Application Report
SLUA427A–June 2007–Revised February 2008

PMBus Support in UCD911x Family of Digital Power Controllers

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ABSTRACT

This application report provides all the necessary information to understand and use the capabilities of the PMBus support in the UCD911x family of digital power controllers from Texas Instruments. This includes details of the PMBus command language and the physical and electrical characteristics of the interface on these devices.

1 Introduction

1.1 PMBus Support Overview

The UCD911x family of digital controllers supports the Power Management Bus (PMBus) protocol, version 1.1. See the following sections for a full description of the supported core and manufacturer-specific commands.

This document describes PMBus support for the following digital controllers:

- UCD9111 – Single-phase synchronous buck digital controller
- UCD9112 – Dual-phase synchronous buck digital controller

These are referred to as the *UCD911x Family of Digital Controllers* throughout this document.

1.2 PMBus Data Formats

The UCD911x family of digital controllers supports the LINEAR data format. For commands related to output voltage, the 16-bit variant is supported (LINEAR-16). For all other commands, the 11-bit variant is supported (LINEAR-11). For details on each of these, see the PMBus Protocol Specification (Part II).

DIRECT mode is not supported by the UCD911x family of digital controllers.

The LINEAR-16 data format works with a separate PMBus command that specifies the exponent used in scaling the mantissa in the LINEAR command to engineering units (the VOUT_MODE command). The VOUT_MODE allows the user to read and write the exponent, as well as data format mode (of which, only LINEAR is supported in the UCD911x).

The UCD911x supports an exponent of –11, to provide the necessary range and resolution of values related to output voltage. PMBus reads of the VOUT_MODE command correctly read this value. PMBus writes to the VOUT_MODE command only acknowledge (ACK) values of LINEAR mode (b000) and an exponent of –11 (0x15). Any other values for VOUT_MODE are negatively acknowledged (NACKed) by the device, when they are attempted to be written.

1.3 Packet Error Check (PEC) Support

The UCD911x requires all transactions over the PMBus to support the SMBus PEC protocol. A PMBus master should generate a proper PEC byte for all transactions and should verify the PEC byte received from the PMBus slave.

1.4 PMBus Clock Rate and Clock Stretching

The UCD911x supports a 100-kHz clock rate. The PMBus master must allow for clock stretching by the UCD911x during the data phase of transactions.

1.5 PMBus Group Command

The Group Command Protocol is supported by the UCD911x family of digital controllers.

1.6 SMBALERT Response Protocol

The UCD911x family of digital controllers supports the SMBALERT response protocol.

The SMBALERT response protocol is a mechanism by which a slave (the UCD911x) can alert a master that it wants to talk. The master processes this event and simultaneously accesses all slaves on the bus (that support the protocol) through the alert response address. Only the slave that caused the alert acknowledges this request. The host performs a modified receive byte operation to get the slave's address. At this point, the master can query the PMBus commands related to status and errors from the slave that caused the alert.

The following is the list of warning or fault conditions which activates the SMBALERT signal:

- Vout > VOUT_OV_WARN_LIMIT
- Vout > VOUT_OV_FAULT_LIMIT
- Vout < VOUT_UV_WARN_LIMIT
- Vout < VOUT_UV_FAULT_LIMIT
- Vout > PREBIAS_MAX_LIMIT
- Iout > IOUT_OC_FAULT_LIMIT
- Vin > VIN_OV_WARN_LIMIT
- Vin < VIN_OFF
- $T_{AMBIENT}$ > OT_FAULT_LIMIT
- $T_{AMBIENT}$ < UT_FAULT_LIMIT
- Number of gate driver current limit flags exceeds configured set limit
- Total ramp up time > TON_MAX_FAULT_LIMIT
- Fan speed > FAN_SPEED_FAULT_LIMIT, when fan monitoring enabled
- Unrecoverable internal errors or memory corruption of nonvolatile memory

For more information on the SMBus alert response protocol, see the System Management Bus (SMBus) specification.

1.7 Nonvolatile Memory on the UCD911x

The UCD911x family of digital controllers has a block of nonvolatile memory. This memory is used to store the following information:

- Configured set points (V_{OUT}, margin voltages, etc.)
- Warning and fault thresholds (OV, OC, temperature, etc.)
- Calibration information (reference offset and gain)

Certain PMBus commands store information to nonvolatile memory when they are written to the UCD911x. During this time, the system cannot perform warning and fault checking for voltage, current, and temperature.

In this scenario, if an overcurrent or an overvoltage condition happened during this window of time (usually < 200 ms), then the controller is unable to detect it and react to it until after this period has elapsed and the device has returned to normal operation.

CAUTION

Because of this, it is highly recommended that a PMBus master not issue any transactions that write to nonvolatile memory to the UCD911x while it is converting power, so that this level of protection still exists.

If you need to change a parameter in nonvolatile memory, it is highly recommended that you do so while the system is not converting power.

Each time the controller is powered on, it checks the integrity of internal program and data memory to verify that it has not been corrupted.

If program memory has been corrupted, the user is unable to communicate with the device via PMBus and the controller does not operate. If data memory has been corrupted, the UCD911x declares an error in the STATUS_CML register and the system is not allowed to convert power.

1.8 PMBus Range Checking

The UCD911x controllers support range checking of PMBus data that is attempted to be written to the device.

When a PMBus master attempts to write data to the UCD911x, the UCD911x checks to make sure the format of the command is correct, according to the command language specification. If it is not, the UCD911x NACKs this request.

After that, it further evaluates the data. If the data that is attempted to be written to the device is out of range for that command (such as setting VOUT_COMMAND to a voltage that the UCD911x cannot support), it is NACKed. Otherwise, the data is ACKed.

This methodology provides an elegant mechanism in which a PMBus master – such as a system host or GUI – can rely on the responses that it gets from the UCD911x without having to validate each command that it writes to the device. This improves bus efficiency and software complexity for the system.

2 Physical and Electrical Characteristics

The UCD911x family of digital controllers supports the PMBus version 1.1 and SMBus version 2.0 specifications.

In addition to the following features, the data sheets for the UCD911x controllers contain details on the physical and electrical specifications for each device.

2.1 PMBus Address Detection

The UCD911x can configure its PMBus address on startup of the controller. When the system is released from reset, two signals are used to measure the voltage (ADDR0 and ADDR1).

After these signals are sampled, the following formula is used to compute the PMBus address for the controller. The controller uses this computed PMBus address from that point on, until the controller is reset or powered off.

Figure 1 shows what PMBus addresses are indicated by the applied voltage.

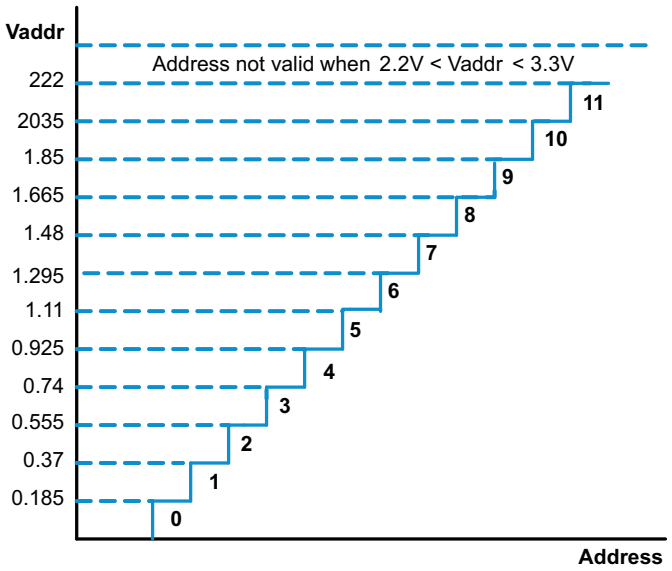

Figure 1. V_{addr} to PMBus Address Translation

Note that the nominal value for each voltage step (and each PMBus address) is in the center of each band.

