00160     calib_params.dig_t2 = (int16_t)(calib_data[3] « 8 | calib_data[2]);
00161     calib_params.dig_t3 = (int16_t)(calib_data[5] « 8 | calib_data[4]);
00162
00163     // Parse pressure calibration data
00164     calib_params.dig_p1 = (uint16_t)(calib_data[7] « 8 | calib_data[6]);
00165     calib_params.dig_p2 = (int16_t)(calib_data[9] « 8 | calib_data[8]);
00166     calib_params.dig_p3 = (int16_t)(calib_data[11] « 8 | calib_data[10]);
00167     calib_params.dig_p4 = (int16_t)(calib_data[13] « 8 | calib_data[12]);
00168     calib_params.dig_p5 = (int16_t)(calib_data[15] « 8 | calib_data[14]);
00169     calib_params.dig_p6 = (int16_t)(calib_data[17] « 8 | calib_data[16]);
00170     calib_params.dig_p7 = (int16_t)(calib_data[19] « 8 | calib_data[18]);
00171     calib_params.dig_p8 = (int16_t)(calib_data[21] « 8 | calib_data[20]);
00172     calib_params.dig_p9 = (int16_t)(calib_data[23] « 8 | calib_data[22]);
00173
00174     calib_params.dig_h1 = calib_data[25];
00175
00176     // Read humidity calibration data (0xE1 to 0xE7)
00177     reg = 0xE1;
00178     ret = i2c_write_blocking(i2c_port, device_addr, &reg, 1, true);
00179     if (ret != 1) {
00180         std::cerr « "Failed to write to BME280 for humidity calibration.\n";
00181         return false;
00182     }
00183
00184     uint8_t hum_calib_data[7];
00185     ret = i2c_read_blocking(i2c_port, device_addr, hum_calib_data, 7, false);
00186     if (ret != 7) {
00187         std::cerr « "Failed to read humidity calibration data from BME280.\n";
00188         return false;
00189     }
00190
00191     // Parse humidity calibration data
00192     calib_params.dig_h2 = (int16_t)(hum_calib_data[1] « 8 | hum_calib_data[0]);
00193     calib_params.dig_h3 = hum_calib_data[2];
00194     calib_params.dig_h4 = (int16_t)((hum_calib_data[3] « 4) | (hum_calib_data[4] & 0x0F));
00195     calib_params.dig_h5 = (int16_t)((hum_calib_data[5] « 4) | (hum_calib_data[4] » 4));
00196     calib_params.dig_h6 = (int8_t)hum_calib_data[6];
00197
00198     return true;
00199 }
00200
00201 bool BME280::configure_sensor() {
00202     uint8_t buf[2];
00203
00204     // Set humidity oversampling (must be set before ctrl_meas)
00205     buf[0] = REG_CTRL_HUM;
00206     buf[1] = 0x05; // Humidity oversampling xl6
00207     int ret = i2c_write_blocking(i2c_port, device_addr, buf, 2, false);
00208     if (ret != 2) {
00209         std::cerr « "Failed to write CTRL_HUM to BME280.\n";
00210         return false;
00211     }
00212
00213     // Write config register
00214     buf[0] = REG_CONFIG;
00215     buf[1] = 0x00; // Default settings
00216     ret = i2c_write_blocking(i2c_port, device_addr, buf, 2, false);
00217     if (ret != 2) {
00218         std::cerr « "Failed to write CONFIG to BME280.\n";
00219         return false;
00220     }
00221
00222     // Write ctrl_meas register

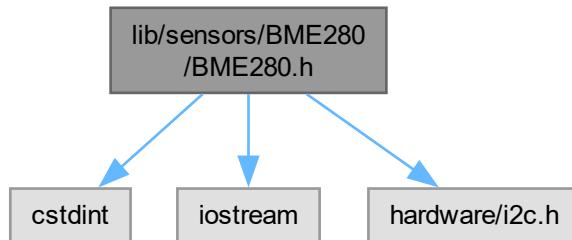
```

```

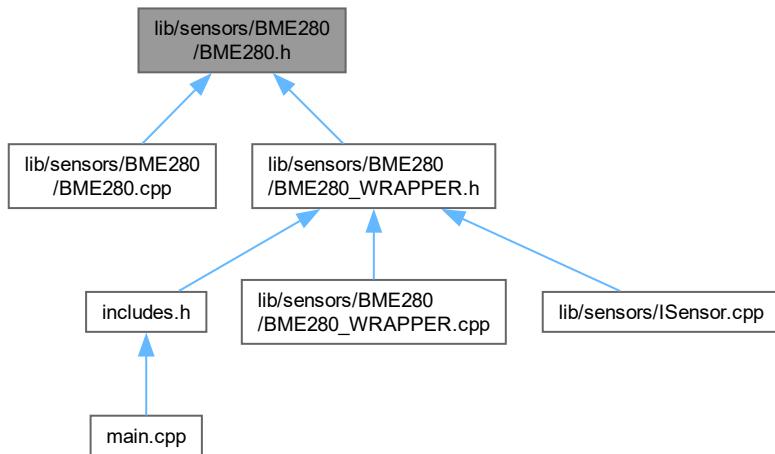
00223     buf[0] = REG_CTRL_MEAS;
00224     buf[1] = 0xB7; // Temp and pressure oversampling x16, normal mode
00225     ret = i2c_write_blocking(i2c_port, device_addr, buf, 2, false);
00226     if (ret !=2) {
00227         std::cerr << "Failed to write CTRL_MEAS to BME280.\n";
00228         return false;
00229     }
00230
00231     return true;
00232 }
```

## 8.77 lib/sensors/BME280/BME280.h File Reference

```
#include <cstdint>
#include <iostream>
#include "hardware/i2c.h"
Include dependency graph for BME280.h:
```



This graph shows which files directly or indirectly include this file:



## Classes

- struct **BME280CalibParam**
- class **BME280**

## 8.78 BME280.h

[Go to the documentation of this file.](#)

```

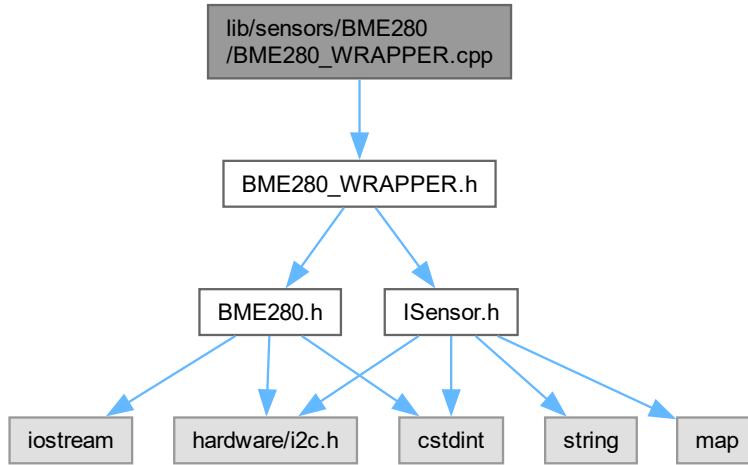
00001 // BME280.h
00002
00003 #ifndef BME280_H
00004 #define BME280_H
00005
00006 #include <cstdint>
00007 #include <iostream>
00008 #include "hardware/i2c.h"
00009
00010 // Calibration parameters structure
00011 struct BME280CalibParam {
00012     // Temperature parameters
00013     uint16_t dig_t1;
00014     int16_t dig_t2;
00015     int16_t dig_t3;
00016
00017     // Pressure parameters
00018     uint16_t dig_p1;
00019     int16_t dig_p2;
00020     int16_t dig_p3;
00021     int16_t dig_p4;
00022     int16_t dig_p5;
00023     int16_t dig_p6;
00024     int16_t dig_p7;
00025     int16_t dig_p8;
00026     int16_t dig_p9;
00027
00028     // Humidity parameters
00029     uint8_t dig_h1;
00030     int16_t dig_h2;
00031     uint8_t dig_h3;
00032     int16_t dig_h4;
00033     int16_t dig_h5;
00034     int8_t dig_h6;
00035 };
00036
00037 // BME280 Class Definition
00038 class BME280 {
00039 public:
00040     // I2C Address Options
00041     static constexpr uint8_t ADDR_SDO_LOW = 0x76;
00042     static constexpr uint8_t ADDR_SDO_HIGH = 0x77;
00043
00044     // Constructor
00045     BME280(i2c_inst_t* i2cPort, uint8_t address = ADDR_SDO_LOW);
00046
00047     // Initialize the sensor
00048     bool init();
00049
00050     // Reset the sensor
00051     void reset();
00052
00053     // Read all raw data: temperature, pressure, and humidity
00054     bool read_raw_all(int32_t* temperature, int32_t* pressure, int32_t* humidity);
00055
00056     // Convert raw data to actual values
00057     float convert_temperature(int32_t temp_raw) const;
00058     float convert_pressure(int32_t pressure_raw) const;
00059     float convert_humidity(int32_t humidity_raw) const;
00060
00061 private:
00062     // Configure the sensor
00063     bool configure_sensor();
00064
00065     // Retrieve calibration parameters from the sensor
00066     bool get_calibration_parameters();
00067
00068     // I2C port and device address
00069     i2c_inst_t* i2c_port;
00070     uint8_t device_addr;
00071

```

```
00072 // Calibration parameters
00073 BME280CalibParam calib_params;
00074
00075 // Initialization status
00076 bool initialized_;
00077
00078 // Fine temperature parameter needed for compensation
00079 mutable int32_t t_fine;
00080
00081 // Register Definitions
00082 static constexpr uint8_t REG_CONFIG = 0xF5;
00083 static constexpr uint8_t REG_CTRL_MEAS = 0xF4;
00084 static constexpr uint8_t REG_CTRL_HUM = 0xF2;
00085 static constexpr uint8_t REG_RESET = 0xE0;
00086
00087 static constexpr uint8_t REG_PRESSURE_MSB = 0xF7;
00088 static constexpr uint8_t REG_TEMPERATURE_MSB = 0xFA;
00089 static constexpr uint8_t REG_HUMIDITY_MSB = 0xFD;
00090
00091 // Calibration Registers
00092 static constexpr uint8_t REG_DIG_T1_LSB = 0x88;
00093 static constexpr uint8_t REG_DIG_T1_MSB = 0x89;
00094 static constexpr uint8_t REG_DIG_T2_LSB = 0x8A;
00095 static constexpr uint8_t REG_DIG_T2_MSB = 0x8B;
00096 static constexpr uint8_t REG_DIG_T3_LSB = 0x8C;
00097 static constexpr uint8_t REG_DIG_T3_MSB = 0x8D;
00098
00099 static constexpr uint8_t REG_DIG_P1_LSB = 0x8E;
00100 static constexpr uint8_t REG_DIG_P1_MSB = 0x8F;
00101 static constexpr uint8_t REG_DIG_P2_LSB = 0x90;
00102 static constexpr uint8_t REG_DIG_P2_MSB = 0x91;
00103 static constexpr uint8_t REG_DIG_P3_LSB = 0x92;
00104 static constexpr uint8_t REG_DIG_P3_MSB = 0x93;
00105 static constexpr uint8_t REG_DIG_P4_LSB = 0x94;
00106 static constexpr uint8_t REG_DIG_P4_MSB = 0x95;
00107 static constexpr uint8_t REG_DIG_P5_LSB = 0x96;
00108 static constexpr uint8_t REG_DIG_P5_MSB = 0x97;
00109 static constexpr uint8_t REG_DIG_P6_LSB = 0x98;
00110 static constexpr uint8_t REG_DIG_P6_MSB = 0x99;
00111 static constexpr uint8_t REG_DIG_P7_LSB = 0x9A;
00112 static constexpr uint8_t REG_DIG_P7_MSB = 0x9B;
00113 static constexpr uint8_t REG_DIG_P8_LSB = 0x9C;
00114 static constexpr uint8_t REG_DIG_P8_MSB = 0x9D;
00115 static constexpr uint8_t REG_DIG_P9_LSB = 0x9E;
00116 static constexpr uint8_t REG_DIG_P9_MSB = 0x9F;
00117
00118 // Humidity Calibration Registers
00119 static constexpr uint8_t REG_DIG_H1 = 0xA1;
00120 static constexpr uint8_t REG_DIG_H2 = 0xE1;
00121 static constexpr uint8_t REG_DIG_H3 = 0xE3;
00122 static constexpr uint8_t REG_DIG_H4 = 0xE4;
00123 static constexpr uint8_t REG_DIG_H5 = 0xE5;
00124 static constexpr uint8_t REG_DIG_H6 = 0xE7;
00125
00126 // Number of calibration parameters to read
00127 static constexpr size_t NUM_CALIB_PARAMS = 24;
00128 };
00129
00130 #endif // BME280_H
```

## 8.79 lib/sensors/BME280/BME280\_WRAPPER.cpp File Reference

```
#include "BME280_WRAPPER.h"
Include dependency graph for BME280_WRAPPER.cpp:
```



## 8.80 BME280\_WRAPPER.cpp

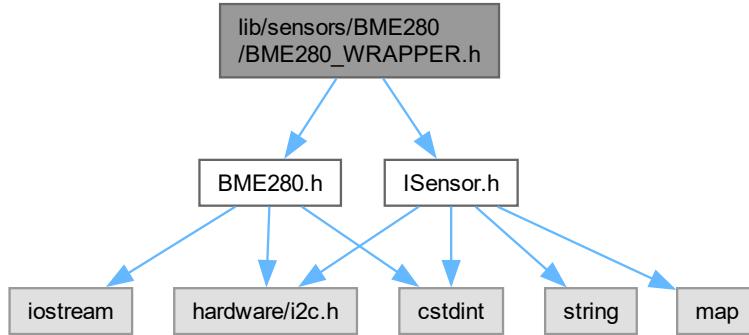
[Go to the documentation of this file.](#)

```

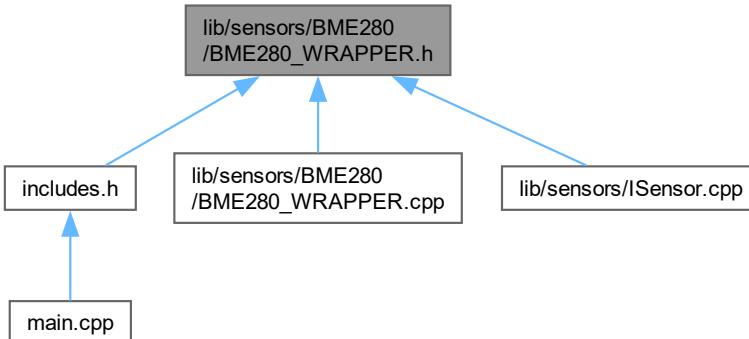
00001 #include "BME280_WRAPPER.h"
00002
00003 BME280Wrapper::BME280Wrapper(i2c_inst_t* i2c) : sensor_(i2c) {}
00004
00005 bool BME280Wrapper::init() {
00006     initialized_ = sensor_.init();
00007     return initialized_;
00008 }
00009
00010 float BME280Wrapper::read_data(SensorDataTypeIdentifier type) {
00011     int32_t temp_raw, pressure_raw, humidity_raw;
00012     sensor_.read_raw_all(&temp_raw, &pressure_raw, &humidity_raw);
00013
00014     switch(type) {
00015         case SensorDataTypeIdentifier::TEMPERATURE:
00016             return sensor_.convert_temperature(temp_raw);
00017         case SensorDataTypeIdentifier::PRESSURE:
00018             return sensor_.convert_pressure(pressure_raw);
00019         case SensorDataTypeIdentifier::HUMIDITY:
00020             return sensor_.convert_humidity(humidity_raw);
00021         default:
00022             return 0.0f;
00023     }
00024 }
00025
00026 bool BME280Wrapper::is_initialized() const {
00027     return initialized_;
00028 }
00029
00030 SensorType BME280Wrapper::get_type() const {
00031     return SensorType::ENVIRONMENT;
00032 }
00033
00034 bool BME280Wrapper::configure(const std::map<std::string, std::string>& config) {
00035     return true;
00036 }
```

## 8.81 lib/sensors/BME280/BME280\_WRAPPER.h File Reference

```
#include "ISensor.h"
#include "BME280.h"
Include dependency graph for BME280_WRAPPER.h:
```



This graph shows which files directly or indirectly include this file:



### Classes

- class [BME280Wrapper](#)

## 8.82 BME280\_WRAPPER.h

[Go to the documentation of this file.](#)

```
00001 // BME280_WRAPPER.h
00002 #ifndef BME280_WRAPPER_H
```

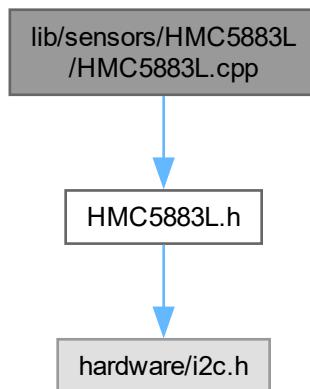
```

00003 #define BME280_WRAPPER_H
00004
00005 #include "ISensor.h"
00006 #include "BME280.h"
00007
00008 class BME280Wrapper : public ISensor {
00009 private:
0010     BME280 sensor_;
0011     bool initialized_ = false;
0012
0013 public:
0014     BME280Wrapper(i2c_inst_t* i2c);
0015
0016     bool init() override;
0017     float read_data(SensorDataTypeIdentifier type) override;
0018     bool is_initialized() const override;
0019     SensorType get_type() const override;
0020     bool configure(const std::map<std::string, std::string>& config) override;
0021
0022 };
0023
0024 #endif // BME280_WRAPPER_H

```

## 8.83 lib/sensors/HMC5883L/HMC5883L.cpp File Reference

#include "HMC5883L.h"  
Include dependency graph for HMC5883L.cpp:



## 8.84 HMC5883L.cpp

[Go to the documentation of this file.](#)

```

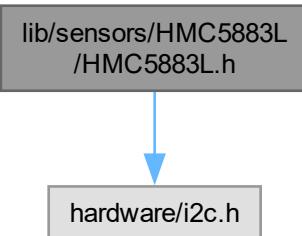
00001 #include "HMC5883L.h"
00002
00003 HMC5883L::HMC5883L(i2c_inst_t* i2c, uint8_t address) : i2c(i2c), address(address) {}
00004
00005 bool HMC5883L::init() {
00006     // Continuous measurement mode, 15Hz data output rate
00007     if (!write_register(0x00, 0x70)) return false;
00008     if (!write_register(0x01, 0x20)) return false;
00009     if (!write_register(0x02, 0x00)) return false;
00010     return true;
00011 }
00012

```

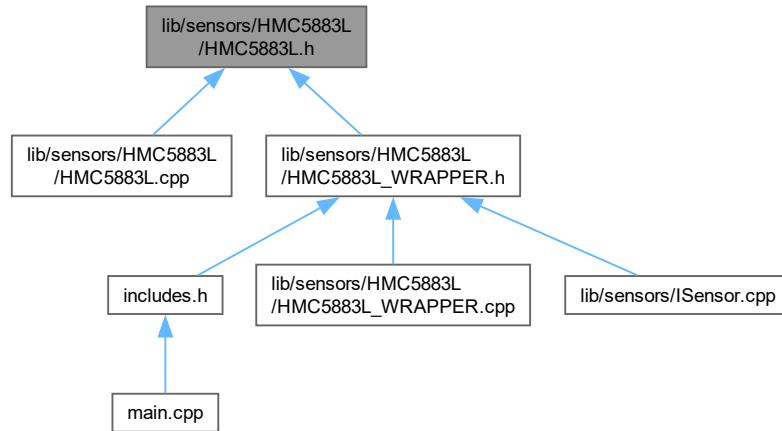
```
00013 bool HMC5883L::read(int16_t& x, int16_t& y, int16_t& z) {
00014     uint8_t buffer[6];
00015     if (!read_register(0x03, buffer, 6)) return false;
00016
00017     x = (buffer[0] << 8) | buffer[1];
00018     z = (buffer[2] << 8) | buffer[3];
00019     y = (buffer[4] << 8) | buffer[5];
00020
00021     if (x > 32767) x -= 65536;
00022     if (y > 32767) y -= 65536;
00023     if (z > 32767) z -= 65536;
00024
00025     return true;
00026 }
00027
00028 bool HMC5883L::write_register(uint8_t reg, uint8_t value) {
00029     uint8_t buffer[2] = {reg, value};
00030     return i2c_write_blocking(i2c, address, buffer, 2, false) == 2;
00031 }
00032
00033 bool HMC5883L::read_register(uint8_t reg, uint8_t* buffer, size_t length) {
00034     if (i2c_write_blocking(i2c, address, &reg, 1, true) != 1) return false;
00035     return i2c_read_blocking(i2c, address, buffer, length, false) == length;
00036 }
```

## 8.85 lib/sensors/HMC5883L/HMC5883L.h File Reference

```
#include "hardware/i2c.h"
Include dependency graph for HMC5883L.h:
```



This graph shows which files directly or indirectly include this file:



## Classes

- class [HMC5883L](#)

## 8.86 HMC5883L.h

[Go to the documentation of this file.](#)

