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| EE 403W Section 4 |
| Line Debugger Protocol |
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|  |
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| An outline of the protocol to communicate between the MC9S08LL64 and a computer interface using the SCI on the microcontroller. The protocol details command structure and numbers. |

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# Command Structure

The following diagram (Table 1) shows the structure of the commands that are sent between the MC9S08LL64 microcontroller and the computer GUI interface.

Table 1 Command Structure

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Byte 0** | **Byte 1** | **Byte 2** | **Byte 3** | **Byte 4 – 10** | **Final Byte – 1** | **Final Byte** |
| **Name** | Preamble | Command Type | Command | Data Byte Count | Data Bytes | CheckSum | End Command |
| **Data** | 0xAA | 0x00 – 0x03 | 0x00 – 0x3F | 0x00 – 0x20 | Varies | Check sum | 0xAF |
| **Function** | Signals start of command | Type of command | What command is being sent | Size of data payload | Data payload | Make sure the command is accurate | Signals end of command |

## Preamble - Byte 0

Byte 0 signals the start of a command. Its value is always 0xAA. The receivers must see a value of 0xAA before processing a command can start. Once the 0xAA is received, the command will be processed

## Command Type - Byte 1

Tells what type of command the data is. The options are listed in Table 2.

## Command – Byte 2

This byte determines how the receiver is to structure a command. The protocol supports up to 256 separate commands. A list of command numbers is available in Table 3.

## Data Bytes – Byte 2

The data bytes tell the system how many bytes of data are associated with the command. This allows the receiver to know how many bytes of data to read before processing the command.

## Data Bytes – Bytes 4 - 35

The data bytes carry the command payload, or the data associated with the command being sent. Each command is able to send up to eight bytes of data with a given command. It is important to read what each data byte is supposed to carry for each command, as the data is different for each command.

## CheckSum – Final Byte - 1

Sum of Command type, command, data byte count and DataBytes

## Final Byte

The final data byte is similar to the preamble data byte. This byte signals the end of the data. It is expected to be the byte after the data bytes. If it is not, the system will discard the command.

# Command Type

The following table (Table 2) contains a list of the command types.

Table 2 Command Types

|  |  |  |
| --- | --- | --- |
| Command Type | Value | Description |
| Set | 0x00 | Sets a value. A response is expected |
| Request | 0x01 | Request data. A response is expected |
| Ack | 0x02 | Acknowledge a request. No response expected. May contain data |

# Command List

The following table (Table 3) contains a list of the commands and their associated command number.

Table 3 Commands

|  |  |
| --- | --- |
| Command Name | Command Number |
| Set Turn Value | 0 |
| Get Turn Value | 1 |
| Set PWM Speed | 2 |
| Get PWM Speed | 3 |
| Get IR Sensor | 4 |
| Alive | 5 |
| Get All Sensors | 6 |
| Get All Data | 7 |
| Get Accelerometer | 8 |
| Set AutoStop Mode | 9 |
| Get AutoStop Mode | 10 |
| Set Max Speed | 11 |
| Get Max Speed | 12 |
| Set Sensor Weights | 13 |
| Get Sensor Weights | 14 |
| Set Coefficients | 15 |
| Get Coefficients | 16 |

# Commands

## Command 0 – Set Turn

By setting the turn value, the register that controls the PWM signal being sent to the servo will be updated to “Turn Value.” A value of zero corresponds to a full left turn and a value of 0x0320 corresponds to a value of full right turn. The intermediate values set the wheels to different positions.

**Set**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 : 1 | Turn Value | Adjusts the steering servo | 0 – 0x0320 |

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 : 1 | Turn Value | Value of steering servo | 0 – 0x0320 |

## Command 1 – Get Turn

Returns the value of the register in the PWM module that controls the current angle of the steering servo.

**Request**

No Date Bytes

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 : 1 | Turn Value | Value of steering servo | 0 – 0x0320 |

## Command 2 – Set PWM Speed

Sets the speed of the car by adjusting the overflow of a PWM module. A value of 500 is zero speed. Maximum forward speed is 1000, and maximum reverse is 0.

**Set**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 : 1 | Speed Value | Adjusts the speed of the vehicle | 0 – 0x03E8 |

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 : 1 | Speed Value | Speed of the vehicle | 0 – 0x03E8 |

## Command 3 – Get PWM Speed

Gets the current PWM value of the vehicle

**Request**

No Date Bytes

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 : 1 | Speed Value | Current value of PWM for speed | 0 – 0x03E8 |

## Command 4 – Get IR Sensor

Returns the value that the selected IR sensor is currently reading

**Request**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 | Sensor Select | Which sensor to read | 0 – 0x08 |

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 | Sensor Number | The sensor number to read | 0 – 0x07 |
| 1 | Sensor Value | Current value of the selected sensor | 0 – 0xFF |

## Command 5 – Alive

A debug command that tells the car the debugger is still present. If a command is not received by the car every 500ms, it will shut itself off to prevent possible damage by running uncontrollably.