The address can be represented by the formula:

PMBus_Addr = ADDR1 × 12 + ADDR0

Two special cases force the address to be evaluated to 127:

- If the formula evaluates to 0
- If either ADDR0 or ADDR1 are sampled at more than 2.2 V

3 Summary of Supported PMBus Commands

This section describes the set of supported PMBus commands for the UCD911x digital controllers.

For details on each of the commands, see the PMBus Protocol Specification, version 1.1.

A row that is shaded reflects a command that is supported by the device. A row that is unshaded implies that the command is unsupported.

The UCD911x also includes a comprehensive security scheme for configuration of the device over PMBus. For more information on the security capabilities of the UCD911x devices, see the application report (SLUA429). Each supported command in Table 1 indicates whether the command is protectable by PMBus security.

Table 1. UCD911x Supported PMBus Commands

Code	Command Name	Configurable PMBus Security	SMBus Transaction Type	Default Value Data Format (in Hexadecimal)	Supported Range	Comments
00h	PAGE		R/W Byte			
01h	OPERATION	Write-protectable	R/W Byte	Unit on, margin off (0x80)		This command has a fixed set of legal values. See the PMBus specification for more information.
02h	ON_OFF_CONFIG	Write-protectable	R/W Byte	Power up by CONTROL, use OPERATION, CONTROL active high, use off delay and fall time (0x1E)		This command has a fixed set of legal values. See the PMBus specification for more information.
03h	CLEAR_FAULTS	No protection	Send Byte			

Table 1. UCD911x Supported PMBus Commands (continued)

Code	Command Name	Configurable PMBus Security	SMBus Transaction Type	Default Value Data Format (in Hexadecimal)	Supported Range	Comments
04h	PHASE	No protection	R/W Byte	For READ_IOUT to read the sum current of both phases (0xFF)	0x00, or 0x01, or 0xFF	Select which phase the following commands work for: READ_IOUT, IOUT_SCALE, IOUT_CAL_OFFSET. If PHASE is 0x00, read/write the first phase. If PHASE is 0x01, read/write the second phase. If PHASE is 0xFF, for READ_IOUT, it will read the sum of both phases. For IOUT_SCALE and IOUT_CAL_OFFSET, the commands will be NACKed. The UCD9111 will NACK this command
05h	Reserved					
06h	Reserved					
07h	Reserved					
08h	Reserved					
09h	Reserved					
0Ah	Reserved					
0Bh	Reserved					
0Ch	Reserved					
0Dh	Reserved					
0Eh	Reserved					
0Fh	Reserved					
10h	WRITE_PROTECT	Write-protectable	R/W Byte	Enable all writes (0x00)		In addition to protection through this WRITE_PROTECT, TI also offers a more comprehensive security scheme. Please review related application note for details. This command has a fixed set of legal values. See the PMBus specification for more information.
11h	STORE_ DEFAULT_ALL	Send-byte-protectable	Send Byte			This command stores all configuration and calibration parameters as well as CLA tables to data flash memory in UCD9111/UCD9112. Note: because of data flash programming, after sending this command, the PMBus host must wait for a minimum of 250 milliseconds before it can issue the next PMBus command.
12h	RESTORE_ DEFAULT_ALL	Send-byte-protectable	Send Byte			This command restores the default configuration and calibration parameters, and the default CLA tables from data flash memory in UCD9111/UCD9112.
13h	STORE_DEFAULT_CODE		Write Byte			
14h	RESTORE_DEFAULT_CODE		Write Byte			
15h	STORE_USER_ALL		Send Byte			
16h	RESTORE_USER_ALL		Send Byte			
17h	STORE_USER_CODE		Write Byte			
18h	RESTORE_USER_CODE		Write Byte			
19h	CAPABILITY	N/A	Read Byte	PEC supported, I2C speed of 100 kHz, SMBALERT supported (0x90)		
1Ah	QUERY		Block Write-Block Read Process Call			
1Bh	Reserved					
1Ch	Reserved					
1Dh	Reserved					
1Eh	Reserved					
1Fh	Reserved					
20h	VOUT_MODE	Write-protectable	R/W Byte	-11 (0x15)		The only value that is allowable for this command is -11, LINEAR mode. Any other value will be NACKed. This command has a fixed set of legal values. See the PMBus specification for more information.
21h	VOUT_COMMAND	Write-protectable	R/W Word	1.000V Linear-16 (0x0800 using an exponent of -11)	MFR_ VOUT_MIN ~ MFR_ VOUT_MAX	This value is represented in volts (V).

Table 1. UCD911x Supported PMBus Commands (continued)

Code	Command Name	Configurable PMBus Security	SMBus Transaction Type	Default Value Data Format (in Hexadecimal)	Supported Range	Comments
22h	VOUT_TRIM	Write-protectable	R/W Word	0V Linear-16 (0x0000 using an exponent of -11)	-0.400V ~ 0.400V	This value is added to VOUT_COMMAND when no margin is selected, or to VOUT_MARGIN_HIGH when margin high is selected, or to VOUT_MARGIN_LOW when margin low is selected. This value is represented in volts (V)
23h	VOUT_CAL_OFFSET		R/W Word			
24h	VOUT_MAX	Write-protectable	R/W Word	UCD9112: 4.000V Linear-16 (0x2000 using an exponent of -11) UCD9111: 2.450V Linear-16 (0x1399 using an exponent of -11)	MFR_ VOUT_MIN ~ MFR_ VOUT_MAX	This value is represented in volts (V)
25h	VOUT_MARGIN_HIGH	Write-protectable	R/W Word	1.120V Linear-16 (0x08F5 using an exponent of -11)	MFR_ VOUT_MIN ~ MFR_ VOUT_MAX	This value is represented in volts (V)
26h	VOUT_MARGIN_LOW	Write-protectable	R/W Word	0.880V Linear-16 (0x070A using an exponent of -11)	MFR_ VOUT_MIN ~ MFR_ VOUT_MAX	This value is represented in volts (V)
27h	VOUT_TRANSITION_RATE	Write-protectable	R/W Word	0.094mV/µs Linear-11 (0xD006)	For UCD9112: 0.05mV/µs – 0.5mV/µs. For UCD9111: 0.05mV/µs – 0.4mV/µs	This value is represented in millivolts per microsecond (mV/µs).
28h	VOUT_DROOP		R/W Word			
29h	VOUT_SCALE_LOOP	Write-protectable	R/W Word	UCD9112: 0.6234 Linear-11 (0XB93F) UCD9111: 1.0000 Linear-11 (0x0001)	UCD9112: 0.50 ~ 1.00 UCD9111: 0.50 ~ 1.20	On an UCD9112 EVM, lower resistor of compensation loop is 10.0k, while upper resistor of compensation loop is 6.04K, the corresponding default value = R1/(R1+R2) = 10.0/(10.0+6.04) = 0.6234. On an UCD9111 EVM, lower resistor of compensation loop is removed. So the value of this parameter is 1.0000. Note: because of data flash programming, after writing a new value, the PMBus host must wait for a minimum of 120 milliseconds before it can issue the next PMBus command. This command is in LINEAR-11 format.
2Ah	VOLTAGE_SCALE_MONITOR	Write-protectable	R/W Word	For UCD9112: 0.571 Linear-11 (0XB924) For UCD9111: 1.000 Linear-11 (0x0001)	UCD9112: 0.250 ~ 1.000 UCD9112: 0.250 ~ 1.200	This command is in LINEAR-11 format.
2Bh	Reserved					
2Ch	Reserved					
2Dh	Reserved					
2Eh	Reserved					
2Fh	Reserved					
30h	COEFFICIENTS		Block R/W (Process Call)			
31h	POUT_MAX		R/W Word			
32h	MAX_DUTY	Write-protectable	R/W Word	95% Linear-11 (0x005F)	0% ~ 99%	This value is in units of percentage
33h	FREQUENCY_SWITCH	Write-protectable	R/W Word	500kHz Linear-11 (0x01F4)	250 kHz ~ 1,000 kHz	This value is represented in kilo-hertz (kHz)
34h	Reserved					
35h	VIN_ON	Write-protectable	R/W Word	5.00V Linear-11 (0xE050)	MFR_VIN_ MIN ~ MFR_VIN_ MAX	Note: VIN_ON value can not be smaller than VIN_OFF value. This value is represented in volts (V)
36h	VIN_OFF	Write-protectable	R/W Word	4.5V Linear-11 (0xE048)	MFR_VIN_ MIN ~ MFR_VIN_ MAX	Note: VIN_ON value can not be smaller than VIN_OFF value. This value is represented in volts (V)
37h	INTERLEAVE		R/W Word			