```

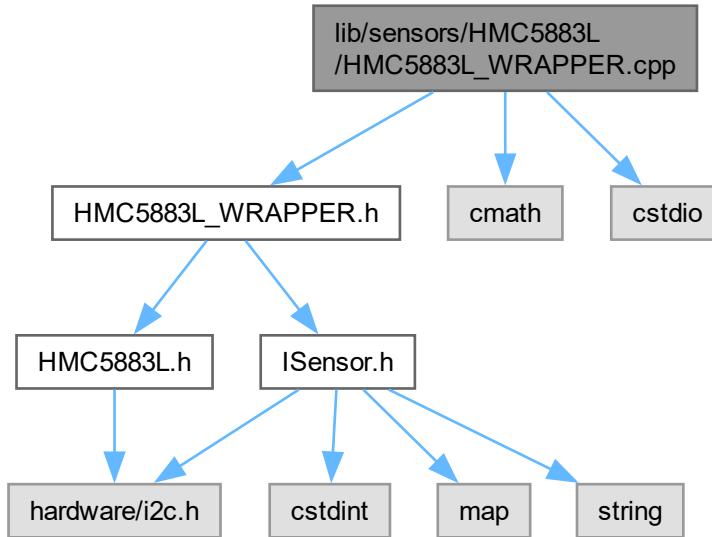
00001 #ifndef HMC5883L_H
00002 #define HMC5883L_H
00003
00004 #include "hardware/i2c.h"
00005
00006 class HMC5883L {
00007 public:
00008     HMC5883L(i2c_inst_t* i2c, uint8_t address = 0x0D);
00009     bool init();
00010     bool read(int16_t& x, int16_t& y, int16_t& z);
00011
00012 private:
00013     i2c_inst_t* i2c;
00014     uint8_t address;
00015
00016     bool write_register(uint8_t reg, uint8_t value);
00017     bool read_register(uint8_t reg, uint8_t* buffer, size_t length);
00018 };
00019
00020 #endif

```

## 8.87 lib/sensors/HMC5883L/HMC5883L\_WRAPPER.cpp File Reference

```
#include "HMC5883L_WRAPPER.h"
#include <cmath>
```

```
#include <cstdio>
Include dependency graph for HMC5883L_WRAPPER.cpp:
```



## 8.88 HMC5883L\_WRAPPER.cpp

[Go to the documentation of this file.](#)

```

00001 #include "HMC5883L_WRAPPER.h"
00002 #include <cmath>
00003 #include <cstdio>
00004
00005 HMC5883LWrapper::HMC5883LWrapper(i2c_inst_t* i2c) : sensor_(i2c), initialized_(false) {}
00006
00007 bool HMC5883LWrapper::init() {
00008     initialized_ = sensor_.init();
00009     return initialized_;
00010 }
00011
00012 float HMC5883LWrapper::read_data(SensorDataTypeIdentifier type) {
00013     if (!initialized_) return 0.0f;
00014
00015     int16_t x, y, z;
00016     if (!sensor_.read(x, y, z)) return 0.0f;
00017
00018     const float LSB_TO_UT = 100.0 / 1090.0;
00019     float x_uT = x * LSB_TO_UT;
00020     float y_uT = y * LSB_TO_UT;
00021     float z_uT = z * LSB_TO_UT;
00022
00023     switch (type) {
00024         case SensorDataTypeIdentifier::MAG_FIELD_X:
00025             return x_uT;
00026         case SensorDataTypeIdentifier::MAG_FIELD_Y:
00027             return y_uT;
00028         case SensorDataTypeIdentifier::MAG_FIELD_Z:
00029             return z_uT;
00030         default:
00031             return 0.0f;
00032     }
00033 }
00034
00035 bool HMC5883LWrapper::is_initialized() const {
00036     return initialized_;
  
```

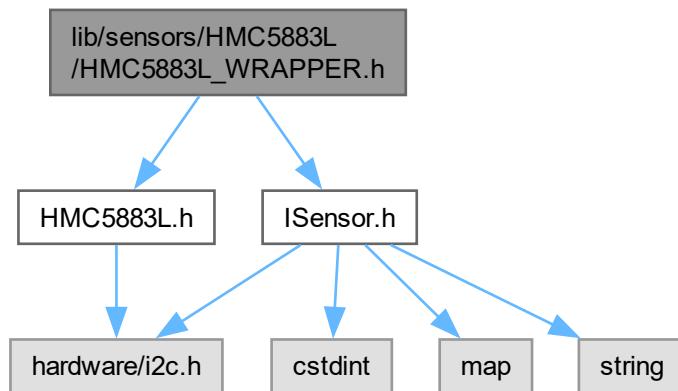
```

00037 }
00038
00039 SensorType HMC5883LWrapper::get_type() const {
00040     return SensorType::MAGNETOMETER;
00041 }
00042
00043 bool HMC5883LWrapper::configure(const std::map<std::string, std::string>& config) {
00044     // Configuration logic if needed
00045     return true;
00046 }

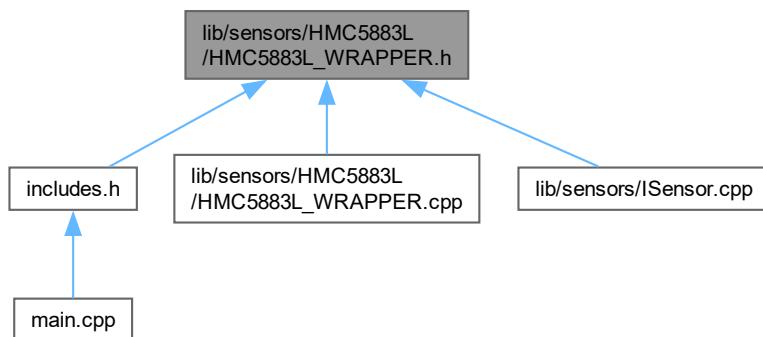
```

## 8.89 lib/sensors/HMC5883L/HMC5883L\_WRAPPER.h File Reference

```
#include "ISensor.h"
#include "HMC5883L.h"
Include dependency graph for HMC5883L_WRAPPER.h:
```



This graph shows which files directly or indirectly include this file:



## Classes

- class [HMC5883LWrapper](#)

## 8.90 HMC5883L\_WRAPPER.h

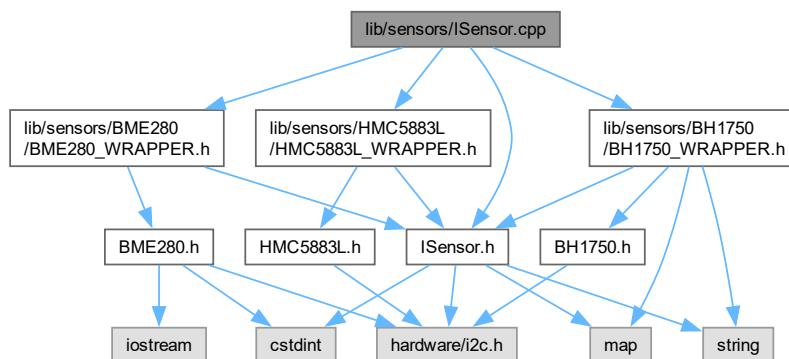
[Go to the documentation of this file.](#)

```
00001 #ifndef HMC5883L_WRAPPER_H
00002 #define HMC5883L_WRAPPER_H
00003
00004 #include "ISensor.h"
00005 #include "HMC5883L.h"
00006
00007 class HMC5883LWrapper : public ISensor {
00008 public:
00009     HMC5883LWrapper(i2c_inst_t* i2c);
00010     bool init() override;
00011     float read_data(SensorDataTypeIdentifier type) override;
00012     bool is_initialized() const override;
00013     SensorType get_type() const override;
00014     bool configure(const std::map<std::string, std::string>& config) override;
00015
00016 private:
00017     HMC5883L sensor_;
00018     bool initialized_;
00019 };
00020
00021 #endif
```

## 8.91 lib/sensors/ISensor.cpp File Reference

Implements the [SensorWrapper](#) class for managing different sensor types.

```
#include "ISensor.h"
#include "lib/sensors/BH1750/BH1750_WRAPPER.h"
#include "lib/sensors/BME280/BME280_WRAPPER.h"
#include "lib/sensors/HMC5883L/HMC5883L_WRAPPER.h"
Include dependency graph for ISensor.cpp:
```



### 8.91.1 Detailed Description

Implements the [SensorWrapper](#) class for managing different sensor types.

This file provides the implementation for initializing, configuring, and reading data from various sensors.

Definition in file [ISensor.cpp](#).

## 8.92 ISensor.cpp

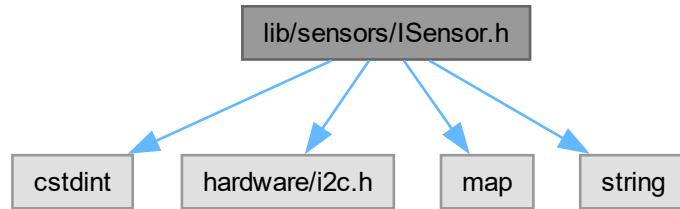
[Go to the documentation of this file.](#)

```
00001 // ISensor.cpp
00002 #include "ISensor.h"
00003 #include "lib/sensors/BH1750/BH1750_WRAPPER.h"
00004 #include "lib/sensors/BME280/BME280_WRAPPER.h"
00005 #include "lib/sensors/HMC5883L/HMC5883L_WRAPPER.h"
00006
00013
00018
00023 SensorWrapper& SensorWrapper::get_instance() {
00024     static SensorWrapper instance;
00025     return instance;
00026 }
00027
00031 SensorWrapper::SensorWrapper() = default;
00032
00039 bool SensorWrapper::sensor_init(SensorType type, i2c_inst_t* i2c) {
00040     switch(type) {
00041         case SensorType::LIGHT:
00042             sensors[type] = new BH1750Wrapper();
00043             break;
00044         case SensorType::ENVIRONMENT:
00045             sensors[type] = new BME280Wrapper(i2c);
00046             break;
00047         case SensorType::IMU:
00048             //sensors[type] = new MPU6050Wrapper(i2c);
00049             break;
00050         case SensorType::MAGNETOMETER:
00051             sensors[type] = new HMC5883LWrapper(i2c);
00052             break;
00053     }
00054     return sensors[type]->init();
00055 }
00056
00063 bool SensorWrapper::sensor_configure(SensorType type, const std::map<std::string, std::string>& config) {
00064     auto it = sensors.find(type);
00065     if (it != sensors.end() && it->second->is_initialized()) {
00066         return it->second->configure(config);
00067     }
00068     std::cerr << "Sensor not initialized or not found: " << static_cast<int>(type) << std::endl;
00069     return false;
00070 }
00071
00078 float SensorWrapper::sensor_read_data(SensorType sensorType, SensorDataTypeIdentifier dataType) {
00079     auto it = sensors.find(sensorType);
00080     if (it != sensors.end() && it->second->is_initialized()) {
00081         return it->second->read_data(dataType);
00082     }
00083     return 0.0f;
00084 }
```

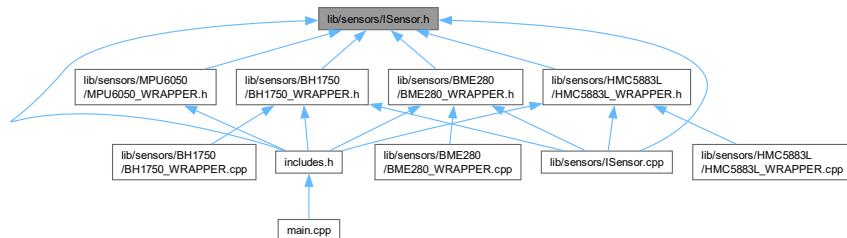
## 8.93 lib/sensors/ISensor.h File Reference

```
#include <cstdint>
#include "hardware/i2c.h"
#include <map>
```

```
#include <string>
Include dependency graph for ISensor.h:
```



This graph shows which files directly or indirectly include this file:



## Classes

- class [ISensor](#)
- class [SensorWrapper](#)

*Manages different sensor types and provides a unified interface for accessing sensor data.*

## Enumerations

- enum class [SensorType](#) { `LIGHT` , `ENVIRONMENT` , `MAGNETOMETER` , `IMU` }
- enum class [SensorDataTypeldentifier](#) {
`LIGHT_LEVEL` , `TEMPERATURE` , `PRESSURE` , `HUMIDITY` ,
`MAG_FIELD_X` , `MAG_FIELD_Y` , `MAG_FIELD_Z` , `GYRO_X` ,
`GYRO_Y` , `GYRO_Z` , `ACCEL_X` , `ACCEL_Y` ,
`ACCEL_Z` }

### 8.93.1 Enumeration Type Documentation

#### 8.93.1.1 SensorType

```
enum class SensorType [strong]
```

**Enumerator**

LIGHT	
ENVIRONMENT	
MAGNETOMETER	
IMU	

Definition at line 10 of file [ISensor.h](#).

**8.93.1.2 SensorDataTypeIdentifier**

```
enum class SensorDataTypeIdentifier [strong]
```

**Enumerator**

LIGHT_LEVEL	
TEMPERATURE	
PRESSURE	
HUMIDITY	
MAG_FIELD_X	
MAG_FIELD_Y	
MAG_FIELD_Z	
GYRO_X	
GYRO_Y	
GYRO_Z	
ACCEL_X	
ACCEL_Y	
ACCEL_Z	

Definition at line 17 of file [ISensor.h](#).

**8.94 ISensor.h**

[Go to the documentation of this file.](#)

```
00001 // ISensor.h
00002 #ifndef ISENSOR_H
00003 #define ISENSOR_H
00004
00005 #include <cstdint>
00006 #include "hardware/i2c.h"
00007 #include <map>
00008 #include <string>
00009
00010 enum class SensorType {
00011     LIGHT,           // BH1750
00012     ENVIRONMENT,    // BME280
00013     MAGNETOMETER,   // HMC5883L
00014     IMU,             // MPU6050
00015 };
00016
00017 enum class SensorDataTypeIdentifier {
00018     LIGHT_LEVEL,
00019     TEMPERATURE,
00020     PRESSURE,
00021     HUMIDITY,
00022     MAG_FIELD_X,
00023     MAG_FIELD_Y,
```

```
00024     MAG_FIELD_Z,  
00025     GYRO_X,  
00026     GYRO_Y,  
00027     GYRO_Z,  
00028     ACCEL_X,  
00029     ACCEL_Y,  
00030     ACCEL_Z  
00031 };  
00032  
00033 class ISensor {  
00034 public:  
00035     virtual ~ISensor() = default;  
00036     virtual bool init() = 0;  
00037     virtual float read_data(SensorDataTypeIdentifier type) = 0;  
00038     virtual bool is_initialized() const = 0;  
00039     virtual SensorType get_type() const = 0;  
00040     virtual bool configure(const std::map<std::string, std::string>& config) = 0;  
00041 };  
00042  
00043 class SensorWrapper {  
00044 public:  
00045     static SensorWrapper& get_instance();  
00046     bool sensor_init(SensorType type, i2c_inst_t* i2c = nullptr);  
00047     bool sensor_configure(SensorType type, const std::map<std::string, std::string>& config);  
00048     float sensor_read_data(SensorType sensorType, SensorDataTypeIdentifier dataType);  
00049  
00050 private:  
00051     std::map<SensorType, ISensor*> sensors;  
00052     SensorWrapper();  
00053 };  
00054  
00055 #endif // ISENSOR_H
```

## 8.95 lib/sensors/MPU6050/MPU6050.cpp File Reference

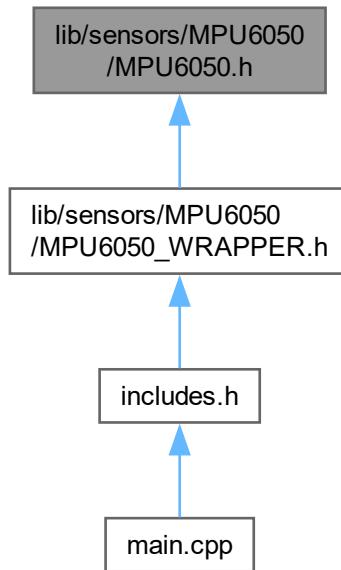
### 8.96 MPU6050.cpp

[Go to the documentation of this file.](#)

00001

## 8.97 lib/sensors/MPU6050/MPU6050.h File Reference

This graph shows which files directly or indirectly include this file:



## 8.98 MPU6050.h

[Go to the documentation of this file.](#)

00001

## 8.99 lib/sensors/MPU6050/MPU6050\_WRAPPER.cpp File Reference

## 8.100 MPU6050\_WRAPPER.cpp

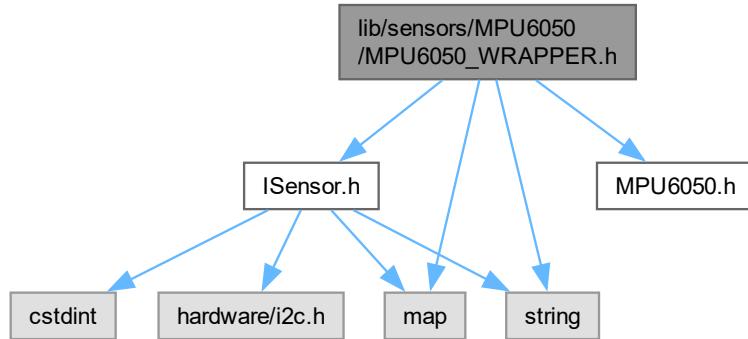
[Go to the documentation of this file.](#)

00001

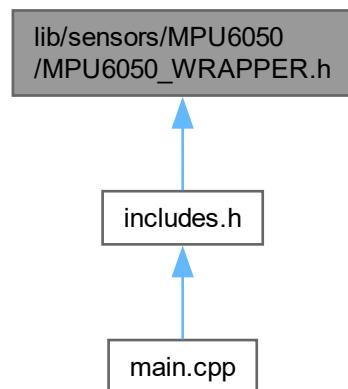
## 8.101 lib/sensors/MPU6050/MPU6050\_WRAPPER.h File Reference

```
#include "ISensor.h"
#include "MPU6050.h"
#include <map>
```

```
#include <string>
Include dependency graph for MPU6050_WRAPPER.h:
```



This graph shows which files directly or indirectly include this file:



## Classes

- class [MPU6050Wrapper](#)

## 8.102 MPU6050\_WRAPPER.h

[Go to the documentation of this file.](#)

```
00001 #ifndef BH1750_WRAPPER_H
00002 #define BH1750_WRAPPER_H
00003
```

```

00004 #include "ISensor.h"
00005 #include "MPU6050.h"
00006 #include <map>
00007 #include <string>
00008
00009 class MPU6050Wrapper : public ISensor {
00010 private:
00011     MPU6050 sensor_;
00012     bool initialized_ = false;
00013
00014 public:
00015     MPU6050Wrapper();
00016
00017     bool init() override;
00018     float read_data(SensorDataTypeIdentifier type) override;
00019     bool is_initialized() const override;
00020     SensorType get_type() const override;
00021
00022     bool configure(const std::map<std::string, std::string>& config);
00023 };
00024
00025 #endif

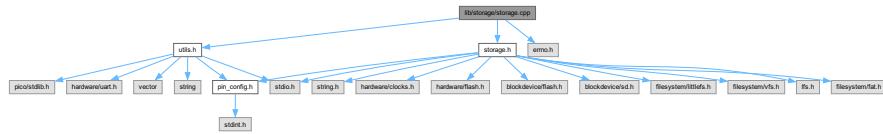
```

## 8.103 lib/storage/storage.cpp File Reference

Implements file system operations for the Kubisat firmware.

```
#include "storage.h"
#include "errno.h"
#include "utils.h"
```

Include dependency graph for storage.cpp:



### Functions

- `bool fs_init (void)`  
*Initializes the file system on the SD card.*

### Variables

- `bool sd_card_mounted = false`

#### 8.103.1 Detailed Description

Implements file system operations for the Kubisat firmware.

This file contains functions for initializing the file system, opening, writing, reading, and closing files.

Definition in file [storage.cpp](#).

## 8.103.2 Function Documentation

### 8.103.2.1 fs\_init()

```
bool fs_init (
    void )
```

Initializes the file system on the SD card.

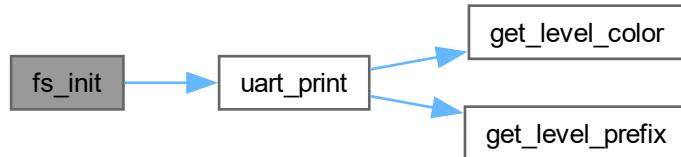
#### Returns

True if initialization was successful, false otherwise.

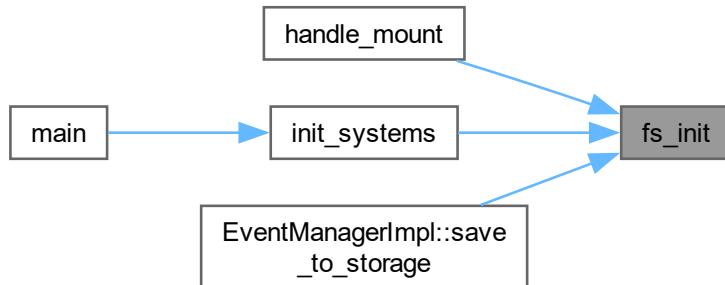
Mounts the littlefs file system on the SD card. If mounting fails, it formats the SD card with littlefs and then attempts to mount again.

Definition at line 25 of file [storage.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 8.103.3 Variable Documentation

#### 8.103.3.1 sd\_card\_mounted

```
bool sd_card_mounted = false
```

Definition at line 17 of file [storage.cpp](#).

## 8.104 storage.cpp

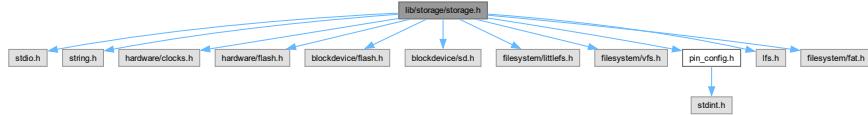
[Go to the documentation of this file.](#)

