Zilker Labs PMBus Command Set - DDC Products

Application Note June 5, 2009 AN2033.0

Digital power design allows for optimal configuration, parametric monitoring and increased efficiency while reducing the number of power supply components. Communication with digital power devices is required to take full advantage of digital power capabilities.

The System Management Interface (SMI) Forum and the Power Management Bus Implementers Forum created a hardware interface and a command language to deal with standardization of a communication interface. This Power Management Bus (PMBus™) command language standard is a comprehensive set of commands used with the industry-standard SMBus to enhance the control and monitoring of digital power circuits and thermal management. The PMBus specification is written in two parts. The first, “Specification Part I – General Requirements Transport and Electrical Interface” on page 5 specifies the physical interface to the PMBus. It includes the SMBus communication bus as the electrical interface and protocol. The second part, “Specification Part II – Command Language” on page 5, describes the command set. This command set includes provision for manufacturer specifiable commands and data.

Zilker Labs’ Digital-DC™ based ICs feature the implementation of PMBus in an efficient power supply controller device. This document describes the standard PMBus commands available in Zilker Labs’ devices that include the DDC™ bus. The DDC bus is an intra-device communication bus for coordination of Zilker Lab’s devices. Manufacturer specific commands are also described in this document. Each command description includes the parameters defined by Zilker Labs that are necessary for its use. This document should be used in conjunction with the PMBus specification documents standard command description and Zilker Labs application notes. The commands in this document are grouped in functional sections in similar fashion to the “PMBus Power System Management Protocol Specifications” found in following website.

http://pmbus.info/developers.php

Each PMBus command is described in the following format:

<Command Name in PMBus Syntax>

Devices: <list of devices that support this command>

Command Code: <in hex>

Type: <SMBus transfer type>

Data Length in Bytes: <number>

Data Format: <PMBus data format>

Factory Value: <in hex and (decimal)>

Units: <data units>

Reference: <reference to related command or application note>

Definition: <brief description of command’s operation>

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Reference Documents

Forum Websites

THE SYSTEM MANAGEMENT INTERFACE FORUM (SMIF)

http://www.powersig.org/

The System Management Interface Forum (SMIF) supports the rapid advancement of an efficient and compatible technology base that promotes power management and systems technology implementations. The SMIF provides a membership path for any company or individual to be active participants in any or all of the various working groups established by the implementer forums.

POWER MANAGEMENT BUS IMPLEMENTERS FORUM (PMBUS-IF)

http://www.pmbus.info/

The PMBus-IF supports the advancement and early adoption of the PMBus protocol for power management. This website offers recent PMBus specification documents, PMBus articles, as well as upcoming PMBus presentations and seminars, PMBus Document Review Board (DRB) meeting notes, and other PMBus related news.

PMBus - Power System Management Bus Protocol Documents

These specification documents may be obtained from the PMBus-IF website described above. These are required reading for complete understanding of the PMBus implementation. This application note will not readdress all of the details contained within the two PMBus Specification documents.

SPECIFICATION PART I – GENERAL REQUIREMENTS TRANSPORT AND ELECTRICAL INTERFACE

Includes the general requirements, defines the transport and electrical interface and timing requirements of hardwired signals.

SPECIFICATION PART II – COMMAND LANGUAGE

Describes the operation of commands, data formats, fault management and defines the command language used with the PMBus.

SMBus - System Management Bus Documents

SMBUS CONTROL METHOD INTERFACE SPECIFICATION

http://www.smbus.org/specs/

This specification defines a System Management Bus (SMBus) interface for Advanced Configuration and Power Interface (ACPI).

Zilker Labs PMBus Commands

Control Commands

OPERATION

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x01

Type: R/W byte - Protectable

Data Length in Bytes: 1

Data Format: Custom

Factory Value: n/a

Units: n/a

Reference: Section 12.1 - PMBus Spec Part II

Definition: Sets Enable, Disable and VOUT Margin modes. Please note that data values of OPERATION that force margin high or low only take effect when the MGN pin is left open (i.e. in the NOMINAL margin state).

NOTE: All margin settings are “Act on Fault” type. “Ignore Fault” settings are ignored and “Act on Fault” is used.

ON_OFF_CONFIG

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x02

Type: R/W byte - Protectable

Data Length in Bytes: 1

Data Format: Custom

Factory Value: 0x16

Units: n/a

Reference: Section 12.2 - PMBus Spec Part II

Definition: Configures the interpretation and coordination of the OPERATION command and the Enable pin (EN).

Output Commands

VOUT_MODE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103,

Command Code: 0x20

Type: Read byte

Data Length in Bytes: 1

Data Format: Mode + Exponent Format Section 8.2 - PMBus Spec Part II

Factory Value: 0x13 (Linear Mode, Exponent = -13)

Units: n/a

Reference: Section 8 - PMBus Spec Part II

Definition: Preset to defined data format of VOUT commands.

VOUT_COMMAND

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x21

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT linear mode

Factory Value: Pin-strap setting value (V1:V0)

Units: V

Reference: Section 8 - PMBus Spec Part II - VOUT_MODE

Definition: Sets the nominal value of the output voltage.

Output voltage = VOUT_COMMAND x 2^{-13}. VOUT_COMMAND cannot be set greater than the lesser of 110% of the pin-strap setting or VOUT_MAX.

VOUT_TRIM

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x22

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Signed VOUT linear mode (see definition)

Factory Value: 0x0000

Units: V

Reference: Section 13.3 - PMBus Spec Part II - VOUT_MODE

Definition: Sets VOUT trim value. The two bytes are formatted as a two’s complement binary mantissa, used in conjunction with the exponent set in VOUT_MODE.

VOUT_CAL_OFFSET

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x23

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Signed VOUT linear mode (see definition)

Factory Value: 0x0000

Units: V

Reference: Section 13.4 - PMBus Spec Part II - VOUT_MODE

Definition: Sets V_{OUT} calibration offset (same function as VOUT_TRIM). The two bytes are formatted as a two’s complement binary mantissa, used in conjunction with the exponent set in VOUT_MODE.

NOTE: This command was previously known as VOUT_CAL.

VOUT_MAX

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x24

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: 1.10 x VOUT_COMMAND

Units: V

Reference: Section 13.5 - PMBus Spec Part II - VOUT_MODE

Definition: Sets the maximum possible value setting of VOUT. The maximum VOUT_MAX setting is 110% of the pin-strap setting.

VOUT_MARGIN_HIGH

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x25

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: 1.05 x VOUT_COMMAND

Units: V

Reference: Section 13.6 - PMBus Spec Part II - VOUT_MODE

Definition: Sets the value of the VOUT during a margin high.

VOUT_MARGIN_LOW

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x26

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: 0.95 x VOUT_COMMAND

Units: V

Reference: Section 13.7 - PMBus Spec Part II - VOUT_MODE

Definition: Sets the value of the VOUT during a margin low.

VOUT_TRANSITION_RATE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x27

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0xBA00 (1)

Units: V/ms

Reference: Section 13.8 - PMBus Spec Part II

Definition: Sets the transition rate during margin or other change of VOUT.

VOUT_DROOP

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x28

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0x0000

Units: mV/A

Reference: AN2034 – Section 13.9 - Current Share Operation for the DDC bus products and PMBus Spec Part II

Definition: Sets the effective load line (V/I slope) for the rail in which the device is used.

MAX_DUTY

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x32

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0xEAF8 (95)

Units: %

Reference: Section 14.3 - PMBus Spec Part II

Definition: Sets the maximum allowable duty cycle of the switching frequency.

NOTE: MAX_DUTY should not be used to set the output voltage of the device. VOUT_COMMAND is the proper method to set the output voltage.

FREQUENCY_SWITCH

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x33

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: Pin-strap setting value (SYNC)

Units: kHz

Reference: Section 14.4 - PMBus Spec Part II

Definition: Sets the switching frequency.

IOUT_CAL_GAIN

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x38

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: ZL2006, ZL2004 0xC200 (2mΩ)

Units: mΩ

Reference: Section 14.8 - PMBus Spec Part I

Definition: Sets the effective impedance for current sensing at +25°C.

NOTE: This command was previously known as IOUT_SCALE.

IOUT_CAL_OFFSET

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x39

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0x0000 (0A)

Units: A

Reference: Section 14.9 - PMBus Spec Part II

Definition: Sets an offset to IOUT readings. Use to compensate for delayed measurements of current ramp.

XTEMP_SCALE

Devices: ZL2006, ZL2008, ZL2004

Command Code: 0xD9

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0xBA00 (1)

Units: 1/°C

Reference:

Definition: Sets a scalar value that is used for calibrating the external temperature. The constant is applied in Equation 1 to produce the read value of XTEMP via the PMBus command READ_TEMPERATURE_2.

NOTE: This value must be ≥ to 1.

$$\text{READ\_TEMPERATURE\_2} = \left(ExternalTemperature \bullet \frac{1}{\text{XTEMP\_SCALE}}\right) + \text{XTEMP\_OFFSET} \quad \text{(EQ. 1)}$$

XTEMP_OFFSET

Devices: ZL2006, ZL2008, ZL2004

Command Code: 0xDA

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0x8000 (0)

Units: °C

Reference:

Definition: Sets a scalar value that is used for calibrating the external temperature. The constant is applied in Equation 2 to produce the read value of XTEMP via the PMBus command READ_TEMPERATURE_2.

NOTE: This value must be greater than or equal to 0.

$$\text{READ\_TEMPERATURE\_2} = \left(ExternalTemperature \bullet \frac{1}{\text{XTEMP\_SCALE}}\right) (+\text{XTEMP\_OFFSET}) \quad \text{(EQ. 2)}$$

Fault Limit Commands

POWER_GOOD_ON

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x5E

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: 0.9 x VOUT_COMMAND

Units: V

Reference: Section 15.32.1 - PMBus Spec Part II

Definition: Sets the voltage threshold for Power-Good indication. Power-Good asserts when the output voltage exceeds POWER_GOOD_ON and de-asserts when the output voltage is less than VOUT_UV_FAULT_LIMIT.