Table 1. UCD911x Supported PMBus Commands (continued)

Code	Command Name	Configurable PMBus Security	SMBus Transaction Type	Default Value Data Format (in Hexadecimal)	Supported Range	Comments
38h	IOUT_CAL_GAIN	Write-protectable	R/W Word	For UCD9112: both phases are 0.781mΩ Linear-11 For UCD9111: only phase is of 0.781 mΩ Linear-11	UCD9112: 0.250mΩ ~ 2.000mΩ UCD9111: 0.250mΩ ~ 9.000 mΩ	For the UCD9112, if PHASE is 0x00, the command applies to the first phase; if PHASE is 0x01, the command applies to the second phase; otherwise the device will NACK the command. For the UCD9111, there is no second phase, so this will be for the gain of the first phase current. This value is represented in milliohms (mΩ)
39h	IOUT_CAL_OFFSET	Write-protectable	R/W Word	0A Linear-11 (0x0000)		For the UCD9112, if PHASE is 0x00, the command applies to the first phase; if PHASE is 0x01, the command applies to the second phase; otherwise the device will NACK the command. For the UCD9111, there is no second phase, so this will be the offset of the first phase current. This value is represented in amperes (A).
3Ah	FAN_CONFIG_1 _2	Write-protectable	R/W Byte	No fan installed, 2 pulses per revolution (0x10)		For more details on fan control, refer to UCD9112/UCD9111 data sheet.
3Bh	FAN_COMMAND_1	Write-protectable	R/W Word	100% duty cycle Linear-11 (0x0064)		This value is represented in units of percentage (%).
3Ch	FAN_COMMAND_2		R/W Word			
3Dh	FAN_CONFIG_3_4		R/W Byte			
3Eh	FAN_COMMAND_3		R/W Word			
3Fh	FAN_COMMAND_4		R/W Word			
40h	VOUT_OV_FAULT_LIMIT	Write-protectable	R/W Word	1.300V Linear-16 (0x0A66)	MFR_ VOUT_MIN ~ MFR_ VOUT_MAX	Note: VOUT_OV_FAULT_LIMIT cannot be smaller than VOUT_OV_WARN_LIMIT. This value is represented in volts (V)
41h	VOUT_OV_FAULT_RESPONSE	Write-protectable	R/W Byte	In case of a VOUT fault, device latches off until fault is cleared. (0x81)		This command has a fixed set of possible values. See the PMBus specification for more detail.
42h	VOUT_OV_WARN_LIMIT	Write-protectable	R/W Word	1.200V Linear-16 (0x0999)	MFR_ VOUT_MIN ~ MFR_ VOUT_MAX	Note: VOUT_OV_FAULT_LIMIT cannot be smaller than VOUT_OV_WARN_LIMIT This value is represented in volts (V)
43h	VOUT_UV_WARN_LIMIT	Write-protectable	R/W Word	0.850V Linear-16 (0x06CC)	MFR_ VOUT_MIN ~ MFR_ VOUT_MAX	Note: VOUT_UV_FAULT_LIMIT cannot be greater than VOUT_UV_WARN_LIMIT. This value is represented in volts (V)
44h	VOUT_UV_FAULT_LIMIT	Write-protectable	R/W Word	0.800V Linear-16 (0x0666)	MFR_ VOUT_MIN ~ MFR_ VOUT_MAX	Note: VOUT_UV_FAULT_LIMIT cannot be greater than VOUT_UV_WARN_LIMIT. This value is represented in volts (V)
45h	VOUT_UV_FAULT_RESPONSE	Write-protectable	R/W Byte	In case of a VOUT fault, device latches off until fault is cleared. (0x81)		This command has a fixed set of possible values. See the PMBus specification for more detail.
46h	IOUT_OC_FAULT_LIMIT	Write-protectable	R/W Word	For UCD9112: 44.00A Linear-11 (0XE2C0) For UCD9111: 24.00A Linear-11 (0X0018)	0.001A ~ MFR_IOUT_MAX	The range is a function of the UCD7230 ILIM multiplier and the DCR of the inductor. Note: IOUT_OC_FAULT_LIMIT cannot be smaller than IOUT_OC_WARN_LIMIT. This value is represented in volts (V)
47h	IOUT_OC_FAULT_RESPONSE	Write-protectable	R/W Byte	In case of an IOUT fault, device shuts down immediately without any retry (0xC1)	Bit7 = 1 Bit6 = 1	Note: only retry (bit7 = 1, bit6 = 1) is supported. This command has a fixed set of possible values. See the PMBus specification for more detail.
48h	IOUT_OC_LV_FAULT_LIMIT		R/W Word			
49h	IOUT_OC_LV_FAULT_ RESPONSE		R/W Byte			
4Ah	IOUT_OC_WARN_LIMIT	Write-protectable	R/W Word	For UCD9112: 42.00A Linear-11 (0XE2A0) For UCD9111: 22.00A Linear-11 (0X0016)	0.001A ~ MFR_IOUT_MAX	The range is a function of the UCD7230 ILIM multiplier and the DCR of the inductor. Note: IOUT_OC_FAULT_LIMIT cannot be smaller than IOUT_OC_WARN_LIMIT. This value is represented in amperes (A).
4Bh	IOUT_UC_FAULT_LIMIT	R/W Word				
4Ch	IOUT_UC_FAULT_RESPONSE	R/W Byte				
4Dh	Reserved For POUT_FAULT_LIMIT	R/W Word				
4Eh	Reserved For: POUT_MAX_FAULT_ RESPONSE	R/W Byte				

Table 1. UCD911x Supported PMBus Commands (continued)

