SHARC BUOY HARDWARE RECOMENDATIONS

Author Jamie Jacobson
Student Number: JCBJAM007
Date: 22 June 202

This Document outlines required changes to the current PCBs to make the system compatible with the STM32L4

Table of Contents

1. Introduction

The Following document outlines hardware changes required to allow the STM32L476RG microcontroller to interface with the SHARCBUOY system. Version 2.0 was designed for the STM32F446RE microcontroller which has some similarities to the L4 however, fundamental pin changes. In addition, some sensors have not been optimally integrated into the SHARCBUOY system. This may be due to omitted pin traces as well as incorrect pin mapping. It may be required that an interrupt pin is required and must be mapped to an onboard wake up pin. Therefore, this document aims to assist with hardware changes as well as to provide a full Pin/memory map for the new System

1.1. Reserved Pins

Some Pins on the stm32l4 microcontroller cannot be used for external mapping. These pins have a specific function and must be received for special cases. In addition, Certain clock/ calibration configurations require that these pins be reserved for clock inputs

1.1.1 Clock Pins

Version 2.1 of the SHARC Buoy uses the MSI PLL as a source for the system clock. This configuration uses an external 32.768 KHz oscillator as a reference[1]. In order to achieve this, Pins PC14 and PC15 are reserved as OSC32_OUT and OSC32_IN respectively. This also allows the device to use the LSE oscillator as a clock source for the RTC.

Summary:

Pin Name	Function	GPIO PORT	GPIO Pin
OSC32_IN	LSE 32.768 KHz input	GPIOC	PC14
OSC32_OUT	LSE 32.768 KHz GND ref	GPIOC	PC15

1.1.2 Wake Up Pins

The STM32l4 Microcontroller has 5 Wake Up pins. These are GPIO Pins that can be configured to wake up the device from any low power mode. These pins are fundamental to allow the buoy to receive messages from the satellite at any point in its operation as well as to allow the IMU to detect events in sleep mode. Therefore, it is unadvisable to connect these pins to any external pin other than an interrupt pin otherwise, the wake-up pins get blocked and functionality is reduced. In addition, incorrect pin mapping and pin configuration can result in sporadic wake ups and unpredictable behavior which can cause the buoy to desynchronies from the primary loop. The Wake-up pins are listed in the table below.

Summary:

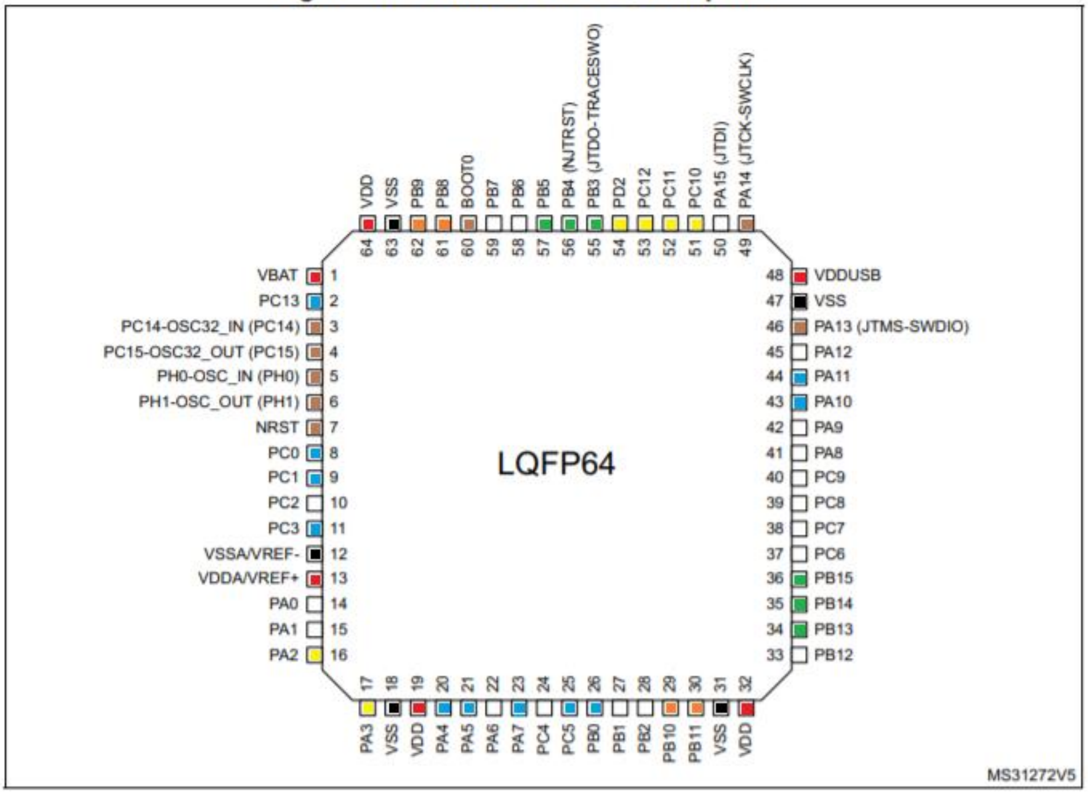
Pin Name	GPIO Port	GPIO Pin
Wake Up Pin 1	GPIOA	PA0
Wake Up Pin 2	GPIOC	PC13
Wake Up Pin 3	GPIOE	PE6
Wake Up Pin 4	GPIOA	PA2
Wake Up Pin 5	GPIOC	PC5

