Introduction

Digital power, the latest evolution in power conversion technology, evokes many different ideas concerning the use of digital technology in power supply systems. Digital power design should ultimately allow for monitoring, dynamic optimization of operating points and increased efficiency while reducing the number of external components.

The power industry required a digital power supply communication standard to move ahead into digital power design. 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 this 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, *PMBus Power System Management Protocol Specification; Part I - General Requirements, Transport and Electrical Interface* specifies the physical interface to the PMBus. It includes the SMBus serial bus as the electrical interface and protocol. The second part, *PMBus Power System Management Protocol Specification; Part II – Command Language*, 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. The 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 chapters in similar fashion to the *PMBus Power System Management Protocol Specification; Part II*.

Each PMBus command is described in the following format:

1.x.x <command name in PMBus syntax>
Devices: <list of devices that support this command>
Command Code: <in hex>
Data Length in Bytes: <number>
Data Format: <PMBus data format>
Factory Value: <in hex>
Units: <data units>
Type: <SMBus transfer type>
Reference: <reference to related command or application note>
Definition: <brief description of command's operation>

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1. Reference Documents

1.1. Forum Websites

1.1.1. The System Management Interface Forum (SMIF)

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.

1.1.2. Power Management Bus Implementers Forum (PMBus-IF)

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.

1.2. 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.

1.2.1. 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.

1.2.2. Specification Part II – Command Language

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

1.3. SMBus - System Management Bus Documents

1.3.1. SMBus Control Method Interface Specification

www.SMBus.org/specs/

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

2. Zilker Labs PMBus Commands

2.1. Control Commands

2.1.1. OPERATION

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x01
Data Length in Bytes: 1
Data Format: Custom
Factory Value: n/a
Units: n/a
Type: R/W byte - Protectable
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: On the ZL2005, ZL2105, and ZL2005P, setting the mode to Margin High – Act on Fault has no effect, meaning it will not act on the fault. Margin-related faults are also not acted upon when set to Margin Low – Act on Fault.

2.1.2. ON_OFF_CONFIG

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x02
Data Length in Bytes: 1
Data Format: Custom
Factory Value: 0x16
Units: n/a
Type: R/W byte - Protectable
Reference: Section 12.2 - PMBus spec part II
Definition: Configures the interpretation of the OPERATION command and the Enable (Control) pin.

2.2. Output Commands

2.2.1. VOUT_MODE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x20
Data Length in Bytes: 1
Data Format: Mode + Exponent Format (PMBus spec part II - section 8.2)
Factory Value: 0x13 (Linear Mode, Exponent = -13)
Units: n/a
Type: Read byte
Reference: PMBus spec part II - section 8
Definition: Preset to defined data format of VOUT commands.

2.2.2. VOUT_COMMAND

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x21
Data Length in Bytes: 2
Data Format: VOUT linear mode (PMBus spec part II - section 8.3.1)
Factory Value: Pin-strap setting value (V1:V0)
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II – section 8, 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.

2.2.3. VOUT_TRIM

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x22
Data Length in Bytes: 2
Data Format: Signed Linear Data Format (see definition below)
Factory Value: 0x0000
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II - section 13.3, 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.

2.2.4. VOUT_CAL_GAIN

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x23
Data Length in Bytes: 2
Data Format: Signed Linear Data Format (see definition below)
Factory Value: 0x0000
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II - section 13.4, VOUT_MODE
Definition: Sets VOUT 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.

2.2.5. VOUT_MAX

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x24
Data Length in Bytes: 2
Data Format: VOUT linear mode (PMBus spec part II - section 8.3.1)
Factory Value: 1.10 x VOUT_COMMAND
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II - section 13.5, VOUT_MODE
Definition: Sets the maximum possible value setting of VOUT. The maximum VOUT_MAX setting is 110% of the pin-strap setting.

2.2.6. VOUT_MARGIN_HIGH

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x25
Data Length in Bytes: 2
Data Format: VOUT linear mode (PMBus spec part II - section 8.3.1)
Factory Value: 1.05 x VOUT_COMMAND
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II - section 13.6, VOUT_MODE
Definition: Sets the value of the VOUT during a margin high.

2.2.7. VOUT_MARGIN_LOW

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x26
Data Length in Bytes: 2
Data Format: VOUT linear mode (PMBus spec part II - section 8.3.1)
Factory Value: 0.95 x VOUT_COMMAND
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II - section 13.7, VOUT_MODE
Definition: Sets the value of the VOUT during a margin low.

2.2.8. VOUT_TRANSITION_RATE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x27
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 0xBA00 (1)
Units: V/ms
Type: R/W word - Protectable
Reference: PMBus spec part II - section 13.8
Definition: Sets the transition rate during margin or other change of VOUT.

2.2.9. VOUT_DROOP

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x28
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 0x0000
Units: mV/A
Type: R/W word - Protectable
Reference: PMBus spec part II - section 13.9
Definition:

2.2.10. MAX_DUTY

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x32
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 0xEAF8 (95)
Units: %
Type: R/W word - Protectable
Reference: PMBus spec part II - section 14.3
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.

2.2.11. FREQUENCY_SWITCH

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x33
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: Pin-strap setting value (SYNC)
Units: kHz
Type: R/W word - Protectable
Reference: PMBus spec part II - section 14.4
Definition: Sets the switching frequency.