VOUT_OV_FAULT_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x40

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: 1.15 x VOUT_COMMAND

Units: V

Reference: Section 15.2 - PMBus Spec Part II

Definition: Sets the VOUT overvoltage fault threshold.

VOUT_UV_FAULT_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x44

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: 0.85 x VOUT_COMMAND

Units: V

Reference: Section 15.6 - PMBus Spec Part II

Definition: Sets the VOUT undervoltage fault threshold.

IOUT_OC_FAULT_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x46

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: Pin-strap setting value. ZL2006 (ILIM1:ILIM0); ZL2004 (ILIM)

Units: A

Reference: Section 15.8 - PMBus Spec Part II

Definition: Sets the IOUT overcurrent fault threshold.

IOUT_AVG_OC_FAULT_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xE7

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 1 x IOUT_OC_FAULT_LIMIT

Units: A

Reference:

Definition: Sets the average IOUT overcurrent fault threshold. Shares the fault bit operation and OC fault response with IOUT_OC_FAULT_LIMIT.

IOUT_UC_FAULT_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x4B

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: -1 x IOUT_OC_FAULT_LIMIT

Units: A

Reference: Section 15.13 - PMBus Spec Part II

Definition: Sets the IOUT undercurrent fault threshold.

IOUT_AVG_UC_FAULT_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xE8

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 1 x IOUT_UC_FAULT_LIMIT

Units: A

Reference:

Definition: Sets the average IOUT undercurrent fault threshold. Shares the fault bit operation and UC fault response with IOUT_UC_FAULT_LIMIT.

OT_FAULT_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x4F

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0xEBE8 (+125°C)

Units: °C

Reference: Section 15.17 - PMBus Spec Part II

Definition: Sets the over-temperature fault threshold.

OT_WARN_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x51

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0xEB70 (+110°C)

Units: °C

Reference: Section 15.19 - PMBus Spec Part II

Definition: Sets the over-temperature warning threshold.

UT_WARN_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x52

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0xDC40 (-30°C)

Units: °C

Reference: Section 15.20 - PMBus Spec Part II

Definition: Sets the undertemperature warning threshold.

UT_FAULT_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x53

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0xE530 (-45°C)

Units: °C

Reference: Section 15.21 - PMBus Spec Part II

Definition: Sets the undertemperature fault threshold.

VIN_OV_FAULT_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x55

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0xD380 (14V)

Units: V

Reference: Section 15.23 - PMBus Spec Part II

Definition: Sets the VIN overvoltage fault threshold.

VIN_OV_WARN_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x57

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0xD360 (13.5V)

Units: V

Reference: Section 15.25 - PMBus Spec Part II

Definition: Sets the VIN overvoltage warning threshold.

VIN_UV_WARN_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x58

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 1.03 x VIN_UV_FAULT_LIMIT

Units: V

Reference: Section 15.26 - PMBus Spec Part II

Definition: Sets the VIN undervoltage warning threshold.

VIN_UV_FAULT_LIMIT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x59

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: Pin-strap setting value (UVLO)

Units: V

Reference: Section 15.27 - PMBus Spec Part II

Definition: Sets the VIN undervoltage fault threshold.

MFR_VMON_OV_FAULT_LIMIT

Devices: ZL2004

Command Code: 0xF5

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0xD300 (12V)

Units: V

Definition: Sets the VMON overvoltage fault threshold. A VMON parameter equals 16 times the voltage applied to the VMON pin. The VMON overvoltage warn limit is automatically set to 90% of this fault value.

MFR_VMON_UV_FAULT_LIMIT

Devices: ZL2004

Command Code: 0xF6

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0xCA80 (5V)

Units: V

Definition: Sets the VMON undervoltage fault threshold. A VMON parameter equals 16x the voltage applied to the VMON pin. The VMON undervoltage warn limit is automatically set to 110% of this fault value.

Fault Response Commands

All Zilker Labs devices' fault responses, including current faults, are defined by Table 1. This table describes the specifics for the Zilker Labs' devices. If a device is used in a current sharing rail, the device will not attempt a retry until the entire current share rail attempts a retry following a disable event.

TABLE 1. ZILKER LABS DEVICE SPECIFICATIONS

BITS	DESCRIPTION	VALUE	MEANING
7:6	Response: For all modes set by bits [7:6], the device: • Pulls SALRT low • Sets the related fault bit in the status registers. Fault bits are only cleared by the CLEAR_FAULTS command.	00	Continuous operation. (Ignore fault)
		01	Delay, Disable and Retry Delay time is specified by bits [2:0] and the delay time unit specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit retries according to the setting in bits [5:3].
		10	Disable and Retry according to the setting in bits [5:3].
		11	The device's output is disabled while the fault is present. Operation resumes and the output is enabled when the fault condition no longer exists.
5:3	Retry Setting	000	No Retry. The output remains disabled.
		001 to 110	The PMBus device attempts to restart the number of times set by these bits. The minimum number is 1 and the maximum number is 6. If the device fails to restart in the allowed number of retries, it disables the output and remains disabled. The time between the start of each attempt to retry is set by the value in bits [2:0] along with the delay time unit specified for that particular fault.
		111	The PMBus device attempts retry continuously until it is commanded to disable (by the Enable pin or OPERATION command), input power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	000 to 111	This time count is used for both the amount of time between retry attempts and for the amount of time a rail is to delay its response after a fault is detected. The retry time and delay time units are defined by the type of fault within each device.

NOTE: The delay time is the time between restart attempts

VOUT_OV_FAULT_RESPONSE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x41

Type: R/W byte - Protectable

Data Length in Bytes: 1

Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)

Factory Value: 0xBF (Retry always, max delay)

Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB

Reference: Section 15.3 - PMBus Spec Part II

Definition: Configures the VOUT overvoltage fault response. Note that the two most significant bits can be written as 01 or 00. However, upon an overvoltage fault, these two bits will be set to 1:0 (i.e. bits (7:6) = 1:0). Thus an overvoltage fault cannot be set to be ignored.

VOUT_UV_FAULT_RESPONSE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x45

Type: R/W byte - Protectable

Data Length in Bytes: 1

Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)

Factory Value: 0xBF (Retry always, max delay)

Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB

Reference: Section 15.7 - PMBus Spec Part II

Definition: Configures the V_{OUT} undervoltage fault response.

MFR_IOUT_OC_FAULT_RESPONSE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xE5

Type: R/W byte - Protectable

Data Length in Bytes: 1

Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)

Factory Value: 0xBF (Retry always, max delay)

Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB

Reference: Section 15.3 - PMBus Spec Part II

Definition: Configures the IOUT overcurrent fault response. The command format is the same as the PMBus standard responses for voltage and temperature faults except that it sets the overcurrent status bit.

Note: The delay time is the time between restart attempts.

MFR_IOUT_UC_FAULT_RESPONSE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xE6

Type: R/W byte - Protectable

Data Length in Bytes: 1

Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)

Factory Value: 0xBF (Retry always, max delay)

Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB

Reference: Section 15.7 - PMBus Spec Part II

Definition: Configures the IOUT undercurrent fault response. The command format is the same as the PMBus standard responses for voltage and temperature faults except that it sets the undercurrent status bit.

Note: The delay time is the time between restart attempts

OT_FAULT_RESPONSE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x50

Type: R/W byte - Protectable

Data Length in Bytes: 1

Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)

Factory Value: 0xBF (Retry always, max delay)

Units: Retry time = 32ms/LSB, Delay = 80ms/LSB

Reference: Section 15.18 - PMBus Spec Part II

Definition: Configures the over-temperature fault response.

Note: The delay time is the time between restart attempts

UT_FAULT_RESPONSE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103
Command Code: 0x54
Type: R/W byte - Protectable
Data Length in Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 32ms/LSB, Delay = 80ms/LSB
Reference: Section 15.22 - PMBus Spec Part II
Definition: Configures the undertemperature fault response.
Note: The delay time is the time between restart attempts

VIN_OV_FAULT_RESPONSE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103
Command Code: 0x56
Type: R/W byte - Protectable
Data Length in Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB
Reference: Section 15.24 - PMBus Spec Part II
Definition: Configures the VIN overvoltage fault response.
Note: The delay time is the time between restart attempts

VIN_UV_FAULT_RESPONSE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103
Command Code: 0x5A
Type: R/W byte - Protectable
Data Length in Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB
Reference: Section 15.28 - PMBus Spec Part II
Definition: Configures the VIN undervoltage fault response.
Note: The delay time is the time between restart attempts

VMON_OV_FAULT_RESPONSE

Devices: ZL2004
Command Code: 0xF8
Type: R/W byte - Protectable
Data Length in Bytes: 1
Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB
Reference: Section 15.24 - PMBus Spec Part II
Definition: Configures the VMON overvoltage fault response.
Note: The delay time is the time between restart attempts

VMON_UV_FAULT_RESPONSE

Devices: ZL2004

Command Code: 0xF9

Type: R/W byte - Protectable

Data Length in Bytes: 1

Data Format: Section 10.5.1 - Custom (PMBus Spec Part II)

Factory Value: 0xBF (Retry always, max delay)

Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB

Reference: Section 15.24 - PMBus Spec Part II

Definition: Configures the VMON undervoltage fault response.

Note: The delay time is the time between restart attempts

OVUV_CONFIG

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xD8

Type: R/W byte - Protectable

Data Length in Bytes: 1

Data Format: Custom (See Table 2)

Factory Value: 0x80

Units: n/a

Reference:

Definition: Configures the output voltage OV and UV fault detection feature as given in the following table.

TABLE 2. OV AND UV FAULT DETECTION FEATURE CONFIGURATION

BITS	PURPOSE	VALUE	DESCRIPTION
7	Controls how an OV fault response shutdown sets the output driver state	0	An OV fault does not enable the low-side power device
		1	An OV fault enables the low-side power device
6:4	Reserved	-	
3:0	Defines the number of consecutive limit violations required to declare an OV or UV fault	N	N+1 consecutive OV or UV violations initiate a fault response

Time Setting Commands

TON_DELAY

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x60

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value:

ZL2006: Pin-strap setting value (DLY1:DLY0)

ZL2004: Pin-strap setting value (SS)

Units: ms

Reference: Section 16.1 - PMBus Spec Part II

Definition: Sets the delay time from ENABLE to start of VOUT rise. The delay time can range from 0ms up to 500s, in steps of 125ns.