[1] See Document: Power Mode and Clock Selection for more information

2. SHARC BUOY Pin Requirements

2.1. Summary

Figure 15. STM32L476Rx LQFP64 pinout(1)



1. The above figure shows the package top view.

Figure 1: STM32L476 Pinout showing allocated pins

Key:

(light blue)	GPIO I/O Pin
(yellow)	USART Pin
(orange)	I2C Pin
(green)	SPI Pin
(red)	Power Supply
(black)	Ground
(grey)	Reserved

DIGITAL IO

GPIO Type	GPIO Port	GPIO Pin	PIN Function
Output	PORTA	PA10	BMP280 CS Pin
Input	PORTA	PA11	IRIDIUM NETWORK AVAILABLE
Output	PORTA	PA4	FLASH CHIP 4 CS
Output	PORTA	PA5	NUCLEOL4 LED
Output	PORTB	PB0	FLASH CHIP 3 CS
Output	PORTC	PC0	FLASH CHIP 1 CS
Output	PORTC	PC1	FLASH CHIP 2 CS
Input	PORTC	PC13	IRIDIUM Ring Indicator
Output	PORTC	PC3	FLASH CHIP WP
Input	PORTC	PC5	MPU6050 INT Pin
Output	PORTC	PC7	IRIDIUM On_Off Pin

UART

UART Port	Rx Pin	Tx Pin	UART Description
USART2	PA2	PA3	Debug USART
UART4	PC11	PC10	GPS USART
UART5	PD2	PC12	IRIDIUM USART

I2C

I2C Port	SCL Pin	SDA Pin	I2C Description
I2C2	PB10	PB11	INA219 I2C
I2C1	PB8	PB9	MPU6050 I2c

SPI

SPI Port	SCK Pin	MISO Pin	MOSI Pin	SPI Description
SPI2	PB13	PB14	PB15	FLASH CHIP SPI
SPI1	PB3	PB4	PB5	BMP280 SPI

2.2. Debug Pins.

Debug allows the microcontroller to interface with the nucleo-l4 onboard LED and output data to a terminal via USART over USB. This allows the user to debug more easily and follow the program.

The proposed pin map for these peripherals are:

STM32L476RG Function	Port	External Pin Name	AF Mapping
GPIO Output	PA5	LED 2 Pin	-
USART2_Tx	PA2	Serial Tx Pin	AF7
USART2_Rx	PA3	Serial Rx Pin	AF7
GPIO Input	PC13	Push Button 1	-

2.3. GPS

The Sharc buoy system uses a UBLOX neo GPS. The current version (NEO 6/7 m) IS a 3.3V USART chip with an additional PPS output. The following is a proposed pin mapping for the GPS module

STM32L476RG Function	**Port**	**External Pin Name**	**AF Mapping**
UART4_Tx	PC10	GPS Rx Pin	AF8
UART4_Rx	PC11	GPS Tx Pin	AF8
TIM2_CHANNEL2	PA1	GPS Input Capture	AF1
Wake UP Pin 3*	PE6	GPS Interrupt Pin	-

*Note: The new neo 9m module contains additional pins which can be very beneficial for extended operations. The inclusion of an Interrupt pin will allow for asynchronous/ passive gps signal acquisition which can improve the lifespan of the device. A recommendation is to map this pin to wake up pin 3 (PE6).

2.4. Flash Chips.

The device utilizes the AT45DB641E-SHN-T 64 M-Bit SPI Flash chips for permanent storage of data. The current hardware config allows for 4 chips to be connected in parallel to a singular SPI port. The pinout configuration for the chips are as follows:

GPIO Output	PC0	Chip 1 Select	-
GPIO Output	PC1	Chip 2 Select	-
GPIO Output	PB0	Chip 3 Select	-
GPIO Output	PA4	Chip 4 Select	-
GPIO Output	PC3	Write Protect	-
SPI2_CK	PB13	SPI CLOCK	AF5
SPI2_MISO	PB14	SP MISO Pin	AF5
SP2_MOSI	PB15	SPI MOSI Pin	AF5

The previous pin mapping for the STM32F4 maps to the STM3L4 in a similar manner and does not require any other hardware alterations.