Code	Command Name	Configurable PMBus Security	SMBus Transaction Type	Default Value Data Format (in Hexadecimal)	Supported Range	Comments
4Fh	OT_FAULT_LIMIT	Write-protectable	R/W Word	120°C Linear-11 (0x0078)	MFR_ TAMBIENT_MIN ~ MFR_ TAMBIENT_MAX	Note: OT_FAULT_LIMIT cannot be lower than OT_WARN_LIMIT. This value is represented in degrees Celsius (°C).
50h	OT_FAULT_RESPONSE	Write-protectable	R/W Byte	In case of a TAMBIENT fault, device latches off until fault is cleared. (0x81)		This command has a fixed set of possible values. See the PMBus specification for more detail.
51h	OT_WARN_LIMIT	Write-protectable	R/W Word	110C Linear-11 (0x006E)	MFR_ TAMBIENT_MIN ~ MFR_ TAMBIENT_MAX	Note: OT_FAULT_LIMIT cannot be lower than OT_WARN_LIMIT. This value is represented in degrees Celsius (°C).
52h	UT_WARN_LIMIT	Write-protectable	R/W Word	-30°C Linear-11 (0x07E2)	MFR_ TAMBIENT_MIN ~ MFR_ TAMBIENT_MAX	Note: UT_FAULT_LIMIT cannot be higher than UT_WARN_LIMIT. This value is represented in degrees Celsius (°C).
53h	UT_FAULT_LIMIT	Write-protectable	R/W Word	-40°C Linear-11 (0x07D8)	MFR_ TAMBIENT_MIN ~ MFR_ TAMBIENT_MAX	Note: UT_FAULT_LIMIT cannot be higher than UT_WARN_LIMIT. This value is represented in degrees Celsius (°C).
54h	UT_FAULT_RESPONSE	Write-protectable	R/W Byte	In case of a TAMBIENT fault, device latches off until fault is cleared. (0x81)		This command has a fixed set of possible values. See the PMBus specification for more detail.
55h	VIN_OV_FAULT_LIMIT	Write-protectable	R/W Word	14.00V Linear-11 (0XE0E0)	MFR_VIN_ MIN ~ MFR_VIN_ MAX	Note: VIN_OV_FAULT_LIMIT cannot be smaller VIN_OV_WARN_LIMIT. This value is represented in volts (V).
56h	VIN_OV_FAULT_RESPONSE	Write-protectable	R/W Byte	In case of a VIN fault, device latches off until fault is cleared. (0x81)		This command has a fixed set of possible values. See the PMBus specification for more detail.
57h	VIN_OV_WARN_LIMIT	Write-protectable	R/W Word	13.20V Linear-11 (0XE0D3)	MFR_VIN_ MIN ~ MFR_VIN_ MAX	Note: VIN_OV_FAULT_LIMIT cannot be smaller VIN_OV_WARN_LIMIT. This value is represented in volts (V).
58h	VIN_UV_WARN_LIMIT		R/W Word			
59h	VIN_UV_FAULT_LIMIT		R/W Word			
5Ah	VIN_UV_FAULT_RESPONSE		R/W Byte			
5Bh	IIN_OC_FAULT_LIMIT		R/W Word			
5Ch	IIN_OC_FAULT_RESPONSE		R/W Byte			
5Dh	IIN_OC_WARN_LIMIT		R/W Word			
5Eh	POWER_GOOD_ON	Write-protectable	R/W Word	0.900V Linear-16 (0x0733 using an exponent of -11)	MFR_ VOUT_MIN ~ MFR_ VOUT_MAX	If VOUT is higher than POWER_GOOD_ON, assert POWER_GOOD signal through PGOOD pin. Note: POWER_GOOD_ON value can not be lower than POWER_GOOD_OFF value. This value is represented in volts (V).
5Fh	POWER_GOOD_OFF	Write-protectable	R/W Word	0.860V Linear-16 (0x06E1 using an exponent of -11)	MFR_ VOUT_MIN ~ MFR_ VOUT_MAX	If VOUT is lower than POWER_GOOD_OFF, negate POWER_GOOD signal through PGOOD pin. Note: POWER_GOOD_ON value can not be lower than POWER_GOOD_OFF value. This value is represented in volts (V).
60h	TON_DELAY	Write-protectable	R/W Word	5ms Linear-11 (0XF80A)	0ms ~ 255 ms	This value is represented in milliseconds (ms).
61h	TON_RISE	Write-protectable	R/W Word	5ms Linear-11 (0xF80A)	0ms ~ 255 ms	This value is represented in milliseconds (ms).
62h	TON_MAX_FAULT_LIMIT	Write-protectable	R/W Word	15 ms Linear-11 (0XF81E)	0ms ~ 255 ms	This value is represented in milliseconds (ms).
63h	TON_MAX_FAULT_RESPONSE	Write-protectable	R/W Byte	In case of a timeout fault, device latches off until fault is cleared. (0x81)		This command has a fixed set of possible values. See the PMBus specification for more detail.
64h	TOFF_DELAY	Write-protectable	R/W Word	5ms Linear-11 (0XF80A)	0ms ~ 255 ms	This value is represented in milliseconds (ms).
65h	TOFF_FALL	Write-protectable	R/W Word	10ms Linear-11 (0XF814)	0ms ~ 255 ms	This value is represented in milliseconds (ms).
66h	TOFF_MAX_WARN_LIMIT	Write-protectable	R/W Word	125ms Linear-11 (0XF8FA)	0ms ~ 255 ms	This value is represented in milliseconds (ms).
67h	Reserved					
68h	POUT_OP_FAULT_LIMIT		R/W Byte			
69h	POUT_OP_FAULT_RESPONSE		R/W Word			
6Ah	POUT_OP_WARN_LIMIT		R/W Word			

Table 1. UCD911x Supported PMBus Commands (continued)

Code	Command Name	Configurable PMBus Security	SMBus Transaction Type	Default Value Data Format (in Hexadecimal)	Supported Range	Comments
6Bh	PIN_OP_WARN_LIMIT		R/W Word			
6Ch	Reserved					
6Dh	Reserved					
6Eh	Reserved					
6Fh	Reserved					
70h	Reserved (Test Input Fuse A)					
71h	Reserved (Test Input Fuse B)					
72h	Reserved (Test Input OR-ing A)					
73h	Reserved (Test Input OR-ing B)					
74h	Reserved (Test Output OR-ing)					
75h	Reserved					
76h	Reserved					
77h	Reserved					
78h	STATUS_BYTE	No protection	Read Byte			
79h	STATUS_WORD	No protection	Read Word			
7Ah	STATUS_VOUT	No protection	Read Byte			
7Bh	STATUS_IOUT	No protection	Read Byte			
7Ch	STATUS_INPUT	No protection	Read Byte			
7Dh	STATUS_TEMPERATURE	No protection	Read Byte			
7Eh	STATUS_CML	No protection	Read Byte			
7Fh	STATUS_OTHER	No protection	Read Byte			
80h	STATUS_MFR_SPECIFIC	No protection	Read Byte			
81h	STATUS_FANS_1_2	No protection	Read Byte			For more details on fan controls, refer to UCD911x data sheet.
82h	STATUS_FANS_3_4		Read Byte			
83h	Reserved					
84h	Reserved					
85h	Reserved					
86h	Reserved					
87h	Reserved					
88h	READ_VIN	No protection	Read Word	Linear-11		This value is in volts (V).
89h	READ_IIN		Read Word			
8Ah	READ_VCAP		Read Word			
8Bh	READ_VOUT	No protection	Read Word	Linear-16		This value is in volts (V).
8Ch	READ_IOUT	No protection	Read Word	Linear-11		For the UCD9112, if PHASE is 0xFF, reads the sum of the two phases. If PHASE is 0x00, reads the first phase. If PHASE is 0x01, reads the second phase. For any other value, the device will NACK this command. For the UCD9111, there is only one phase and will return that phase current. This value is in amperes (A).
8Dh	READ_TEMPERATURE_1	No protection	Read Word	Linear-11		This uses the internal temperature sensor. This value is in degrees Celsius (°C).
8Eh	READ_TEMPERATURE_2 Note: This command is supported for UCD9112 only.	No protection	Read Word	Linear-11		This temperature is reported via the remote temperature sensor attached to pin TEMP. The MFR_REMOTE_TEMP_CAL command specifies the offset and scale of this sensor, assuming that is close to linear. This value is in degrees Celsius (°C).
8Fh	READ_TEMPERATURE_3		Read Word			
90h	READ_FAN SPEED_1	No protection	Read Word	Linear-11		For more details on fan controls, refer to UCD9112/UCD9111 data sheet. This value is in RPM.
91h	READ_FAN SPEED_2		Read Word			
92h	READ_FAN SPEED_3		Read Word			
93h	READ_FAN SPEED_4		Read Word			
94h	READ_DUTY_CYCLE	No protection	Read Word	Linear-11		This value is in percentage (%).
95h	READ_FREQUENCY	No protection	Read Word	Linear-11		This value is in kilo-hertz (kHz).