TON_RISE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x61

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value:

ZL2006: Pin-strap setting value (DLY1:DLY0)

ZL2004: Pin-strap setting value (SS)

Units: ms

Reference: Section 16.2 - PMBus Spec Part II

Definition: Sets the rise time of VOUT after ENABLE and TON_DELAY. The delay time can range from 0ms to 200ms, in steps of 12.5µs.

TOFF_DELAY

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x64

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 1 x tON_DELAY

Units: ms

Reference: Section 16.5 - PMBus Spec Part II

Definition: Sets the delay time from DISABLE to start of VOUT fall. The delay time can range from 0ms up to 500s, in steps of 125ns.

TOFF_FALL

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x65

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 1 x TON_RISE

Units: ms

Reference: Section 16.6 - PMBus Spec Part II

Definition: Sets the fall time for V_{OUT} after DISABLE and tOFF_DELAY. The delay time can range from 0ms to 200ms, in steps of 12.5µs.

POWER_GOOD_DELAY

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xD4

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value:

ZL2006, ZL2004: Pin-strap setting value 1 x TON_RISE

Units: ms

Reference:

Definition: Sets the delay applied between the output exceeding the PG threshold (POWER_GOOD_ON) and asserting the PG pin. The factory value is equal to TON_RISE. The delay time can range from 0ms up to 500s, in steps of 125ns. A 1ms minimum configured value is recommended to apply proper debounce to this signal.

Status Commands

CLEAR_FAULTS

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103
Command Code: 0x03
Type: Send Byte
Data Length in Bytes: 0
Data Format: n/a
Factory Value: n/a
Units: n/a
Reference: Section 15.1 - PMBus Spec Part II
Definition: Clears fault indications.

STATUS_BYTE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103
Command Code: 0x78
Type: Read byte
Data Length in Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: n/a
Reference: Section 17.1 - PMBus Spec Part II
Definition: Returns an abbreviated status for fast reads.

STATUS_WORD

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103
Command Code: 0x79
Type: Read word
Data Length in Bytes: 2
Data Format: Custom
Factory Value: 0x0000
Units: n/a
Reference: Section 17.2 - PMBus Spec Part II
Definition: Returns the general status information used to indicate subsequent status to be read for more detail.

STATUS_VOUT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103
Command Code: 0x7A
Type: Read byte
Data Length in Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: n/a
Reference: Section 17.3 - PMBus Spec Part II
Definition: Returns the V_{OUT} specific status.

STATUS_IOUT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x7B

Type: Read byte

Data Length in Bytes: 1

Data Format: Custom

Factory Value: 0x00

Units: n/a

Reference: Section 17.4 - PMBus Spec Part II

Definition: Returns the IOUT specific status.

STATUS_INPUT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x7C

Type: Read byte

Data Length in Bytes: 1

Data Format: Custom

Factory Value: 0x00

Units: n/a

Reference: Section 17.5 - PMBus Spec Part II

Definition: Returns specific status specific to the input.

STATUS_TEMPERATURE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x7D

Type: Read byte

Data Length in Bytes: 1

Data Format: Custom

Factory Value: 0x00

Units: n/a

Reference: Section 17.6 - PMBus Spec Part II

Definition: Returns the temperature specific status.

STATUS_CML

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x7E

Type: Read byte

Data Length in Bytes: 1

Data Format: Custom

Factory Value: 0x00

Units: n/a

Reference: Section 17.7 - PMBus Spec Part II

Definition: Returns the Communication, Logic and Memory specific status.

STATUS_MFR

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x80

Type: Read byte

Data Length in Bytes: 1

Data Format: Custom

Factory Value: 0x00

Units: n/a

Reference: Section 17.9 - PMBus Spec Part II

Definition: Returns the Communication, Logic and Memory specific status. VMON fault and warning bits only apply to the ZL2004. The VMON warn thresholds are set according to Equations 3 and 4:

$$\text{VMON\_UV Warn Limit} = 110\% \times \text{VMON\_UV\_FAULT\_LIMIT} \quad \text{(EQ. 3)}$$

$$\text{VMON\_OV Warn Limit} = 90\% \times \text{VMON\_OV\_FAULT\_LIMIT} \quad \text{(EQ. 4)}$$

TABLE 3.

BIT	FAULT MEANING
7	Reserved
6	Reserved
5	VMON UV Warning
4	VMON OV Warning
3	TSW
2	Reserved
1	VMON UV Fault
0	VMON OV Fault

Monitor Commands

READ_VIN

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x88

Type: Read word

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: n/a

Units: V

Reference: Section 18.1 - PMBus Spec Part II

Definition: Returns the input voltage reading. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.

READ_VOUT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x8B

Type: Read word

Data Length in Bytes: 2

Data Format: Section 8.3.1 - PMBus Spec Part II - VOUT Linear Mode

Factory Value: n/a

Units: V

Reference: Section 18.4 - PMBus Spec Part II

Definition: Returns the output voltage reading. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.

READ_IOUT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x8C

Type: Read word

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: n/a

Units: A

Reference: Section 18.5 - PMBus Spec Part II

Definition: Returns the output current reading. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.

READ_TEMPERATURE_1

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x8D

Type: Read word

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: n/a

Units: °C

Reference: Section 18.6 - PMBus Spec Part II

Definition: Returns the temperature reading internal to the device. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.

READ_TEMPERATURE_2

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x8E

Type: Read word

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: n/a

Units: °C

Reference: Section 18.6 - PMBus Spec Part II

Definition: Returns the reading from the external temperature device connected to XTEMP. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.

READ_DUTY_CYCLE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x94

Type: Read word

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: n/a

Units: %

Reference: Section 18.9 - PMBus Spec Part II

Definition: Returns the target duty cycle during the ENABLE state. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.

READ_FREQUENCY

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x95

Type: Read word

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: n/a

Units: kHz

Reference: Section 18.10 - PMBus Spec Part II

Definition: Returns the measured operating switch frequency. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.

MFR_READ_VMON

Devices: ZL2004

Command Code: 0xF7

Type: Read word

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: n/a

Units: V

Definition: Returns the value equal to 16x the voltage applied to the VMON pin. Devices will NACK this command when not enabled or not in the monitor mode (see “USER_CONFIG” on page 32).

SNAPSHOT_CONTROL

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xF3

Type: R/W byte

Data Length in Bytes: 1

Data Format: Custom

Factory Value: n/a

Units: n/a

Definition:

Writing a 1 will cause the device to copy the current SNAPSHOT values from flash to the 32-byte SNAPSHOT command parameter.

Writing a 2 will cause the device to write the current SNAPSHOT values to a set location in flash.

All other values will be ignored.

SNAPSHOT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xEA

Type: Block Read

Data Length in Bytes: 32

Data Format: Custom

Factory Value: n/a

Units: n/a

Definition: The SNAPSHOT command is a 32-byte read-back of parametric and status values.

TABLE 4.

BYTE NUMBER	VALUE	FORMAT
31:22	Reserved	0x00
21	Manufacturer Specific Status Byte	Byte
20	CML Status Byte	Byte
19	Temperature Status Byte	Byte
18	Input Status Byte	Byte
17	I_{OUT} Status Byte	Byte
16	V_{OUT} Status Byte	Byte
15:14	Switching Frequency	Linear Data Format
13:12	External Temperature	Linear Data Format
11:10	Internal Temperature	Linear Data Format
9:8	Duty Cycle	Linear Data Format
7:6	Peak Current	Linear Data Format
5:4	Load Current	Linear Data Format
3:2	V_{OUT}	V_{OUT} linear mode
1:0	V_{IN}	Linear Data Format

Identification Commands

DEVICE_ID

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xE4

Type: Block Read

Data Length in Bytes: 16

Data Format: ASCII

Factory Value: <part number/die revision/firmware revision>

Units: n/a

Reference: n/a

Definition: Returns the 16-byte (character) device identifier string.

PMBUS_REVISION

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x98

Type: Read byte

Data Length in Bytes: 1

Data Format: Hex

Factory Value: <revision implemented>

Units: n/a

Reference: Section 22.1 - PMBus Spec Part II

Definition: Returns the revision of the PMBus implemented in the device.

MFR_ID

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x99

Type: Block R/W - Protectable

Data Length in Bytes: user defined

Data Format: ASCII

Factory Value: null

Units: n/a

Reference: Section 22.2 - PMBus Spec Part II

Definition: Sets a user defined identification. The sum total of characters in MFR_ID, MFR_MODEL, MFR_REVISION, MFR_LOCATION, MFR_DATE, MFR_SERIAL and USER_DATA_00 plus one byte per command cannot exceed 128 characters. This limitation includes multiple writes of this command before a STORE command. To clear multiple writes, perform a RESTORE, write this command then perform a STORE/RESTORE.

MFR_MODEL

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x9A

Type: Block R/W - Protectable

Data Length in Bytes: user defined

Data Format: ASCII

Factory Value: null

Units: n/a

Reference: Section 22.2.2 - PMBus Spec Part II

Definition: Sets a user defined model. The sum total of characters in MFR_ID, MFR_MODEL, MFR_REVISION, MFR_LOCATION, MFR_DATE, MFR_SERIAL and USER_DATA_00 plus one byte per command cannot exceed 128 characters. This limitation includes multiple writes of this command before a STORE command. To clear multiple writes, perform a RESTORE, write this command then perform a STORE/RESTORE.

MFR_REVISION

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x9B

Type: Block R/W - Protectable

Data Length in Bytes: user defined

Data Format: ASCII

Factory Value: null

Units: n/a

Reference: Section 22.2.3 - PMBus Spec Part II

Definition: Sets a user defined revision. The sum total of characters in MFR_ID, MFR_MODEL, MFR_REVISION, MFR_LOCATION, MFR_DATE, MFR_SERIAL and USER_DATA_00 plus one byte per command cannot exceed 128 characters. This limitation includes multiple writes of this command before a STORE command. To clear multiple writes, perform a RESTORE, write this command then perform a STORE/RESTORE.