2.2.12. IOUT_CAL_GAIN

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x38
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: ZL2005: 0xC200 (2mΩ); ZL2105: 0xEBC0 (120mΩ)
Units: mΩ
Type: R/W word - Protectable
Reference: PMBus spec part II - section 14.8
Definition: Sets the expected impedance for current sensing at 25°C.
NOTE: This command was previously known as IOUT_SCALE.

2.2.13. IOUT_CAL_OFFSET

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x39
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 0x0000 (0 Amps)
Units: A
Type: R/W word - Protectable
Reference: PMBus spec part II - section 14.9
Definition: Sets an offset to IOUT readings.

2.2.14. XTEMP_SCALE

Devices: ZL2105
Command Code: 0xD9
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 1
Units: 1/°C
Type: R/W word - Protectable
Reference:
Definition: Sets a scalar value that is used for calibrating the external temperature. The constant is applied in the equation below to produce the read value of XTEMP via the PMBus command READ_TEMPERATURE_2.
NOTE: This value must be greater than or equal to 1.

$$READ\_TEMPERATURE\_2 = \left(ExternalTemperature \cdot \frac{1}{XTEMP\_SCALE} \right) + XTEMP\_OFFSET$$

2.2.15. XTEMP_OFFSET

Devices: ZL2105
Command Code: 0xDA
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 0
Units: °C
Type: R/W word - Protectable
Reference:
Definition: Sets a scalar value that is used for calibrating the external temperature. The constant is applied in the equation below 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.

$$READ\_TEMPERATURE\_2 = \left(ExternalTemperature \cdot \frac{1}{XTEMP\_SCALE} \right) + XTEMP\_OFFSET$$

2.3. Fault Limit Commands

2.3.1. POWER_GOOD_ON

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x5E
Data Length in Bytes: 2
Data Format: VOUT linear mode (PMBus spec part II - section 8.3.1)
Factory Value: 0.9 x VOUT_COMMAND
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.32.1
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.

2.3.2. VOUT_OV_FAULT_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x40
Data Length in Bytes: 2
Data Format: VOUT linear mode (PMBus spec part II - section 8.3.1)
Factory Value: 1.15 x VOUT_COMMAND
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.2
Definition: Sets the VOUT overvoltage fault threshold.

2.3.3. VOUT_UV_FAULT_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x44
Data Length in Bytes: 2
Data Format: VOUT linear mode (PMBus spec part II - section 8.3.1)
Factory Value: 0.85 x VOUT_COMMAND
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.6
Definition: Sets the VOUT undervoltage fault threshold.

2.3.4. IOUT_OC_FAULT_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x46
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: Pin-strap setting value. ZL2005: (ILIM1:ILIM0); ZL2105: (ILIM)
Units: A
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.8
Definition: Sets the IOUT overcurrent fault threshold.

2.3.5. IOUT_AVG_OC_FAULT_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xE7
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 1 x IOUT_OC_FAULT_LIMIT
Units: A
Type: R/W word - Protectable
Reference:
Definition: Sets the average IOUT overcurrent fault threshold. Shares the fault bit operation and OC fault response with IOUT_OC_FAULT_LIMIT.

2.3.6. IOUT_UC_FAULT_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x4B
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: -1 x IOUT_OC_FAULT_LIMIT
Units: A
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.13
Definition: Sets the IOUT undercurrent fault threshold.

2.3.7. IOUT_AVG_UC_FAULT_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xE8
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 1 x IOUT_UC_FAULT_LIMIT
Units: A
Type: R/W word - Protectable
Reference:
Definition: Sets the average IOUT undercurrent fault threshold. Shares the fault bit operation and UC fault response with IOUT_UC_FAULT_LIMIT.

2.3.8. OT_FAULT_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x4F
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 0xEBE8 (125)
Units: degrees C
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.17
Definition: Sets the overtemperature fault threshold.

2.3.9. OT_WARN_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x51
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 0xEB70 (110)
Units: degrees C
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.19
Definition: Sets the overtemperature warning threshold.

2.3.10. UT_WARN_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x52
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 0xDC40 (-30)
Units: degrees C
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.20
Definition: Sets the undertemperature warning threshold.

2.3.11. UT_FAULT_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x53
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 0xE530 (-45)
Units: degrees C
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.21
Definition: Sets the undertemperature fault threshold.

2.3.12. VIN_OV_FAULT_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x55
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 0xD380 (14)
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.23
Definition: Sets the VIN overvoltage fault threshold.

2.3.13. VIN_OV_WARN_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x57
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 1.2 x VIN_UV_FAULT_LIMIT
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.25
Definition: Sets the VIN overvoltage warning threshold.

2.3.14. VIN_UV_WARN_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x58
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 1.03 x VIN_UV_FAULT_LIMIT
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.26
Definition: Sets the VIN undervoltage warning threshold.

2.3.15. VIN_UV_FAULT_LIMIT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x59
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: Pin-strap setting value (UVLO)
Units: V
Type: R/W word - Protectable
Reference: PMBus spec part II - section 15.27
Definition: Sets the VIN undervoltage fault threshold.

2.3.16. MFR_VMON_OV_FAULT_LIMIT

Devices: ZL2004
Command Code: 0xF5
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 12 V
Units: V
Type: R/W word - Protectable
Definition: Sets the VMON overvoltage fault threshold.

2.3.17. MFR_VMON_UV_FAULT_LIMIT

Devices: ZL2004
Command Code: 0xF6
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 5 V
Units: V
Type: R/W word - Protectable
Definition: Sets the VMON undervoltage fault threshold.