Table 1. UCD911x Supported PMBus Commands (continued)

Code	Command Name	Configurable PMBus Security	SMBus Transaction Type	Default Value Data Format (in Hexadecimal)	Supported Range	Comments
96h	READ_POUT Note: This command is supported on UCD9111 only.	No protection	Read Word	Linear-11		This value is in watts (W)
97h	READ_PIN					
98h	PMBus_REVISION	No protection	Read Byte	PMBus Specs Part I: 1.1 PMBus Specs Part II: 1.1 (0x21)		
99h	MFR_ID	Write-protectable	R/W Block, 12 data bytes	"TI"		Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 120 ms before issuing the next PMBus command to the device so that the operation can complete. This value is a null-terminated ASCII string.
9Ah	MFR_MODEL	Write-protectable	R/W Block, 20 data bytes	For UCD9112: "UCD9112 2-PHASE POL" For UCD9111: "UCD9111 1-PHASE POL"		Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 120 ms before issuing the next PMBus command to the device so that the operation can complete. This value is a null-terminated ASCII string.
9Bh	MFR_REVISION	Write-protectable	R/W Block, 18 data bytes	For UCD9112: "UCD9112 REVISION" For UCD9111: "UCD9111 REVISION"		Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 170 ms before issuing the next PMBus command to the device so that the operation can complete. This value is a null-terminated ASCII string.
9Ch	MFR_LOCATION	Write-protectable	R/W Block, 12 data bytes	"DALLAS, TX"		Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 120 ms before issuing the next PMBus command to the device so that the operation can complete. This value is a null-terminated ASCII string.
9Dh	MFR_DATE	Write-protectable	R/W Block, 12 data bytes	UCD9112: "070510", which stands for May 10, 2007 UCD9111: "070531", which stands for May 31, 2007		Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 120 ms before issuing the next PMBus command to the device so that the operation can complete. This value is a null-terminated ASCII string.
9Eh	MFR_SERIAL	Write-protectable	R/W Block, 20 data bytes	For UCD9112: "UCD9112 SERIAL" For UCD9111: "UCD9111 SERIAL"		Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 120 ms before issuing the next PMBus command to the device so that the operation can complete. This value is a null-terminated ASCII string
9Fh	Reserved					
A0h	MFR_VIN_MIN	Write-protectable	R/W Word	4.500V Linear-11 (0XE048)	4.500V ~ 16.000V	Note: actual VIN limits may be narrower. Please refer to UCD9112/UCD9111 data sheet for more information. This value is in volts (V).
A1h	MFR_VIN_MAX	Write-protectable	R/W Word	15.000V Linear-11 (0XE0F0)	4.500V ~ 16.000V	Note: actual VIN limits may be narrower. Please refer to UCD9112/UCD9111 data sheet for more information. This value is in volts (V).
A2h	MFR_IIN_MAX		Read Word			
A3h	MFR_PIN_MAX		Read Word			
A4h	MFR_VOUT_MIN	Write-protectable	R/W Word	0.300V Linear-11 (0xB133)	UCD9112: 0.300V ~ 4.000V UCD9111: 0.300V ~ 6.000V	This value is in volts (V).
A5h	MFR_VOUT_MAX	Write-protectable	R/W Word	UCD9112: 4.000V Linear-11 (0xCA00) UCD9111: 2.500V Linear-11 (0xC280)	UCD9112: 0.300V ~ 4.000V UCD9111: 0.300V ~ 6.000V	This value is in volts (V).
A6h	MFR_IOUT_MAX	Write-protectable	R/W Word	For UCD9112: 48.00A Linear-11 (0xE300) For UCD9111: 24.00A Linear-11 (0x0018)	Less than 125.00A	This value is in amperes (A).
A7h	MFR_POUT_MAX		Read Word			
A8h	MFR_TAMBIENT_MAX	Write-protectable	R/W Word	125.0°C Linear-11 (0xEBE8)	Up to 125.0°C	This value is in degrees Celsius (°C).
A9h	MFR_TAMBIENT_MIN	Write-protectable	R/W Word	-40.0°C Linear-11 (0xEEC0)	Down to -40.0°C	This value is in degrees Celsius (°C).

Table 1. UCD911x Supported PMBus Commands (continued)

Code	Command Name	Configurable PMBus Security	SMBus Transaction Type	Default Value Data Format (in Hexadecimal)	Supported Range	Comments
AAh	MFR_EFFICIENCY_LL					
ABh	MFR_EFFICIENCY_HL					
ACh	Reserved					
ADh	Reserved					
AEh	Reserved					
AFh	Reserved					
B0h	USER_DATA_00	Write-protectable	Block R/W, 32 data bytes			Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 175 ms before issuing the next PMBus command to the device so that the operation can complete. This value is a null-terminated ASCII string.
B1h	USER_DATA_01		Block R/W			
B2h	USER_DATA_02		Block R/W			
B3h	USER_DATA_03		Block R/W			
B4h	USER_DATA_04		Block R/W			
B5h	USER_DATA_05		Block R/W			
B6h	USER_DATA_06		Block R/W			
B7h	USER_DATA_07		Block R/W			
B8h	USER_DATA_08		Block R/W			
B9h	USER_DATA_09		Block R/W			
BAh	USER_DATA_10		Block R/W			
BBh	USER_DATA_11		Block R/W			
BCh	USER_DATA_12		Block R/W			
BDh	USER_DATA_13		Block R/W			
BEh	USER_DATA_14		Block R/W			
BFh	USER_DATA_15		Block R/W			
C0h	Reserved					
C1h	Reserved					
C2h	Reserved					
C3h	Reserved					
C4h	Reserved					
C5h	Reserved					
C6h	Reserved					
C7h	Reserved					
C8h	Reserved					
C9h	Reserved					
CAh	Reserved					
CBh	Reserved					
CCh	Reserved					
CDh	Reserved					
CEh	Reserved					
CFh	Reserved					
D0h	POWER_GOOD_POLARITY	Write-protectable	R/W Byte	Active low (0x00)	Active low (0x00) Active high (0x01)	Power good polarity: 0x01 for active high; 0x00 for active low; all other values are invalid and will be NACKed. Active low/high is relative to IO pin 21 (PGOOD) of UCD911x.
D1h	CLF_EVENTS	Write-protectable	R/W Word	50 current limit flags (0x0032)		Total number of current limit flags (for both phases, if multi-phase) that, if detected, will cause an interrupt and action by the UCD911x controller. This value is a 16-bit unsigned integer.
D2h	VOUT_SENSE_UPPER_RESISTOR	Write-protectable	R/W Word	UCD9112: 6.04k Linear-11 (0xD8C1) UCD9111: 6.031K Linear-11 (0xCB04)	0 ~ 20k	This is the upper Vout sense resistor in kΩ. Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 120 ms before issuing the next PMBus command to the device so that the operation can complete.
D3h	VIN_SCALE	Write-protectable	R/W Word	0.148 Linear-11 (0xB84C)	0.03 ~ 1.0	The VIN (pin 4 of UCD911x) voltage divider ratio = Rlower/(Rlower+Rupper). For the EVM, the ratio = 2K/(2K+11.5K) = 0.148.