```
00001 /*
00002  * Copyright 2024, Hiroyuki OYAMA. All rights reserved.
00003  *
00004  * SPDX-License-Identifier: BSD-3-Clause
00005 */
00006 #include "storage.h"
00007 #include "errno.h"
00008 #include "utils.h"
00009
00016
00017 bool sd_card_mounted = false;
00018
00025 bool fs_init(void) {
00026     sd_card_mounted = false;
00027     uart_print("fs_init littlefs on SD card", VerbosityLevel::INFO);
00028     blockdevice_t *sd = blockdevice_sd_create(SD_SPI_PORT,
00029                                              SD_MOSI_PIN,
00030                                              SD_MISO_PIN,
00031                                              SD_SCK_PIN,
00032                                              SD_CS_PIN,
00033                                              24 * MHZ,
00034                                              false);
00035     filesystem_t *fat = filesystem_fat_create();
00036
00037     std::string statusString;
00038     int err = fs_mount("/", fat, sd);
00039     if (err == -1) {
00040         statusString = "Formatting / with FAT";
00041         uart_print(statusString, VerbosityLevel::INFO);
00042         err = fs_format(fat, sd);
00043         if (err == -1) {
00044             statusString = "fs_format error: " + std::string(strerror(errno));
00045             uart_print(statusString, VerbosityLevel::ERROR);
00046             return false;
00047         }
00048         err = fs_mount("/", fat, sd);
00049         if (err == -1) {
00050             statusString = "fs_mount error: " + std::string(strerror(errno));
00051             uart_print(statusString, VerbosityLevel::ERROR);
00052             return false;
00053         }
00054     }
00055
00056     sd_card_mounted = true;
00057     return true;
00058 }
```

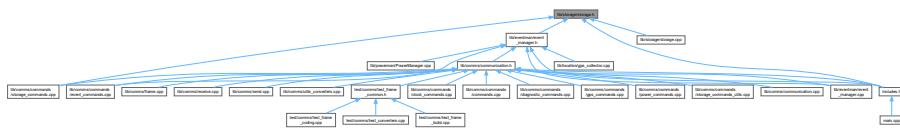
## 8.105 lib/storage/storage.h File Reference

```
#include <stdio.h>
#include <string.h>
#include <hardware/clocks.h>
#include <hardware/flash.h>
#include "blockdevice/flash.h"
#include "blockdevice/sd.h"
#include "filesystem/littlefs.h"
```

```
#include "filesystem/vfs.h"
#include "pin_config.h"
#include "lfs.h"
#include "filesystem/fat.h"
Include dependency graph for storage.h:
```



This graph shows which files directly or indirectly include this file:



## Classes

- struct [FileHandle](#)

## Functions

- `bool fs_init (void)`  
*Initializes the file system on the SD card.*
- `FileHandle fs_open_file (const char *filename, const char *mode)`
- `ssize_t fs_write_file (FileHandle &handle, const void *buffer, size_t size)`
- `ssize_t fs_read_file (FileHandle &handle, void *buffer, size_t size)`
- `bool fs_close_file (FileHandle &handle)`
- `bool fs_file_exists (const char *filename)`

## Variables

- `bool sd_card_mounted`

## 8.105.1 Function Documentation

### 8.105.1.1 `fs_init()`

```
bool fs_init (
    void )
```

Initializes the file system on the SD card.

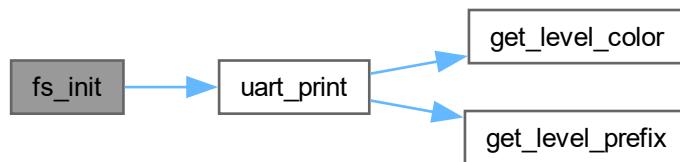
**Returns**

True if initialization was successful, false otherwise.

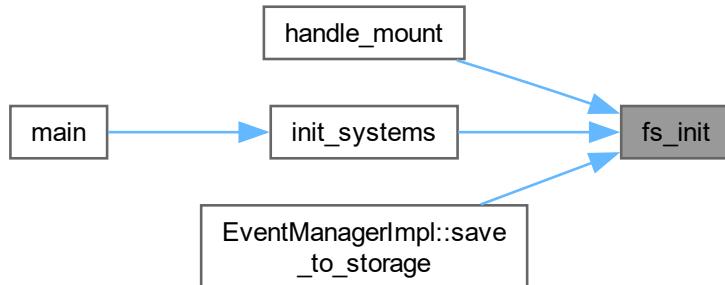
Mounts the littlefs file system on the SD card. If mounting fails, it formats the SD card with littlefs and then attempts to mount again.

Definition at line 25 of file [storage.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 8.105.1.2 `fs_open_file()`

```

FileHandle fs_open_file (
    const char * filename,
    const char * mode)
  
```

### 8.105.1.3 `fs_write_file()`

```

ssize_t fs_write_file (
    FileHandle & handle,
    const void * buffer,
    size_t size)
  
```

**8.105.1.4 fs\_read\_file()**

```
ssize_t fs_read_file (
    FileHandle & handle,
    void * buffer,
    size_t size)
```

**8.105.1.5 fs\_close\_file()**

```
bool fs_close_file (
    FileHandle & handle)
```

**8.105.1.6 fs\_file\_exists()**

```
bool fs_file_exists (
    const char * filename)
```

**8.105.2 Variable Documentation****8.105.2.1 sd\_card\_mounted**

```
bool sd_card_mounted [extern]
```

Definition at line 17 of file [storage.cpp](#).

**8.106 storage.h**

[Go to the documentation of this file.](#)

```
00001 #ifndef STORAGE_H
00002 #define STORAGE_H
00003
00004 #include <stdio.h>
00005 #include <string.h>
00006 #include <hardware/clocks.h>
00007 #include <hardware/flash.h>
00008 #include "blockdevice/flash.h"
00009 #include "blockdevice/sd.h"
00010 #include "filesystem/littlefs.h"
00011 #include "filesystem/vfs.h"
00012 #include "pin_config.h"
00013 #include "lfs.h"
00014 #include "filesystem/fat.h"
00015
00016
00017 extern bool sd_card_mounted;
00018
00019 struct FileHandle {
00020     int fd;
00021     bool is_open;
00022 };
00023
00024 bool fs_init(void);
00025 FileHandle fs_open_file(const char* filename, const char* mode);
00026 ssize_t fs_write_file(FileHandle& handle, const void* buffer, size_t size);
00027 ssize_t fs_read_file(FileHandle& handle, void* buffer, size_t size);
00028 bool fs_close_file(FileHandle& handle);
00029 bool fs_file_exists(const char* filename);
00030
00031 #endif
```

```

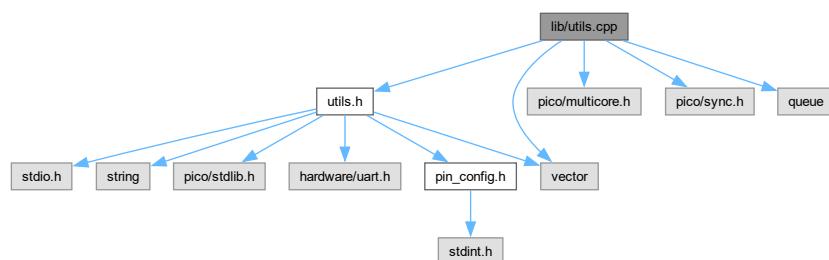
00032
00033 // void example_file_operations() {
00034 //     // Open a file for writing
00035 //     FileHandle log_file = fs_open_file("/log.txt", "w");
00036 //     if (!log_file.is_open) {
00037 //         uartPrint("Failed to open log file");
00038 //         return;
00039 //     }
00040
00041 //     // Write some data
00042 //     const char* message = "Hello, World!\n";
00043 //     ssize_t written = fs_write_file(log_file, message, strlen(message));
00044 //     if (written < 0) {
00045 //         uartPrint("Failed to write to log file");
00046 //     }
00047
00048 //     // Close the file
00049 //     fs_close_file(log_file);
00050
00051 //     // Open file for reading
00052 //     log_file = fs_open_file("/log.txt", "r");
00053 //     if (!log_file.is_open) {
00054 //         uartPrint("Failed to open log file for reading");
00055 //         return;
00056 //     }
00057
00058 //     // Read the data
00059 //     char buffer[128];
00060 //     ssize_t bytes_read = fs_read_file(log_file, buffer, sizeof(buffer) - 1);
00061 //     if (bytes_read > 0) {
00062 //         buffer[bytes_read] = '\0'; // Null terminate the string
00063 //         uartPrint(buffer);
00064 //     }
00065
00066 //     // Close the file
00067 //     fs_close_file(log_file);
00068 // }

```

## 8.107 lib/utils.cpp File Reference

Implementation of utility functions for the Kubisat firmware.

```
#include "utils.h"
#include "pico/multicore.h"
#include "pico/sync.h"
#include <vector>
#include <queue>
Include dependency graph for utils.cpp:
```



### Functions

- std::string [get\\_level\\_color](#) (VerbosityLevel level)  
*Gets ANSI color code for verbosity level.*

- std::string `get_level_prefix` (VerbosityLevel level)  
*Gets text prefix for verbosity level.*
- void `uart_print` (const std::string &msg, VerbosityLevel level, bool logToFile, uart\_inst\_t \*uart)  
*Prints a message to the UART with a timestamp and core number.*
- uint16\_t `crc16` (const uint8\_t \*data, size\_t length)  
*Calculates the CRC16 checksum of the given data.*

## Variables

- static mutex\_t `uart_mutex`  
*Mutex for UART access protection.*
- VerbosityLevel `g_uart_verbosity` = VerbosityLevel::EVENT  
*Global verbosity level setting.*

## 8.107.1 Detailed Description

Implementation of utility functions for the Kubisat firmware.

Definition in file [utils.cpp](#).

## 8.107.2 Function Documentation

### 8.107.2.1 `get_level_color()`

```
std::string get_level_color (
    VerbosityLevel level)
```

Gets ANSI color code for verbosity level.

#### Parameters

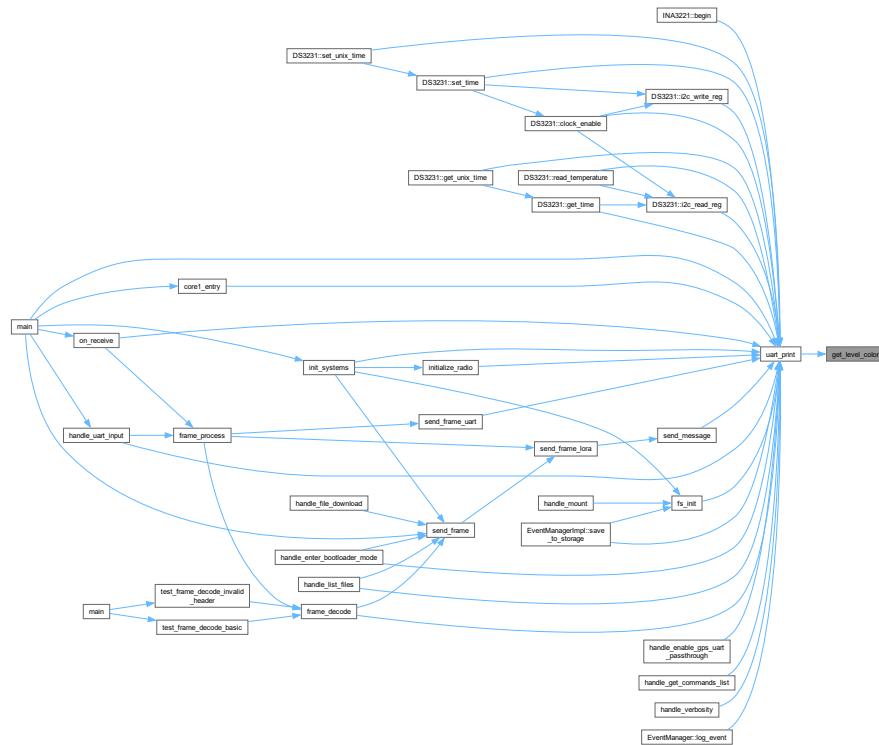
<code>level</code>	The verbosity level
--------------------	---------------------

#### Returns

ANSI color escape sequence

Definition at line 26 of file [utils.cpp](#).

Here is the caller graph for this function:



### 8.107.2.2 get\_level\_prefix()

```
std::string get_level_prefix (
    VerbosityLevel level)
```

Gets text prefix for verbosity level.

#### Parameters

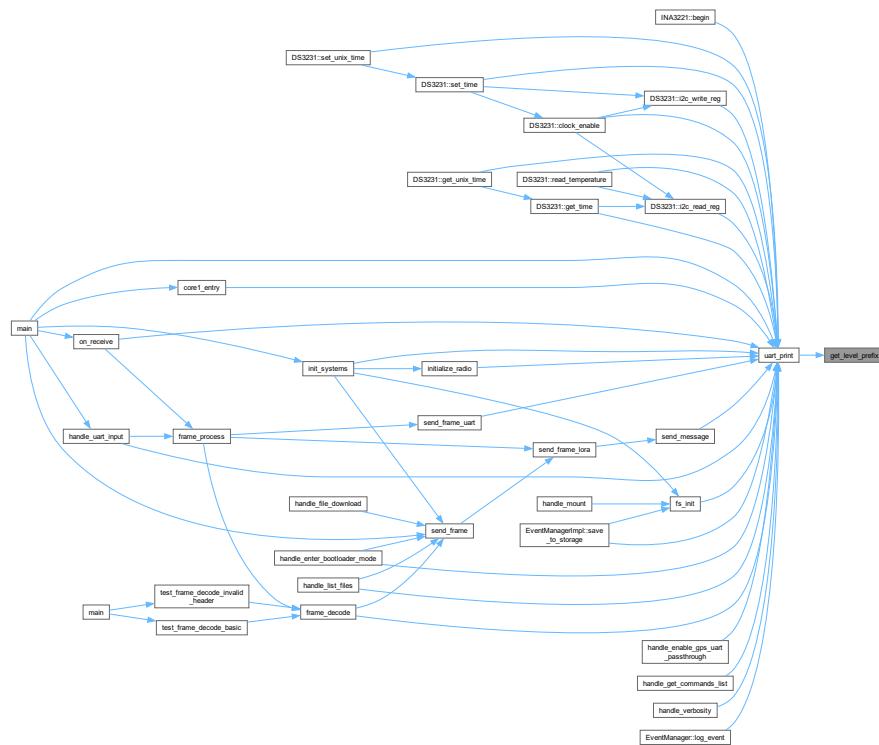
<i>level</i>	The verbosity level
--------------	---------------------

#### Returns

Text prefix for the level

Definition at line 43 of file [utils.cpp](#).

Here is the caller graph for this function:



### 8.107.2.3 uart\_print()

```
void uart_print (
    const std::string & msg,
    VerbosityLevel level,
    bool logToFile,
    uart_inst_t * uart)
```

Prints a message to the UART with a timestamp and core number.

Prints a message to UART with timestamp and formatting.

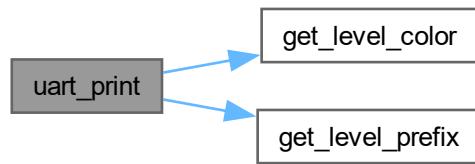
#### Parameters

<i>msg</i>	The message to print.
<i>logToFile</i>	A flag indicating whether to log the message to a file (currently not implemented).
<i>uart</i>	The UART instance to use for printing.

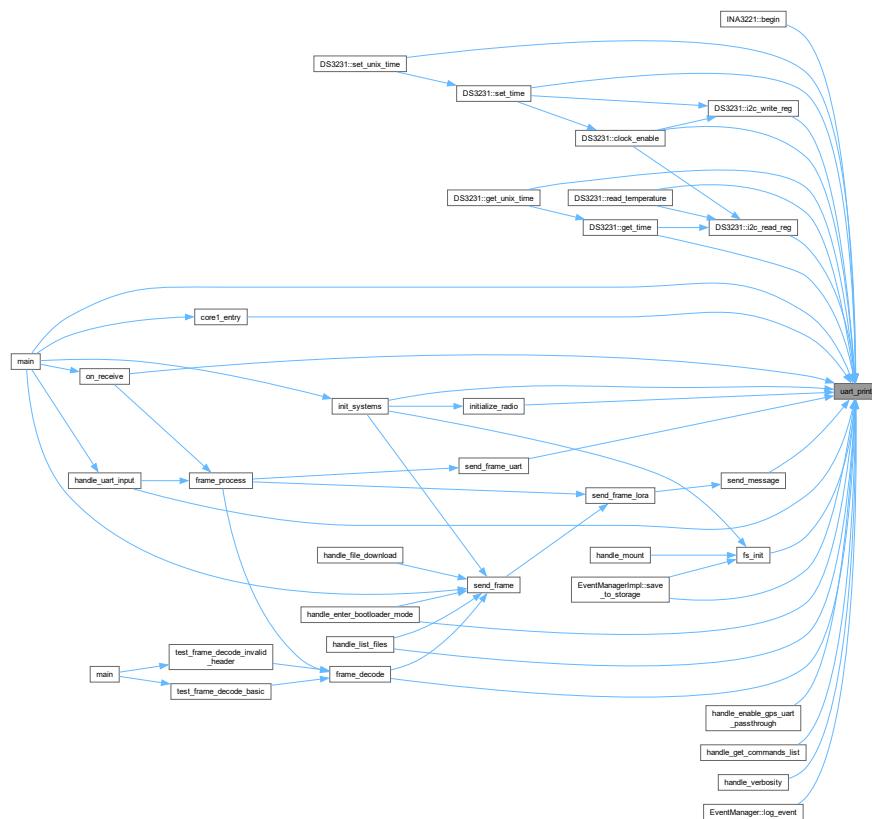
Prints the given message to the specified UART, prepending it with a timestamp and the core number. Uses a mutex to ensure thread-safe access to the UART.

Definition at line 62 of file [utils.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



#### 8.107.2.4 crc16()

```
uint16_t crc16 (
    const uint8_t * data,
    size_t length)
```

Calculates the CRC16 checksum of the given data.

Calculates CRC16 checksum.

**Parameters**

<i>data</i>	A pointer to the data buffer.
<i>length</i>	The length of the data in bytes.

**Returns**

The CRC16 checksum.

Calculates the CRC16 checksum using the standard algorithm.

Definition at line 97 of file [utils.cpp](#).

## 8.107.3 Variable Documentation

### 8.107.3.1 uart\_mutex

```
mutex_t uart_mutex [static]
```

Mutex for UART access protection.

Definition at line 14 of file [utils.cpp](#).

### 8.107.3.2 g\_uart\_verbosity

```
VerbosityLevel g_uart_verbosity = VerbosityLevel::EVENT
```

Global verbosity level setting.

Global verbosity level setting for UART output.

Definition at line 18 of file [utils.cpp](#).

## 8.108 utils.cpp

[Go to the documentation of this file.](#)

```
00001 #include "utils.h"
00002 #include "pico/multicore.h"
00003 #include "pico/sync.h"
00004 #include <vector>
00005 #include <queue>
00006
00011
00012
00014 static mutex_t uart_mutex;
00015
00016
00018 VerbosityLevel g_uart_verbosity = VerbosityLevel::EVENT;
00019
00020
00026 std::string get_level_color(VerbosityLevel level) {
00027     switch (level) {
00028         case VerbosityLevel::ERROR:    return ANSI_RED;
00029         case VerbosityLevel::WARNING: return ANSI_YELLOW;
00030         case VerbosityLevel::INFO:     return ANSI_GREEN;
00031         case VerbosityLevel::DEBUG:   return ANSI_BLUE;
```

```

00032         case VerboseLevel::EVENT:      return ANSI_CYAN;
00033     default:                      return "";
00034 }
00035 }
00036
00037
00043 std::string get_level_prefix(VerboseLevel level) {
00044     switch (level) {
00045         case VerboseLevel::ERROR:    return "ERROR: ";
00046         case VerboseLevel::WARNING:  return "WARNING: ";
00047         case VerboseLevel::INFO:     return "INFO: ";
00048         case VerboseLevel::DEBUG:    return "DEBUG: ";
00049         case VerboseLevel::EVENT:    return "EVENT: ";
00050     default:                      return "";
00051 }
00052 }
00053
00062 void uart_print(const std::string& msg, VerboseLevel level, bool logToFile, uart_inst_t* uart) {
00063     if (static_cast<int>(level) > static_cast<int>(g_uart_verbosity)) {
00064         return;
00065     }
00066
00067     static bool mutex_initiated = false;
00068     if (!mutex_initiated) {
00069         mutex_init(&uart_mutex);
00070         mutex_initiated = true;
00071     }
00072
00073     uint32_t timestamp = to_ms_since_boot(get_absolute_time());
00074     uint core_num = get_core_num();
00075
00076     // Create formatted message with color
00077     std::string color = get_level_color(level);
00078     std::string prefix = get_level_prefix(level);
00079     std::string msgToSend = "[" + std::to_string(timestamp) + "ms] - Core " +
00080                           std::to_string(core_num) + ":" +
00081                           color + prefix + ANSI_RESET + msg + "\r\n";
00082
00083     // Print to UART
00084     mutex_enter_blocking(&uart_mutex);
00085     uart_puts(uart, msgToSend.c_str());
00086     mutex_exit(&uart_mutex);
00087 }
00088
00089
00097 uint16_t crc16(const uint8_t *data, size_t length) {
00098     uint16_t crc = 0xFFFF;
00099     for (size_t i = 0; i < length; i++) {
00100         crc ^= data[i];
00101         for (int j = 0; j < 8; j++) {
00102             if (crc & 0x0001) {
00103                 crc = (crc >> 1) ^ 0xA001;
00104             } else {
00105                 crc >>= 1;
00106             }
00107         }
00108     }
00109     return crc;
00110 }

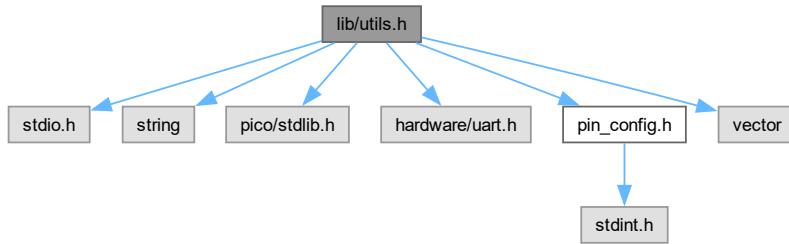
```

## 8.109 lib/utils.h File Reference

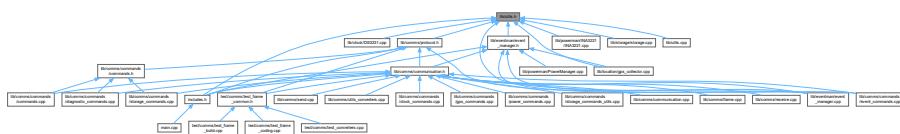
Utility functions and definitions for the Kabisat firmware.

