

## MCP19111 PMBus™ Firmware

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### OVERVIEW

This document briefly describes the implementation of the PMBus™ Protocol Revision 1.1 with a subset of commands on the Microchip MCP19111 Point-of-Load (POL) converter (ARD00609).

MCP19111 supports both 100 kHz and 400 kHz I<sup>2</sup>C bus speeds. Addressing is 7-bit, with a default address value of 0x55. The address can be changed using a custom command and stored in the nonvolatile memory.

The implementation supports Packet Error Checking (PEC) transparently, based on the number of bytes sent or received.

The bus master is signaled using the #SMBALERT pin, which is asserted low when an error occurs. This PMBus implementation does not support master mode communication.

PMBus commands are one-byte command codes. The protocol also specifies “extended” two-byte commands, but this implementation does not offer support for such commands.

The firmware implements storing of the default parameters (both PMBus and MCP19111 specific) into nonvolatile memory and restores them either at start-up or by user command. PMBus devices generally recognize two data formats: linear and direct. The current implementation uses the linear format:

### EQUATION 1:

$$X = Y \times 2^N$$

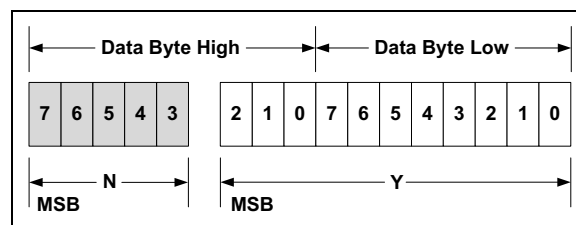
where:

- X = real value
- Y = the mantissa
- N = the exponent

For the output voltage, the linear exponent is fixed to -10, giving a resolution of 2<sup>-10</sup>. For all the other values using this format, the device will report using fixed exponents, but it will accept values with arbitrary exponents.

The output voltage values are reported using a 16-bit value, which represents only the mantissa. The exponent is found using a separate command. For the rest of the values (input voltage, output current and operating temperature), the 16-bit value has the format shown in Figure 1. A 5-bit exponent (in gray) is followed by an 11-bit mantissa, yielding the value X, as shown in Equation 1.

Although not specifically noted, all data is represented in a little-endian form.



**FIGURE 1:** Linear Data Format.

# TB3139

## LIST OF IMPLEMENTED COMMANDS

TABLE 1: IMPLEMENTED COMMANDS

No.	Command Name	Code	Write/Read Bytes	Notes
1	OPERATION	0x01	1/1	
2	ON_OFF_CONFIG	0x02	1/1	
3	CLEAR_FAULTS	0x03	0/0	
4	STORE_DEFAULT_ALL	0x11	0/0	
5	RESTORE_DEFAULT_ALL	0x12	0/0	
6	VOUT_MODE	0x20	0/1	Read-only, linear format and -10 exponent
7	VOUT_COMMAND	0x21	2/2	
8	VOUT_TRIM	0x22	2/2	
9	VOUT_MAX	0x24	2/2	
10	MAX_DUTY	0x32	2/2	Not active
11	FREQUENCY_SWITCH	0x33	2/2	Minimum 100 kHz, maximum 750 kHz
12	VOUT_OV_FAULT_LIMIT	0x40	2/2	
13	VOUT_OV_WARN_LIMIT	0x42	2/2	
14	VOUT_UV_WARN_LIMIT	0x43	2/2	
15	VOUT_UV_FAULT_LIMIT	0x44	2/2	
16	IOUT_OC_FAULT_LIMIT	0x46	0/2	Read-only, value writable by manufacturer command
17	IOUT_OC_WARN_LIMIT	0x4A	0/2	Read-only, value writable by manufacturer command
18	OT_FAULT_LIMIT	0x4F	2/2	
19	OT_WARN_LIMIT	0x51	2/2	
20	VIN_OV_FAULT_LIMIT	0x55	2/2	
21	VIN_OV_WARN_LIMIT	0x57	2/2	
22	VIN_UV_WARN_LIMIT	0x58	2/2	
23	VIN_UV_FAULT_LIMIT	0x59	2/2	
24	POWER_GOOD_ON	0x5E	2/2	
25	POWER_GOOD_OFF	0x5F	2/2	
—	TON_DELAY	0x60	2/2	Removed
26	TON_RISE	0x61	2/2	Supports ramps up to 32 ms
—	TOFF_DELAY	0x64	2/2	Removed
27	TOFF_FALL	0x65	2/2	Supports ramps up to 32 ms
28	STATUS_BYTE	0x78	0/1	
29	STATUS_WORD	0x79	0/2	
30	STATUS_VOUT	0x7A	0/1	
31	STATUS_IOUT	0x7B	0/1	
32	STATUS_INPUT	0x7C	0/1	
33	STATUS_TEMPERATURE	0x7D	0/1	
34	STATUS_CML	0x7E	0/1	
35	STATUS_OTHER	0x7F	0/1	
36	READ_VIN	0x88	0/2	
37	READ_VOUT	0x8B	0/2	
38	READ_IOUT	0x8C	0/2	
39	READ_TEMPERATURE_1	0x8D	0/2	
40	MFR_ID	0x99	0/2	