2.4. Fault Response Commands

2.4.1. VOUT_OV_FAULT_RESPONSE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x41
Data Length in Bytes: 1
Data Format: Custom (PMBus spec part II - section 10.5.1)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB
Type: R/W byte - Protectable
Reference: PMBus spec part II - section 15.3
Definition: Configures the VOUT overvoltage fault response. Note that the two most significant bits can be written to zeros. 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.
Note: The delay time is the time between restart attempts

2.4.2. VOUT_UV_FAULT_RESPONSE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x45
Data Length in Bytes: 1
Data Format: Custom (PMBus spec part II - section 10.5.1)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB
Type: R/W byte - Protectable
Reference: PMBus spec part II - section 15.7
Definition: Configures the VOUT undervoltage fault response. Note that the two most significant bits can be written to zeros. However, upon an undervoltage fault, these two bits will be set to 1:0 (i.e. bits (7:6) = 1:0).
Note: The delay time is the time between restart attempts

2.4.3. MFR_IOUT_OC_FAULT_RESPONSE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xE5
Data Length in Bytes: 1
Data Format: Custom (PMBus spec part II - section 10.5.1)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB
Type: R/W byte - Protectable
Reference: PMBus spec part II - section 15.3
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.

2.4.4. MFR_IOUT_UC_FAULT_RESPONSE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xE6
Data Length in Bytes: 1
Data Format: Custom (PMBus spec part II - section 10.5.1)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB
Type: R/W byte - Protectable
Reference: PMBus spec part II - section 15.7
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

2.4.5. OT_FAULT_RESPONSE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x50
Data Length in Bytes: 1
Data Format: Custom (PMBus spec part II - section 10.5.1)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 32ms/LSB, Delay = 80ms/LSB
Type: R/W byte - Protectable
Reference: PMBus spec part II - section 15.18
Definition: Configures the overtemperature fault response.
Note: The delay time is the time between restart attempts

2.4.6. UT_FAULT_RESPONSE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x54
Data Length in Bytes: 1
Data Format: Custom (PMBus spec part II - section 10.5.1)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 32ms/LSB, Delay = 80ms/LSB
Type: R/W byte - Protectable
Reference: PMBus spec part II - section 15.22
Definition: Configures the undertemperature fault response.
Note: The delay time is the time between restart attempts

2.4.7. VIN_OV_FAULT_RESPONSE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x56
Data Length in Bytes: 1
Data Format: Custom (PMBus spec part II - section 10.5.1)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB
Type: R/W byte - Protectable
Reference: PMBus spec part II - section 15.24
Definition: Configures the VIN overvoltage fault response.
Note: The delay time is the time between restart attempts

2.4.8. VIN_UV_FAULT_RESPONSE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x5A
Data Length in Bytes: 1
Data Format: Custom (PMBus spec part II - section 10.5.1)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB
Type: R/W byte - Protectable
Reference: PMBus spec part II - section 15.28
Definition: Configures the VIN undervoltage fault response.
Note: The delay time is the time between restart attempts

2.4.9. VMON_OV_FAULT_RESPONSE

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

2.4.10. VMON_UV_FAULT_RESPONSE

Devices: ZL2004
Command Code: 0xF9
Data Length in Bytes: 1
Data Format: Custom (PMBus spec part II - section 10.5.1)
Factory Value: 0xBF (Retry always, max delay)
Units: Retry time = 8.2ms/LSB, Delay = 10ms/LSB
Type: R/W byte - Protectable
Reference: PMBus spec part II - section 15.24
Definition: Configures the VMON undervoltage fault response.
Note: The delay time is the time between restart attempts

2.4.11. OVUV_CONFIG

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xD8
Data Length in Bytes: 1
Data Format: Custom (See table)
Factory Value: 0x80
Units: n/a
Type: R/W byte - Protectable
Reference:
Definition: Configures the output voltage OV and UV fault detection feature as given in the following table.

Field	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

2.5. Time Setting Commands

2.5.1. TON_DELAY

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x60
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value:
ZL2005: Pin-strap setting value (DLY1:DLY0)
ZL2105: Pin-strap setting value (DLY)
Units: ms
Type: R/W word - Protectable
Reference: PMBus spec part II - section 16.1
Definition: Sets the delay time from ENABLE to start of VOUT rise. The delay time can range from 0 milliseconds up to 500 seconds, in steps of 125 nanoseconds.

2.5.2. TON_RISE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x61
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value:
ZL2005: Pin-strap setting value (SS1:SS0)
ZL2105: Pin-strap setting value (SS)
Units: ms
Type: R/W word - Protectable
Reference: PMBus spec part II - section 16.2
Definition: Sets the rise time of VOUT after ENABLE and TON_DELAY. The delay time can range from 0 to 200 milliseconds, in steps of 12.5 microseconds.

2.5.3. TOFF_DELAY

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x64
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 1 x TON_DELAY
Units: ms
Type: R/W word - Protectable
Reference: PMBus spec part II - section 16.5
Definition: Sets the delay time from DISABLE to start of VOUT fall. The delay time can range from 0 millisecond up to 500 seconds, in steps of 125 nanoseconds.

2.5.4. TOFF_FALL

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x65
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: 1 x TON_RISE
Units: ms
Type: R/W word - Protectable
Reference: PMBus spec part II - section 16.6
Definition: Sets the fall time for VOUT after DISABLE and TOFF_DELAY. The delay time can range from 0 to 200 milliseconds, in steps of 12.5 microseconds.