```
#include <stdio.h>
#include <string>
#include "pico/stl.h"
#include "hardware/uart.h"
#include "pin_config.h"
#include <vector>
```

Include dependency graph for utils.h:



This graph shows which files directly or indirectly include this file:



## Macros

- #define **ANSI\_RED** "\033[31m"  
*ANSI escape codes for terminal color output.*
- #define **ANSI\_GREEN** "\033[32m"
- #define **ANSI\_YELLOW** "\033[33m"
- #define **ANSI\_BLUE** "\033[34m"
- #define **ANSI\_CYAN** "\033[36m"
- #define **ANSI\_RESET** "\033[0m"

## Enumerations

- enum class **VerbosityLevel** {  
    **SILENT** = 0 , **ERROR** = 1 , **WARNING** = 2 , **INFO** = 3 ,  
    **EVENT** = 4 , **DEBUG** = 5 }

*Verbosity levels for logging system.*

## Functions

- void **uart\_print** (const std::string &msg, **VerbosityLevel** level=**VerbosityLevel::INFO**, bool logToFile=false, **uart\_inst\_t** \*uart=**DEBUG\_UART\_PORT**)  
*Prints a message to UART with timestamp and formatting.*
- uint16\_t **crc16** (const uint8\_t \*data, size\_t length)  
*Calculates CRC16 checksum.*

## Variables

- [VerbosityLevel g\\_uart\\_verbosity](#)

*Global verbosity level setting for UART output.*

### 8.109.1 Detailed Description

Utility functions and definitions for the Kabisat firmware.

Contains UART logging, color definitions, and CRC calculations

Definition in file [utils.h](#).

### 8.109.2 Macro Definition Documentation

#### 8.109.2.1 ANSI\_RED

```
#define ANSI_RED "\033[31m"
```

ANSI escape codes for terminal color output.

Definition at line [20](#) of file [utils.h](#).

#### 8.109.2.2 ANSI\_GREEN

```
#define ANSI_GREEN "\033[32m"
```

Definition at line [21](#) of file [utils.h](#).

#### 8.109.2.3 ANSI\_YELLOW

```
#define ANSI_YELLOW "\033[33m"
```

Definition at line [22](#) of file [utils.h](#).

#### 8.109.2.4 ANSI\_BLUE

```
#define ANSI_BLUE "\033[34m"
```

Definition at line [23](#) of file [utils.h](#).

#### 8.109.2.5 ANSI\_CYAN

```
#define ANSI_CYAN "\033[36m"
```

Definition at line [24](#) of file [utils.h](#).

#### 8.109.2.6 ANSI\_RESET

```
#define ANSI_RESET "\033[0m"
```

Definition at line [25](#) of file [utils.h](#).

### 8.109.3 Enumeration Type Documentation

#### 8.109.3.1 VerbosityLevel

```
enum class VerbosityLevel [strong]
```

Verbosity levels for logging system.

## Enumerator

SILENT	No output
ERROR	Only critical errors
WARNING	Warnings and errors
INFO	Normal operation information
EVENT	Events
DEBUG	Detailed debug information

Definition at line 31 of file [utils.h](#).

## 8.109.4 Function Documentation

### 8.109.4.1 uart\_print()

```
void uart_print (
    const std::string & msg,
    VerbosityLevel level,
    bool logToFile,
    uart_inst_t * uart)
```

Prints a message to UART with timestamp and formatting.

#### Parameters

<i>msg</i>	The message to print
<i>level</i>	Message verbosity level
<i>logToFile</i>	Whether to store the message in log storage
<i>uart</i>	The UART port to use

Prints a message to UART with timestamp and formatting.

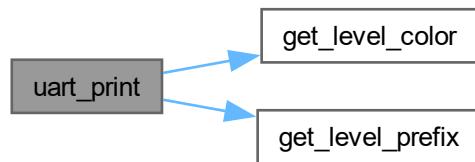
#### Parameters

<i>msg</i>	The message to print.
<i>logToFile</i>	A flag indicating whether to log the message to a file (currently not implemented).
<i>uart</i>	The UART instance to use for printing.

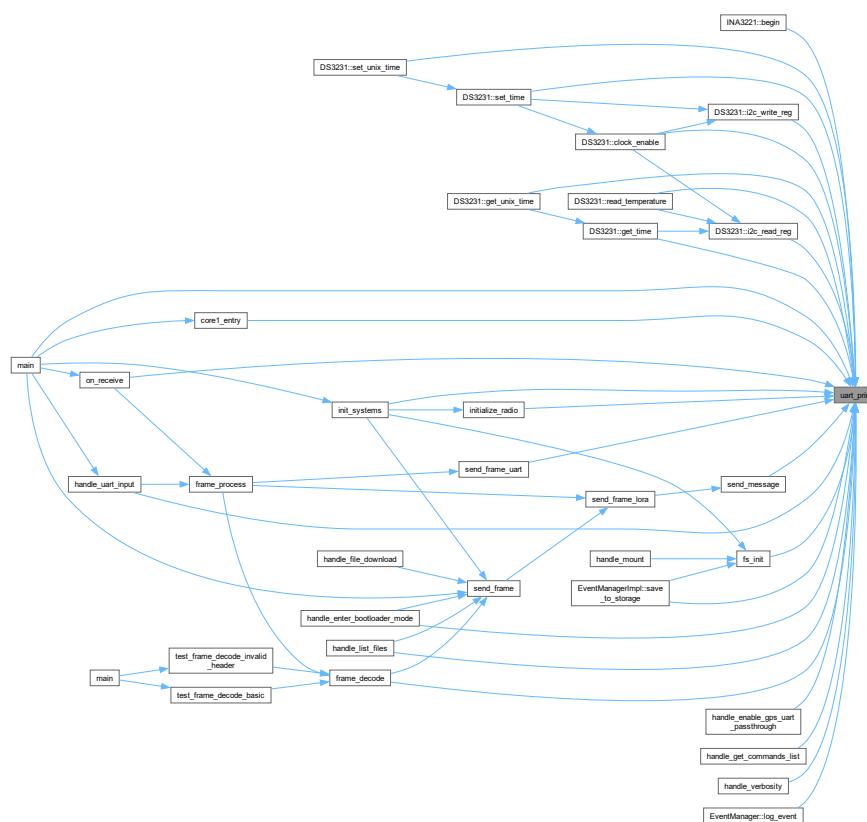
Prints the given message to the specified UART, prepending it with a timestamp and the core number. Uses a mutex to ensure thread-safe access to the UART.

Definition at line 62 of file [utils.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



#### 8.109.4.2 crc16()

```

uint16_t crc16 (
    const uint8_t * data,
    size_t length)
  
```

Calculates CRC16 checksum.

**Parameters**

<i>data</i>	Pointer to data buffer
<i>length</i>	Length of data in bytes

**Returns**

Calculated CRC16 value

Calculates CRC16 checksum.

**Parameters**

<i>data</i>	A pointer to the data buffer.
<i>length</i>	The length of the data in bytes.

**Returns**

The CRC16 checksum.

Calculates the CRC16 checksum using the standard algorithm.

Definition at line 97 of file [utils.cpp](#).

## 8.109.5 Variable Documentation

### 8.109.5.1 g\_uart\_verbosity

`VerbosityLevel g_uart_verbosity [extern]`

Global verbosity level setting for UART output.

Controls which messages are displayed:

- SILENT (0): No output
- ERROR (1): Only errors
- WARNING (2): Warnings and errors
- INFO (3): Normal operation information
- DEBUG (4): Detailed debug information

**Note**

Can be changed at runtime through the command interface

**See also**

[VerbosityLevel](#)  
[handle\\_verbosity](#)

Global verbosity level setting for UART output.

Definition at line 18 of file [utils.cpp](#).

## 8.110 utils.h

[Go to the documentation of this file.](#)

```

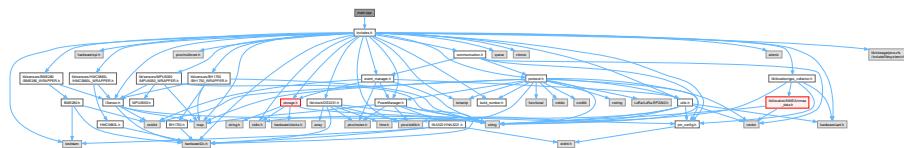
00001 #ifndef UTILS_H
00002 #define UTILS_H
00003
00004 #include <stdio.h>
00005 #include <string>
00006 #include "pico/stdlib.h"
00007 #include "hardware/uart.h"
00008 #include "pin_config.h"
00009 #include <vector>
00010
00011
00017
00018
00020 #define ANSI_RED      "\033[31m"
00021 #define ANSI_GREEN    "\033[32m"
00022 #define ANSI_YELLOW   "\033[33m"
00023 #define ANSI_BLUE     "\033[34m"
00024 #define ANSI_CYAN     "\033[36m"
00025 #define ANSI_RESET   "\033[0m"
00026
00027
00031 enum class VerbosityLevel {
00032     SILENT = 0,
00033     ERROR = 1,
00034     WARNING = 2,
00035     INFO = 3,
00036     EVENT = 4,
00037     DEBUG = 5
00038 };
00039
00040
00053 extern VerbosityLevel g_uart_verbosity;
00054
00055
00063 void uart_print(const std::string& msg,
00064                 VerbosityLevel level = VerbosityLevel::INFO,
00065                 bool logToFile = false,
00066                 uart_inst_t* uart = DEBUG_UART_PORT);
00067
00068
00069
00076 uint16_t crc16(const uint8_t *data, size_t length);
00077
00078 #endif

```

## 8.111 main.cpp File Reference

```
#include "includes.h"
```

Include dependency graph for main.cpp:



### Macros

- `#define LOG_FILENAME "/log.txt"`

### Functions

- `void core1_entry ()`
- `bool init_systems ()`
- `int main ()`

## Variables

- PowerManager powerManager (MAIN\_I2C\_PORT)
- DS3231 systemClock (MAIN\_I2C\_PORT)
- char buffer [BUFFER\_SIZE]
- int bufferIndex = 0

### 8.111.1 Macro Definition Documentation

#### 8.111.1.1 LOG\_FILENAME

```
#define LOG_FILENAME "/log.txt"
```

Definition at line 3 of file [main.cpp](#).

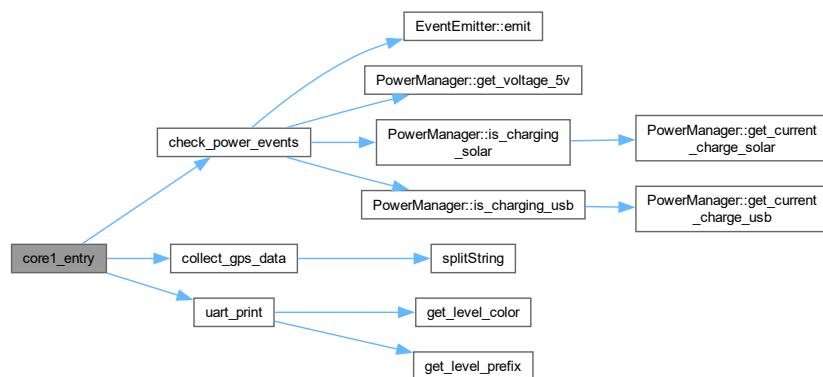
### 8.111.2 Function Documentation

#### 8.111.2.1 core1\_entry()

```
void core1_entry ()
```

Definition at line 11 of file [main.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

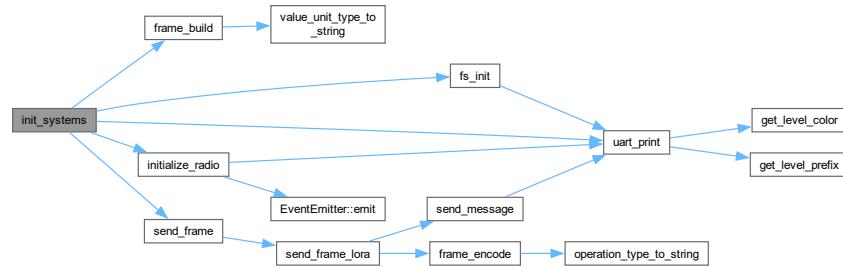


### 8.111.2.2 init\_systems()

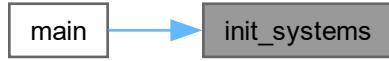
```
bool init_systems ()
```

Definition at line 20 of file [main.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

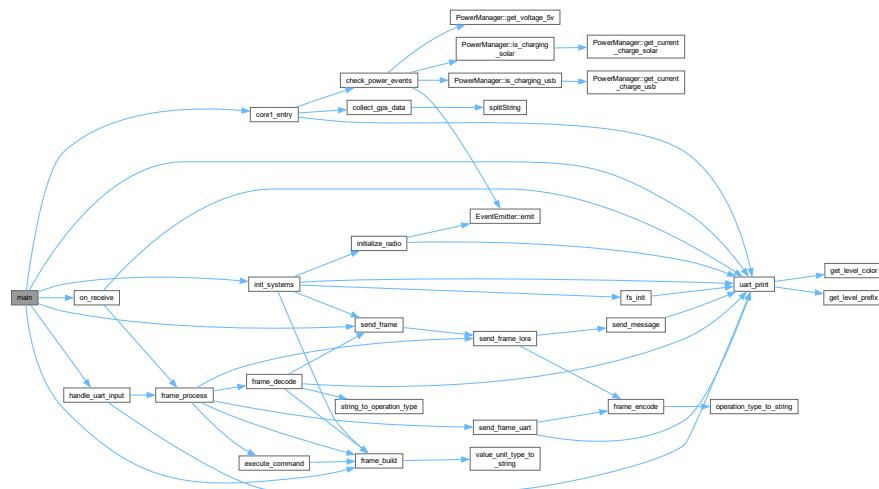


### 8.111.2.3 main()

```
int main (
    void )
```

Definition at line 94 of file [main.cpp](#).

Here is the call graph for this function:



### 8.111.3 Variable Documentation

#### 8.111.3.1 powerManager

```
PowerManager powerManager(MAIN_I2C_PORT) (
    MAIN_I2C_PORT )
```

#### 8.111.3.2 systemClock

```
DS3231 systemClock(MAIN_I2C_PORT) (
    MAIN_I2C_PORT )
```

#### 8.111.3.3 buffer

```
char buffer[BUFFER_SIZE]
```

Definition at line 8 of file [main.cpp](#).

#### 8.111.3.4 bufferIndex

```
int bufferIndex = 0
```

Definition at line 9 of file [main.cpp](#).

## 8.112 main.cpp

[Go to the documentation of this file.](#)

```

00001 #include "includes.h"
00002
00003 #define LOG_FILENAME "/log.txt"
00004
00005 PowerManager powerManager(MAIN_I2C_PORT);
00006 DS3231 systemClock(MAIN_I2C_PORT);
00007
00008 char buffer[BUFFER_SIZE];
00009 int bufferIndex = 0;
00010
00011 void core1_entry() {
00012     uart_print("Starting core 1", VerbosityLevel::DEBUG);
00013     while (true) {
00014         collect_gps_data();
00015         check_power_events(powerManager);
00016         sleep_ms(10);
00017     }
00018 }
00019
00020 bool init_systems() {
00021     stdio_init_all();
00022
00023     uart_init(DEBUG_UART_PORT, DEBUG_UART_BAUD_RATE);
00024     gpio_set_function(DEBUG_UART_TX_PIN, UART_FUNCSEL_NUM(DEBUG_UART_PORT, DEBUG_UART_TX_PIN));
00025     gpio_set_function(DEBUG_UART_RX_PIN, UART_FUNCSEL_NUM(DEBUG_UART_PORT, DEBUG_UART_RX_PIN));
00026
00027     uart_init(GPS_UART_PORT, GPS_UART_BAUD_RATE);
00028     gpio_set_function(GPS_UART_TX_PIN, UART_FUNCSEL_NUM(GPS_UART_PORT, GPS_UART_TX_PIN));
00029     gpio_set_function(GPS_UART_RX_PIN, UART_FUNCSEL_NUM(GPS_UART_PORT, GPS_UART_RX_PIN));
00030
00031     gpio_init(PICO_DEFAULT_LED_PIN);
00032     gpio_set_dir(PICO_DEFAULT_LED_PIN, GPIO_OUT);
00033
00034     i2c_init(MAIN_I2C_PORT, 400 * 1000);
00035     gpio_set_function(MAIN_I2C_SCL_PIN, GPIO_FUNC_I2C);
00036     gpio_set_function(MAIN_I2C_SDA_PIN, GPIO_FUNC_I2C);
00037     gpio_pull_up(MAIN_I2C_SCL_PIN);
00038     gpio_pull_up(MAIN_I2C_SDA_PIN);
00039
00040     if (true)
00041     {
00042         gpio_init(GPS_POWER_ENABLE_PIN);
00043         gpio_set_dir(GPS_POWER_ENABLE_PIN, GPIO_OUT);
00044         gpio_put(GPS_POWER_ENABLE_PIN, 1);
00045     }
00046     system("color");
00047
00048     bool radioInitSuccess = false;
00049     radioInitSuccess = initialize_radio();
00050
00051     bool sdInitDone = fs_init();
00052     if (sdInitDone) {
00053         FILE *fp = fopen(LOG_FILENAME, "w");
00054         if (fp) {
00055             uart_print("Log file opened.", VerbosityLevel::DEBUG);
00056             int bytesWritten = fprintf(fp, "System init started.\n");
00057             uart_print("Written " + std::to_string(bytesWritten) + " bytes.", VerbosityLevel::DEBUG);
00058             int closeStatus = fclose(fp);
00059             uart_print("Close file status: " + std::to_string(closeStatus), VerbosityLevel::DEBUG);
00060
00061             struct stat file_stat;
00062             if (stat(LOG_FILENAME, &file_stat) == 0) {
00063                 size_t fileSize = file_stat.st_size;
00064                 uart_print("File size: " + std::to_string(fileSize) + " bytes",
00065                           VerbosityLevel::DEBUG);
00066             } else {
00067                 uart_print("Failed to get file size", VerbosityLevel::ERROR);
00068             }
00069             uart_print("File path: /" + std::string(LOG_FILENAME), VerbosityLevel::DEBUG);
00070         } else {
00071             uart_print("Failed to open log file for writing.", VerbosityLevel::ERROR);
00072         }
00073     }
00074
00075     if (sdInitDone) {
00076         uart_print("SD card init: OK", VerbosityLevel::DEBUG);
00077     } else {
00078         uart_print("SD card init: FAILED", VerbosityLevel::ERROR);
00079     }
00080
00081     if (radioInitSuccess) {

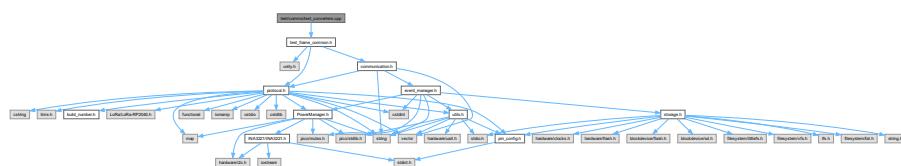
```

```

00082     uart_print("Radio init: OK", VerbosityLevel::DEBUG);
00083 } else {
00084     uart_print("Radio init: FAILED", VerbosityLevel::ERROR);
00085 }
00086
00087 Frame boot = frame_build(ExecutionResult::INFO, 0, 0, "HELLO");
00088 send_frame(boot);
00089
00090 return radioInitSuccess;
00091 }
00092
00093
00094 int main()
00095 {
00096     init_systems();
00097     multicore_launch_core1(core1_entry);
00098
00099     gpio_put(PICO_DEFAULT_LED_PIN, 0);
00100
00101     bool powerManagerInitStatus = powerManager.initialize();
00102     if (powerManagerInitStatus)
00103     {
00104         std::map<std::string, std::string> powerConfig = {
00105             {"operating_mode", "continuous"},
00106             {"averaging_mode", "16"},
00107         };
00108         powerManager.configure(powerConfig);
00109     } else {
00110         uart_print("Power manager init error", VerbosityLevel::ERROR);
00111     }
00112
00113     Frame boot = frame_build(ExecutionResult::INFO, 0, 0, "START");
00114     send_frame(boot);
00115
00116     std::string bootString = "System init completed @ " +
00117     std::to_string(to_ms_since_boot(get_absolute_time())) + " ms";
00118     uart_print(bootString, VerbosityLevel::WARNING);
00119
00120     gpio_put(PICO_DEFAULT_LED_PIN, 1);
00121
00122     while (true)
00123     {
00124         int packetSize = LoRa.parse_packet();
00125         if (packetSize)
00126         {
00127             on_receive(packetSize);
00128         }
00129
00130         handle_uart_input();
00131     }
00132
00133     return 0;
00134 }
```

## 8.113 test/comms/test\_converters.cpp File Reference

```
#include "test_frame_common.h"
Include dependency graph for test_converters.cpp:
```



### Functions

- void **test\_operation\_type\_conversion ()**
- void **test\_value\_unit\_type\_conversion ()**
- void **test\_exception\_type\_conversion ()**
- void **test\_hex\_string\_conversion ()**

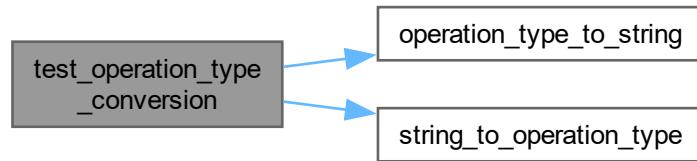
### 8.113.1 Function Documentation

#### 8.113.1.1 test\_operation\_type\_conversion()