TABLE 1: IMPLEMENTED COMMANDS (CONTINUED)

No.	Command Name	Code	Write/Read Bytes	Notes
41	MFR_MODEL	0x9A	0/2	
42	MFR_REVISION	0x9B	0/2	
43	MFR_SPECIFIC_OCCON	0xD0	1/1	Not active
44	MFR_SPECIFIC_CSGSCON	0xD1	1/1	Not active
45	MFR_SPECIFIC_CSDGCON	0xD2	1/1	Not active
46	MFR_SPECIFIC_CMPZCON	0xD3	1/1	Not active
47	MFR_SPECIFIC_SLPCRCON	0xD4	1/1	Not active
48	MFR_SPECIFIC_DEADCON	0xD5	1/1	Not active
49	MFR_SPECIFIC_ALPHA	0xD6	1/1	$\alpha$ temperature coefficient value
50	MFR_SPECIFIC_I2CADD	0xD7	1/1	I <sup>2</sup> C address; change activates on next power-up
51	MFR_SPECIFIC_IOUTCHAN	0xDA	1/1	Selects ADC channel for measuring output current
52	MFR_SPECIFIC_HWREGS	0xDB	6/6	Replaces commands 0xD0 through 0xD5
53	MFR_SPECIFIC_OC_SET	0xDC	4/4	Sets I <sub>OUT</sub> fault and warning limits in ADC units
54	MFR_SPECIFIC_READ_ADC	0xDD	1/2	Reads an arbitrary ADC channel; Write sets the channel
55	MFR_SPECIFIC_VOUTCALIB	0xDE	1/1	V <sub>OUT</sub> ADC channel offset correction
56	MFR_SPECIFIC_ICALIB	0xDF	12/12	I <sub>OUT</sub> polynomial coefficients (3 x 32-bit values)

## DESCRIPTION OF MANUFACTURER COMMANDS

All manufacturer commands have a PMBus-compliant format, but the data is not in the standard linear format.

### MFR\_SPECIFIC\_OCCON

This command will read and write the OCCON hardware register.

An example of a read transaction using the default 0x55h I<sup>2</sup>C address is shown in [Table 2](#).

**TABLE 2: EXAMPLE READ TRANSACTION (DEFAULT 0X55H I<sup>2</sup>C ADDRESS)**

Byte Number		Byte 1	Byte 2		Byte 3	Byte 4	
Command Structure	Start	Slave Address Write	Command Code	Restart	Slave Address Read	OCCON Value	Stop
Value	S	0xAA	0xD0	RS	0xAB	0xE6	P

### MFR\_SPECIFIC\_CSGSCON

This command will read and write the CSGSCON hardware register.

### MFR\_SPECIFIC\_CSDGCON

This command will read and write the CSDGCON hardware register.

### MFR\_SPECIFIC\_CMPZCON

This command will read and write the CMPZCON hardware register.

### MFR\_SPECIFIC\_SLPCRCON

This command will read and write the SLPCRCON hardware register.

### MFR\_SPECIFIC\_DEADCON

This command will read and write the DEADCON hardware register.

### MFR\_SPECIFIC\_ALPHA

The temperature coefficient ALPHA can be read and written using this command. For additional information, see Appendix C: "Calibration Example" from "MCP19111 PMBus-Enabled Point-of-Load (POL) Converter Reference Design User's Guide" (DS50002379). This command is only valid for the boards using an external temperature sensor to output current temperature compensation.

### MFR\_SPECIFIC\_I2CADD

The 7-bit I<sup>2</sup>C address of the device can be read and written using this command. The actual address is not changed immediately; the user must issue a `STORE_ALL` command and power-down the board. On the next power-up, the new address will be read from the nonvolatile memory and applied.

### MFR\_SPECIFIC\_IOUTCHAN

This command allows the user to change the input ADC channel for reading the output current. This gives greater flexibility in either using the internal amplifier or using an external one. The value read or written is the actual ADC channel code as described in the MCP19110/MCP19111 Data Sheet.