Table 1. UCD911x Supported PMBus Commands (continued)

Code	Command Name	Configurable PMBus Security	SMBus Transaction Type	Default Value Data Format (in Hexadecimal)	Supported Range	Comments
D4h	CLA_TABLE_NUM_ ROW_NUM	No protection	R/W Byte	CLA coefficient table 0, row 0 (0x0)0		This command is used for both reading and writing of a row from the CLA coefficient table using the MFR_SPECIFIC_05 command. The bit layout of this byte is as follows: bit 0 ~ bit 4: row number (from 0 to 16) bit 5, bit 6: reserved b7: table number (0: table 0, 1: table 1)
D5h	CLA_ROW_ COEFFICIENTS	Write-protectable	R/W Block, 12 data bytes			Each CLA coefficient is represented by a signed long integer (4 bytes, where the upper 2 bytes are sign bytes: 0xFFFF for negative, and 0x0000 for positive), and there are 3 coefficients for each row, so 12 bytes for each row.
D6h	STORE_CLA_TABLE	Send-byte-protectable	Send Byte			Save the CLA Coefficient table designated by MFR04_CLA_TABLE_NUM_ROW_NUM in registers to data flash. Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 120 ms before issuing the next PMBus command to the device so that the operation can complete.
D7h	MFR_SPECIFIC_07		Mfr. Defined			
D8h	MFR_SPECIFIC_08		Mfr. Defined			
D9h	MFR_SPECIFIC_09		Mfr. Defined			
DAh	USER_RAM_00	Write-protectable	R/W Byte	Reset (0x00)	0x00 ~ 0xFF	This command allows the user to read/write a byte to RAM from/to the device that will be reset to a known value (0x00) upon reset of the controller. This will enable the user to tell at any given time if the controller has been reset during operation.
DBh	SOFT_RESET	Send-byte-protectable	Send Byte			This command shuts down Vout if it is on and then reset the controller.
DCh	TEMPERATURE_SENSOR_SELECT Note: This command is supported only on UCD9111.	Write-protectable	R/W Byte	External sensor (0x01)	External sensor (0x01) Internal sensor (0x00)	This command allows the user to select the temperature sensor (internal or external).
DDh	MFR_SPECIFIC_13		Mfr. Defined			
DEh	ENABLE_PHASE Note: This command is supported only for UCD9112.	Write-protectable	R/W Byte	For UCD9112: Both phases (0x03)	0x01, 0x02, or 0x03	For the UCD911x, this command selects the phase to enable to use for current calibration: 0x01: phase 1 only 0x02: phase 2 only 0x03: both phase1 and phase 2 For the UCD9111, this command is NACKed.
DFh	ALMOST_ZERO_MAX	Write-protectable	R/W Word	0.300V Linear-16 (0x0266 using an exponent of -11)	0V ~ 0.500V	Output voltage below this setting is treated as zero by the device. When start-up, if there is output voltage above this value, the device treats it as a pre-bias. During stop procedure, if output voltage is still higher than this setting after TON_MAX_FAULT_LIMIT elapses, warning is reported. This value is in volts (V).
E0h	PREBIAS_MAX	Write-protectable	R/W Word	UCD9112: 3.650V Linear-16 (0x1D33 using an exponent of -11) UCD9111: 2.450V Linear-16 (0x1399 using an exponent of -11)	UCD9112: 3.000V ~ 4.000V UCD9111: 2.000V ~ 6.000V	The maximum pre-bias voltage the system can start regulation from. If output voltage is above this setting at start-up, then the device will treat it as an overvoltage fault condition. The lowest bit in STATUS_MFR_SPECIFIC will be set. This value is in volts (V).
E1h	MFR_SPECIFIC_17		Mfr. Defined			
E2h	REMOTE_TEMP_CAL	Write-protectable	R/W Block, 4 data bytes	Offset is 333 Linear-11 (0x014D) Slope is -476 Linear-11 (0x0624)		The first 2 bytes of the data block are for calibrating the remote temperature sensor offset, while the last 2 bytes of the data block are for calibration the remote temperature sensor slope. These values are used to calculate a temperature reading from the remote temperature sensor when a READ_TEMPERATURE_2 command is called.
E3h	TRACKING_ENABLE	Write-protectable	R/W Byte	Voltage tracking disabled (0x00)	0x00 for disable, 0x01 for enable	Specifies whether or not the voltage tracking feature is enabled. If enabled, soft start and soft stop will “follow” the voltage on pin 8 (TRACK) of UCD911x, rather than performing normal soft start and stop.
E4h	MFR_SPECIFIC_20		Mfr. Defined			
E5h	MFR_SPECIFIC_21		Mfr. Defined			
E6h	LOUT Note: This command is supported only on UCD9112.	Write-protectable	R/W Byte	0.5µH (0x05)	0µH ~ 25.5µH	Specifies the value (in one 10th of a µH) of output inductor for current ripple calculations. Note: UCD9111 will NACK this command.

Table 1. UCD911x Supported PMBus Commands (continued)

Code	Command Name	Configurable PMBus Security	SMBus Transaction Type	Default Value Data Format (in Hexadecimal)	Supported Range	Comments
E7h	TRACKING_SCALE_ MONITOR	Write-protectable	R/W Word	UCD9112: 0.571 Linear-11 (0xB924) UCD9111: 1.000 Linear-11 (0x0001)	0.250 ~ 1.000	
E8h	FAN_SPEED_FAULT_ LIMIT	Write-protectable	R/W Word	1000RPM Linear-11 (0x03E8)	0RPM ~ 32000RPM	For more details on fan controls, refer to UCD911x data sheet. This value is in RPM.
E9h	LOGGED_MAX_ TEMPERATURE	Write-protectable	R/W Block, 3 data bytes	The first two bytes uses Linear-11 (0x000000)		The first 2 bytes of the data block are for the to-be-logged (for a write) or logged (for a read) maximum temperature of the power supply measured by the remote temperature sensor. Of the first 2 bytes, the 1st byte is the most significant byte of the maximum temperature, while the second byte is the least-significant byte of the maximum temperature. For a write, the third byte of the data block instructs the controller whether or not to reset the logged maximum temperature in data flash to 0x0000: 0x01, do a reset; otherwise, do not reset. For a read, the third byte returns 0x00. For more details, see Chapter 3 on data logging. Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 120 ms before issuing the next PMBus command to the device so that the operation can complete.
EAh	LOGGED_FAULT	Write-protectable	R/W block, 3 data bytes	No faults (0x000000)		This writes/logs or reads/reports faults to or from data flash memory. When there is a fault, the corresponding fault bit is set to 1; otherwise, it is reset to 0. The first byte of the data block comprises 8 bits, each of which is defined as follows: Bit0: VIN overvoltage fault Bit1: unused (for UCD9112); Insufficient Vin (VIN_OFF threshold) (for UCD9111) Bit2: VOUT overvoltage fault Bit3: VOUT undervoltage fault Bit4: Over-temperature fault Bit5: Under-temperature fault Bit6: Turn-on max fault Bit7: Voltage tracking error The second byte of the data block comprises 8 bits, each of which is defined as follows: Bit0: IOUT overcurrent fault Bit1: Fan speed fault Bit2–Bit6: reserved for other faults Bit7: reserved, don't use this bit The third byte of the data block instructs the controller whether or not to reset the 2 fault bytes in data flash to 0x0000: 0x01, do a reset; otherwise, do not reset. Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 120 ms before issuing the next PMBus command to the device so that the operation can complete.
ECh	MFR_SPECIFIC_28		Mfr. Defined			
EDh	For UCD9112 only: LIGHT_LOAD_ENABLE	Write-protectable	R/W Byte	Static dual-phase mode (0x01)	0x01, or 0x02	Specifies which operation mode is used for light load processing: 0x01 for static dual-phase mode: system stays in dual-phase mode and is not optimized for light-load processing. 0x02 for static single-phase mode: system stays in single-phase mode and is optimized for light-load processing.
EEh	MFR_SPECIFIC_30		Mfr. Defined			
EFh	MFR_SPECIFIC_31		Mfr. Defined			
F0h	MFR_SPECIFIC_32		Mfr. Defined			