MFR_LOCATION

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x9C

Type: Block R/W - Protectable

Data Length in Bytes: user defined

Data Format: ASCII

Factory Value: null

Units: n/a

Reference: Section 22.2.4 - PMBus Spec Part II

Definition: Sets a user defined location identifier. The sum total of characters in MFR_ID, MFR_MODEL, MFR_REVISION, MFR_LOCATION, MFR_DATE, MFR_SERIAL and USER_DATA_00 plus one byte per command cannot exceed 128 characters. This limitation includes multiple writes of this command before a STORE command. To clear multiple writes, perform a RESTORE, write this command then perform a STORE/RESTORE.

MFR_DATE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x9D

Type: Block R/W - Protectable

Data Length in Bytes: user defined

Data Format: ASCII

Factory Value: null

Units: n/a

Reference: Section 22.2.5 - PMBus Spec Part II

Definition: Sets a user defined date. The sum total of characters in MFR_ID, MFR_MODEL, MFR_REVISION, MFR_LOCATION, MFR_DATE, MFR_SERIAL and USER_DATA_00 plus one byte per command cannot exceed 128 characters. This limitation includes multiple writes of this command before a STORE command. To clear multiple writes, perform a RESTORE, write this command then perform a STORE/RESTORE.

MFR_SERIAL

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x9E

Type: Block R/W - Protectable

Data Length in Bytes: user defined

Data Format: ASCII

Factory Value: null

Units: n/a

Reference: Section 22.2.6 - PMBus Spec Part II

Definition: Sets a user defined serialized identifier. The sum total of characters in MFR_ID, MFR_MODEL, MFR_REVISION, MFR_LOCATION, MFR_DATE, MFR_SERIAL and USER_DATA_00 plus one byte per command cannot exceed 128 characters. This limitation includes multiple writes of this command before a STORE command. To clear multiple writes, perform a RESTORE, write this command then perform a STORE/RESTORE.

USER_DATA_00

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xB0

Type: Block R/W - Protectable

Data Length in Bytes: user defined

Data Format: ASCII

Factory Value: null

Units: n/a

Reference: Section 23 - PMBus Spec Part II

Definition: Sets a user defined data. The sum total of characters in MFR_ID, MFR_MODEL, MFR_REVISION, MFR_LOCATION, MFR_DATE, MFR_SERIAL and USER_DATA_00 plus one byte per command cannot exceed 128 characters. This limitation includes multiple writes of this command before a STORE command. To clear multiple writes, perform a RESTORE, write this command then perform a STORE/RESTORE.

Other Configuration Commands

MFR_CONFIG

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xD0

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Custom

Factory Value:

ZL2006: Pin-strap setting value (ILIM1)

ZL2004: 0x3A11

Definition: Configures several manufacturer-level features. The data field is defined in Table 5.

TABLE 5.

BITS	PURPOSE	VALUE	DESCRIPTION
15:11	Current Sense Blanking Delay	D	Sets the delay, **D**, in 32ns steps
10:8	Current Sense Fault Count	C	Sets the number of consecutive O**C** or U**C** violations required for a fault to 2**C**+1.
7	Enable XTEMP measurements	0	No temperature are performed on XTEMP
		1	Temperature measurements are performed on XTEMP
6	Temperature sensor control (Note 1)	0	The internal temperature sensor is used for warning and fault checks
		1	An external 2N3904 NPN on XTEMP is used for warning and fault checks
5:4	Current Sense Control (Note 2)	00	Current sense uses GND-referenced, down-slope sense
		01	Current sense uses VOUT-referenced, down-slope sensing
		10	Current sense uses VOUT-referenced, up-slope sensing
		11	Reserved
3	NLR During Ramp	0	Wait for PG
		1	Always on
2	Alternate Ramp Control	0	Alternate Ramp Disabled
		1	Alternate Ramp Enabled
1	PG Pin Output Control	0	PG is open-drain
		1	PG is push-pull
0	SYNC Pin Output Control	0	SYNC is open-drain
		1	SYNC is push-pull

NOTES:

1. When selecting XTEMP (bit 6), be sure to have the XTEMP enabled in bit 7.
2. Not available on the ZL2106 or ZL2103

USER_CONFIG

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xD1

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Custom

Factory Value: Pin-strap setting value (CFG)

Units: n/a

Reference:

Definition: Configures several user-level features. The data field is defined Table 6. This command overrides the CONFIG pin settings.

TABLE 6.

BITS	PURPOSE	VALUE	DESCRIPTION
15:14	Minimum Duty Cycle	N	Sets the minimum duty cycle ((N+1)/(2^8)) during a ramp when “Minimum Duty Cycle” (Bit 13) is enabled. For example, if Minimum Duty Cycle input N is set to 3, the minimum duty cycle is $(3+1)/(2^8) = (1/64)$.
13	Minimum Duty Cycle Control	0	Minimum Duty Cycle is Disabled
		1	Minimum Duty Cycle is Enabled
12	Alternate Ramp Down	0	Output follows TOFF_FALL ramp time
		1	Output is set to high impedance/open mode during ramp down VOUT_UV threshold is reached
11	SYNC Time-out Enable	0	SYNC output remains on after device is disabled
		1	SYNC turns off 500ms after device is disabled
10	Reserved	-	Reserved
9	PID Feed-Forward Control	0	PID Coefficients are corrected for VDD variation
		1	PID Coefficients are not corrected for VDD variations
8	Fault Spreading Mode	0	Received faults cause sequenced shutdown
		1	Received faults cause immediate shutdown
7	SMBus Transmit Clk Rate	0	* SMBus transmit is always disabled in DDC devices
6	SYNC Utilization Control	0	Auto-configure using the SYNC pin and FREQUENCY_SWITCH parameter
		1	Switch using the SYNC input
5	SYNC Output Control	0	Configure the SYNC pin as an input-only
		1	Drive the switch clock out of SYNC when using the internal oscillator
4	SMBus Transmit Inhibit	0	* SMBus transmit is always disabled in DDC devices
3	SMBus Timeout Inhibit	0	* SMBus transmit is always disabled in DDC devices
2	OFF Low-side Control	0	The low-side drive is off when device is disabled
		1	The low-side drive is on when device is disabled
1:0	Standby Mode	00	Enter low-power mode when device is disabled (no READ_xxxx data available)
		01	Monitor for faults when device is disabled (READ_xxxx data available)
		10	Reserved
		11	Monitor for faults using pulsed mode. (READ_xxxx data available upon read command)

MISC_CONFIG

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xE9

Type: R/W word – Protectable

Data Length in Bytes: 2

Data Format: Custom

Factory Value: 0x0000

Definition: This command sets a few options pertaining to ramp timing accuracy and current-driven control. The format of this command is shown in Table 7.

TABLE 7.

BITS	PURPOSE	VALUE	DESCRIPTION
15	Broadcast Margin (see DDC_CONFIG)	0	Disabled
		1	Enabled
14	Broadcast Enable (see DDC_CONFIG)	0	Disabled
		1	Enabled
13	Adaptive Compensation	0	Disabled
		1	Enabled
12	Reserved	0	Reserved
11:10	I-sense gain factor (ZL2004 only)	00	DCR = 25mV
		01	DCR = 35mV
		10	DCR = 50mV
		11	Reserved
9	Adaptive Compensation Update Rate	0	Taps are updated every 3ms
		1	Taps are updated every 12ms
8	Reserved	0	Reserved
7	Precise Ramp-Up Delay	0	Monitor mode enabled creating a more accurate delay time. This mode also enables certain circuits that may affect standby power.
		1	Normal, low standby power, delay operation
6	Diode Emulation (Note 3)	0	Disabled
		1	Enabled, enter diode emulation at low current loads to improve efficiency
5:3	Adaptive Compensation Half-Ripple Factor	N	Determines second load point for Adaptive Compensation: $I_{LOAD2} = (2^{(N+1)+1}) * I_{RIPPLE}/2$ N: 0 1 2 3 4 5 6 7 C: 3 5 9 17 33 65 129 257
2	Minimum GL Pulse	0	Disabled
		1	Enabled, limited to 10% * 1/Fsw
1	Snapshot	0	Disabled
		1	Enabled
0	Adaptive Frequency (Note 3)	0	Disabled, Fsw fixed
		1	Enabled

NOTE:

3. Not available on the ZL2106 or ZL2103

PID_TAPS

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xD5

Type: Block R/W - Protectable

Data Length in Bytes: 9

Data Format: Custom

Factory Value:

ZL2006: Pin-strap setting value (FC1:FC0)

ZL2004: Pin-strap setting value (FC)

Units: n/a

Reference: AN2035 – Digital Control Loop Compensation for the DDC bus products

Definition: Configures the linear control loop filter coefficients. The PID algorithm implements the following Z-domain function in Equation 5:

$$\frac{A + Bz^{-1} + Cz^{-2}}{1 - z^{-1}} \quad \text{(EQ. 5)}$$

The coefficients A, B, and C are represented using a pseudo-floating point format similar to the V_{OUT} parameters (with the addition of a sign bit), defined as Equation 6:

$$A = (-1)^{S} \cdot 2^{E} \cdot M \quad \text{(EQ. 6)}$$

where M is a two-byte unsigned mantissa, S is a sign-bit, and E is a 7-bit two's-complement signed integer. The 9-byte data field is defined in Table 8. S is stored as the MSB of the E byte.

TABLE 8.

BYTE	PURPOSE	DEFINITION
8	Tap C - E	Coefficient C exponent + S
7	Tap C - M [15:8]	Coefficient C mantissa, high-byte
6	Tap C - M [7:0]	Coefficient C mantissa, low-byte
5	Tap B - E	Coefficient B exponent + S
4	Tap B - M [15:8]	Coefficient B mantissa, high-byte
3	Tap B - M [7:0]	Coefficient B mantissa, low-byte
2	Tap A - E	Coefficient A exponent + S
1	Tap A - M [15:8]	Coefficient A mantissa, high-byte
0	Tap A - M [7:0]	Coefficient A mantissa, low-byte

NOTE: Data bytes are transmitted on thePMBus in the order of Byte 0 through Byte 8.