**Request**

No data bytes

## Command 6 – Get All Sensors

Returns the value of all of the IR sensors.

**Request**

No data bytes

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 | Sensor 0 Value | Current value of sensor 0 | 0 – 0xFF |
| 1 | Sensor 1 Value | Current value of sensor 1 | 0 – 0xFF |
| 2 | Sensor 2 Value | Current value of sensor 2 | 0 – 0xFF |
| 3 | Sensor 3 Value | Current value of sensor 3 | 0 – 0xFF |
| 4 | Sensor 4 Value | Current value of sensor 4 | 0 – 0xFF |
| 5 | Sensor 5 Value | Current value of sensor 5 | 0 – 0xFF |
| 6 | Sensor 6 Value | Current value of sensor 6 | 0 – 0xFF |
| 7 | Sensor 7 Value | Current value of sensor 7 | 0 – 0xFF |

## Command 7 – Get All Data

Gets all of the diagnostic data from the microcontroller including PWM values, physical speed, and IR sensor values.

**Request**

No data bytes

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0:1 | PWM Turn Value | PWM value of steering servo | 0x00 – 0x0320 |
| 2:3 | PWM Speed Value | PWM value controlling the speed | 0x00 – 0x03E8 |
| 4:5 | Physical Speed | Actual speed of vehicle | 0x00 - 0xFFFF |
| 6:7 | RPM of Wheels | Rotations per minute of the wheels | 0x00 – 0xFFFF |
| 8 | Sensor 0 Value | Current value of sensor 0 | 0 – 0xFF |
| 9 | Sensor 1 Value | Current value of sensor 1 | 0 – 0xFF |
| 10 | Sensor 2 Value | Current value of sensor 2 | 0 – 0xFF |
| 11 | Sensor 3 Value | Current value of sensor 3 | 0 – 0xFF |
| 12 | Sensor 4 Value | Current value of sensor 4 | 0 – 0xFF |
| 13 | Sensor 5 Value | Current value of sensor 5 | 0 – 0xFF |
| 14 | Sensor 6 Value | Current value of sensor 6 | 0 – 0xFF |
| 15 | Sensor 7 Value | Current value of sensor 7 | 0 – 0xFF |
| 16 | Acceleration X | Acceleration in the X direction | 0x00 – 0xFF |
| 17 | Acceleration Y | Acceleration in the Y direction | 0x00 – 0xFF |
| 18 | Acceleration Z | Acceleration in the Z direction | 0x00 - 0xFF |
| 19 | Empty |  |  |
| 20:21 | PID Value | Value of the PID controller | 0x000 – 0xFFFF |

## Command 8 – Get Accelerometer

Returns the values of the accelerometer

**Request**

No data bytes

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 | Acceleration X | Acceleration in the X direction | 0x00 – 0xFF |
| 1 | Acceleration Y | Acceleration in the Y direction | 0x00 – 0xFF |
| 2 | Acceleration Z | Acceleration in the Z direction | 0x00 - 0xFF |

## Command 9 – Set AutoStop Mode

Determines whether the car should automatically stop if communication with the diagnostics is lost. A value of 0x01 will cause the car to automatically stop when communication with the host diagnostics is lost.

**Request**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 | AutoStop Enable | Should the car automatically stop | 0x00, 0x01 |
| 1 | Period | Period to wait before AutoStop occurs. Each value of 0x01 corresponds to 20ms | 0x00 – 0xFF |

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 | AutoStop Enable | Value of the autostop | 0x00, 0x01 |
| 1 | Period | Period to wait before AutoStop occurs. Each value of 0x01 corresponds to 20ms | 0x00 – 0xFF |

## Command 10 – Get AutoStop Mode

Determines whether the car should automatically stop if communication with the diagnostics is lost. A value of 0x01 will cause the car to automatically stop when communication with the host diagnostics is lost.