2.5.5. POWER_GOOD_DELAY

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xD4
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value:

ZL2005: Pin-strap setting value (SS1:SS0) = (1 x TON_RISE)
ZL2105: Pin-strap setting value (SS) = (1 x TON_RISE)

Units: ms
Type: R/W word - Protectable
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 based on TON_RISE.

2.6. Status Commands

2.6.1. CLEAR_FAULTS

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x03
Data Length in Bytes: 0
Data Format: n/a
Factory Value: n/a
Units: n/a
Type: R/W byte
Reference: PMBus spec part II - section 15.1
Definition: Clears fault indications.

2.6.2. STATUS_BYTE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x78
Data Length in Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: n/a
Type: Read byte
Reference: PMBus spec part II - section 17.1
Definition: Returns an abbreviated status for fast reads.

2.6.3. STATUS_WORD

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x79
Data Length in Bytes: 2
Data Format: Custom
Factory Value: 0x0000
Units: n/a
Type: Read word
Reference: PMBus spec part II - section 17.2
Definition: Returns the general status information used to indicate subsequent status to be read for more detail.

2.6.4. STATUS_VOUT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x7A
Data Length in Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: n/a
Type: Read byte
Reference: PMBus spec part II - section 17.3
Definition: Returns the VOUT specific status.

2.6.5. STATUS_IOUT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x7B
Data Length in Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: n/a
Type: Read byte
Reference: PMBus spec part II - section 17.4
Definition: Returns the IOUT specific status.

2.6.6. STATUS_INPUT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x7C
Data Length in Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: n/a
Type: Read byte
Reference: PMBus spec part II - section 17.5
Definition: Returns specific status specific to the input.

2.6.7. STATUS_TEMPERATURE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x7D
Data Length in Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: n/a
Type: Read byte
Reference: PMBus spec part II - section 17.6
Definition: Returns the temperature specific status.

2.6.8. STATUS_CML

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x7E
Data Length in Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: n/a
Type: Read byte
Reference: PMBus spec part II - section 17.7
Definition: Returns the Communication, Logic and Memory specific status.

2.6.9. STATUS_MFR

Devices: ZL2004, ZL2006
Command Code: 0xTODO
Data Length in Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: n/a
Type: Read byte
Reference: PMBus spec part II - section 17.7
Definition: Returns the Communication, Logic and Memory specific status.

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

2.7. Monitor Commands

2.7.1. READ_VIN

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x88
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: n/a
Units: V
Type: Read word
Reference: PMBus spec part II – section 18.1
Definition: Returns the input voltage reading. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.

2.7.2. READ_VOUT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x8B
Data Length in Bytes: 2
Data Format: VOUT linear mode (PMBus spec part II - section 8.3.1)
Factory Value: n/a
Units: V
Type: Read word
Reference: PMBus spec part II – section 18.4
Definition: Returns the output voltage reading. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.

2.7.3. READ_IOUT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x8C
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: n/a
Units: A
Type: Read word
Reference: PMBus spec part II – section 18.5
Definition: Returns the output current reading. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.

2.7.4. READ_TEMPERATURE_1

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x8D
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: n/a
Units: degrees C
Type: Read word
Reference: PMBus spec part II – section 18.6
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.

2.7.5. READ_TEMPERATURE_2

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x8E
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: n/a
Units: degrees C
Type: Read word
Reference: PMBus spec part II – section 18.6
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.

2.7.6. READ_FAN_SPEED_1

Devices: ZL2005
Command Code: 0x90
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: n/a
Units: RPM
Type: Read word
Reference: PMBus spec part II – section 18.7
Definition: Returns the fan 1 speed reading on the TACH pin assuming 1 pulse per revolution (ppr). The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode. Maximum TACH rate of 30,000 ppr.

2.7.7. READ_DUTY_CYCLE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x94
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: n/a
Units: %
Type: Read word
Reference: PMBus spec part II – section 18.9
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.

2.7.8. READ_FREQUENCY

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x95
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: n/a
Units: kHz
Type: Read word
Reference: PMBus spec part II – section 18.10
Definition: Returns the measured operating switch frequency. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.

2.7.9. MFR_READ_VMON

Devices: ZL2004
Command Code: 0xF7
Data Length in Bytes: 2
Data Format: Linear Data Format (PMBus spec part II - section 7.1)
Factory Value: n/a
Units: V
Type: Read word
Definition: Returns the measured input voltage VMON. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.

2.8. Identification Commands

2.8.1. DEVICE_ID

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xE4
Data Length in Bytes: 16
Data Format: ASCII
Factory Value: <part number/die revision/firmware revision>
Units: n/a
Type: Block Read
Reference: n/a
Definition: Returns the 16-byte device identifier string.

2.8.2. PMBUS_REVISION

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x98
Data Length in Bytes: 1
Data Format: Hex
Factory Value: <revision implemented>
Units: n/a
Type: Read byte
Reference: PMBus spec part II – section 22.1
Definition: Returns the revision of the PMBus implemented in the device.

2.8.3. MFR_ID

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x99
Data Length in Bytes: user defined
Data Format: ASCII
Factory Value: null
Units: n/a
Type: Block R/W - Protectable
Reference: PMBus spec part II – section 22.2.1
Definition: Returns a manufacturer entered 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.