PID_TAPS_ADAPT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xF2

Type: Block R/W - Protectable

Data Length in Bytes: 9

Data Format: Custom (see “PID_TAPS” on page 34).

Factory Value:

ZL2006: Pin-strap setting value (FC1:FC0)

ZL2004: Pin-strap setting value (FC)

Units: n/a

Reference: AN2035 – Digital Control Loop Compensation for the DDC bus products

Definition: The PID_TAPS_ADAPT command is set to the calculated taps for an average load current equal to a multiple of one-half of the ripple current. The command follows the same format as the PID_TAPS (see previous section) and is used by the adaptive compensation algorithm over varying load.

The algorithm uses a linear interpolation to adjust operating Taps A, B, and C, with respect to the average load current. Two optimal sets of taps are required. One set of taps corresponds to $I_{RIPPLE}/2$, which is configured by the PID_TAPS command, while the other set is configured by the PID_TAPS_ADAPT command and corresponds to c*Iripple/2 where c is the Half-Ripple Factor, $(2^{(N+1)+1})$, and is configured using the Adaptive Compensation Half-Ripple Factor field (N, bits 5:3) in MISC_CONFIG.

INDUCTOR

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xD6

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Section 7.1 - PMBus Spec Part II - Linear Data Format

Factory Value: 0xB23D (0.56µH)

Units: µH

Reference: AN2035 – Digital Control Loop Compensation for the DDC bus products

Definition: Informs the device of circuit’s inductor value. This is used in adaptive frequency calculations relating to the inductor ripple current divided by two.

NLR_CONFIG

Devices: ZL2006, ZL2008, ZL2004

Command Code: 0xD7

Type: Block R/W - Protectable

Data Length in Bytes: 4

Data Format: Custom

Factory Value:

ZL2006: Pin-strap setting value (FC1:FC0)

ZL2004: Pin-strap setting value (FC)

Units: n/a

Reference: AN2032 NLR Configuration for DDC products

Definition: Configures the non-linear response (NLR) control parameters. The 4-byte data field is defined in Table 8. Not available on the ZL2106 or ZL2103.

TABLE 9.

BITS	PURPOSE	VALUE	DESCRIPTION
31:30	Outer threshold multiplier	O	Sets multiplier of inner threshold for outer threshold setting, **O*LI** and **O*UI**
29:27	NLR threshold: Load-Inner	LI	Sets inner comparator threshold for a loading event to ~ = 0.005*(**LI**+1)*V_{OUT}
26:24	NLR threshold: Unload-Inner	UI	Sets inner comparator threshold for an unloading event to ~ = 0.005*(**UI**+1)*V_{OUT}
23:20	Max time: Load-Outer threshold correction time	LOT	Sets outer thresh, maximum correction time for a loading event = **LOT***t_{SW}/64 (s)
19:16	Max time: Load-Inner threshold correction time	LIT	Sets inner thresh, maximum correction time for a loading event = **LOT***t_{SW}/64 (s)
15:12	Max time: Unload-Outer threshold correction time	UOT	Sets outer thresh, maximum correction time for an unloading event = **UOT***t_{SW}/64 (s)
11:8	Max time: Unload-Inner threshold correction time	UIT	Sets inner thresh, maximum correction time for an unloading event = **UIT***t_{SW}/64 (s)
7:4	Load Blanking time control	LB	Sets NLR blanking time for a loading event as described in Table 10.
3:0	Unload Blanking time control	UB	Sets NLR blanking time for an unloading event as described in Table 10.

TABLE 10. LOADING EVENTS

LB OR UB	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
t_{SW}/64 UNITS	1	2	3	5	9	17	33	49	65	81	97	129	161	177	193	225

TABLE 11.

BITS	PURPOSE	VALUE	DESCRIPTION
7	Selects the temp sensor source for tempco correction (Note 5)	0	Selects the internal temperature sensor
		1	Selects the XTEMP pin for temperature measurements (2N3904 junction typical)
6:0	Sets tempco correction in units of 100ppm/°C for IOUT_CAL_GAIN and 100µA/ °C for IOUT_CALL_OFFSET	TC	$R_{SEN\ (EXT\ RDSon\ and\ DCR)}$ = IOUT_CAL_GAIN x (1+**TC** x (T-25)) where R_{SEN} = resistance of sense element
			$R_{SEN\ (INT\ FET)}$ = IOUT_CAL_OFFSET x (1+**TC** x 10^{-4} x (T-25)) where R_{SEN} = resistance of sense element

NOTES:

4. Typical temperature coefficients are ~3900ppm/°C (0x27) for copper and ~4800ppm/°C (0x30) for silicon.
5. When selecting XTEMP (bit 7), be sure to have the XTEMP enabled in MFR_CONFIG, bit 7.

TABLE 12.

BITS	PURPOSE	VALUE	DESCRIPTION
15	Sets the high to low transition deadtime mode	0	Adaptive H-to-L deadtime control.
		1	Freeze the H-to-L deadtime at last value.
14:8	Sets the minimum allowed H-to-L deadtime during dynamic control	H	Limits the minimum allowed H-to-L deadtime to H x 2ns (signed)
7	Sets the low to high transition deadtime mode	0	Adaptive L-to-H deadtime control.
		1	Freezes the L-to-H deadtime at its current value
6:0	Sets the minimum allowed L-to-H deadtime	L	Limits the minimum allowed L-to-H deadtime to L x 2ns (signed)

TEMPCO_CONFIG

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xDC

Type: R/W byte - Protectable

Data Length in Bytes: 1

Data Format: Custom

Factory Value: ZL2006, ZL2004 0x2C (4400ppm/ °C) (see Note 4)

Definition: Configures the correction factor and temperature measurement source when performing temperature coefficient correction for current sense. Current sense scale is corrected for external FET controllers and the current sense offset is corrected for internal FET controllers. The command parameter has the following format as shown in Table 11.

To determine the hex value of the Tempco Correction factor (TC) for current scale of a power stage using $r_{DS(ON)}$ current sensing, first determine the temperature coefficient of resistance for the conductor, α. This is found with Equation 7:

$$\alpha = \frac{R_{REF} - R}{R_{REF}(T_{REF} - T)} \quad \text{(EQ. 7)}$$

Where:R = Conductor resistance at temperature “T”

R_{REF} = Conductor resistance at reference temperature T_{REF}

α = Temperature coefficient of resistance for the conductor material

T = Temperature measured by temperature sensor, in °C

T_{REF} = Reference temperature that α is specified at for the conductor material

After α is determined, convert the value in units of 100ppm/°C. This is done with Equation 8:

This value is then converted to a hex value.

$$TC = \frac{\alpha \times 10^6}{100} \quad \text{(EQ. 8)}$$

Note: TEMPCO_CONFIG values are applied as negative correction to a positive temperature coefficient.

DEADTIME

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xDD

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Custom – two 2's complement bytes

Factory Value: ZL2006: 0x3C3C, ZL2004: 0x3C3C

Units: ns

Reference:

Definition: Sets the non-overlap between PWM transitions using a 2-byte data field. The most-significant byte controls the high-side to low-side deadtime value as a single 2's-complement signed value in units of ns. The least-significant byte controls the low-side to high-side deadtime value. Positive values imply a non-overlap of the FET drive on-times. Negative values imply an overlap of the FET drive on-times. The default value of the maximum deadtime for the adaptive deadtime algorithm is 60ns. Writing a value to this command immediately before writing the DEADTIME_CONFIG command will set a new maximum for the adaptive deadtime algorithm. The device will operate at the deadtime values written to this command when adaptive deadtime is disabled.

DEADTIME_CONFIG

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xDE

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Custom

Factory Value: ZL2006: 0x0484, ZL2004: 0x8484

Units: n/a

Reference:

Definition: Configures the deadtime optimization algorithm used by the device. The starting, maximum deadtime value for adaptive mode is set by the DEADTIME command. The data field is described in Table 12.

Group Commands

SEQUENCE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xE0

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Custom

Factory Value: Pin-strap setting value (CFG)

Units: n/a

Reference:

Definition: Identifies the Rail DDC ID of the prequel and sequel rails when performing multi-rail sequencing. The device will enable its output (using the programmed delay values in Table 13) when its EN or OPERATION enable state, as defined by ON_OFF_CONFIG, is set and the prequel device has issued a Power-Good event on the DDC bus. The device will disable its output (using the programmed delay values) when the sequel device has issued a Power-Down event on the DDC bus.

TABLE 13.

BITS	PURPOSE	VALUE	DESCRIPTION
15	Prequel Enable	0	Disable, no prequel preceding this rail
		1	Enable, prequel to this rail is defined by bits 12:8
14:13	Reserved	0	Reserved
12:8	Prequel Rail DDC ID	0 to 31 (0x00 to 0x1F)	Set to the Rail DDC ID of the rail that should precede this device's rail in a sequence order.
7	Sequel Enable	0	Disable, no sequel following this rail
		1	Enable, sequel to this rail is defined by bits 12:8
6:5	Reserved	0	Reserved
4:0	Sequel Rail DDC ID	0 to 31 (0x00 to 0x1F)	Set to the Rail DDC ID of the rail that should follow this device's rail in a sequence order.

TABLE 14.

BITS	PURPOSE	VALUE	DESCRIPTION
7	Enables Voltage Tracking	0	Tracking is disabled
		1	Tracking is enabled
6:3	Reserved	-	Reserved
2	Controls the tracking ratio	0	Output tracks 100% of VTRK
		1	Output tracks 50% of VTRK
1	Controls Upper Track Limit	0	Output is limited by target voltage
		1	Output is limited by VTRK pin
0	Controls ramp-up behavior	0	The output is not allowed to track VTRK down before power-good
		1	The output is allowed to track VTRK down before power-good

The data field is a two-byte value. The most-significant byte contains the 5-bit Rail DDC ID of the prequel device. The least-significant byte contains the 5-bit Rail DDC ID of the sequel device. The most significant bit of each byte contains the enable of the prequel or sequel mode. This command overrides the corresponding sequence configuration set by the CONFIG pin settings.