```
void test_operation_type_conversion (
    void )
```

Definition at line 4 of file [test\\_converters.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

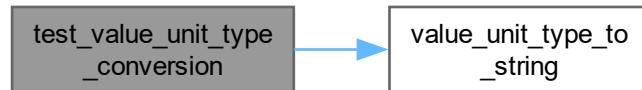


#### 8.113.1.2 test\_value\_unit\_type\_conversion()

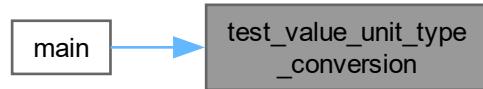
```
void test_value_unit_type_conversion (
    void )
```

Definition at line 13 of file [test\\_converters.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

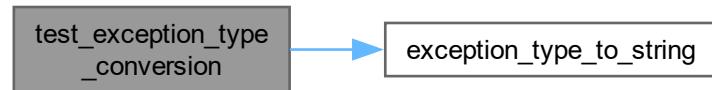


#### 8.113.1.3 test\_exception\_type\_conversion()

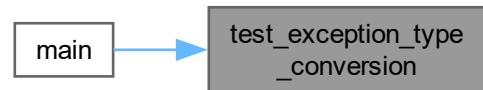
```
void test_exception_type_conversion ( void )
```

Definition at line 20 of file [test\\_converters.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



#### 8.113.1.4 test\_hex\_string\_conversion()

```
void test_hex_string_conversion (
    void )
```

Definition at line 27 of file [test\\_converters.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



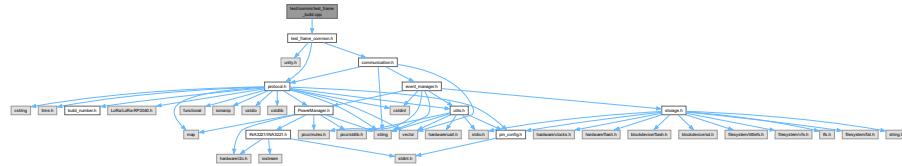
## 8.114 test\_converters.cpp

[Go to the documentation of this file.](#)

```
00001 // test_frame_converters.cpp
00002 #include "test_frame_common.h"
00003
00004 void test_operation_type_conversion() {
00005     OperationType type = OperationType::GET;
00006     std::string str = operation_type_to_string(type);
00007     OperationType converted = string_to_operation_type(str);
00008
00009     TEST_ASSERT_EQUAL(type, converted);
00010     TEST_ASSERT_EQUAL_STRING("GET", str.c_str());
00011 }
00012
00013 void test_value_unit_type_conversion() {
00014     ValueUnit unit = ValueUnit::VOLT;
00015     std::string str = value_unit_type_to_string(unit);
00016
00017     TEST_ASSERT_EQUAL_STRING("V", str.c_str());
00018 }
00019
00020 void test_exception_type_conversion() {
00021     ExceptionType type = ExceptionType::INVALID_PARAM;
00022     std::string str = exception_type_to_string(type);
00023
00024     TEST_ASSERT_EQUAL_STRING("INVALID PARAM", str.c_str());
00025 }
00026
00027 void test_hex_string_conversion() {
00028     std::string hex = "0A0B0C";
00029     std::vector<uint8_t> bytes = hex_string_to_bytes(hex);
00030
00031     TEST_ASSERT_EQUAL(3, bytes.size());
00032     TEST_ASSERT_EQUAL(0x0A, bytes[0]);
00033     TEST_ASSERT_EQUAL(0x0B, bytes[1]);
00034     TEST_ASSERT_EQUAL(0x0C, bytes[2]);
00035 }
```

## 8.115 test/comms/test\_frame\_build.cpp File Reference

```
#include "test_frame_common.h"
Include dependency graph for test_frame_build.cpp:
```



### Functions

- `void test_frame_build_success ()`
- `void test_frame_build_error ()`
- `void test_frame_build_info ()`

#### 8.115.1 Function Documentation

##### 8.115.1.1 test\_frame\_build\_success()

```
void test_frame_build_success (
    void )
```

Definition at line 4 of file [test\\_frame\\_build.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 8.115.1.2 test\_frame\_build\_error()

```
void test_frame_build_error (
    void )
```

Definition at line 15 of file [test\\_frame\\_build.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 8.115.1.3 test\_frame\_build\_info()

```
void test_frame_build_info (
    void )
```

Definition at line 24 of file [test\\_frame\\_build.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



## 8.116 test\_frame\_build.cpp

[Go to the documentation of this file.](#)

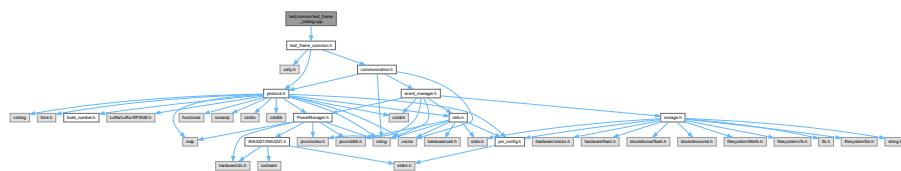
```

00001 // test_frame_build.cpp
00002 #include "test_frame_common.h"
00003
00004 void test_frame_build_success() {
00005     Frame frame = frame_build(ExecutionResult::SUCCESS, 1, 2, "test_value", ValueUnit::VOLT);
00006
00007     TEST_ASSERT_EQUAL(1, frame.direction);
00008     TEST_ASSERT_EQUAL(OperationType::ANS, frame.operationType);
00009     TEST_ASSERT_EQUAL(1, frame.group);
00010     TEST_ASSERT_EQUAL(2, frame.command);
00011     TEST_ASSERT_EQUAL_STRING("test_value", frame.value.c_str());
00012     TEST_ASSERT_EQUAL_STRING("V", frame.unit.c_str());
00013 }
00014
00015 void test_frame_build_error() {
00016     Frame frame = frame_build(ExecutionResult::ERROR, 1, 2, "error_message");
00017
00018     TEST_ASSERT_EQUAL(1, frame.direction);
00019     TEST_ASSERT_EQUAL(OperationType::ERR, frame.operationType);
00020     TEST_ASSERT_EQUAL_STRING("error_message", frame.value.c_str());
00021     TEST_ASSERT_EQUAL_STRING("", frame.unit.c_str());
00022 }
00023
00024 void test_frame_build_info() {
00025     Frame frame = frame_build(ExecutionResult::INFO, 1, 2, "info_message");
00026
00027     TEST_ASSERT_EQUAL(1, frame.direction);
00028     TEST_ASSERT_EQUAL(OperationType::INF, frame.operationType);
00029     TEST_ASSERT_EQUAL_STRING("info_message", frame.value.c_str());
00030 }
  
```

## 8.117 test/comms/test\_frame\_coding.cpp File Reference

```
#include "test_frame_common.h"
```

Include dependency graph for test\_frame\_coding.cpp:



### Functions

- void [test\\_frame\\_encode\\_basic\(\)](#)
- void [test\\_frame\\_decode\\_basic\(\)](#)
- void [test\\_frame\\_decode\\_invalid\\_header\(\)](#)

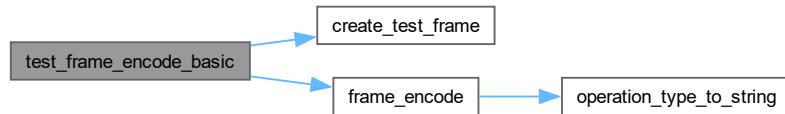
## 8.117.1 Function Documentation

### 8.117.1.1 test\_frame\_encode\_basic()

```
void test_frame_encode_basic (
    void )
```

Definition at line 4 of file [test\\_frame\\_coding.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

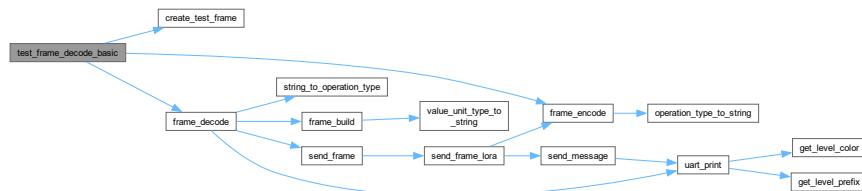


### 8.117.1.2 test\_frame\_decode\_basic()

```
void test_frame_decode_basic (
    void )
```

Definition at line 14 of file [test\\_frame\\_coding.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

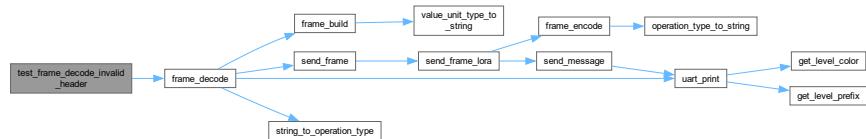


### 8.117.1.3 test\_frame\_decode\_invalid\_header()

```
void test_frame_decode_invalid_header (
    void )
```

Definition at line 26 of file [test\\_frame\\_coding.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



## 8.118 test\_frame\_coding.cpp

[Go to the documentation of this file.](#)

```
00001 // test_frame_codec.cpp
00002 #include "test_frame_common.h"
00003
00004 void test_frame_encode_basic() {
00005     Frame frame = create_test_frame();
00006     std::string encoded = frame_encode(frame);
00007     TEST_ASSERT_NOT_EQUAL(0, encoded.length());
```

```

00009     TEST_ASSERT_TRUE(encoded.find(FRAME_BEGIN) != std::string::npos);
00010     TEST_ASSERT_TRUE(encoded.find(FRAME_END) != std::string::npos);
00011     TEST_ASSERT_TRUE(encoded.find("test_value") != std::string::npos);
00012 }
00013
00014 void test_frame_decode_basic() {
00015     Frame original = create_test_frame();
00016     std::string encoded = frame_encode(original);
00017     Frame decoded = frame_decode(encoded);
00018
00019     TEST_ASSERT_EQUAL(original.direction, decoded.direction);
00020     TEST_ASSERT_EQUAL(original.group, decoded.group);
00021     TEST_ASSERT_EQUAL(original.command, decoded.command);
00022     TEST_ASSERT_EQUAL_STRING(original.value.c_str(), decoded.value.c_str());
00023     TEST_ASSERT_EQUAL_STRING(original.unit.c_str(), decoded.unit.c_str());
00024 }
00025
00026 void test_frame_decode_invalid_header() {
00027     std::string invalid_frame = "INVALID" + std::string(1, DELIMITER) + "rest_of_frame";
00028     bool exceptionThrown = false;
00029
00030     try {
00031         Frame decoded = frame_decode(invalid_frame);
00032     } catch (const std::runtime_error& e) {
00033         exceptionThrown = true;
00034     } catch (...) {
00035         // Catch any other exceptions to avoid crashing the test
00036     }
00037
00038     TEST_ASSERT_TRUE(exceptionThrown);
00039 }

```

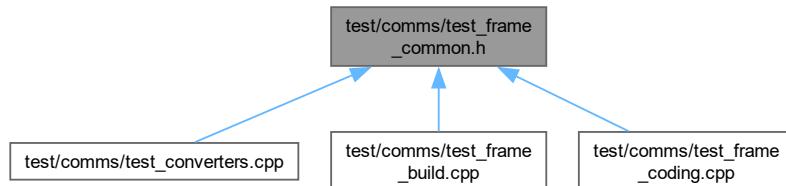
## 8.119 test/comms/test\_frame\_common.h File Reference

```
#include "unity.h"
#include "protocol.h"
#include "communication.h"

Include dependency graph for test_frame_common.h:
```



This graph shows which files directly or indirectly include this file:



### Functions

- [Frame create\\_test\\_frame \(\)](#)

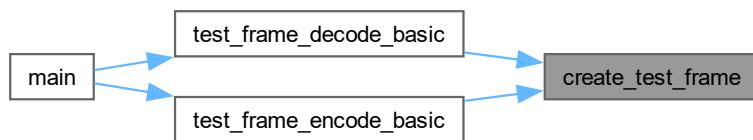
## 8.119.1 Function Documentation

### 8.119.1.1 create\_test\_frame()

```
Frame create_test_frame ()
```

Definition at line 10 of file [test\\_frame\\_common.h](#).

Here is the caller graph for this function:



## 8.120 test\_frame\_common.h

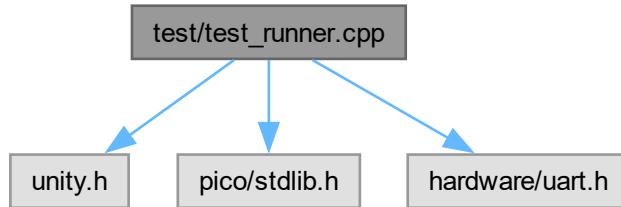
[Go to the documentation of this file.](#)

```
00001 // test_frame_common.h
00002 #ifndef TEST_FRAME_COMMON_H
00003 #define TEST_FRAME_COMMON_H
00004
00005 #include "unity.h"
00006 #include "protocol.h"
00007 #include "communication.h"
00008
00009 // Helper function to create a test frame
0010 Frame create_test_frame() {
0011     Frame frame;
0012     frame.header = FRAME_BEGIN;
0013     frame.direction = 1;
0014     frame.operationType = OperationType::GET;
0015     frame.group = 1;
0016     frame.command = 2;
0017     frame.value = "test_value";
0018     frame.unit = "V";
0019     frame.footer = FRAME_END;
0020     return frame;
0021 }
0022
0023 #endif
```

## 8.121 test/test\_runner.cpp File Reference

```
#include "unity.h"
#include "pico/stdlib.h"
```

```
#include "hardware/uart.h"
Include dependency graph for test_runner.cpp:
```



## Functions

- void `test_frame_encode_basic` (void)
- void `test_frame_decode_basic` (void)
- void `test_frame_decode_invalid_header` (void)
- void `test_frame_build_success` (void)
- void `test_frame_build_error` (void)
- void `test_frame_build_info` (void)
- void `test_operation_type_conversion` (void)
- void `test_value_unit_type_conversion` (void)
- void `test_exception_type_conversion` (void)
- void `test_hex_string_conversion` (void)
- int `main` (void)

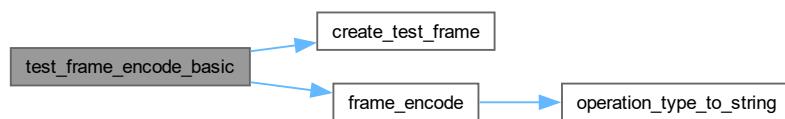
### 8.121.1 Function Documentation

#### 8.121.1.1 `test_frame_encode_basic()`

```
void test_frame_encode_basic (
    void ) [extern]
```

Definition at line 4 of file `test_frame_coding.cpp`.

Here is the call graph for this function:



Here is the caller graph for this function:

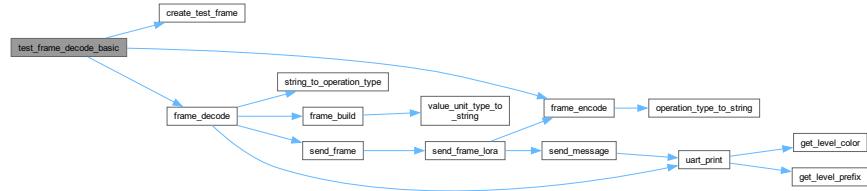


### 8.121.1.2 test\_frame\_decode\_basic()

```
void test_frame_decode_basic (
    void ) [extern]
```

Definition at line 14 of file [test\\_frame\\_coding.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

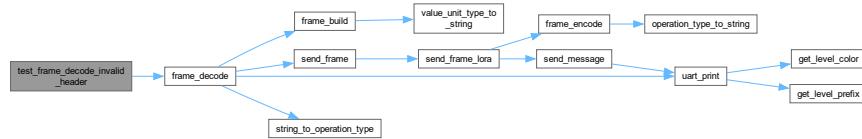


### 8.121.1.3 test\_frame\_decode\_invalid\_header()

```
void test_frame_decode_invalid_header (
    void ) [extern]
```

Definition at line 26 of file [test\\_frame\\_coding.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



#### 8.121.1.4 test\_frame\_build\_success()

```
void test_frame_build_success (
    void ) [extern]
```

Definition at line 4 of file [test\\_frame\\_build.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 8.121.1.5 test\_frame\_build\_error()

```
void test_frame_build_error (
    void ) [extern]
```

Definition at line 15 of file [test\\_frame\\_build.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



### 8.121.1.6 test\_frame\_build\_info()

```
void test_frame_build_info (
    void ) [extern]
```

Definition at line 24 of file [test\\_frame\\_build.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

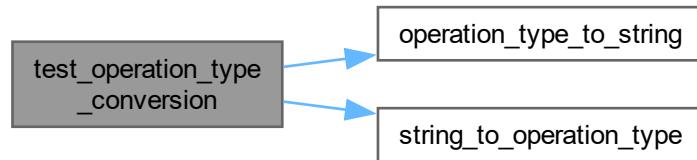


#### 8.121.1.7 `test_operation_type_conversion()`

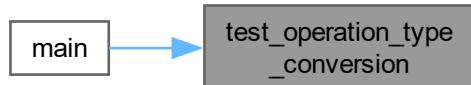
```
void test_operation_type_conversion (
    void ) [extern]
```

Definition at line 4 of file [test\\_converters.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

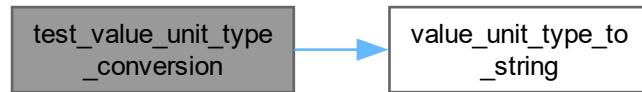


### 8.121.1.8 test\_value\_unit\_type\_conversion()

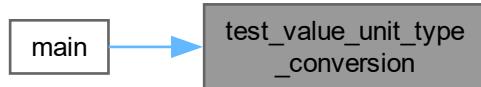
```
void test_value_unit_type_conversion (
    void ) [extern]
```

Definition at line 13 of file [test\\_converters.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

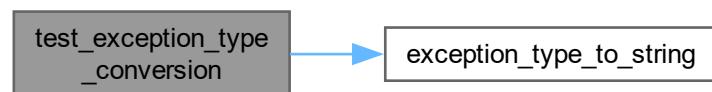


### 8.121.1.9 test\_exception\_type\_conversion()

```
void test_exception_type_conversion (
    void ) [extern]
```

Definition at line 20 of file [test\\_converters.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:



#### 8.121.1.10 `test_hex_string_conversion()`

```
void test_hex_string_conversion (
    void ) [extern]
```

Definition at line 27 of file [test\\_converters.cpp](#).

Here is the call graph for this function:



Here is the caller graph for this function:

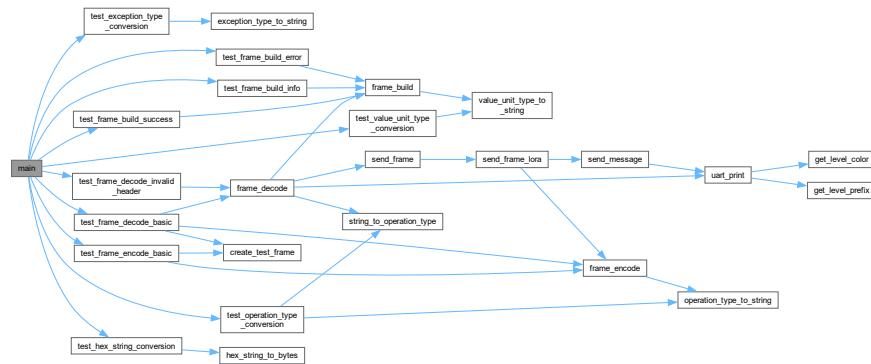


#### 8.121.1.11 `main()`

```
int main (
    void )
```

Definition at line 18 of file [test\\_runner.cpp](#).

Here is the call graph for this function:



## 8.122 test\_runner.cpp

[Go to the documentation of this file.](#)