2.8.4. MFR_MODEL

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x9A
Data Length in Bytes: user defined
Data Format: ASCII
Factory Value: null
Units: n/a
Type: Block R/W - Protectable
Reference: PMBus spec part II – section 22.2.2
Definition: Returns a manufacturer entered 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.

2.8.5. MFR_REVISION

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x9B
Data Length in Bytes: user defined
Data Format: ASCII
Factory Value: null
Units: n/a
Type: Block R/W - Protectable
Reference: PMBus spec part II – section 22.2.3
Definition: Returns a manufacturer entered 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.

2.8.6. MFR_LOCATION

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x9C
Data Length in Bytes: user defined
Data Format: ASCII
Factory Value: null
Units: n/a
Type: Block R/W - Protectable
Reference: PMBus spec part II – section 22.2.4
Definition: Returns a manufacturer entered 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.

2.8.7. MFR_DATE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x9D
Data Length in Bytes: user defined
Data Format: ASCII
Factory Value: null
Units: n/a
Type: Block R/W - Protectable
Reference: PMBus spec part II – section 22.2.5
Definition: Returns a manufacturer entered 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.

2.8.8. MFR_SERIAL

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x9E
Data Length in Bytes: user defined
Data Format: ASCII
Factory Value: null
Units: n/a
Type: Block R/W - Protectable
Reference: PMBus spec part II – section 22.2.6
Definition: Returns a manufacturer entered serial 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.
Note: some programmer vendors have limitations on the length of the serial numbers. It is recommended to keep the serial number to 6 bytes in length.

2.8.9. USER_DATA_00

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xB0
Data Length in Bytes: user defined
Data Format: ASCII
Factory Value: null
Units: n/a
Type: Block R/W - Protectable
Reference: PMBus spec part II – section 23
Definition: Returns user entered 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.

2.9. Other Configuration Commands

2.9.1. MFR_CONFIG

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xD0
Data Length in Bytes: 2
Data Format: Custom
Factory Value:
ZL2005: Pin-strap setting value (ILIM1)
ZL2105: 0x8001
Type: R/W word - Protectable
Definition: Configures several manufacturer-level features. The data field is defined in the following table. Note: For ZL2105, when f_{SW} > 800kHz, the current sense delay should be 256ns.

MFR_CONFIG Command Format for ZL2005, ZL2105, and ZL2005P

Field	Purpose	Value	Description
15:11	Current Sense Blanking Delay	D (see description)	Sets the delay, D, in 32ns steps
10:8	Current Sense Fault Count	C (see description)	Sets the number of consecutive OC or UC violations required for a fault to 2C+1.
7	Enable XTEMP measurements	0	No temperature are performed on XTEMP
		1	Temperature measurements are performed on XTEMP
6	Temperature sensor control	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	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	Current sense uses VOUT-referenced, up/down slope selected by nominal duty-cycle
3:2	Reserved	00	Reserved
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

MFR_CONFIG Command Format for ZL2004 and ZL2006

Field	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 OC or UC violations required for a fault to 2C+1.
7	Enable XTEMP measurements	0	No temperature are performed on XTEMP
		1	Temperature measurements are performed on XTEMP
6	Temperature sensor control	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	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	Current sense uses VOUT-referenced, up/down slope selected by nominal duty-cycle
3	Reserved	0	Reserved
2	Set Initial Ramp Enabled	0	Set Initial Ramp Disabled
		1	Set Initial 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

2.9.2. USER_CONFIG

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xD1
Data Length in Bytes: 2
Data Format: Custom
Factory Value: Pin-strap setting value (CFG)
Units: n/a
Type: R/W word - Protectable
Reference:
Definition: Configures several user-level features. The data field is defined in the following table. This command overrides the CONFIG pin settings.

USER_CONFIG format for ZL2005, ZL2105, and ZL2005P

Field	Purpose	Value	Description
15:12	Reserved	-	Reserved
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 Control	0	Received faults are ignored
		1	Received faults cause a shut-down
7	SMBus Master Clock Rate	0	Operate at 100 kHz in master mode
		1	Operate at 400 kHz in master mode
6	SYNC utilization control	0	Auto-configure using the SYNC pin and FREQUENCY_SWITCH parameter
		1	Switch using the SYNC input (device waits for external sync signal before regulation)
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 master transmissions are allowed
		1	SMBus master transmissions are not allowed
3	SMBus Timeout Inhibit	0	SMBus Idle and Fault timeouts are enabled
		1	SMBus Idle and Fault timeouts are inhibited
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
		01	Monitor for faults when device is disabled
		10	Reserved
		11	Monitor for faults using pulsed mode.

USER_CONFIG format for ZL2004 and ZL2006

Field	Purpose	Value	Description
15:14	Minimum Duty Cycle	N	Sets the minimum duty cycle ((N+1) / (2^8)) out of the PID during ramps if the Set Minimum Duty Cycle is Enabled. For example, if Minimum Duty Cycle input N is set to 3, the minimum duty cycle is (3+1) / (2^8) = (4 / 256) = (1 / 64) %.
13	Minimum Duty Cycle Enable	0	Minimum Duty Cycle Shelf is Disabled
		1	Minimum Duty Cycle Shelf is Enabled
12	Ramp Down Minimum Step	0	Ramps are terminated when reference logic determines that ramp is done
		1	Ramps are terminated when minimum duty cycle flag is tripped
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 Control	0	Received faults are ignored
		1	Received faults cause a shut-down
7	SMBus Master Clock Rate	0	Operate at 100 kHz in master mode
		1	Operate at 400 kHz in master mode
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 master transmissions are allowed
		1	SMBus master transmissions are not allowed
3	SMBus Timeout Inhibit	0	SMBus Idle and Fault timeouts are enabled
		1	SMBus Idle and Fault timeouts are inhibited
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
		01	Monitor for faults when device is disabled
		10	Reserved
		11	Monitor for faults using pulsed mode.