2.5. Iridium

The device uses a satellite modem to transmit data from a remote location via the Iridium Satellite Constellation. A Rock block 9603 modem is used to communicate with the network and can transmit a maximum of 340 bytes in a single transmission session. The microcontroller can interface with the modem by sending AT commands over USART at a fixed baud rate of 19200 bit/s. The system has additional RTS and CTS pins for RS232 flow control however, the default communication setting does not require this and therefore is left out. The modem also contains 2 Indicator output pins: NetAv – active high when enough network signal is available to transmit a message, Ring Indicator – Alerts device when an incoming Satellite message is available. Finally, the device has a control pin that turns the modem on and off. This significantly reduces the power output and keeps the modem in a low power state.

Note: The previous Iridium pin mapping for the STM32F4 is as follows.

BUOY HEADER PIN	MODULE/CHIP PINS (IF USED)	MODULE/CHIP PIN NAME	STM32 BOARD NET NAME	STM32F446RE MAPPING	F446RE PORT	TYPE
1	8	5v in	+5V			POWER
2	6	TXD	IRID_TX	UART5_TX	PC12	UART TX
3	4	NetAv	IRID_NETAV	GPIOC13	PC13	Digital Input
4	5	RI	IRID_RI	GPIOC14	PC14	Digital Input
5	1	RXD	IRID_RX	UART5_RX	PD2	UART RX
6	7	OnOff	IRID_ONOFF	GPIOC15	PC15	Digital Output
7	10	GND	GND			GROUND

This pin mapping results in several conflicts on the STM32l4 microcontroller. The pins RI (PC14) and OnOff (PC15) are reserved for the LSE oscillator input and output. The Pin NetAv is mapped to a wake-up pin which should rather be mapped to the Ring Indicator Pin. This will allow for the device to asynchronously receive satellite messages even while in sleep mode. Therefore, the following pin map is suggested for the STM32l4

GPIO Output	PC7	On Off Pin	-
GPIO Input	PC13	Ring Indicator	-
GPIO Input	PA11	Network Available	-
UART5_Tx	PC12	Serial Tx Pin	AF8
UART5_Rx	PD2	Serial Rx Pin	AF8

Recommendations:

In the future, additional hardware recommendations are:

1. Move Ring Indicator to PC13 (Wake Up Pin 2)
2. Move UART5 Rx, Tx Pins to LPUART (PC0, PC1)

2.6. BMP280

The BMP 280 is an SPI/I2C digital environmental sensor for sampling pressure and temperature. The system interfaces with the device via SPI on SPI1. The device has no other interrupt pins and a single digital input for chip select. The Pin Mapping remains largely unchanged as there are no conflicts on the stm32l4. The Pin map is as follows:

GPIO Output	PA10	Chip Select Pin	-
SPI1_CK	PB3	SPI CLOCK	AF6
SPI1_MISO	PB4	SPI MISO	AF6
SPI1_MOSI	PB5	SPI MOSI	AF6

2.7. INA219 Current Sensor

The device uses the INA219 I2C current sensor to measure Shunt Voltage, Battery Voltage, Current and power. The device will be used to monitor the onboard battery to ensure the device draws a steady current. The microcontroller interfaces with the device through I2C2 which, on the stm32l4 is on different pins to the stm32F4. On the STM32L4, I2C2 is on Pins PB10 (I2C2_SCL) and PB11 (I2C_SDA) (I2C_SDA). The New pinout is shown in the table below

I2C2_SCL	PB10	I2C Serial Clock Line	AF4
I2C2_SDA	PB11	I2C Serial Data Line	AF4

2.8. MPU6050

The MPu6050 is a 6 DOF I2C IMU. The device contains an accelerometer and a gyro. In addition, the device has an onboard Digital Low Pass filter and digital motion processor. The I2C Pin mapping remains largely unchanged however, previous version of the hardware did not accommodate for the device's interrupt pin. This can cause synchronization issues as well as a loss of functionality. It is recommended to incorporate an interrupt pin into the hardware in order to allow for interrupt-based sampling as well as asynchronous event detection. This can be achieved by mapping the interrupt pin to Wake Up Pin 5 (PC5).

Hence, The New PCB Pin Map is shown in the table below

I2C1_SCL	PB8	I2C Serial Clock Line	AF4
I2C1_SDA	PB9	I2c Serial Data Line	AF4
GPIO Input	PC5	Interrupt Pin	-

3. Conclusion

These hardware changes should result in a more optimal system with increased functionality and power saving performance. In addition, more asynchronous behavior is introduced allowing for faster, more autonomous operability.