```

00001 // test_runner.cpp
00002 #include "unity.h"
00003 #include "pico/stdlib.h"
00004 #include "hardware/uart.h"
00005
00006 // External test function declarations
00007 extern void test_frame_encode_basic(void);
00008 extern void test_frame_decode_basic(void);
00009 extern void test_frame_decode_invalid_header(void);
00010 extern void test_frame_build_success(void);
00011 extern void test_frame_build_error(void);
00012 extern void test_frame_build_info(void);
00013 extern void test_operation_type_conversion(void);
00014 extern void test_value_unit_type_conversion(void);
00015 extern void test_exception_type_conversion(void);
00016 extern void test_hex_string_conversion(void);
00017
00018 int main(void) {
00019     stdio_init_all();
00020     uart_init(uart0, 115200);
00021     gpio_set_function(0, GPIO_FUNC_UART);
00022     gpio_set_function(1, GPIO_FUNC_UART);
00023
00024     UNITY_BEGIN();
00025     uart_puts(uart0, "begin unity tests\n");
00026
00027     // Frame codec tests
00028     uart_puts(uart0, "begin frame codec tests\n");
00029     RUN_TEST(test_frame_encode_basic);
00030     RUN_TEST(test_frame_decode_basic);
00031     RUN_TEST(test_frame_decode_invalid_header);
00032     uart_puts(uart0, "end frame codec tests\n");
00033
00034     // Frame build tests
00035     uart_puts(uart0, "begin frame build tests\n");
00036     RUN_TEST(test_frame_build_success);
00037     RUN_TEST(test_frame_build_error);
00038     RUN_TEST(test_frame_build_info);
00039     uart_puts(uart0, "end frame build tests\n");
00040
00041     // Converter tests
00042     uart_puts(uart0, "begin converter tests\n");
00043     RUN_TEST(test_operation_type_conversion);
00044     RUN_TEST(test_value_unit_type_conversion);
00045     RUN_TEST(test_exception_type_conversion);
00046     RUN_TEST(test_hex_string_conversion);
00047     uart_puts(uart0, "end converter tests\n");
00048
00049     return UNITY_END();
00050 }
```



# Index

\_BH1750\_DEFAULT\_MTREG  
  BH1750.h, [254](#)  
\_BH1750\_DEVICE\_ID  
  BH1750.h, [253](#)  
\_BH1750\_MTREG\_MAX  
  BH1750.h, [253](#)  
\_BH1750\_MTREG\_MIN  
  BH1750.h, [253](#)  
\_\_attribute\_\_  
  Event Manager, [46](#), [49](#)  
\_filterRes  
  INA3221, [126](#)  
\_i2c  
  INA3221, [126](#)  
\_i2c\_addr  
  BH1750, [72](#)  
  INA3221, [126](#)  
\_masken\_reg  
  INA3221, [126](#)  
\_read  
  INA3221, [122](#)  
\_shuntRes  
  INA3221, [126](#)  
\_write  
  INA3221, [123](#)  
~EventManager  
  EventManager, [105](#)  
~ISensor  
  ISensor, [127](#)  
  
ACCEL\_X  
  ISensor.h, [274](#)  
ACCEL\_Y  
  ISensor.h, [274](#)  
ACCEL\_Z  
  ISensor.h, [274](#)  
ADDR\_SDO\_HIGH  
  BME280, [78](#)  
ADDR\_SDO\_LOW  
  BME280, [78](#)  
address  
  HMC5883L, [117](#)  
Alert Functions, [62](#)  
  enable\_alerts, [64](#)  
  get\_crit\_alert, [65](#)  
  get\_power\_valid\_alert, [67](#)  
  get\_warn\_alert, [65](#)  
  set\_alert\_latch, [67](#)  
  set\_crit\_alert\_limit, [63](#)  
  set\_power\_valid\_limit, [64](#)  
  
ANS  
  set\_warn\_alert\_limit, [63](#)  
ANSI  
  protocol.h, [191](#)  
ANSI\_BLUE  
  utils.h, [292](#)  
ANSI\_CYAN  
  utils.h, [292](#)  
ANSI\_GREEN  
  utils.h, [292](#)  
ANSI\_RED  
  utils.h, [292](#)  
ANSI\_RESET  
  utils.h, [292](#)  
ANSI\_YELLOW  
  utils.h, [292](#)  
avg\_mode  
  INA3221::conf\_reg\_t, [91](#)  
  
bcd\_to\_bin  
  DS3231, [98](#)  
begin  
  BH1750, [70](#)  
  Configuration Functions, [52](#)  
BH1750, [69](#)  
  \_i2c\_addr, [72](#)  
  begin, [70](#)  
  BH1750, [70](#)  
  configure, [70](#)  
  CONTINUOUS\_HIGH\_RES\_MODE, [70](#)  
  CONTINUOUS\_HIGH\_RES\_MODE\_2, [70](#)  
  CONTINUOUS\_LOW\_RES\_MODE, [70](#)  
  get\_light\_level, [71](#)  
  Mode, [69](#)  
  ONE\_TIME\_HIGH\_RES\_MODE, [70](#)  
  ONE\_TIME\_HIGH\_RES\_MODE\_2, [70](#)  
  ONE\_TIME\_LOW\_RES\_MODE, [70](#)  
  POWER\_ON, [70](#)  
  RESET, [70](#)  
  UNCONFIGURED\_POWER\_DOWN, [70](#)  
  write8, [71](#)  
BH1750.h  
  \_BH1750\_DEFAULT\_MTREG, [254](#)  
  \_BH1750\_DEVICE\_ID, [253](#)  
  \_BH1750\_MTREG\_MAX, [253](#)  
  \_BH1750\_MTREG\_MIN, [253](#)  
BH1750Wrapper, [72](#)  
  BH1750Wrapper, [73](#)  
  configure, [74](#)  
  get\_i2c\_addr, [73](#)  
  get\_type, [74](#)

init, 73  
 initialized\_, 74  
 is\_initialized, 74  
 read\_data, 73  
 sensor\_, 74  
**bin\_to\_bcd**  
 DS3231, 97  
**BME280**, 75  
 ADDR\_SDO\_HIGH, 78  
 ADDR\_SDO\_LOW, 78  
 BME280, 76  
 calib\_params, 79  
 configure\_sensor, 78  
 convert\_humidity, 77  
 convert\_pressure, 77  
 convert\_temperature, 77  
 device\_addr, 79  
 get\_calibration\_parameters, 78  
 i2c\_port, 79  
 init, 77  
 initialized\_, 79  
 NUM\_CALIB\_PARAMS, 84  
 read\_raw\_all, 77  
 REG\_CONFIG, 79  
 REG\_CTRL\_HUM, 79  
 REG\_CTRL\_MEAS, 79  
 REG\_DIG\_H1, 83  
 REG\_DIG\_H2, 83  
 REG\_DIG\_H3, 83  
 REG\_DIG\_H4, 83  
 REG\_DIG\_H5, 84  
 REG\_DIG\_H6, 84  
 REG\_DIG\_P1\_LSB, 81  
 REG\_DIG\_P1\_MSB, 81  
 REG\_DIG\_P2\_LSB, 81  
 REG\_DIG\_P2\_MSB, 81  
 REG\_DIG\_P3\_LSB, 81  
 REG\_DIG\_P3\_MSB, 81  
 REG\_DIG\_P4\_LSB, 82  
 REG\_DIG\_P4\_MSB, 82  
 REG\_DIG\_P5\_LSB, 82  
 REG\_DIG\_P5\_MSB, 82  
 REG\_DIG\_P6\_LSB, 82  
 REG\_DIG\_P6\_MSB, 82  
 REG\_DIG\_P7\_LSB, 82  
 REG\_DIG\_P7\_MSB, 82  
 REG\_DIG\_P8\_LSB, 83  
 REG\_DIG\_P8\_MSB, 83  
 REG\_DIG\_P9\_LSB, 83  
 REG\_DIG\_P9\_MSB, 83  
 REG\_DIG\_T1\_LSB, 80  
 REG\_DIG\_T1\_MSB, 80  
 REG\_DIG\_T2\_LSB, 80  
 REG\_DIG\_T2\_MSB, 80  
 REG\_DIG\_T3\_LSB, 81  
 REG\_DIG\_T3\_MSB, 81  
 REG\_HUMIDITY\_MSB, 80  
 REG\_PRESSURE\_MSB, 80  
 REG\_RESET, 80  
 REG\_TEMPERATURE\_MSB, 80  
 reset, 77  
 t\_fine, 79  
**BME280CalibParam**, 84  
 dig\_h1, 86  
 dig\_h2, 86  
 dig\_h3, 86  
 dig\_h4, 87  
 dig\_h5, 87  
 dig\_h6, 87  
 dig\_p1, 85  
 dig\_p2, 85  
 dig\_p3, 85  
 dig\_p4, 85  
 dig\_p5, 86  
 dig\_p6, 86  
 dig\_p7, 86  
 dig\_p8, 86  
 dig\_p9, 86  
 dig\_t1, 85  
 dig\_t2, 85  
 dig\_t3, 85  
**BME280Wrapper**, 87  
 BME280Wrapper, 88  
 configure, 89  
 get\_type, 89  
 init, 89  
 initialized\_, 89  
 is\_initialized, 89  
 read\_data, 89  
 sensor\_, 89  
**BOOL**  
 protocol.h, 191  
**BOOT**  
 Event Manager, 44  
**buffer**  
 main.cpp, 299  
**BUFFER\_SIZE**  
 pin\_config.h, 231  
**bufferIndex**  
 main.cpp, 299  
**BUILD\_NUMBER**  
 build\_number.h, 145  
**build\_number.h**, 145  
 BUILD\_NUMBER, 145  
**bus\_conv\_time**  
 INA3221::conf\_reg\_t, 91  
**calculate\_checksum**  
 storage\_commands\_utils.cpp, 173  
 storage\_commands\_utils.h, 176  
**calib\_params**  
 BME280, 79  
**century**  
 ds3231\_data\_t, 100  
**ch1\_en**  
 INA3221::conf\_reg\_t, 91  
**ch2\_en**

INA3221::conf\_reg\_t, 91  
ch3\_en  
INA3221::conf\_reg\_t, 91  
CHANGED  
Event Manager, 45  
charging\_solar\_active\_  
PowerManager, 141  
charging\_usb\_active\_  
PowerManager, 141  
check\_power\_alerts  
PowerManager, 139  
check\_power\_events  
Event Manager, 45  
CLOCK  
Event Manager, 44  
Clock Commands, 1  
Clock Management Commands, 11  
handle\_clock\_sync\_interval, 13  
handle\_get\_last\_sync\_time, 13  
handle\_time, 11  
handle\_timezone\_offset, 12  
systemClock, 14  
clock\_commands.cpp  
CLOCK\_GROUP, 155  
CLOCK\_SYNC\_INTERVAL, 156  
LAST\_SYNC\_TIME, 156  
TIME, 155  
TIMEZONE\_OFFSET, 155  
clock\_enable  
DS3231, 95  
CLOCK\_GROUP  
clock\_commands.cpp, 155  
clock\_mutex\_  
DS3231, 99  
CLOCK\_SYNC\_INTERVAL  
clock\_commands.cpp, 156  
ClockEvent  
Event Manager, 45  
collect\_gps\_data  
gps\_collector.cpp, 220  
gps\_collector.h, 222  
command  
Frame, 114  
Command System, 14  
CommandHandler, 15  
commandHandlers, 16  
CommandMap, 15  
execute\_command, 15  
CommandAccessLevel  
protocol.h, 191  
CommandHandler  
Command System, 15  
frame.cpp, 187  
commandHandlers  
Command System, 16  
CommandMap  
Command System, 15  
COMMS  
Event Manager, 44  
CommsEvent  
Event Manager, 44  
communication.cpp  
initialize\_radio, 177  
interval, 179  
lastPrintTime, 179  
lastReceiveTime, 179  
lastSendTime, 178  
msgCount, 178  
outgoing, 178  
communication.h  
determine\_unit, 185  
handle\_uart\_input, 182  
initialize\_radio, 181  
on\_receive, 181  
send\_frame, 183  
send\_frame\_lora, 184  
send\_frame\_uart, 183  
send\_message, 183  
split\_and\_send\_message, 185  
Configuration Functions, 50  
begin, 52  
get\_die\_id, 53  
get\_manufacturer\_id, 53  
INA3221, 51  
read\_register, 54  
reset, 52  
set\_averaging\_mode, 58  
set\_bus\_conversion\_time, 59  
set\_bus\_measurement\_disable, 58  
set\_bus\_measurement\_enable, 57  
set\_mode\_continuous, 55  
set\_mode\_power\_down, 55  
set\_mode\_triggered, 56  
set\_shunt\_conversion\_time, 59  
set\_shunt\_measurement\_disable, 57  
set\_shunt\_measurement\_enable, 56  
configure  
BH1750, 70  
BH1750Wrapper, 74  
BME280Wrapper, 89  
HMC5883LWrapper, 120  
ISensor, 127  
MPU6050Wrapper, 132  
PowerManager, 138  
configure\_sensor  
BME280, 78  
CONTINUOUS\_HIGH\_RES\_MODE  
BH1750, 70  
CONTINUOUS\_HIGH\_RES\_MODE\_2  
BH1750, 70  
CONTINUOUS\_LOW\_RES\_MODE  
BH1750, 70  
conv\_ready  
INA3221::masken\_reg\_t, 128  
convert\_humidity  
BME280, 77

convert\_pressure  
     BME280, 77  
 convert\_temperature  
     BME280, 77  
 core1\_entry  
     main.cpp, 297  
 CORE1\_START  
     Event Manager, 44  
 CORE1\_STOP  
     Event Manager, 44  
 crc16  
     utils.cpp, 288  
     utils.h, 294  
 create\_test\_frame  
     test\_frame\_common.h, 311  
 crit\_alert\_ch1  
     INA3221::masken\_reg\_t, 129  
 crit\_alert\_ch2  
     INA3221::masken\_reg\_t, 129  
 crit\_alert\_ch3  
     INA3221::masken\_reg\_t, 129  
 crit\_alert\_latch\_en  
     INA3221::masken\_reg\_t, 130  
  
 DATA\_COMMAND  
     storage\_commands.cpp, 170  
 DATA\_READY  
     Event Manager, 45  
 date  
     ds3231\_data\_t, 100  
 DATETIME  
     protocol.h, 191  
 day  
     ds3231\_data\_t, 100  
 days\_of\_week  
     DS3231.h, 153  
 DEBUG  
     utils.h, 293  
 DEBUG\_UART\_BAUD\_RATE  
     pin\_config.h, 230  
 DEBUG\_UART\_PORT  
     pin\_config.h, 230  
 DEBUG\_UART\_RX\_PIN  
     pin\_config.h, 230  
 DEBUG\_UART\_TX\_PIN  
     pin\_config.h, 230  
 DELIMITER  
     protocol.h, 196  
 determine\_unit  
     communication.h, 185  
 device\_addr  
     BME280, 79  
 Diagnostic Commands, 17  
     handle\_enter\_bootloader\_mode, 20  
     handle\_get\_build\_version, 18  
     handle\_get\_commands\_list, 17  
     handle\_verbosity, 19  
 dig\_h1  
     BME280CalibParam, 86  
  
 dig\_h2  
     BME280CalibParam, 86  
 dig\_h3  
     BME280CalibParam, 86  
 dig\_h4  
     BME280CalibParam, 87  
 dig\_h5  
     BME280CalibParam, 87  
 dig\_h6  
     BME280CalibParam, 87  
 dig\_p1  
     BME280CalibParam, 85  
 dig\_p2  
     BME280CalibParam, 85  
 dig\_p3  
     BME280CalibParam, 85  
 dig\_p4  
     BME280CalibParam, 85  
 dig\_p5  
     BME280CalibParam, 86  
 dig\_p6  
     BME280CalibParam, 86  
 dig\_p7  
     BME280CalibParam, 86  
 dig\_p8  
     BME280CalibParam, 86  
 dig\_p9  
     BME280CalibParam, 86  
 dig\_t1  
     BME280CalibParam, 85  
 dig\_t2  
     BME280CalibParam, 85  
 dig\_t3  
     BME280CalibParam, 85  
 direction  
     Frame, 114  
 DS3231, 92  
     bcd\_to\_bin, 98  
     bin\_to\_bcd, 97  
     clock\_enable, 95  
     clock\_mutex\_, 99  
     DS3231, 93  
     ds3231\_addr, 99  
     get\_time, 93  
     get\_unix\_time, 95  
     i2c, 99  
     i2c\_read\_reg, 96  
     i2c\_write\_reg, 96  
     read\_temperature, 94  
     set\_time, 93  
     set\_unix\_time, 94  
 DS3231.h  
     days\_of\_week, 153  
     DS3231\_CONTROL\_REG, 153  
     DS3231\_CONTROL\_STATUS\_REG, 153  
     DS3231\_DATE\_REG, 152  
     DS3231\_DAY\_REG, 152  
     DS3231\_DEVICE\_ADRESS, 152

DS3231\_HOURS\_REG, 152  
DS3231\_MINUTES\_REG, 152  
DS3231\_MONTH\_REG, 152  
DS3231\_SECONDS\_REG, 152  
DS3231\_TEMPERATURE\_LSB\_REG, 153  
DS3231\_TEMPERATURE\_MSB\_REG, 153  
DS3231\_YEAR\_REG, 153  
FRIDAY, 153  
MONDAY, 153  
SATURDAY, 153  
SUNDAY, 153  
THURSDAY, 153  
TUESDAY, 153  
WEDNESDAY, 153  
ds3231\_addr  
    DS3231, 99  
DS3231\_CONTROL\_REG  
    DS3231.h, 153  
DS3231\_CONTROL\_STATUS\_REG  
    DS3231.h, 153  
ds3231\_data\_t, 99  
    century, 100  
    date, 100  
    day, 100  
    hours, 100  
    minutes, 100  
    month, 100  
    seconds, 100  
    year, 100  
DS3231\_DATE\_REG  
    DS3231.h, 152  
DS3231\_DAY\_REG  
    DS3231.h, 152  
DS3231\_DEVICE\_ADDRESS  
    DS3231.h, 152  
DS3231\_HOURS\_REG  
    DS3231.h, 152  
DS3231\_MINUTES\_REG  
    DS3231.h, 152  
DS3231\_MONTH\_REG  
    DS3231.h, 152  
DS3231\_SECONDS\_REG  
    DS3231.h, 152  
DS3231\_TEMPERATURE\_LSB\_REG  
    DS3231.h, 153  
DS3231\_TEMPERATURE\_MSB\_REG  
    DS3231.h, 153  
DS3231\_YEAR\_REG  
    DS3231.h, 153  
  
emit  
    EventEmitter, 101  
enable\_alerts  
    Alert Functions, 64  
END\_COMMAND  
    storage\_commands.cpp, 170  
ENVIRONMENT  
    ISensor.h, 274  
ERR  
    protocol.h, 191  
ERROR  
    Event Manager, 45  
    protocol.h, 190  
    utils.h, 293  
EVENT  
    utils.h, 293  
event  
    event\_manager.h, 216  
    EventLog, 104  
Event Commands, 21  
    handle\_get\_event\_count, 22  
    handle\_get\_last\_events, 21  
Event Manager, 41  
    \_\_attribute\_\_, 46, 49  
    BOOT, 44  
    CHANGED, 45  
    check\_power\_events, 45  
    CLOCK, 44  
    ClockEvent, 45  
    COMMS, 44  
    CommsEvent, 44  
    CORE1\_START, 44  
    CORE1\_STOP, 44  
    DATA\_READY, 45  
    ERROR, 45  
    EventGroup, 43  
    eventLogId, 48  
    eventManager, 49  
    FALL\_RATE\_THRESHOLD, 48  
    FALLING\_TREND\_REQUIRED, 48  
    fallingTrendCount, 48  
    get\_event, 47  
    GPS, 44  
    GPS\_SYNC, 45  
    GPSEvent, 45  
    lastPowerState, 48  
    lastSolarState, 49  
    lastUSBState, 49  
    LOCK, 45  
    log\_event, 46  
    LOST, 45  
    LOW\_BATTERY, 44  
    MSG\_RECEIVED, 45  
    MSG\_SENT, 45  
    OVERCHARGE, 44  
    PASS\_THROUGH\_END, 45  
    PASS\_THROUGH\_START, 45  
    POWER, 44  
    POWER\_FALLING, 44  
    POWER\_NORMAL, 44  
    POWER\_OFF, 45  
    POWER\_ON, 45  
    PowerEvent, 44  
    RADIO\_ERROR, 45  
    RADIO\_INIT, 45  
    SHUTDOWN, 44  
    SOLAR\_ACTIVE, 44

SOLAR\_INACTIVE, 44  
 SYSTEM, 44  
 systemClock, 49  
 SystemEvent, 44  
 UART\_ERROR, 45  
 USB\_CONNECTED, 44  
 USB\_DISCONNECTED, 44  
 VOLTAGE\_LOW\_THRESHOLD, 48  
 VOLTAGE\_OVERCHARGE\_THRESHOLD, 48  
 WATCHDOG\_RESET, 44  
**EVENT\_BUFFER\_SIZE**  
 event\_manager.h, 215  
**EVENT\_LOG\_FILE**  
 event\_manager.h, 215  
**event\_manager.h**  
 event, 216  
 EVENT\_BUFFER\_SIZE, 215  
 EVENT\_LOG\_FILE, 215  
 group, 216  
 id, 216  
 timestamp, 216  
 to\_string, 216  
**eventCount**  
 EventManager, 107  
**EventEmitter**, 101  
 emit, 101  
**EventGroup**  
 Event Manager, 43  
**EventLog**, 102  
 event, 104  
 group, 103  
 id, 103  
 timestamp, 103  
 to\_string, 103  
**eventLogId**  
 Event Manager, 48  
**EventManager**, 104  
 ~EventManager, 105  
 eventCount, 107  
 EventManager, 105  
 eventMutex, 108  
 events, 107  
 get\_event\_count, 106  
 init, 106  
 load\_from\_storage, 107  
 needsPersistence, 108  
 nextEventId, 108  
 save\_to\_storage, 106  
 writeIndex, 108  
**eventManager**  
 Event Manager, 49  
**EventManagerImpl**, 109  
 EventManagerImpl, 110  
 load\_from\_storage, 111  
 save\_to\_storage, 111  
**eventMutex**  
 EventManager, 108  
**eventRegister**

frame.cpp, 187  
**events**  
 EventManager, 107  
**exception\_type\_to\_string**  
 protocol.h, 192  
 utils\_converters.cpp, 206  
**ExceptionType**  
 protocol.h, 191  
**execute\_command**  
 Command System, 15  
**ExecutionResult**  
 protocol.h, 190  
**FALL\_RATE\_THRESHOLD**  
 Event Manager, 48  
 PowerManager, 140  
**FALLING\_TREND\_REQUIRED**  
 Event Manager, 48  
 PowerManager, 140  
**fallingTrendCount**  
 Event Manager, 48  
**fd**  
 FileHandle, 112  
**FileHandle**, 112  
 fd, 112  
 is\_open, 112  