2.9.3. PID_TAPS

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xD5
Data Length in Bytes: 9
Data Format: Custom
Factory Value:
ZL2005, ZL200B: Pin-strap setting value (FC1:FC0)
ZL2105: Pin-strap setting value (FC)
Units: n/a
Type: Block R/W - Protectable
Reference: AN2016
Definition: Configures the linear control loop filter coefficients. The PID algorithm implements the following Z-domain function:

$$\frac{A + Bz^{-1} + Cz^{-2}}{1 - z^{-1}}$$

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

$$A = (-1)^S \cdot 2^E \cdot M$$

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 the following table. S is stored as the MSB of the E byte.

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: The above data bytes are transmitted on the PMBus in the order of Byte 0 through Byte 8

2.9.4. NLR_CONFIG

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xD7
Data Length in Bytes: 2
Data Format: Custom
Factory Value:
ZL2005: Pin-strap setting value (FC1)
ZL2105: 0xA2A0
Units: n/a
Type: R/W word - Protectable
Reference:
Definition: Configures the non-linear response (NLR) control algorithm. The 2-byte data field is defined in the following table.

NLR_CONFIG Command Format for ZL2005, ZL2105, and ZL2005P

Field	Purpose	Value	Description
15	Controls the NLR enable	0	The NLR feature is disabled
		1	The NLR feature is enabled
14:12	Sets the high-side (control FET) NLR threshold	HT	Sets the high-side comparator threshold to approximately 0.005 x (HT+1) x Vout
11	Controls the outer NLR comparators	0	The outer NLR comparators are disabled
		1	The outer NLR comparators are enabled
10:8	Sets the low-side (sync FET) NLR threshold	LT	Sets the low-side comparator threshold to approximately 0.005 x (LT+1) x Vout
7:6	Sets the maximum high-side correction time	HC	Sets the maximum high-side correction time to Tsw x ((2*HC) +1)/64
5:4	Sets the maximum low-side correction time	LC	Sets the maximum low-side correction time to Tsw x ((2*LC) +1)/64
3:0	NLR Blanking time control	B	Adds to the NLR blanking time by B x Tsw / 64.

NLR_CONFIG Command Format for ZL2004 and ZL2006

Field	Purpose	Value	Description
15	Controls the NLR Enable	0	NLR feature is disabled
		1	NLR feature is enabled
14:12	Sets the high-side NLR threshold	HT	Sets the high-side comparator threshold to approximately 0.005*(HT+1)*Vout
11:8	Sets the low-side NLR threshold	LT	Sets the low-side comparator threshold to approximately 0.005*(LT+1)*Vout
7:5	Sets the maximum high-side correction time	HC	Sets the maximum high-side correction time to HC*Tsw/64 (sec)
4:2	Sets the maximum low-side correction time	LC	Sets the maximum low-side correction time to LC*Tsw/64 (sec)
1:0	NLR Blanking time control	B	Sets the NLR blanking time to B*Tsw/32 (sec)

2.9.5. TEMPCO_CONFIG

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xDC
Data Length in Bytes: 1
Data Format: Custom
Factory Value: ZL2005: 0x2C; ZL2105: 0x00
Type: R/W byte - Protectable
Definition: Configures the correction factor and temperature measurement source when performing temperature coefficient correction for current sense. The command parameter has the following format.

Field	Purpose	Value	Description
7	Selects the temp sensor source for tempco correction	0	Selects the internal temperature sensor
		1	Selects an external 2N3904 NPN on XTEMP
6:0	Sets the tempco correction factor in units of 100ppm/C	TC	R_{sen} = IOUT_SCALE x (1 + TC x (T-25)) Where R_{sen} = Resistance of Sense Element

To determine the Tempco Correction Factor (TC) for a power stage using $R_{DS(ON)}$ current sensing, we first try to determine α, which is the temperature coefficient of resistance of the conductor. This is found with the equation below:

$$\alpha = \frac{R_{REF} - R}{R_{REF}(T_{REF} - T)}$$

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

After α is determined, you will need to convert the value in units of 100ppm/^{o}C. This is done with the following equation:

$$TC = \frac{\alpha \times 10^{6}}{100}$$

NOTE: For a power stage using DCR sensing, you will instead need to determine what material your inductor is made out of (typically Copper) and convert its temperature coefficient to units of 100ppm/^{o}C.

2.9.6. DEADTIME

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xDD
Data Length in Bytes: 2
Data Format: Custom – two 2's complement bytes
Factory Value: ZL2005: 0x3C3C; ZL2105: 0x3C20
Units: ns
Type: R/W word - Protectable
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 on-times. Negative values imply an overlap of the FET on-times.

2.9.7. DEADTIME_CONFIG

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xDE
Data Length in Bytes: 2
Data Format: Custom
Factory Value: ZL2005: 0x0505; ZL2105: 0x0484
Units: n/a
Type: R/W word - Protectable
Reference:
Definition: Configures the deadtime optimization algorithm used by the device. The data field is described in the following table.