Table 1. UCD911x Supported PMBus Commands (continued)

Code	Command Name	Configurable PMBus Security	SMBus Transaction Type	Default Value Data Format (in Hexadecimal)	Supported Range	Comments
F1h	SETUP_PASSWORD	No protection	R/W Block, 12 data bytes	For UCD9112: Default password is “TI9112” (0x544939313132) For UCD9111: Default password “TI9111” (0x544939313131)		This command is used to set up a 6-byte password for PMBus security (write-protection or send-byte-protection). A valid password is any 6-byte value other than 0x000000000000 or 0x000000000001. The password is stored in data flash. If the stored password matches the default password, security is off; otherwise, security is on. The value of the stored password cannot be read back. For a write, the first 6 bytes must be either the current password if security is on, or the default password if security is off; and the next 6 bytes are a new password to be set to and to be stored in data flash memory. If an invalid password is sent, this command is locked up and no more security setup is allowed until the next power reset of UCD9112/UCD9111. Once a valid new password is sent, the security is turned on; however, as one exception, if the new password matches the default password, security is turned off instead. If security is off, a read returns 0x000000000000000000000000; if security is on, a read returns 0x000000000000000000000001; if security setup is locked up due to incorrect password entry, a read returns 0x000000000000000000000002;. A PMBus host only needs to interpret the last byte to decide whether it is 0x00 (security off) or 0x01 (security on) or 0x02 (security setup is locked). For more details, review a separate application note on PMBus security. Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 120 ms before issuing the next PMBus command to the device so that the operation can complete.
F2h	DISABLE_SECURITY	No protection	R/W Block, 6 data bytes			When security is on, this command is used to temporarily disable the security before the next power reset of UCD9112/UCD9111 so that a host can send any command that is either write-protected or send-byte-protected based on a security bit mask. When security is off, this command will be NACKed. For a write, if security is on, and if a 6-byte data block matches the stored password, the write is ACKed and a PMBus host is allowed to send any command that is either write-protected or send-byte-protected before the next power reset; otherwise, if the 6-byte data block does not match the stored password, the command is NACKed, and no retry is allowed and the command is locked up until the next power reset. For a read, a value of 0x000000000000 is returned if security is temporarily disabled by successfully writing this command previously; and a value of 0x000000000001 is returned if the security has not been temporarily disabled yet; and a value of 0x000000000002 is returned if the command is locked up due to incorrect password entry. For more details, review a separate application note on PMBus security.
F3h	MFR_SPECIFIC_35		Mfr. Defined			

Table 1. UCD911x Supported PMBus Commands (continued)

Code	Command Name	Configurable PMBus Security	SMBus Transaction Type	Default Value Data Format (in Hexadecimal)	Supported Range	Comments
F4	SECURITY_BIT_MASK	Write-protectable	R/W Block, 32 data bytes			This command is used to individually enable or disable security feature for a write-protectable or send-byte-protectable PMBus command. When protection is enabled for a PMBus command and when security is on, the PMBus command is write-protected or send-byte-protected. The bit mask contains 32 bytes or 256 bits, with each bit corresponding to a PMBus command based on command code order. Assuming bitMask[32] contains the 32 bytes of the bit mask, then bit 7 of bitMask[0] corresponds to command 0x00, …, bit 0 of bitMask[0] to command 0x07, bit 7 of bitMask[1] to command 0x08, …, bit 0 of bitMask[1] to command 0x0F, …, bit 7 of bitMask[31] to command 0xF8, …, bit 0 of bitMask[31] to command 0xFF. When a bit is set, the corresponding PMBus command is protected if security is on; when a bit is reset, the corresponding PMBus command is not protected even if security is on. If security is on, command MFR34_DISABLE_SECURITY needs to be called to temporarily disable security and then modify the security bit mask; if security is off, the security bit mask can be modified anytime. The bit mask is stored in data flash. Some PMBus commands are neither write-protectable nor send-byte-protectable. Therefore, the bit mask does not apply to these commands. For more details, review a separate application note on PMBus security. Writing this command to the UCD911x will write this data directly to data flash. Because of this, the master must wait for 120 ms before issuing the next PMBus command to the device so that the operation can complete.
F5h	MFR_SPECIFIC_37		Mfr. Defined			
F6h	MFR_SPECIFIC_38		Mfr. Defined			
F7h	MFR_SPECIFIC_39		Mfr. Defined			
F8h	MFR_SPECIFIC_40		Mfr. Defined			
F9h	MFR_SPECIFIC_41		Mfr. Defined			
FAh	MFR_SPECIFIC_42		Mfr. Defined			
FBh	MFR_SPECIFIC_43		Mfr. Defined			
FCh	MFR_SPECIFIC_44		Mfr. Defined			
FDh	DEVICE_ID	No protection	Read Block, 12 data bytes	Varies		This is an ASCII string that uniquely represents the device ID. The GUI uses this field to key off of for all TI Digital Power controller applications to determine the device's capabilities, commands it supports, and what editors/forms to show. The format of this field is: <DeviceID>|<Revision>|<Date>[|<Device Info>] DeviceID can be UCD9111 or UCD9112 The Revision is the revision of the internal code with convention <major>, <minor>, <build> Date is in the format YYMMDD Device Info is any device specific information terminated by EOL. This is an optional field.
FEh	MFR_SPECIFIC_COMMAND_EXT		Extended Command			
FFh	PMBUS_COMMAND_EXT		Extended Command			

4 PMBus Commands by Category

This section lists the supported PMBus commands supported by the UCD911x by category, for easy reference.

The PMBus command code of each command also has been included, so that each can be referenced in Table 1. In addition, if the command is a PMBus manufacturer-specific command, it is labeled with [MFR] and if it is user-specific command, it is labeled with a [USER].

Table 1 presents details on each command's operation.