### MFR\_SPECIFIC\_HWREGS

This command replaces the commands 0xD0 through 0xD5 by reading and writing a block of 6 bytes that represent the values for the hardware configuration registers. The registers are read and written in the data block in the following order: OCCON, CSGSCON, CSDGCON, CMPZCON, SLPCRCON and DEADCON. The values are written directly into the configuration registers so the user must take care if doing this while the converter is on.

## MFR\_SPECIFIC\_OC\_SET

This command sets and reads the output current warning and fault thresholds in ADC units. The data consists of four bytes: the first two are for the current fault threshold, and the second two for the current warning threshold. The ADC values should be calculated using the function described in the MFR\_SPECIFIC\_ICALIB section. All data is represented in a little-endian form.

IOUT_OC_FAULT_LIMIT		IOUT_OC_WARN_LIMIT	
Byte 1	Byte 2	Byte 1	Byte 2
0	1	2	3

## MFR\_SPECIFIC\_READ\_ADC

This command allows reading an arbitrary ADC channel. Writing a byte using this command will set the ADC channel to that value. Reading two bytes using this command will result in a 12-bit value (4 x 10-bit ADC readings summed together). All data is represented in a little-endian form.

## MFR\_SPECIFIC\_VOUTCALIB

This command reads and writes the output voltage ADC channel offset in ADC units. This is critical because the readings on this channel are used to calibrate the actual output voltage.

## MFR\_SPECIFIC\_ICALIB

This command is used to read or write the output current polynomial function coefficients. For the firmware version that doesn't use temperature compensation, the function is second order and uses three coefficients.

### EQUATION 2:

$$I_{OUT} = f(v) = aX^2 + bX + c$$

**TABLE 3: MFR\_SPECIFIC\_ICALIB COMMAND WRITTEN 12-BYTE BLOCK**

A				B				C			
LSB			MSB	LSB			MSB	LSB			MSB
Byte 1	Byte 2	Byte 3	Byte 4	Byte 1	Byte 2	Byte 3	Byte 4	Byte 1	Byte 2	Byte 3	Byte 4
0	1	2	3	4	5	6	7	8	9	10	11

For the firmware versions using an external temperature sensor to compensate output current, the equation is just a first order one; instead of A, the ambient temperature reading ( $T_0$ ) will be stored. The value is a 12-bit ADC reading of the temperature sensor.

For more information, see Appendix C. "Calibration Example" from "MCP19111 PMBus-Enabled Point-of-Load (POL) Converter Reference Design User's Guide" (DS50002379).

Since the coefficients are real numbers and all the calculations are done in integer arithmetic, they need to be scaled to maintain accuracy. The ADC current readings are 10-bit readings and must be converted into volts in order to use the ADC reading directly. Equation 3 provides the conversion equation.

### EQUATION 3:

$$V = ADC_{counts} \frac{5}{2^{10}}$$

The ADC reference is 5V.

The conversion of ADC readings to Amperes is shown in Equation 4:

### EQUATION 4:

$$f(ADC) = a \left( x \frac{5}{2^{10}} \right)^2 + bx \frac{5}{2^{10}} + c$$

We still need to scale the coefficients to have the common denominator  $2^{24}$ :

### EQUATION 5:

$$f(ADC) = \frac{ax^2 \times 25 \times 2^4 + bx \times 5 \times 2^{14} + c \times 2^{24}}{2^{24}}$$

By scaling the equation coefficients, we obtain the values that are stored into the device:

### EQUATION 6:

$$\begin{aligned} A &= a \times 400 \\ B &= b \times 81920 \\ C &= c \times 16777216 \end{aligned}$$

The MFR\_SPECIFIC\_ICALIB command will read or write a 12-byte block representing A, B and C (Table 3) each as a long integer (32-bit, signed). All data is represented in little-endian form.

## CONCLUSION

The PMBus protocol implementation on the MCP19111 has a large number of standard commands which allow the device to function properly in any standardized system. The manufacturer commands offer even greater flexibility during the development stage because internal compensation registers and various other settings are accessible at run-time.

## RECOMMENDED READING

The following related documents should be referred to:

- **MCP19110/MCP19111 Data Sheet – “Digitally Enhanced Power Analog Controller with Integrated Synchronous Driver” (DS20002331)**
- **“PMBus-Enabled Point-of-Load (POL) Converter Reference Design User’s Guide” (DS50002379)**
- **“PMBus Monitoring Graphical User Interface User’s Guide” (DS50002380).**

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