Field	Purpose	Value	Description
15	Sets the high to low transition control method	0	Adjusts the H-to-L deadtime dynamically
		1	Freezes the H-to-L deadtime at its current 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 control method	0	Adjusts the L-to-H deadtime dynamically
		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)

2.9.8. POLA_VADJ_CONFIG

Devices: ZL2005P
Command Code: 0xD6
Data Length in Bytes: 1
Data Format: Custom
Factory Value: Pin-strap setting value (V0)
Units: n/a
Type: R/W word - Protectable
Reference:
Definition: Configures the Device's voltage pin-straps to either conform to the POLA standard or to follow Zilker Labs' method. The command format is shown in the table below.

Field	Purpose	Value	Description
15:0	POLA Config	0x00	Standard Mode • Device will use V0/V1 pins to set output voltage (VOUT_COMMAND), output voltage fault limits, and maximum output voltage (VOUT_MAX) • The VADJ pin will be inactive
		0x01	POLA Mode • Device will use VADJ pin to set output voltage (VOUT_COMMAND), output voltage fault limits, and maximum output voltage (VOUT_MAX) • The V0/V1 pins will be inactive • Sync pin can be used for pinstrap
		0x02	POLA_MODE with SYNC Pin Disabled • Device will use VADJ pin to set output voltage (VOUT_COMMAND), output voltage fault limits, and maximum output voltage (VOUT_MAX) • The V0/V1 pins will be inactive • Fsw defaults to 400kHz, and can only be changed via PMBus • Sync discovery disabled (no resistor or external sync allowed)

2.9.9. MISC_CONFIG

Devices: ZL2004, ZL2006
Command Code: 0xD0
Data Length in Bytes: 2
Data Format: Custom
Factory Value: 0x0000
Type: R/W word – Protectable
Definition: This command sets a few options pertaining to ramp timing accuracy and current-driven control. The format of this command is shown in the table below.

MISC_CONFIG Command Format for ZL2006

Field	Purpose	Value	Description
15:9	Reserved	0	Unused.
8	Precise Ramp Down Delay	0	Disabled
		1	Tight ramp-down delay accuracy
7	Precise Ramp Up Delay	0	Disabled
		1	Internal Oscillator selected, tight ramp-up delay accuracy
6	Diode Emulation	0	Disabled
		1	Enabled at low Iloads to improve efficiency
5:2	Output current ripple threshold	N	Current threshold when the load goes discontinuous.
1:0	Reserved	00	

MISC_CONFIG Command Format for ZL2004

Field	Purpose	Value	Description
15:9	Reserved	0	Unused.
8	Precise Ramp Down Delay	0	Disabled
		1	Tight ramp-down delay accuracy
7	Precise Ramp Up Delay	0	Disabled
		1	Internal Oscillator selected, tight ramp-up delay accuracy
6	Diode Emulation	0	Disabled
		1	Enabled at low Iloads to improve efficiency
5:2	Output current ripple threshold	N	Current threshold when the load goes discontinuous.
1:0	Reserved	11	Reserved
		10	RdsOn = 50mV DCR = 100mV
		01	RdsOn = 35mV DCR = 50mV
		00	RdsOn = 25mV = DCR

2.10. Group Commands

2.10.1. INTERLEAVE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x37
Data Length in Bytes: 2
Data Format: Custom
Factory Value: SMBusAddr MOD 8
Units: n/a
Type: R/W word - Protectable
Reference: PMBus spec part II – section 14.7
Definition: Configures the device phase offset of a device in a group. Please 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.

2.10.2. SEQUENCE

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xE0
Data Length in Bytes: 2
Data Format: Custom
Factory Value: Pin-strap setting value (CFG)
Units: n/a
Type: R/W word - Protectable
Reference:
Definition: Sets the serial interface address of the prequel and sequel devices when using group sequencing. The device will enable its output (using the programmed delay values) 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 serial bus. The device will disable its output (using the programmed delay values) when the sequel device has issued a Power Down event on the serial bus.
The data field is a two-byte value. The most-significant byte contains the serial interface address of the prequel device (left-justified). The least-significant byte contains the address of the sequel device. The unused least-significant bit of both addresses must be 0 (i.e., the byte for address 0x21 would be 0x42). An address byte value of 0x00 for the prequel defines that device as the first device in a sequence. An address byte value of 0x00 for the sequel defines the device to be the last device in a sequence. A SEQUENCE command value of 0x0000 disables device sequencing, unless defined by pin-straps. This command overrides the corresponding CONFIG pin settings.

NOTE: On the ZL2006 and ZL2004, the Upper and Lower bytes pertain to a right-justified DDC address instead of the SMBus address. However, having a value of zero for a given byte will disable prequel/sequel functionality, despite how DDC addresses range from 0-31. As a workaround, use a value such as 0x20 when needing to use DDC address 0 as a prequel or sequel, as the lower 5 bits of the DDC address are zero, but the entire value isn’t.

2.10.3. TRACK_CONFIG

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xE1
Data Length in Bytes: 1
Data Format: Custom
Factory Value:
ZL2005: Pin-strap setting value (SS1)
ZL2105: Pin-strap setting value (SS)
Units: n/a
Type: R/W byte - Protectable
Reference:
Definition: Configures the voltage tracking modes of the device. The data field is described in the following table.