TRACK_CONFIG

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xE1

Type: R/W byte - Protectable

Data Length in Bytes: 1

Data Format: Custom

Factory Value:

ZL2006, ZL2004: Pin-strap setting value (SS1)

Units: n/a

Reference:

Definition: Configures the voltage tracking modes of the device. The data field is described in Table 14.

TABLE 15.

BITS	PURPOSE	VALUE	DESCRIPTION
15:12	Reserved	0	Reserved
11:8	Broadcast Group	0 to 15	Group number used for broadcast events. (i.e. Broadcast Enable and Broadcast Margin) Set this number to the same value for all rails/devices that should respond to each other's broadcasted event. This function is enabled by the bits 15 and 14 in the MISC_CONFIG command.
7:6	Reserved	0	Reserved
5	DDC TX Inhibit	1	DDC Transmission Inhibited
		0	DDC Transmission Enabled
4:0	DDC ID	0 to 31	Sets the rail's DDC ID for sequencing and fault spreading. This ID is set the same for all devices when they are implemented in a current share rail. For the ZL2006 and ZL2004, this same ID must be used as the ID value in ISHARE_CONFIG.

DDC_CONFIG

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xD3

Type: R/W Word - Protectable

Data Length in Bytes: 2

Data Format: Custom

Factory Value: Lowest five bits of the SMBus Address.

Units: n/a

Reference:

Definition: Configures the DDC bus

DDC_GROUP

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xE2

Type: R/W Block - Protectable

Data Length in Bytes: 4

Data Format: Custom

Factory Value: 0x00000000

Units: n/a

Reference:

Definition: This command sets which rail DDC IDs should be listened to for fault spreading information. The data sent is a 4-byte, 32-bit, bit vector where every bit represents a rail's DDC ID. A bit set to 1 indicates a device DDC ID to which the configured device will respond upon receiving a fault spreading event. In this vector, bit 0 of byte 0 corresponds to the rail with DDC ID 0. Following through, Bit 7 of byte 3 corresponds to the rail with DDC ID 31.

Note: For the ZL2006 and ZL2004, The device/rail's own DDC ID should not be set within the DDC_GROUP command for that device/rail.

All devices in a current share rail must shutdown for the rail to report a shutdown.

If fault spread mode is enabled in USER_CONFIG (Bit 8 set to 1), the device will immediately shut down if one of its DDC_GROUP members fail. The device/rail will attempt its configured restart only after all devices/rails within the DDC_GROUP have cleared their faults.

If fault spread mode is disabled in USER_CONFIG (Bit 8 cleared to 0), the device will perform a sequenced shutdown as defined by the SEQUENCE command setting. The rails/devices in a sequencing set only attempt their configured restart after all faults have cleared within the DDC_GROUP.

ISHARE_CONFIG

Devices: ZL2006, ZL2008, ZL2004

Command Code: 0xD2

Type: R/W Word - Protectable

Data Length in Bytes: 2

Data Format: Custom

Factory Value: 0x0000

Units: n/a

Reference: AN2034 – Current Share Operation for the DDC bus products

Definition: Configures the device for current sharing communication over the DDC bus. The command format is described in Table 16:

TABLE 16.

BITS	PURPOSE	VALUE	DESCRIPTION
15:8	IShare DDC ID	0 to 31 (0x00 to 0x1F)	Sets the current share rail's DDC ID for each device within a current share rail. Set to the same DDC ID as in DDC_CONFIG. This DDC ID is used for sequencing and fault spreading when used in a current share rail.
7:5	Number of Members	0 to 7	Number of devices in current share rail -1. Example: 3 device current share rail, use 3 – 1 = 2
4:2	Member Position	0 to 7	Position of device within current share rail
1	Reserved	0	Reserved
0	I-Share Control	1	Device is a member of a current share rail
		0	Device is not a member of a current share rail

INTERLEAVE

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x37

Type: R/W word - Protectable

Data Length in Bytes: 2

Data Format: Custom

Factory Value:

Default Group Number: 0 (0x00)

Default Number in Group: 16 (0x00)

Default Position in Group: SMBus Address MOD 8 (four LSB's of SMBus address)

Units: n/a

Reference: Section 14.7 - PMBus Spec Part I

Definition: Configures the phase offset of a device that is sharing a common SYNC clock with other devices. Note that for Zilker devices, a value of 0 for the Number in Group field is interpreted as 16, to allow for phase spreading groups of up to 16 devices.

The value of INTERLEAVE is not strictly adhered to when used in devices of a current sharing rail. For current sharing rails, INTERLEAVE is used to set the initial phase of the rail. The current share devices then automatically distribute their phase relative to the INTERLEAVE setting. Refer to AN2034 for phase control rules of a current share rail.

TABLE 17.

BITS	PURPOSE	VALUE	DESCRIPTION
15:12	Reserved	0	Reserved
11:8	Group Number	0 to 15	Sets a number to a group of interleaved rails
7:4	Number in Group	16, 1 to 15 (0 = 16)	Sets the number of rails in the group A value of 0 is interpreted as 16
3:0	Position in Group	0 to 15	Sets position of the device's rail within the group

PHASE_CONTROL

Devices: ZL2006, ZL2008, ZL2004

Command Code: 0xF0

Type: R/W Byte - Protectable

Data Length in Bytes: 1

Data Format: Custom

Factory Value: 0x00

Units: n/a

Reference: AN2034

Definition: This command controls Phase adding/dropping when the device is setup for current sharing. If data written to this command is 0x01, the device phase is considered active while a value of 0x00 will be interpreted as disabled or dropped phase. Any other value written to this command will be ignored.

Supervisory Commands

STORE_DEFAULT_ALL

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x11

Type: Send Byte

Data Length in Bytes: 0

Data Format: n/a

Factory Value: n/a

Units: n/a

Reference: Section 11.2 - PMBus Spec Part II

Definition: Stores, at the DEFAULT level, all PMBus values that were written since the last restore command. To clear the DEFAULT store, perform a RESTORE_FACTORY then STORE_DEFAULT_ALL. To add to the DEFAULT store, perform a RESTORE_DEFAULT_ALL, write commands to be added, then STORE_DEFAULT_ALL. Wait 20ms after a STORE command.

RESTORE_DEFAULT_ALL

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x12

Type: Send Byte

Data Length in Bytes: 0

Data Format: n/a

Factory Value: n/a

Units: n/a

Reference: Section 11.3 - PMBus Spec Part I

Definition: Restores PMBus settings that were stored using STORE_DEFAULT_ALL. Command performed at power up. Security level is changed to level 1 following this command.

STORE_USER_ALL

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x15

Type: Send Byte

Data Length in Bytes: 0

Data Format: n/a

Factory Value: n/a

Units: n/a

Reference: Section 11.6 - PMBus Spec Part I

Definition: Stores, at the USER level, all PMBus values that were changed since the last restore command. To clear the USER store, perform a RESTORE_FACTORY then STORE_USER_ALL. To add to the USER store, perform a RESTORE_USER_ALL, write commands to be added, then STORE_USER_ALL. Wait 20ms after a STORE command.

RESTORE_USER_ALL

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0x16

Type: Send Byte

Data Length in Bytes: 0

Data Format: n/a

Factory Value: n/a

Units: n/a

Reference: Section 11.7 - PMBus Spec Part I

Definition: Restores PMBus settings that were stored using STORE_USER_ALL. Command performed at power up. Security level is changed to Level 1 following this command.

RESTORE_FACTORY

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xF4

Type: Send Byte /Protectable

Data Length in Bytes: 0

Data Format: n/a

Factory Value: n/a

Units: n/a

Reference:

Definition: Restores the device to the hard-coded factory values and pin-strap definitions. The device retains the DEFAULT and USER stores for restoring. Security level is changed to Level 1 following this command.

PRIVATE_PASSWORD

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xFB

Type: Block R/W

Data Length in Bytes: 9

Data Format: Custom

Factory Value: 0x000000000000000000

Units: n/a

Reference: AN2031

Definition: Sets the private password string. Password strings have the same format as the MFR_ID parameters.

PUBLIC_PASSWORD

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xFC

Type: Block R/W

Data Length in Bytes: 4

Data Format: Custom

Factory Value: 0x0000

Units: n/a

Reference: AN2031

Definition: Sets the public password string.

UNPROTECT

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xFD

Type: Block R/W

Data Length in Bytes: 32

Data Format: Custom

Factory Value: 0xFF…FF

Units: n/a

Reference: AN2031

Definition: Sets a 256-bit (32-byte) parameter which identifies which commands are to be protected against write-access at lower security levels. Each bit in this parameter corresponds to a command according to the command's code. The command with a code of 00h (PAGE) is protected by the least-significant bit of the least-significant byte, followed by the command with a code of 01h and so forth. Note that all possible commands have a corresponding bit regardless of whether they are protectable or supported by the device. Clearing a command's UNPROTECT bit indicates that write-access to that command is only allowed if the device's security level has been raised to an appropriate level. The UNPROTECT bits in the DEFAULT store require a security level 3 or greater to be writeable. The UNPROTECT bits in the USER store require a security level of 2 or higher.

SECURITY_LEVEL

Devices: ZL2006, ZL2008, ZL2004, ZL2106, ZL2103

Command Code: 0xFA

Type: Read Byte

Data Length in Bytes: 1

Data Format: Hex

Factory Value: 0x01

Units: n/a

Reference: AN2031

Definition: The device provides write protection for individual commands. Each bit in the UNPROTECT parameter controls whether its corresponding command is writeable (commands are always readable). If a command is not writeable, a password must be entered in order to change its parameter (i.e. to enable writes to that command). There are two types of passwords, public and private. The public password provides a simple lock-and-key protection against accidental changes to the device. It would typically be sent to the device in the application prior to making changes. Private passwords allow commands marked as non-writeable in the UNPROTECT parameter to be changed. Private passwords are intended for protecting factory-installed configurations and would not typically be used in the application. Each store (USER and DEFAULT) can have its own UNPROTECT string and private password. If a command is marked as non-writeable in the DEFAULT UNPROTECT parameter (its corresponding bit is cleared), the private password in the DEFAULT Store must be sent in order to change that command. If a command is writeable according to the Default UNPROTECT parameter, it may still be marked as non-writeable in the User Store UNPROTECT parameter. In this case, the User private password can be sent to make the command writeable.