4.1 Calibration

- PHASE (0x04)
- VOUT_TRIM (0x22)
- VOUT_SCALE_LOOP (0x29)
- VOUT_SCALE_MONITOR (0x2A)
- IOUT_CAL_GAIN (0x38)
- IOUT_CAL_OFFSET (0x39)
- VOUT_SENSE_UPPER_RESISTOR [MFR] (0xD2)
- VIN_SCALE [MFR] (0xD3)
- ENABLE_PHASE [MFR] (0xDE)
- REMOTE_TEMP_CAL [MFR] (0xD2)

4.2 Configuration

- WRITE_PROTECT (0x10)
- VOUT_MODE (0x20)
- VOUT_COMMAND (0x21)
- VOUT_MAX (0x24)
- VOUT_MARGIN_HIGH (0x25)
- VOUT_MARGIN_LOW (0x26)
- VOUT_TRANSITION_RATE (0x27)
- MAX_DUTY (0x32)
- FREQUENCY_SWITCH (0x33)
- TEMPERATURE_SENSOR_SELECT [MFR] (0xDC) (only on UCD9111)
- FAN_CONFIG_1_2 (0x3A)
- FAN_COMMAND_1 (0x3B)
- POWER_GOOD_POLARITY [MFR] (0xD0)
- CLF_EVENTS [MFR] (0xD1)
- TRACKING_ENABLE [MFR] (0xE3)
- LOUT [MFR] (0xE6) (only on UCD9112)
- TRACKING_SCALE_MONITOR [MFR] (0xE7)
- LIGHT_LOAD_ENABLE [MFR] (0xED)
- VIN_ON (0x35)
- VIN_OFF (0x36)
- VOUT_OV_FAULT_LIMIT (0x40)
- VOUT _OV_FAULT_RESPONSE (0x41)
- VOUT _OV_WARN_LIMIT (0x42)
- VOUT _UV_WARN_LIMIT (0x43)
- VOUT _UV_FAULT_LIMIT (0x44)
- VOUT _UV_FAULT_RESPONSE (0x45)
- IOUT_OC_FAULT_LIMIT (0x46)
- IOUT_OC_FAULT_RESPONSE (0x47)

- IOUT_OC_WARN_LIMIT (0x4A)
- OT_FAULT_LIMIT (0x4F)
- OT_FAULT_RESPONSE (0x50)
- OT_WARN_LIMIT (0x51)
- UT_WARN_LIMIT (0x52)
- UT_FAULT_LIMIT (0x53)
- UT_FAULT_RESPONSE (0x54)
- VIN_OV_FAULT_LIMIT (0x55)
- VIN_OV_FAULT_RESPONSE (0x56)
- VIN_OV_WARN_LIMIT (0x57)
- PREBIAS_MAX [MFR] (0xE0)
- FAN_SPEED_FAULT_LIMIT [MFR] (0xE8)

4.3 Manufacturer Information

- CAPABILITY (0x19)
- PMBUS_REVISION (0x98)
- MFR_ID (0x99)
- MFR_MODEL (0x9A)
- MFR_REVISION (0x9B)
- MFR_LOCATION (0x9C)
- MFR_DATE (0x9D)
- MFR_SERIAL (0x9E)
- MFR_VIN_MIN (0xA0)
- MFR_VIN_MAX (0xA1)
- MFR_VOUT_MIN (0xA4)
- MFR_VOUT_MAX (0xA5)
- MFR_IOUT_MAX (0xA6)
- MFR_TAMBIENT_MAX (0xA8)
- MFR_TAMBIENT_MIN (0xA9)
- ALMOST_ZERO_MAX [MFR] (0xDF)
- DEVICE_ID [MFR] (0xFD)

4.4 On/Off Configuration

- OPERATION (0x01)
- ON_OFF_CONFIG (0x02)
- POWER_GOOD_ON (0x5E)
- POWER_GOOD_OFF (0x5F)
- TON_DELAY (0x60)
- TON_RISE (0x61)
- TON_MAX_FAULT_LIMIT (0x62)
- TON_MAX_FAULT_RESPONSE (0x63)
- TOFF_DELAY (0x64)
- TOFF_FALL (0x65)
- TOFF_MAX_WARN_LIMIT (0x66)

4.5 Status

- STATUS_BYTE (0x78)
- STATUS_WORD (0x79)
- STATUS_VOUT (0x7A)

- STATUS_IOUT (0x7B)
- STATUS_INPUT (0x7C)
- STATUS_TEMPERATURE (0x7D)
- STATUS_CML (0x7E)
- STATUS_OTHER (0x7F)
- STATUS_MFR_SPECIFIC (0x80)
- STATUS_FANS_1_2 (0x81)
- READ_VIN (0x88)
- READ_VOUT (0x8B)
- READ_IOUT (0x8C)
- READ_POUT (0x96) (only on UCD9111)
- READ_TEMPERATURE_1 (0x8D)
- READ_TEMPERATURE_2 (0x8E)
- READ_FAN_SPEED_1 (0x90)
- READ_DUTY_CYCLE (0x94)
- READ_FREQUENCY (0x95)
- LOGGED_MAX_TEMPERATURE [MFR] (0xE9)
- LOGGED_FAULT [MFR] (0xEA)

4.6 User Parameters

- USER_DATA_00 [USER] (0xB0)

5 PMBus Data Flash Commands

When certain PMBus commands in the UCD911x are written to the device from a PMBus master, they are written directly into data flash and not stored in operational memory. This is done to save device resources and processing time for noncritical PMBus commands that are not used during operation and on a day-to-day basis.

This places certain limitations on when the next PMBus command can be processed by the UCD911x controller. If a command is received before the specified amount of time has elapsed, then the UCD911x is unable to process the incoming command and is likely to result in an error.

This also infers that the STORE_DEFAULT_ALL and RESTORE_DEFAULT_ALL commands have no effect for these commands.

The PMBus command code of each command also has been included, so that each is referenced in Table 1. In addition, if the command is a PMBus manufacturer-specific command, it is labeled with [MFR] and if it is user-specific command, it is labeled with a [USER].

For details on each command's operation, see Table 1.

The following set of commands are those that write directly into data flash and are not stored in operating memory:

- STORE_DEFAULT_ALL (0x11)
- VOUT_SCALE_LOOP (0x29)
- MFR_ID (0x99)
- MFR_MODEL (0x9A)
- MFR_REVISION (0x9B)
- MFR_LOCATION (0x9C)
- MFR_DATE (0x9D)
- MFR_SERIAL (0x9E)
- USER_DATA_00 [USER] (0xB0)
- VOUT_UPPER_RESISTOR [MFR] (0xD2)
- STORE_CLA_TABLE [MFR] (0xD6)

- LOGGED_MAX_TEMPERATURE [MFR] (0xE9)
- LOGGED_FAULT [MFR] (0xEA)
- SETUP_PASSWORD [MFR] (0xF1)
- SECURITY_BIT_MASK [MFR] (0xF4)

6 Additional Features

6.1 Fault Logging

The UCD911x controllers support logging of operational faults that occur during operation of the controller to nonvolatile memory. The UCD911x logs/records the following two items to its internal data flash memory:

- **Maximum remote temperature:** UCD911x monitors the remote temperature via a remote temperature sensor. If a remote temperature reading is above OT_WARN_LIMIT value, this new temperature reading needs to be logged to data flash memory. The PMBus master needs to use MAX_RECORDED_TEMP command to retrieve the maximum remote temperature. This command allows the reset of the recorded maximum remote temperature value as well.
- **Type of Fault:** Whenever UCD911x detects a fault, the type of fault should be recorded to the data flash. The PMBus master needs to use SHUTDOWN_FAULT command to retrieve the type of fault(s) that occurred in the system. This command allows the reset of this value as well.

Both these values need to be stored in the calibration segment of the data flash. Also, these values could be from the time since the device has been in operation. See the documentation of the MAX_RECORDED_TEMP and SHUTDOWN_FAULT for more details.

6.2 Related Documentation and Reference

For more information regarding PMBus and UCD9111 and UCD9112 digital power controllers, refer to the following literature.

- *UCD9112, Digital Dual-Phase Synchronous Buck Controller* data sheet (SLVS711)
- *Configuration Security for UCD91xx Digital Controllers* application report (SLUA428)
- *PMBus Power System Management Protocol Specification, Part I – General Requirements, Transport And Electrical Interface*, Version 1.1, PMBus Implementors Forum, February 5, 2007
- *PMBus Power System Management Protocol Specification, Part II – Command Language*, Version 1.1, PMBus Implementors Forum, February 5, 2007
- *System Management Bus (SMBus) Specification*, Version 2.0, SBS Implementers Forum, August 3, 2000

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