**Request**

No data bytes

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 | AutoStop Enable | Value of the autostop | 0x00, 0x01 |
| 1 | Period | Period to wait before AutoStop occurs. Each value of 0x01 corresponds to 20ms | 0x00 – 0xFF |

## Command 11 – Set Speed Limit

Limits the maximum speed of the car to a fraction of the maximum physical speed

**Request**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 | Speed Limit Enable | Enforce a speed limit | 0x00, 0x01 |
| 1 | empty |  |  |
| 2-3 | Speed Limit | Maximum speed of the vehicle | 0x0000 – 0x01F4 |

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 | Speed Limit Enable | Enforce a speed limit | 0x00, 0x01 |
| 1 | empty |  |  |
| 2-3 | Speed Limit | Maximum speed of the vehicle | 0x0000 – 0x01F4 |

## Command 12 – Get Speed Limit

Limits the maximum speed of the car to a fraction of the maximum physical speed

**Request**

No data bytes

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0 | Speed Limit Enable | Enforce a speed limit | 0x00, 0x01 |
| 1 | empty |  |  |
| 2-3 | Speed Limit | Maximum speed of the vehicle | 0x0000 – 0x01F4 |

## Command 13 – Set Sensor Weights

Sets the weights of the sensors

**Request**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0-1 | Sensor 0 Weight | Weight of sensor 0 | 0x0000-0xFFFF |
| 2-3 | Sensor 1 Weight | Weight of sensor 1 | 0x0000-0xFFFF |
| 4-5 | Sensor 2 Weight | Weight of sensor 2 | 0x0000-0xFFFF |
| 6-7 | Sensor 3 Weight | Weight of sensor 3 | 0x0000-0xFFFF |
| 8-9 | Sensor 4 Weight | Weight of sensor 4 | 0x0000-0xFFFF |
| 10-11 | Sensor 5 Weight | Weight of sensor 5 | 0x0000-0xFFFF |
| 12-13 | Sensor 6 Weight | Weight of sensor 6 | 0x0000-0xFFFF |
| 14-15 | Sensor 7 Weight | Weight of sensor 7 | 0x0000-0xFFFF |

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 0-1 | Sensor 0 Weight | Weight of sensor 0 | 0x0000-0xFFFF |
| 2-3 | Sensor 1 Weight | Weight of sensor 1 | 0x0000-0xFFFF |
| 4-5 | Sensor 2 Weight | Weight of sensor 2 | 0x0000-0xFFFF |
| 6-7 | Sensor 3 Weight | Weight of sensor 3 | 0x0000-0xFFFF |
| 8-9 | Sensor 4 Weight | Weight of sensor 4 | 0x0000-0xFFFF |
| 10-11 | Sensor 5 Weight | Weight of sensor 5 | 0x0000-0xFFFF |
| 12-13 | Sensor 6 Weight | Weight of sensor 6 | 0x0000-0xFFFF |
| 14-15 | Sensor 7 Weight | Weight of sensor 7 | 0x0000-0xFFFF |

## Command 14 – Set Sensor Weights

Gets the weights of the sensors

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 0-1 | Sensor 0 Weight | Weight of sensor 0 | 0x0000-0xFFFF |
| 2-3 | Sensor 1 Weight | Weight of sensor 1 | 0x0000-0xFFFF |
| 4-5 | Sensor 2 Weight | Weight of sensor 2 | 0x0000-0xFFFF |
| 6-7 | Sensor 3 Weight | Weight of sensor 3 | 0x0000-0xFFFF |
| 8-9 | Sensor 4 Weight | Weight of sensor 4 | 0x0000-0xFFFF |
| 10-11 | Sensor 5 Weight | Weight of sensor 5 | 0x0000-0xFFFF |
| 12-13 | Sensor 6 Weight | Weight of sensor 6 | 0x0000-0xFFFF |
| 14-15 | Sensor 7 Weight | Weight of sensor 7 | 0x0000-0xFFFF |

## Command 15 – Set Coefficients

Sets the coefficients

**Request**

|  |  |  |  |
| --- | --- | --- | --- |
| Byte Number | Byte Name | Description | Values |
| 0-1 | Kp | Proportional | 0x0000-0xFFFF |
| 2-3 | Ki | Integral | 0x0000-0xFFFF |
| 4-5 | Kd | Derivative | 0x0000-0xFFFF |

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 0-1 | Kp | Proportional | 0x0000-0xFFFF |
| 2-3 | Ki | Integral | 0x0000-0xFFFF |
| 4-5 | Kd | Derivative | 0x0000-0xFFFF |

## Command 16 – Get Coefficients

Gets the coefficients

**Request**

No data bytes

**Ack**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 0-1 | Kp | Proportional | 0x0000-0xFFFF |
| 2-3 | Ki | Integral | 0x0000-0xFFFF |
| 4-5 | Kd | Derivative | 0x0000-0xFFFF |