**footer**  
 Frame, 114  
**Frame**, 112  
 command, 114  
 direction, 114  
 footer, 114  
 group, 114  
 header, 114  
 operationType, 114  
 unit, 114  
 value, 114  
**Frame Handling**, 36  
 frame\_build, 39  
 frame\_decode, 37  
 frame\_encode, 36  
 frame\_process, 38  
**frame.cpp**  
 CommandHandler, 187  
 eventRegister, 187  
**FRAME\_BEGIN**  
 protocol.h, 196  
**frame\_build**  
 Frame Handling, 39  
**frame\_decode**  
 Frame Handling, 37  
**frame\_encode**  
 Frame Handling, 36  
**FRAME\_END**  
 protocol.h, 196  
**frame\_process**  
 Frame Handling, 38  
**FRIDAY**  
 DS3231.h, 153

fs\_close\_file  
    storage.h, 283  
fs\_file\_exists  
    storage.h, 283  
fs\_init  
    storage.cpp, 279  
    storage.h, 281  
fs\_open\_file  
    storage.h, 282  
fs\_read\_file  
    storage.h, 282  
fs\_write\_file  
    storage.h, 282

g\_uart\_verbosity  
    utils.cpp, 289  
    utils.h, 295

GET  
    protocol.h, 191

get\_calibration\_parameters  
    BME280, 78

get\_crit\_alert  
    Alert Functions, 65

get\_current  
    INA3221, 125

get\_current\_charge\_solar  
    PowerManager, 137

get\_current\_charge\_total  
    PowerManager, 137

get\_current\_charge\_usb  
    PowerManager, 137

get\_current\_draw  
    PowerManager, 137

get\_current\_ma  
    Measurement Functions, 61

get\_die\_id  
    Configuration Functions, 53

get\_event  
    Event Manager, 47

get\_event\_count  
    EventManager, 106

get\_gga\_tokens  
    NMEAData, 134

get\_i2c\_addr  
    BH1750Wrapper, 73

get\_instance  
    SensorWrapper, 143

get\_level\_color  
    utils.cpp, 285

get\_level\_prefix  
    utils.cpp, 286

get\_light\_level  
    BH1750, 71

get\_manufacturer\_id  
    Configuration Functions, 53

get\_power\_valid\_alert  
    Alert Functions, 67

get\_rmc\_tokens  
    NMEAData, 134

get\_shunt\_voltage  
    Measurement Functions, 60

get\_time  
    DS3231, 93

get\_type  
    BH1750Wrapper, 74  
    BME280Wrapper, 89  
    HMC5883LWrapper, 119  
    ISensor, 127  
    MPU6050Wrapper, 132

get\_unix\_time  
    DS3231, 95

get\_voltage  
    Measurement Functions, 62

get\_voltage\_5v  
    PowerManager, 138

get\_voltage\_battery  
    PowerManager, 138

get\_warn\_alert  
    Alert Functions, 65

gga\_mutex  
    NMEAData, 135

gga\_tokens\_  
    NMEAData, 134

GPS  
    Event Manager, 44

GPS Commands, 23  
    handle\_enable\_gps\_uart\_passthrough, 24  
    handle\_get\_gga\_data, 26  
    handle\_get\_rmc\_data, 25  
    handle\_gps\_power\_status, 23

gps\_collector.cpp  
    collect\_gps\_data, 220  
    MAX\_RAW\_DATA\_LENGTH, 219  
    nmea\_data, 221  
    splitString, 220

gps\_collector.h  
    collect\_gps\_data, 222

GPS\_POWER\_ENABLE\_PIN  
    pin\_config.h, 231

GPS\_SYNC  
    Event Manager, 45

GPS\_UART\_BAUD\_RATE  
    pin\_config.h, 231

GPS\_UART\_PORT  
    pin\_config.h, 231

GPS\_UART\_RX\_PIN  
    pin\_config.h, 231

GPS\_UART\_TX\_PIN  
    pin\_config.h, 231

GPSEvent  
    Event Manager, 45

group  
    event\_manager.h, 216  
    EventLog, 103  
    Frame, 114

GYRO\_X  
    ISensor.h, 274

GYRO\_Y  
  ISensor.h, 274

GYRO\_Z  
  ISensor.h, 274

handle\_clock\_sync\_interval  
  Clock Management Commands, 13

handle\_enable\_gps\_uart\_passthrough  
  GPS Commands, 24

handle\_enter\_bootloader\_mode  
  Diagnostic Commands, 20

handle\_file\_download  
  Storage Commands, 33

handle\_get\_build\_version  
  Diagnostic Commands, 18

handle\_get\_commands\_list  
  Diagnostic Commands, 17

handle\_get\_current\_charge\_solar  
  Power Commands, 30

handle\_get\_current\_charge\_total  
  Power Commands, 31

handle\_get\_current\_charge\_usb  
  Power Commands, 29

handle\_get\_current\_draw  
  Power Commands, 32

handle\_get\_event\_count  
  Event Commands, 22

handle\_get\_gga\_data  
  GPS Commands, 26

handle\_get\_last\_events  
  Event Commands, 21

handle\_get\_last\_sync\_time  
  Clock Management Commands, 13

handle\_get\_power\_manager\_ids  
  Power Commands, 27

handle\_get\_rmc\_data  
  GPS Commands, 25

handle\_get\_voltage\_5v  
  Power Commands, 28

handle\_get\_voltage\_battery  
  Power Commands, 28

handle\_gps\_power\_status  
  GPS Commands, 23

handle\_list\_files  
  Storage Commands, 34

handle\_mount  
  Storage Commands, 35

handle\_time  
  Clock Management Commands, 11

handle\_timezone\_offset  
  Clock Management Commands, 12

handle\_uart\_input  
  communication.h, 182  
  receive.cpp, 198

handle\_verbosity  
  Diagnostic Commands, 19

header  
  Frame, 114

hex\_string\_to\_bytes

protocol.h, 194  
utils\_converters.cpp, 209

HMC5883L, 115  
  address, 117  
  HMC5883L, 115  
  i2c, 117  
  init, 116  
  read, 116  
  read\_register, 117  
  write\_register, 116

HMC5883LWrapper, 118  
  configure, 120  
  get\_type, 119  
  HMC5883LWrapper, 119  
  init, 119  
  initialized\_, 120  
  is\_initialized, 119  
  read\_data, 119  
  sensor\_, 120

hours  
  ds3231\_data\_t, 100

HUMIDITY  
  ISensor.h, 274

i2c  
  DS3231, 99  
  HMC5883L, 117

i2c\_port  
  BME280, 79

i2c\_read\_reg  
  DS3231, 96

i2c\_write\_reg  
  DS3231, 96

id  
  event\_manager.h, 216  
  EventLog, 103

IMU  
  ISensor.h, 274

INA3221, 120  
  \_filterRes, 126  
  \_i2c, 126  
  \_i2c\_addr, 126  
  \_masken\_reg, 126  
  \_read, 122  
  \_shuntRes, 126  
  \_write, 123  
  Configuration Functions, 51  
  get\_current, 125

INA3221 Power Monitor, 50

INA3221.h  
  INA3221\_ADDR40\_GND, 243  
  INA3221\_ADDR41\_VCC, 243  
  INA3221\_ADDR42\_SDA, 243  
  INA3221\_ADDR43\_SCL, 243  
  ina3221\_addr\_t, 242  
  ina3221\_avg\_mode\_t, 244  
  INA3221\_CH1, 243  
  INA3221\_CH2, 243  
  INA3221\_CH3, 243

INA3221\_CH\_NUM, 244  
ina3221\_ch\_t, 243  
ina3221\_conv\_time\_t, 243  
INA3221\_REG\_CH1\_BUSV, 243  
INA3221\_REG\_CH1\_CRIT\_ALERT\_LIM, 243  
INA3221\_REG\_CH1\_SHUNTV, 243  
INA3221\_REG\_CH1\_WARNING\_ALERT\_LIM,  
243  
INA3221\_REG\_CH2\_BUSV, 243  
INA3221\_REG\_CH2\_CRIT\_ALERT\_LIM, 243  
INA3221\_REG\_CH2\_SHUNTV, 243  
INA3221\_REG\_CH2\_WARNING\_ALERT\_LIM,  
243  
INA3221\_REG\_CH3\_BUSV, 243  
INA3221\_REG\_CH3\_CRIT\_ALERT\_LIM, 243  
INA3221\_REG\_CH3\_SHUNTV, 243  
INA3221\_REG\_CH3\_WARNING\_ALERT\_LIM,  
243  
INA3221\_REG\_CONF, 243  
INA3221\_REG\_CONF\_AVG\_1, 244  
INA3221\_REG\_CONF\_AVG\_1024, 244  
INA3221\_REG\_CONF\_AVG\_128, 244  
INA3221\_REG\_CONF\_AVG\_16, 244  
INA3221\_REG\_CONF\_AVG\_256, 244  
INA3221\_REG\_CONF\_AVG\_4, 244  
INA3221\_REG\_CONF\_AVG\_512, 244  
INA3221\_REG\_CONF\_AVG\_64, 244  
INA3221\_REG\_CONF\_CT\_1100US, 244  
INA3221\_REG\_CONF\_CT\_140US, 244  
INA3221\_REG\_CONF\_CT\_204US, 244  
INA3221\_REG\_CONF\_CT\_2116US, 244  
INA3221\_REG\_CONF\_CT\_332US, 244  
INA3221\_REG\_CONF\_CT\_4156US, 244  
INA3221\_REG\_CONF\_CT\_588US, 244  
INA3221\_REG\_CONF\_CT\_8244US, 244  
INA3221\_REG\_DIE\_ID, 243  
INA3221\_REG\_MANUF\_ID, 243  
INA3221\_REG\_MASK\_ENABLE, 243  
INA3221\_REG\_PWR\_VALID\_HI\_LIM, 243  
INA3221\_REG\_PWR\_VALID\_LO\_LIM, 243  
INA3221\_REG\_SHUNTV\_SUM, 243  
INA3221\_REG\_SHUNTV\_SUM\_LIM, 243  
ina3221\_reg\_t, 243  
SHUNT\_VOLTAGE\_LSB\_UV, 244  
INA3221::conf\_reg\_t, 90  
avg\_mode, 91  
bus\_conv\_time, 91  
ch1\_en, 91  
ch2\_en, 91  
ch3\_en, 91  
mode\_bus\_en, 90  
mode\_continious\_en, 90  
mode\_shunt\_en, 90  
reset, 91  
shunt\_conv\_time, 91  
INA3221::masken\_reg\_t, 128  
conv\_ready, 128  
crit\_alert\_ch1, 129  
crit\_alert\_ch2, 129  
crit\_alert\_ch3, 129  
crit\_alert\_latch\_en, 130  
pwr\_valid\_alert, 129  
reserved, 130  
shunt\_sum\_alert, 129  
shunt\_sum\_en\_ch1, 130  
shunt\_sum\_en\_ch2, 130  
shunt\_sum\_en\_ch3, 130  
timing\_ctrl\_alert, 128  
warn\_alert\_ch1, 129  
warn\_alert\_ch2, 129  
warn\_alert\_ch3, 129  
warn\_alert\_latch\_en, 130  
ina3221\_  
PowerManager, 140  
INA3221\_ADDR40\_GND  
INA3221.h, 243  
INA3221\_ADDR41\_VCC  
INA3221.h, 243  
INA3221\_ADDR42\_SDA  
INA3221.h, 243  
INA3221\_ADDR43\_SCL  
INA3221.h, 243  
ina3221\_addr\_t  
INA3221.h, 242  
ina3221\_avg\_mode\_t  
INA3221.h, 244  
INA3221\_CH1  
INA3221.h, 243  
INA3221\_CH2  
INA3221.h, 243  
INA3221\_CH3  
INA3221.h, 243  
INA3221\_CH\_NUM  
INA3221.h, 244  
ina3221\_ch\_t  
INA3221.h, 243  
ina3221\_conv\_time\_t  
INA3221.h, 243  
INA3221\_REG\_CH1\_BUSV  
INA3221.h, 243  
INA3221\_REG\_CH1\_CRIT\_ALERT\_LIM  
INA3221.h, 243  
INA3221\_REG\_CH1\_SHUNTV  
INA3221.h, 243  
INA3221\_REG\_CH1\_WARNING\_ALERT\_LIM  
INA3221.h, 243  
INA3221\_REG\_CH2\_BUSV  
INA3221.h, 243  
INA3221\_REG\_CH2\_CRIT\_ALERT\_LIM  
INA3221.h, 243  
INA3221\_REG\_CH2\_SHUNTV  
INA3221.h, 243  
INA3221\_REG\_CH2\_WARNING\_ALERT\_LIM  
INA3221.h, 243  
INA3221\_REG\_CH3\_BUSV  
INA3221.h, 243

INA3221\_REG\_CH3\_CRIT\_ALERT\_LIM  
   INA3221.h, 243

INA3221\_REG\_CH3\_SHUNTV  
   INA3221.h, 243

INA3221\_REG\_CH3\_WARNING\_ALERT\_LIM  
   INA3221.h, 243

INA3221\_REG\_CONF  
   INA3221.h, 243

INA3221\_REG\_CONF\_AVG\_1  
   INA3221.h, 244

INA3221\_REG\_CONF\_AVG\_1024  
   INA3221.h, 244

INA3221\_REG\_CONF\_AVG\_128  
   INA3221.h, 244

INA3221\_REG\_CONF\_AVG\_16  
   INA3221.h, 244

INA3221\_REG\_CONF\_AVG\_256  
   INA3221.h, 244

INA3221\_REG\_CONF\_AVG\_4  
   INA3221.h, 244

INA3221\_REG\_CONF\_AVG\_512  
   INA3221.h, 244

INA3221\_REG\_CONF\_AVG\_64  
   INA3221.h, 244

INA3221\_REG\_CONF\_CT\_1100US  
   INA3221.h, 244

INA3221\_REG\_CONF\_CT\_140US  
   INA3221.h, 244

INA3221\_REG\_CONF\_CT\_204US  
   INA3221.h, 244

INA3221\_REG\_CONF\_CT\_2116US  
   INA3221.h, 244

INA3221\_REG\_CONF\_CT\_332US  
   INA3221.h, 244

INA3221\_REG\_CONF\_CT\_4156US  
   INA3221.h, 244

INA3221\_REG\_CONF\_CT\_588US  
   INA3221.h, 244

INA3221\_REG\_CONF\_CT\_8244US  
   INA3221.h, 244

INA3221\_REG\_DIE\_ID  
   INA3221.h, 243

INA3221\_REG\_MANUF\_ID  
   INA3221.h, 243

INA3221\_REG\_MASK\_ENABLE  
   INA3221.h, 243

INA3221\_REG\_PWR\_VALID\_HI\_LIM  
   INA3221.h, 243

INA3221\_REG\_PWR\_VALID\_LO\_LIM  
   INA3221.h, 243

INA3221\_REG\_SHUNTV\_SUM  
   INA3221.h, 243

INA3221\_REG\_SHUNTV\_SUM\_LIM  
   INA3221.h, 243

ina3221\_reg\_t  
   INA3221.h, 243

includes.h, 146

INF

protocol.h, 191

INFO  
   protocol.h, 190

utils.h, 293

init  
   BH1750Wrapper, 73

BME280, 77

BME280Wrapper, 89

EventManager, 106

HMC5883L, 116

HMC5883LWrapper, 119

ISensor, 127

MPU6050Wrapper, 132

init\_systems  
   main.cpp, 297

initialize  
   PowerManager, 137

initialize\_radio  
   communication.cpp, 177

  communication.h, 181

initialized\_  
   BH1750Wrapper, 74

BME280, 79

BME280Wrapper, 89

HMC5883LWrapper, 120

MPU6050Wrapper, 133

  PowerManager, 140

Interface  
   protocol.h, 192

interval  
   communication.cpp, 179

INVALID\_OPERATION  
   protocol.h, 192

INVALID\_PARAM  
   protocol.h, 192

is\_charging\_solar  
   PowerManager, 138

is\_charging\_usb  
   PowerManager, 139

is\_initialized  
   BH1750Wrapper, 74

BME280Wrapper, 89

HMC5883LWrapper, 119

ISensor, 127

MPU6050Wrapper, 132

is\_open  
   FileHandle, 112

ISensor, 126

  ~ISensor, 127

  configure, 127

  get\_type, 127

  init, 127

  is\_initialized, 127

  read\_data, 127

ISensor.h  
   ACCEL\_X, 274

  ACCEL\_Y, 274

  ACCEL\_Z, 274

ENVIRONMENT, 274  
GYRO\_X, 274  
GYRO\_Y, 274  
GYRO\_Z, 274  
HUMIDITY, 274  
IMU, 274  
LIGHT, 274  
LIGHT\_LEVEL, 274  
MAG\_FIELD\_X, 274  
MAG\_FIELD\_Y, 274  
MAG\_FIELD\_Z, 274  
MAGNETOMETER, 274  
PRESSURE, 274  
SensorDataTypelIdentifier, 274  
SensorType, 273  
TEMPERATURE, 274

LAST\_SYNC\_TIME  
    clock\_commands.cpp, 156

lastPowerState  
    Event Manager, 48

lastPrintTime  
    communication.cpp, 179

lastReceiveTime  
    communication.cpp, 179

lastSendTime  
    communication.cpp, 178

lastSolarState  
    Event Manager, 49

lastUSBState  
    Event Manager, 49

lib/clock/DS3231.cpp, 147  
lib/clock/DS3231.h, 151, 154

lib/comms/commands/clock\_commands.cpp, 154, 156  
lib/comms/commands/commands.cpp, 158  
lib/comms/commands/commands.h, 159, 161  
lib/comms/commands/diagnostic\_commands.cpp, 162  
lib/comms/commands/event\_commands.cpp, 163, 164  
lib/comms/commands/gps\_commands.cpp, 165  
lib/comms/commands/power\_commands.cpp, 167, 168  
lib/comms/commands/storage\_commands.cpp, 169, 171  
lib/comms/commands/storage\_commands\_utils.cpp, 173, 175  
lib/comms/commands/storage\_commands\_utils.h, 175, 177  
lib/comms/communication.cpp, 177, 179  
lib/comms/communication.h, 180, 185  
lib/comms/frame.cpp, 186, 187  
lib/comms/protocol.h, 189, 196  
lib/comms/receive.cpp, 197, 199  
lib/comms/send.cpp, 200, 204  
lib/comms/utils\_converters.cpp, 205, 210  
lib/eventman/event\_manager.cpp, 210, 212  
lib/eventman/event\_manager.h, 213, 217  
lib/location/gps\_collector.cpp, 219, 221  
lib/location/gps\_collector.h, 222, 223  
lib/location/NMEA/NMEA\_data.cpp, 224  
lib/location/NMEA/NMEA\_data.h, 225, 226

lib/pin\_config.cpp, 227, 228  
lib/pin\_config.h, 229, 235  
lib/powerman/INA3221/INA3221.cpp, 236  
lib/powerman/INA3221/INA3221.h, 241, 245  
lib/powerman/PowerManager.cpp, 247  
lib/powerman/PowerManager.h, 249, 250  
lib/sensors/BH1750/BH1750.cpp, 251  
lib/sensors/BH1750/BH1750.h, 252, 254  
lib/sensors/BH1750/BH1750\_WRAPPER.cpp, 254, 255  
lib/sensors/BH1750/BH1750\_WRAPPER.h, 256, 257  
lib/sensors/BME280/BME280.cpp, 257, 258  
lib/sensors/BME280/BME280.h, 261, 262  
lib/sensors/BME280/BME280\_WRAPPER.cpp, 264  
lib/sensors/BME280/BME280\_WRAPPER.h, 265  
lib/sensors/HMC5883L/HMC5883L.cpp, 266  
lib/sensors/HMC5883L/HMC5883L.h, 267, 268  
lib/sensors/HMC5883L/HMC5883L\_WRAPPER.cpp, 268, 269  
lib/sensors/HMC5883L/HMC5883L\_WRAPPER.h, 270, 271  
lib/sensors/ISensor.cpp, 271, 272  
lib/sensors/ISensor.h, 272, 274  
lib/sensors/MPU6050/MPU6050.cpp, 275  
lib/sensors/MPU6050/MPU6050.h, 276  
lib/sensors/MPU6050/MPU6050\_WRAPPER.cpp, 276  
lib/sensors/MPU6050/MPU6050\_WRAPPER.h, 276, 277  
lib/storage/storage.cpp, 278, 280  
lib/storage/storage.h, 280, 283  
lib/utils.cpp, 284, 289  
lib/utils.h, 290, 296

LIGHT  
    ISensor.h, 274

LIGHT\_LEVEL  
    ISensor.h, 274

LIST\_FILES\_COMMAND  
    storage\_commands.cpp, 171

load\_from\_storage  
    EventManager, 107  
    EventManagerImpl, 111

LOCK  
    Event Manager, 45

log\_event  
    Event Manager, 46

LOG\_FILENAME  
    main.cpp, 297

LORA  
    protocol.h, 192

lora\_address\_local  
    pin\_config.cpp, 228  
    pin\_config.h, 234

lora\_address\_remote  
    pin\_config.cpp, 228  
    pin\_config.h, 234

lora\_cs\_pin  
    pin\_config.cpp, 227  
    pin\_config.h, 234

LORA\_DEFAULT\_DIO0\_PIN

pin\_config.h, 233  
**LORA\_DEFAULT\_RESET\_PIN**  
 pin\_config.h, 233  
**LORA\_DEFAULT\_SPI**  
 pin\_config.h, 233  
**LORA\_DEFAULT\_SPI\_FREQUENCY**  
 pin\_config.h, 233  
**LORA\_DEFAULT\_SS\_PIN**  
 pin\_config.h, 233  
**lora\_irq\_pin**  
 pin\_config.cpp, 228  
 pin\_config.h, 234  
**lora\_reset\_pin**  
 pin\_config.cpp, 227  
 pin\_config.h, 234  
**LOST**  
 Event Manager, 45  
**LOW\_BATTERY**  
 Event Manager, 44  
**MAG\_FIELD\_X**  
 ISensor.h, 274  
**MAG\_FIELD\_Y**  
 ISensor.h, 274  
**MAG\_FIELD\_Z**  
 ISensor.h, 274  
**MAGNETOMETER**  
 ISensor.h, 274  
**main**  
 main.cpp, 298  
 test\_runner.cpp, 318  
**main.cpp**, 296  
 buffer, 299  
 bufferIndex, 299  
 core1\_entry, 297  
 init\_systems, 297  
 LOG\_FILENAME, 297  
 main, 298  
 powerManager, 299  
 systemClock, 299  
**MAIN\_I2C\_PORT**  
 pin\_config.h, 230  
**MAIN\_I2C\_SCL\_PIN**  
 pin\_config.h, 231  
**MAIN\_I2C\_SDA\_PIN**  
 pin\_config.h, 230  
**MAX\_BLOCK\_SIZE**  
 storage\_commands.cpp, 170  
**MAX\_RAW\_DATA\_LENGTH**  
 gps\_collector.cpp, 219  
**Measurement Functions**, 60  
 get\_current\_ma, 61  
 get\_shunt\_voltage, 60  
 get\_voltage, 62  
**MILIAMP**  
 protocol.h, 191  
**minutes**  
 ds3231\_data\_t, 100  
**Mode**

BH1750, 69  
**mode\_bus\_en**  
 INA3221::conf\_reg\_t, 90  
**mode\_continious\_en**  
 INA3221::conf\_reg\_t, 90  