The device supports four levels of security. Each level is designed to be used by a particular class of users, ranging from module manufacturers to end users, as discussed below. Levels 0 and 1 correspond to the public password. All other levels require a private password. Writing a private password can only raise the security level. Writing a public password will reset the level down to 0 or 1. Figure 1 shows the algorithm used by the device to determine if a particular command write is allowed.

Security Level 3 – Module Vendor

Level 3 is intended primarily for use by Module vendors to protect device configurations in the Default Store. Clearing a UNPROTECT bit in the Default Store implies that a command is writeable only at Level 3 and above. The device's security level is raised to Level 3 by writing the private password value previously stored in the Default Store. To be effective, the module vendor must clear the UNPROTECT bit corresponding to the STORE_DEFAULT_ALL and RESTORE_FACTORY commands. Otherwise, Level 3 protection is ineffective since the entire store could be replaced by the user, including the enclosed private password.

Security Level 2 – User

Level 2 is intended for use by the end user of the device. Clearing a UNPROTECT bit in the User Store implies that a command is writeable only at Level 2 and above. The device's security level is raised to Level 2 by writing the private password value previously stored in the User Store. To be effective, the user must clear the UNPROTECT bit corresponding to the STORE_USER_ALL, RESTORE_DEFAULT_ALL, STORE_DEFAULT_ALL, and RESTORE_FACTORY commands. Otherwise, Level 2 protection is ineffective since the entire store could be replaced, including the enclosed private password.

Security Level 1 – Public

Level 1 is intended to protect against accidental changes to ordinary commands by providing a global write-enable. It can be used to protect the device from erroneous bus operations. It provides access to commands whose UNPROTECT bit is set in both the Default and User Store. Security is raised to Level 1 by writing the public password stored in the User Store using the PUBLIC_PASSWORD command. The public password stored in the Default Store has no effect.

Security Level 0 - Unprotected

Level 0 implies that only commands which are always writeable (e.g. PUBLIC_PASSWORD) are available. This represents the lowest authority level and hence the most protected state of the device. The level can be reduced to 0 by using PUBLIC_PASSWORD to write any value which does not match the stored public password.

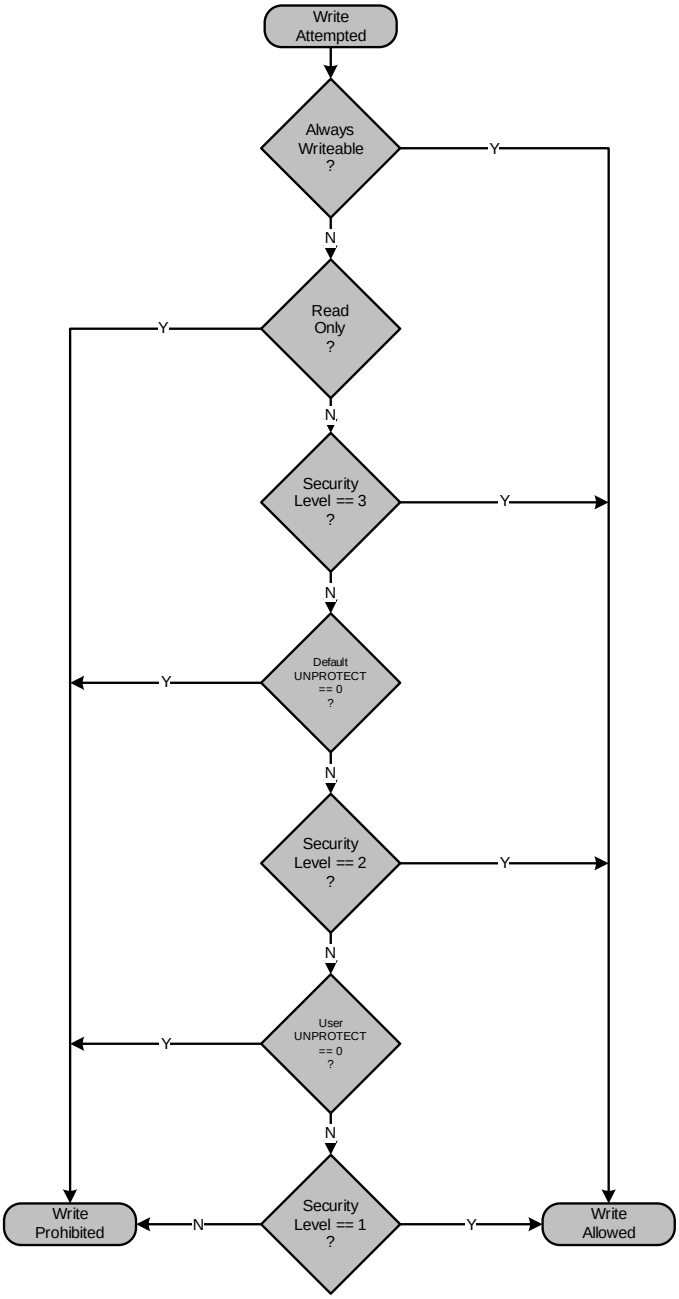

FIGURE 1. ALGORITHM USED TO DETERMINE WHEN A COMMAND IS WRITEABLE

Glossary

Protectable: The data available in these commands are protectable. The UNPROTECT command is used for the protect function.

Linear Format: The linear format is defined in the PMBus specification. The data is a two byte value consisting of an exponent and a mantissa.

V_{OUT} linear mode format: The VOUT linear mode is defined in the PMBus specification for a number of VOUT command values. The Zilker Labs' devices use the linear V_{OUT} mode with an exponent of -13. Thus the actual V_{OUT} command value will be: **V_{OUT} command voltage** = (V_{OUT} command data) x 2^{-13}.

Custom Format: The custom format describes the command data as being a collection of single bits or sets of bits.

Quick Reference Table

PMBUS COMMAND	COMMAND CODE	DATA BYTES	PMBUS DATA FORMAT	DATA UNITS	TYPE	FACTORY VALUE HEX (DEC)	AN2033 SECTION
OPERATION	0x01	1	CUSTOM		R/W byte	n/a	page 6
ON_OFF_CONFIG	0x02	1	CUSTOM		R/W byte	0x16	page 6
CLEAR_FAULTS	0x03	0	n/a		Send byte	n/a	page 22
STORE_DEFAULT_ALL	0x11	0	n/a		Send byte	n/a	page 44
RESTORE_DEFAULT_ALL	0x12	0	n/a		Send byte	n/a	page 44
STORE_USER_ALL	0x15	0	n/a		Send byte	n/a	page 44
RESTORE_USER_ALL	0x16	0	n/a		Send byte	n/a	page 44
VOUT_MODE	0x20	1	CUSTOM		Read byte	0x13	page 7
VOUT_COMMAND	0x21	2	VOUT LINEAR	V	R/W word	V1:V0 pins	page 7
VOUT_TRIM	0x22	2	SIGNED VOUT LINEAR	V	R/W word	0x0000 (0)	page 7
VOUT_CAL_OFFSET	0x23	2	SIGNED VOUT LINEAR	V	R/W word	0x0000 (0)	page 7
VOUT_MAX	0x24	2	VOUT LINEAR	V	R/W word	1.1 x VOUT_COMMAND	page 8
VOUT_MARGIN_HIGH	0x25	2	VOUT LINEAR	V	R/W word	1.05 x VOUT_COMMAND	page 8
VOUT_MARGIN_LOW	0x26	2	VOUT LINEAR	V	R/W word	0.95 x VOUT_COMMAND	page 8
VOUT_TRANSITION_RATE	0x27	2	LINEAR	V/ms	R/W word	0xBA00 (1.0)	page 8
VOUT_DROOP	0x28	2	LINEAR	mV/A	R/W word	0x0000 (0)	page 9
MAX_DUTY	0x32	2	LINEAR	%	R/W word	0xEAF8 (95)	page 9
FREQUENCY_SWITCH	0x33	2	LINEAR	kHz	R/W word	SYNC pin	page 9
INTERLEAVE	0x37	2	CUSTOM		R/W word	0x01 (SA1:SA0)	page 42
IOUT_CAL_GAIN	0x38	2	LINEAR	mV/A	R/W word	0xC200 (2)	page 9

Quick Reference Table (Continued)