**mode\_shunt\_en**  
 INA3221::conf\_reg\_t, 90  
**MONDAY**  
 DS3231.h, 153  
**month**  
 ds3231\_data\_t, 100  
**MOUNT\_COMMAND**  
 storage\_commands.cpp, 171  
**MPU6050Wrapper**, 131  
 configure, 132  
 get\_type, 132  
 init, 132  
 initialized\_, 133  
 is\_initialized, 132  
 MPU6050Wrapper, 132  
 read\_data, 132  
 sensor\_, 133  
**MSG RECEIVED**  
 Event Manager, 45  
**MSG SENT**  
 Event Manager, 45  
**msgCount**  
 communication.cpp, 178  
**needsPersistence**  
 EventManager, 108  
**nextEventId**  
 EventManager, 108  
**nmea\_data**  
 gps\_collector.cpp, 221  
 NMEA\_data.cpp, 224  
 NMEA\_data.h, 226  
**NMEA\_data.cpp**  
 nmea\_data, 224  
**NMEA\_data.h**  
 nmea\_data, 226  
**NMEAData**, 133  
 get\_gga\_tokens, 134  
 get\_rmc\_tokens, 134  
 gga\_mutex\_, 135  
 gga\_tokens\_, 134  
 NMEAData, 134  
 rmc\_mutex\_, 135  
 rmc\_tokens\_, 134  
 update\_gga\_tokens, 134  
 update\_rmc\_tokens, 134  
**NONE**  
 protocol.h, 191, 192  
**NOT\_ALLOWED**  
 protocol.h, 192  
**NUM\_CALIB\_PARAMS**  
 BME280, 84  
**on\_receive**

communication.h, 181  
receive.cpp, 198  
ONE\_TIME\_HIGH\_RES\_MODE  
    BH1750, 70  
ONE\_TIME\_HIGH\_RES\_MODE\_2  
    BH1750, 70  
ONE\_TIME\_LOW\_RES\_MODE  
    BH1750, 70  
operation\_type\_to\_string  
    protocol.h, 192  
    utils\_converters.cpp, 207  
OperationType  
    protocol.h, 190  
operationType  
    Frame, 114  
outgoing  
    communication.cpp, 178  
OVERCHARGE  
    Event Manager, 44  
PA\_OUTPUT\_PA\_BOOST\_PIN  
    pin\_config.h, 234  
PA\_OUTPUT\_RFO\_PIN  
    pin\_config.h, 234  
PARAM\_UNNECESSARY  
    protocol.h, 192  
PASS\_THROUGH\_END  
    Event Manager, 45  
PASS\_THROUGH\_START  
    Event Manager, 45  
pin\_config.cpp  
    lora\_address\_local, 228  
    lora\_address\_remote, 228  
    lora\_cs\_pin, 227  
    lora\_irq\_pin, 228  
    lora\_reset\_pin, 227  
pin\_config.h  
    BUFFER\_SIZE, 231  
    DEBUG\_UART\_BAUD\_RATE, 230  
    DEBUG\_UART\_PORT, 230  
    DEBUG\_UART\_RX\_PIN, 230  
    DEBUG\_UART\_TX\_PIN, 230  
    GPS\_POWER\_ENABLE\_PIN, 231  
    GPS\_UART\_BAUD\_RATE, 231  
    GPS\_UART\_PORT, 231  
    GPS\_UART\_RX\_PIN, 231  
    GPS\_UART\_TX\_PIN, 231  
    lora\_address\_local, 234  
    lora\_address\_remote, 234  
    lora\_cs\_pin, 234  
    LORA\_DEFAULT\_DIO0\_PIN, 233  
    LORA\_DEFAULT\_RESET\_PIN, 233  
    LORA\_DEFAULT\_SPI, 233  
    LORA\_DEFAULT\_SPI\_FREQUENCY, 233  
    LORA\_DEFAULT\_SS\_PIN, 233  
    lora\_irq\_pin, 234  
    lora\_reset\_pin, 234  
    MAIN\_I2C\_PORT, 230  
    MAIN\_I2C\_SCL\_PIN, 231  
    MAIN\_I2C\_SDA\_PIN, 230  
    PA\_OUTPUT\_PA\_BOOST\_PIN, 234  
    PA\_OUTPUT\_RFO\_PIN, 234  
    READ\_BIT, 233  
    SD\_CARD\_DETECT\_PIN, 232  
    SD\_CS\_PIN, 232  
    SD\_MISO\_PIN, 232  
    SD\_MOSI\_PIN, 232  
    SD\_SCK\_PIN, 232  
    SD\_SPI\_PORT, 231  
    SPI\_PORT, 233  
    SX1278\_CS, 232  
    SX1278\_MISO, 232  
    SX1278\_MOSI, 233  
    SX1278\_SCK, 232  
POWER  
    Event Manager, 44  
Power Commands, 27  
    handle\_get\_current\_charge\_solar, 30  
    handle\_get\_current\_charge\_total, 31  
    handle\_get\_current\_charge\_usb, 29  
    handle\_get\_current\_draw, 32  
    handle\_get\_power\_manager\_ids, 27  
    handle\_get\_voltage\_5v, 28  
    handle\_get\_voltage\_battery, 28  
POWER\_FALLING  
    Event Manager, 44  
POWER\_NORMAL  
    Event Manager, 44  
POWER\_OFF  
    Event Manager, 45  
POWER\_ON  
    BH1750, 70  
    Event Manager, 45  
PowerEvent  
    Event Manager, 44  
powerman\_mutex\_  
    PowerManager, 141  
PowerManager, 135  
    charging\_solar\_active\_, 141  
    charging\_usb\_active\_, 141  
    check\_power\_alerts, 139  
    configure, 138  
    FALL\_RATE\_THRESHOLD, 140  
    FALLING\_TREND\_REQUIRED, 140  
    get\_current\_charge\_solar, 137  
    get\_current\_charge\_total, 137  
    get\_current\_charge\_usb, 137  
    get\_current\_draw, 137  
    get\_voltage\_5v, 138  
    get\_voltage\_battery, 138  
    ina3221\_, 140  
    initialize, 137  
    initialized\_, 140  
    is\_charging\_solar, 138  
    is\_charging\_usb, 139  
    powerman\_mutex\_, 141  
    PowerManager, 136

read\_device\_ids, 137  
 SOLAR\_CURRENT\_THRESHOLD, 140  
 USB\_CURRENT\_THRESHOLD, 140  
 VOLTAGE\_LOW\_THRESHOLD, 140  
 VOLTAGE\_OVERCHARGE\_THRESHOLD, 140  
 powerManager  
     main.cpp, 299  
 PRESSURE  
     ISensor.h, 274  
 protocol.h  
     ANS, 191  
     BOOL, 191  
     CommandAccessLevel, 191  
     DATETIME, 191  
     DELIMITER, 196  
     ERR, 191  
     ERROR, 190  
     exception\_type\_to\_string, 192  
     ExceptionType, 191  
     ExecutionResult, 190  
     FRAME\_BEGIN, 196  
     FRAME\_END, 196  
     GET, 191  
     hex\_string\_to\_bytes, 194  
     INF, 191  
     INFO, 190  
     Interface, 192  
     INVALID\_OPERATION, 192  
     INVALID\_PARAM, 192  
     LORA, 192  
     MILIAMP, 191  
     NONE, 191, 192  
     NOT\_ALLOWED, 192  
     operation\_type\_to\_string, 192  
     OperationType, 190  
     PARAM\_UNNECESSARY, 192  
     READ\_ONLY, 191  
     READ\_WRITE, 191  
     SECOND, 191  
     SET, 191  
     string\_to\_operation\_type, 193  
     SUCCESS, 190  
     TEXT, 191  
     UART, 192  
     UNDEFINED, 191  
     value\_unit\_type\_to\_string, 194  
     ValueUnit, 191  
     VOLT, 191  
     WRITE\_ONLY, 191  
 pwr\_valid\_alert  
     INA3221::masken\_reg\_t, 129  
 RADIO\_ERROR  
     Event Manager, 45  
 RADIO\_INIT  
     Event Manager, 45  
 read  
     HMC5883L, 116  
 READ\_BIT

pin\_config.h, 233  
 read\_data  
     BH1750Wrapper, 73  
     BME280Wrapper, 89  
     HMC5883LWrapper, 119  
     ISensor, 127  
     MPU6050Wrapper, 132  
 read\_device\_ids  
     PowerManager, 137  
 READ\_ONLY  
     protocol.h, 191  
 read\_raw\_all  
     BME280, 77  
 read\_register  
     Configuration Functions, 54  
     HMC5883L, 117  
 read\_temperature  
     DS3231, 94  
 READ\_WRITE  
     protocol.h, 191  
 receive.cpp  
     handle\_uart\_input, 198  
     on\_receive, 198  
 receive\_ack  
     storage\_commands\_utils.cpp, 174  
     storage\_commands\_utils.h, 176  
 REG\_CONFIG  
     BME280, 79  
 REG\_CTRL\_HUM  
     BME280, 79  
 REG\_CTRL\_MEAS  
     BME280, 79  
 REG\_DIG\_H1  
     BME280, 83  
 REG\_DIG\_H2  
     BME280, 83  
 REG\_DIG\_H3  
     BME280, 83  
 REG\_DIG\_H4  
     BME280, 83  
 REG\_DIG\_H5  
     BME280, 84  
 REG\_DIG\_H6  
     BME280, 84  
 REG\_DIG\_P1\_LSB  
     BME280, 81  
 REG\_DIG\_P1\_MSB  
     BME280, 81  
 REG\_DIG\_P2\_LSB  
     BME280, 81  
 REG\_DIG\_P2\_MSB  
     BME280, 81  
 REG\_DIG\_P3\_LSB  
     BME280, 81  
 REG\_DIG\_P3\_MSB  
     BME280, 81  
 REG\_DIG\_P4\_LSB  
     BME280, 82

REG\_DIG\_P4\_MSB  
    BME280, 82  
REG\_DIG\_P5\_LSB  
    BME280, 82  
REG\_DIG\_P5\_MSB  
    BME280, 82  
REG\_DIG\_P6\_LSB  
    BME280, 82  
REG\_DIG\_P6\_MSB  
    BME280, 82  
REG\_DIG\_P7\_LSB  
    BME280, 82  
REG\_DIG\_P7\_MSB  
    BME280, 82  
REG\_DIG\_P8\_LSB  
    BME280, 83  
REG\_DIG\_P8\_MSB  
    BME280, 83  
REG\_DIG\_P9\_LSB  
    BME280, 83  
REG\_DIG\_P9\_MSB  
    BME280, 83  
REG\_DIG\_T1\_LSB  
    BME280, 80  
REG\_DIG\_T1\_MSB  
    BME280, 80  
REG\_DIG\_T2\_LSB  
    BME280, 80  
REG\_DIG\_T2\_MSB  
    BME280, 80  
REG\_DIG\_T3\_LSB  
    BME280, 81  
REG\_DIG\_T3\_MSB  
    BME280, 81  
REG\_HUMIDITY\_MSB  
    BME280, 80  
REG\_PRESSURE\_MSB  
    BME280, 80  
REG\_RESET  
    BME280, 80  
REG\_TEMPERATURE\_MSB  
    BME280, 80  
reserved  
    INA3221::masken\_reg\_t, 130  
RESET  
    BH1750, 70  
reset  
    BME280, 77  
    Configuration Functions, 52  
    INA3221::conf\_reg\_t, 91  
rmc\_mutex\_  
    NMEAData, 135  
rmc\_tokens\_  
    NMEAData, 134  
SATURDAY  
    DS3231.h, 153  
save\_to\_storage  
    EventManager, 106  
                EventManagerImpl, 111  
SD\_CARD\_DETECT\_PIN  
    pin\_config.h, 232  
sd\_card\_mounted  
    storage.cpp, 280  
    storage.h, 283  
SD\_CS\_PIN  
    pin\_config.h, 232  
SD\_MISO\_PIN  
    pin\_config.h, 232  
SD\_MOSI\_PIN  
    pin\_config.h, 232  
SD\_SCK\_PIN  
    pin\_config.h, 232  
SD\_SPI\_PORT  
    pin\_config.h, 231  
SECOND  
    protocol.h, 191  
seconds  
    ds3231\_data\_t, 100  
send.cpp  
    send\_frame, 203  
    send\_frame\_lora, 202  
    send\_frame\_uart, 202  
    send\_message, 201  
    split\_and\_send\_message, 204  
send\_data\_block  
    storage\_commands\_utils.cpp, 174  
    storage\_commands\_utils.h, 176  
send\_frame  
    communication.h, 183  
    send.cpp, 203  
send\_frame\_lora  
    communication.h, 184  
    send.cpp, 202  
send\_frame\_uart  
    communication.h, 183  
    send.cpp, 202  
send\_message  
    communication.h, 183  
    send.cpp, 201  
sensor\_  
    BH1750Wrapper, 74  
    BME280Wrapper, 89  
    HMC5883LWrapper, 120  
    MPU6050Wrapper, 133  
sensor\_configure  
    SensorWrapper, 143  
sensor\_init  
    SensorWrapper, 143  
sensor\_read\_data  
    SensorWrapper, 144  
SensorDataTypelIdentifier  
    ISensor.h, 274  
sensors  
    SensorWrapper, 144  
SensorType  
    ISensor.h, 273

SensorWrapper, 141  
 get\_instance, 143  
 sensor\_configure, 143  
 sensor\_init, 143  
 sensor\_read\_data, 144  
 sensors, 144  
 SensorWrapper, 142

SET  
 protocol.h, 191

set\_alert\_latch  
 Alert Functions, 67

set\_averaging\_mode  
 Configuration Functions, 58

set\_bus\_conversion\_time  
 Configuration Functions, 59

set\_bus\_measurement\_disable  
 Configuration Functions, 58

set\_bus\_measurement\_enable  
 Configuration Functions, 57

set\_crit\_alert\_limit  
 Alert Functions, 63

set\_mode\_continuous  
 Configuration Functions, 55

set\_mode\_power\_down  
 Configuration Functions, 55

set\_mode\_triggered  
 Configuration Functions, 56

set\_power\_valid\_limit  
 Alert Functions, 64

set\_shunt\_conversion\_time  
 Configuration Functions, 59

set\_shunt\_measurement\_disable  
 Configuration Functions, 57

set\_shunt\_measurement\_enable  
 Configuration Functions, 56

set\_time  
 DS3231, 93

set\_unix\_time  
 DS3231, 94

set\_warn\_alert\_limit  
 Alert Functions, 63

shunt\_conv\_time  
 INA3221::conf\_reg\_t, 91

shunt\_sum\_alert  
 INA3221::masken\_reg\_t, 129

shunt\_sum\_en\_ch1  
 INA3221::masken\_reg\_t, 130

shunt\_sum\_en\_ch2  
 INA3221::masken\_reg\_t, 130

shunt\_sum\_en\_ch3  
 INA3221::masken\_reg\_t, 130

SHUNT\_VOLTAGE\_LSB\_UV  
 INA3221.h, 244

SHUTDOWN  
 Event Manager, 44

SILENT  
 utils.h, 293

SOLAR\_ACTIVE

Event Manager, 44

SOLAR\_CURRENT\_THRESHOLD  
 PowerManager, 140

SOLAR\_INACTIVE  
 Event Manager, 44

SPI\_PORT  
 pin\_config.h, 233

split\_and\_send\_message  
 communication.h, 185  
 send.cpp, 204

splitString  
 gps\_collector.cpp, 220

START\_COMMAND  
 storage\_commands.cpp, 170

Storage Commands, 33  
 handle\_file\_download, 33  
 handle\_list\_files, 34  
 handle\_mount, 35

storage.cpp  
 fs\_init, 279  
 sd\_card\_mounted, 280

storage.h  
 fs\_close\_file, 283  
 fs\_file\_exists, 283  
 fs\_init, 281  
 fs\_open\_file, 282  
 fs\_read\_file, 282  
 fs\_write\_file, 282  
 sd\_card\_mounted, 283

storage\_commands.cpp  
 DATA\_COMMAND, 170  
 END\_COMMAND, 170  
 LIST\_FILES\_COMMAND, 171  
 MAX\_BLOCK\_SIZE, 170  
 MOUNT\_COMMAND, 171  
 START\_COMMAND, 170  
 STORAGE\_GROUP, 170

storage\_commands\_utils.cpp  
 calculate\_checksum, 173  
 receive\_ack, 174  
 send\_data\_block, 174

storage\_commands\_utils.h  
 calculate\_checksum, 176  
 receive\_ack, 176  
 send\_data\_block, 176

STORAGE\_GROUP  
 storage\_commands.cpp, 170

string\_to\_operation\_type  
 protocol.h, 193  
 utils\_converters.cpp, 208

SUCCESS  
 protocol.h, 190

SUNDAY  
 DS3231.h, 153

SX1278\_CS  
 pin\_config.h, 232

SX1278\_MISO  
 pin\_config.h, 232

SX1278\_MOSI  
pin\_config.h, 233

SX1278\_SCK  
pin\_config.h, 232

SYSTEM  
Event Manager, 44

systemClock  
Clock Management Commands, 14  
Event Manager, 49  
main.cpp, 299

SystemEvent  
Event Manager, 44

t\_fine  
BME280, 79

TEMPERATURE  
ISensor.h, 274

test/comms/test\_converters.cpp, 301, 304

test/comms/test\_frame\_build.cpp, 305, 307

test/comms/test\_frame\_coding.cpp, 307, 309

test/comms/test\_frame\_common.h, 310, 311

test/test\_runner.cpp, 311, 319

test\_converters.cpp  
test\_exception\_type\_conversion, 303  
test\_hex\_string\_conversion, 303  
test\_operation\_type\_conversion, 302  
test\_value\_unit\_type\_conversion, 302

test\_exception\_type\_conversion  
test\_converters.cpp, 303  
test\_runner.cpp, 317

test\_frame\_build.cpp  
test\_frame\_build\_error, 305  
test\_frame\_build\_info, 306  
test\_frame\_build\_success, 305

test\_frame\_build\_error  
test\_frame\_build.cpp, 305  
test\_runner.cpp, 314

test\_frame\_build\_info  
test\_frame\_build.cpp, 306  
test\_runner.cpp, 315

test\_frame\_build\_success  
test\_frame\_build.cpp, 305  
test\_runner.cpp, 314

test\_frame\_coding.cpp  
test\_frame\_decode\_basic, 308  
test\_frame\_decode\_invalid\_header, 309  
test\_frame\_encode\_basic, 308

test\_frame\_common.h  
create\_test\_frame, 311

test\_frame\_decode\_basic  
test\_frame\_coding.cpp, 308  
test\_runner.cpp, 313

test\_frame\_decode\_invalid\_header  
test\_frame\_coding.cpp, 309  
test\_runner.cpp, 313

test\_frame\_encode\_basic  
test\_frame\_coding.cpp, 308  
test\_runner.cpp, 312

test\_hex\_string\_conversion  
test\_converters.cpp, 303  
test\_runner.cpp, 318

test\_operation\_type\_conversion  
test\_converters.cpp, 302  
test\_runner.cpp, 316

test\_runner.cpp  
main, 318  
test\_exception\_type\_conversion, 317  
test\_frame\_build\_error, 314  
test\_frame\_build\_info, 315  
test\_frame\_build\_success, 314  
test\_frame\_decode\_basic, 313  
test\_frame\_decode\_invalid\_header, 313  
test\_frame\_encode\_basic, 312  
test\_hex\_string\_conversion, 318  
test\_operation\_type\_conversion, 316  
test\_value\_unit\_type\_conversion, 316

test\_value\_unit\_type\_conversion  
test\_converters.cpp, 302  
test\_runner.cpp, 316

TEXT  
protocol.h, 191

THURSDAY  
DS3231.h, 153

TIME  
clock\_commands.cpp, 155

timestamp  
event\_manager.h, 216  
EventLog, 103

TIMEZONE\_OFFSET  
clock\_commands.cpp, 155

timing\_ctrl\_alert  
INA3221::masken\_reg\_t, 128

to\_string  
event\_manager.h, 216  
EventLog, 103

TUESDAY  
DS3231.h, 153

UART  
protocol.h, 192

UART\_ERROR  
Event Manager, 45

uart\_mutex  
utils.cpp, 289

uart\_print  
utils.cpp, 287  
utils.h, 293

UNCONFIGURED\_POWER\_DOWN  
BH1750, 70

UNDEFINED  
protocol.h, 191

unit  
Frame, 114

update\_gga\_tokens  
NMEAData, 134

update\_rmc\_tokens  
NMEAData, 134

USB\_CONNECTED

Event Manager, 44  
USB\_CURRENT\_THRESHOLD  
    PowerManager, 140  
USB\_DISCONNECTED  
    Event Manager, 44  
utils.cpp  
    crc16, 288  
    g\_uart\_verbosity, 289  
    get\_level\_color, 285  
    get\_level\_prefix, 286  
    uart\_mutex, 289  
    uart\_print, 287  
utils.h  
    ANSI\_BLUE, 292  
    ANSI\_CYAN, 292  
    ANSI\_GREEN, 292  
    ANSI\_RED, 292  
    ANSI\_RESET, 292  
    ANSI\_YELLOW, 292  
    crc16, 294  
    DEBUG, 293  
    ERROR, 293  
    EVENT, 293  
    g\_uart\_verbosity, 295  
    INFO, 293  
    SILENT, 293  
    uart\_print, 293  
    VerbosityLevel, 292  
    WARNING, 293  
utils\_converters.cpp  
    exception\_type\_to\_string, 206  
    hex\_string\_to\_bytes, 209  
    operation\_type\_to\_string, 207  
    string\_to\_operation\_type, 208  
    value\_unit\_type\_to\_string, 206

value  
    Frame, 114  
value\_unit\_type\_to\_string  
    protocol.h, 194  
    utils\_converters.cpp, 206

ValueUnit  
    protocol.h, 191

VerbosityLevel  
    utils.h, 292

VOLT  
    protocol.h, 191

VOLTAGE\_LOW\_THRESHOLD  
    Event Manager, 48  
    PowerManager, 140

VOLTAGE\_OVERCHARGE\_THRESHOLD  
    Event Manager, 48  
    PowerManager, 140

warn\_alert\_ch1  
    INA3221::masken\_reg\_t, 129

warn\_alert\_ch2  
    INA3221::masken\_reg\_t, 129

warn\_alert\_ch3