PMBUS COMMAND	COMMAND CODE	DATA BYTES	PMBUS DATA FORMAT	DATA UNITS	TYPE	FACTORY VALUE HEX (DEC)	AN2033 SECTION
IOUT_CAL_OFFSET	0x39	2	LINEAR	A	R/W word	0	page 10
VOUT_OV_FAULT_LIMIT	0x40	2	VOUT LINEAR	V	R/W word	1.15 x VOUT_COMMAND	page 11
VOUT_OV_FAULT_RESPONSE	0x41	1	CUSTOM		R/W byte	0xBF	page 16
VOUT_UV_FAULT_LIMIT	0x44	2	VOUT LINEAR	V	R/W word	0.85 x VOUT_COMMAND	page 11
VOUT_UV_FAULT_RESPONSE	0x45	1	CUSTOM		R/W byte	0xBF	page 17
IOUT_OC_FAULT_LIMIT	0x46	2	LINEAR	A	R/W word	ILIM pin(s)	page 11
IOUT_UC_FAULT_LIMIT	0x4B	2	LINEAR	A	R/W word	-1 x IOUT_OC_FAULT_LIMIT	page 12
OT_FAULT_LIMIT	0x4F	2	LINEAR	C	R/W word	0xEBE8 (125)	page 12
OT_FAULT_RESPONSE	0x50	1	CUSTOM		R/W byte	0xBF	page 17
OT_WARN_LIMIT	0x51	2	LINEAR	C	R/W word	0xEB70 (110)	page 13
UT_WARN_LIMIT	0x52	2	LINEAR	C	R/W word	0xDC40 (-30)	page 13
UT_FAULT_LIMIT	0x53	2	LINEAR	C	R/W word	0xE530 (-45)	page 13
UT_FAULT_RESPONSE	0x54	1	CUSTOM		R/W byte	0xBF	page 18
VIN_OV_FAULT_LIMIT	0x55	2	LINEAR	V	R/W word	0xD380 (14)	page 13
VIN_OV_FAULT_RESPONSE	0x56	1	CUSTOM		R/W byte	0xBF	page 18
VIN_OV_WARN_LIMIT	0x57	2	LINEAR	V	R/W word	0xD360 (13.5)	page 14
VIN_UV_WARN_LIMIT	0x58	2	LINEAR	V	R/W word	1.03 x VIN_UV_FAULT_LIMIT	page 14
VIN_UV_FAULT_LIMIT	0x59	2	LINEAR	V	R/W word	UVLO	page 14
VIN_UV_FAULT_RESPONSE	0x5A	1	CUSTOM		R/W byte	0xBF	page 18
POWER_GOOD_ON	0x5E	2	VOUT LINEAR	V	R/W word	0.9 x VOUT_COMMAND	page 11
TON_DELAY	0x60	2	LINEAR	ms	R/W word	DLY pin(s)	page 20
TON_RISE	0x61	2	LINEAR	ms	R/W word	SS pin(s)	page 20
TOFF_DELAY	0x64	2	LINEAR	ms	R/W word	1 x TON_DLY	page 20
TOFF_FALL	0x65	2	LINEAR	ms	R/W word	1 x TON_RISE	page 21
STATUS_BYTE	0x78	1	CUSTOM		Read byte	n/a	page 22
STATUS_WORD	0x79	2	CUSTOM		Read word	n/a	page 22

Quick Reference Table *(Continued)*

PMBUS COMMAND	COMMAND CODE	DATA BYTES	PMBUS DATA FORMAT	DATA UNITS	TYPE	FACTORY VALUE HEX (DEC)	AN2033 SECTION
STATUS_VOUT	0x7A	1	CUSTOM		Read byte	n/a	page 22
STATUS_IOUT	0x7B	1	CUSTOM		Read byte	n/a	page 23
STATUS_INPUT	0x7C	1	CUSTOM		Read byte	n/a	page 23
STATUS_TEMPERATURE	0x7D	1	CUSTOM		Read byte	n/a	page 23
STATUS_CML	0x7E	1	CUSTOM		Read byte	n/a	page 23
STATUS_MFR	0x80	1	CUSTOM		Read byte	n/a	page 24
READ_VIN	0x88	2	LINEAR	V	Read word	n/a	page 25
READ_VOUT	0x8B	2	VOUT LINEAR	V	Read word	n/a	page 25
READ_IOUT	0x8C	2	LINEAR	A	Read word	n/a	page 25
READ_TEMPERATURE_1	0x8D	2	LINEAR	C	Read word	n/a	page 25
READ_TEMPERATURE_2	0x8E	2	LINEAR	C	Read word	n/a	page 26
READ_DUTY_CYCLE	0x94	2	LINEAR	%	Read word	n/a	page 26
READ_FREQUENCY	0x95	2	LINEAR	kHz	Read word	n/a	page 26
PMBUS_REVISION	0x98	1	HEX		Read byte	n/a	page 28
MFR_ID	0x99		ASCII		Block R/W	<null>	page 28
MFR_MODEL	0x9A		ASCII		Block R/W	<null>	page 28
MFR_REVISION	0x9B		ASCII		Block R/W	<null>	page 29
MFR_LOCATION	0x9C		ASCII		Block R/W	<null>	page 29
MFR_DATE	0x9D		ASCII		Block R/W	<null>	page 29
MFR_SERIAL	0x9E		ASCII		Block R/W	<null>	page 30
USER_DATA_00	0xB0		ASCII		Block R/W	<null>	page 30
MFR_CONFIG	0xD0	2	CUSTOM		R/W word	ILIM1 pin	page 31
USER_CONFIG	0xD1	2	CUSTOM		R/W word	CFG pin	page 32
ISHARE_CONFIG	0xD2	2	CUSTOM		R/W word	0x0000	page 42

Quick Reference Table (Continued)

PMBUS COMMAND	COMMAND CODE	DATA BYTES	PMBUS DATA FORMAT	DATA UNITS	TYPE	FACTORY VALUE HEX (DEC)	AN2033 SECTION
DDC_CONFIG	0xD3	2	CUSTOM		R/W word	5-bit LSB of SMBus Address	page 40
POWER_GOOD_DELAY	0xD4	2	LINEAR	ms	R/W word	SS pin(s) (TON_RISE)	page 21
PID_TAPS	0xD5	9	CUSTOM		Block R/W	FC pin(s)	page 34
INDUCTOR	0xD6	1	CUSTOM		R/W byte	V0 pin	page 35
NLR_CONFIG	0xD7	2	CUSTOM		R/W word	FC1	page 36
OVUV_CONFIG	0xD8	1	CUSTOM		R/W byte	0x80	page 19
XTEMP_SCALE	0xD9	2	LINEAR	C	R/W word	0xBA00 (1)	page 10
XTEMP_OFFSET	0xDA	2	LINEAR	C	R/W word	0x0000 (0)	page 10
TEMPCO_CONFIG	0xDC	1	CUSTOM		R/W byte	0x2C	page 37
DEADTIME	0xDD	2	LINEAR	ns	R/W word	0x3C3C	page 38
DEADTIME_CONFIG	0xDE	2	CUSTOM		R/W word	0x0505	page 38
SEQUENCE	0xE0	2	CUSTOM		R/W word	CFG pin	page 39
TRACK_CONFIG	0xE1	1	CUSTOM		R/W byte	SS1 pin	page 40
DDC_GROUP	0xE2	4	CUSTOM		Block R/W	0x00000000	page 41
DEVICE_ID	0xE4	16	ASCII		Block read	n/a	page 28
MFR_IOUT_OC_FAULT_ RESPONSE	0xE5	1	CUSTOM		R/W byte	0xBF	page 17
MFR_IOUT_UC_FAULT_ RESPONSE	0xE6	1	CUSTOM		R/W byte	0xBF	page 17
IOUT_AVG_OC_FAULT_LIMIT	0xE7	2	LINEAR	A	R/W word	IOUT_OC_FAULT_LIMIT	page 12
IOUT_AVG_UC_FAULT_LIMIT	0xE8	2	LINEAR	A	R/W word	IOUT_UC_FAULT_LIMIT	page 12
MISC_CONFIG	0xE9	2	CUSTOM		R/W word		page 33
SNAPSHOT	0xEA	32	CUSTOM		Block read		page 27
PHASE_CONTROL	0xF0	1	CUSTOM		R/W byte		page 43
PID_TAPS_ADAPT	0xF2	9	CUSTOM		Block R/W	FC pin(s)	page 35
SNAPSHOT_CONTROL	0xF3	1	CUSTOM		R/W byte		page 27
RESTORE_FACTORY	0xF4	0	n/a		Send byte	n/a	page 45
MFR_VMON_OV_FAULT_LIMIT	0xF5	2	LINEAR	V	R/W word	0xD300 (12)	page 14

Quick Reference Table *(Continued)*

PMBUS COMMAND	COMMAND CODE	DATA BYTES	PMBUS DATA FORMAT	DATA UNITS	TYPE	FACTORY VALUE HEX (DEC)	AN2033 SECTION
MFR_VMON_UV_FAULT_LIMIT	0xF6	2	LINEAR	V	R/W word	0xCA80 (5)	page 15
MFR_READ_VMON	0xF7	2	LINEAR	V	R/W word	n/a	page 26
VMON_OV_FAULT_ RESPONSE	0xF8	1	CUSTOM		R/W byte	0xBF	page 18
VMON_UV_FAULT_RESPONSE	0xF9	1	CUSTOM		R/W byte	0xBF	page 19
SECURITY_LEVEL	0xFA	1	HEX		Read byte	n/a	page 46
PRIVATE_PASSWORD	0xFB	9	ASCII		Block R/W	0x000000000000000000	page 45
PUBLIC_PASSWORD	0xFC	4	ASCII		Block R/W	0x00000000	page 45
UNPROTECT	0xFD	32	CUSTOM		Block R/W	0xFF…FF	page 45

NOTE: “Factory Values” refers to hard coded values or pin-strap values that are loaded upon a “FACTORY_RESTORE”

Related Tools and Documentation

DOCUMENT	DESCRIPTION
AN2015	ZL2006, ZL2008, ZL2004 Current Protection and Reporting Techniques
AN2031	Writing Configuration Files for Zilker Labs Devices
AN2032	NLR Configuration for the DDC bus products
AN2034	Current Share Operation for the DDC bus products
AN2035	Digital Control Loop Compensation for the DDC bus products

Revision History

DATE	REV. #	COMMENT
May 2008	1.0	Initial release
August 2008	1.1	Added SEQUENCE command table Corrected ISHARE_CONFIG and INTERLEAVE command descriptions Updated TEMPCO_CONFIG command Added “not while enabled” notes to certain commands Corrected INTERLEAVE command table Clarified Precise ramp bits in MISC_CONFIG
October 2008	1.2	Added ZL2103 and ZL2106 references Corrected MFR_CONFIG: bit 2, ‘1’ = Enabled Added “DCR” descriptor to TC calculation in TEMPCO_CONFIG Removed SMBus control bits 4 and 7 in USER_CONFIG Added note 1 to TEMPCO_CONFIG Corrected DEADTIME factory initial values
June 4, 2009	AN2033.0	Conversion from Word to Frame. Issued AN2033. Applied all Intersil Standards. Rev 0 marks New document.