Field	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

2.10.4. DDC_CONFIG

Devices: ZL2004, ZL2006
Command Code: 0xD3
Data Length in Bytes: 2
Data Format: Custom
Factory Value: Lowest five bits of the PMBus Address.
Units: n/a
Type: R/W Word - Protectable
Reference:
Definition: Configures the DDC bus

Field	Purpose	Value	Description
15:13	Reserved	0	Reserved
12:8	Group Address	0 to 31	Address used for group events
7:6	Reserved	0	Reserved
5	DDC TX Inhibit	1	DDC Transmission Inhibited
		0	DDC Transmission Enabled
4:0	Controls ramp-up behavior	0 to 31	Sets the current sharing group DDC address for sequencing and fault spreading as a group. This address is used for the dynamic current sharing algorithm to identify the group number. The address is right justified.

2.10.5. DDC_GROUP

Devices: ZL2004, ZL2006
Command Code: 0xE2
Data Length in Bytes: 4
Data Format: Custom
Factory Value: 0x00000000
Units: n/a
Type: R/W Block - Protectable
Reference:
Definition: This command sets which DDC device addresses should be listened to for fault spreading information. The data sent is a 4-byte, 32-bit, bitvector where every bit represents a DDC address. A bit set to 1 indicates a device DDC address to which the configured device will respond upon receiving a fault spreading event. In this vector, bit 0 of byte 0 corresponds to the device at DDC address 0. Following through, Bit 7 of byte 3 corresponds to the device at DDC address 31.

With devices that have DDC_GROUP, there are some important differences in the way devices respond to fault events. If fault spread enable is set in USER_CONFIG a device will immediately shut down if one of its DDC_GROUP members fail. However, if fault spread enable is not set then the devices will “sequence down” in both directions from the failed device. This means a device above the failed device will not shut down until its prequel does, and a device below the failed device will not shut down until its sequel does. This is of course dependent on the setting of the SEQUENCE command. In both cases, groups of devices will “sequence up” from the origin of the sequencing chain or restart if not sequencing once all faults in devices in the DDC_GROUP have cleared.

2.10.6. ISHARE_CONFIG

Devices: ZL2004, ZL2006
Command Code: 0xD2
Data Length in Bytes: 2
Data Format: Custom
Factory Value: 0x0000
Units: n/a
Type: R/W Word - Protectable
Reference:
Definition: Configures the device for current sharing over the DDC bus. The command format is described in the table below:

Field	Purpose	Value	Description
15:8	Virtual Comm. Bus Current Sharing Group Address	0 to 31	Sets the current sharing group DDC address for sequencing and fault spreading as a group. This address is used for the dynamic current sharing algorithm to identify the group number. The address is right justified.
7:5	Number of Members	M	Total number of I-Sharing Members in group.
4:2	Member Position	N	Member Device Number within the I-Share group vector

2.10.7. PHASE_CONTROL

Devices: ZL2004, ZL2006
Command Code: 0xF0
Data Length in Bytes: 1
Data Format: Custom
Factory Value: 0x00
Units: n/a
Type: R/W Byte - Protectable
Reference:
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.

2.11. Supervisory Commands

2.11.1. STORE_DEFAULT_ALL

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x11
Data Length in Bytes: 0
Data Format: n/a
Factory Value: n/a
Units: n/a
Type: R/W byte
Reference: PMBus spec part II – section 11.2
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.

2.11.2. RESTORE_DEFAULT_ALL

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0x12
Data Length in Bytes: 0
Data Format: n/a
Factory Value: n/a
Units: n/a
Type: R/W byte
Reference: PMBus spec part II – section 11.3
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.

2.11.3. STORE_USER_ALL

Devices: ZL2005, ZL2105, ZL2004, ZL2006
Command Code: 0x15
Data Length in Bytes: 0
Data Format: n/a
Factory Value: n/a
Units: n/a
Type: R/W byte
Reference: PMBus spec part II – section 11.6
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.

2.11.4. RESTORE_USER_ALL

Devices: ZL2005, ZL2105, ZL2004, ZL2006
Command Code: 0x16
Data Length in Bytes: 0
Data Format: n/a
Factory Value: n/a
Units: n/a
Type: R/W byte
Reference: PMBus spec part II – section 11.7
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.

2.11.5. RESTORE_FACTORY

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xF4
Data Length in Bytes: 0
Data Format: n/a
Factory Value: n/a
Units: n/a
Type: R/W byte /Protectable
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.

2.11.6. PRIVATE_PASSWORD

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xFB
Data Length in Bytes: 9
Data Format: Custom
Factory Value: 0x0000
Units: n/a
Type: Block R/W
Reference:
Definition: Sets the private password string. Password strings have the same format as the MFR_ID parameters.

2.11.7. PUBLIC_PASSWORD

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xFC
Data Length in Bytes: 4
Data Format: Custom
Factory Value: 0x0000
Units: n/a
Type: Block R/W
Reference:
Definition: Sets the public password string.

2.11.8. UNPROTECT

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xFD
Data Length in Bytes: 32
Data Format: Custom
Factory Value: 0xFF…FF
Units: n/a
Type: Block R/W
Reference:
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 PROTECT 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 PROTECT bits in the DEFAULT store require a security level 3 or greater to be writeable. The PROTECT bits in the USER store require a security level of 2 or higher.

2.11.9. SECURITY_LEVEL

Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006
Command Code: 0xFA
Data Length in Bytes: 1
Data Format: Hex
Factory Value: 0x01
Units: n/a
Type: Read Byte
Reference:
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 PROTECT 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 PROTECT bit corresponding to the STORE_DEFAULT_ALL command. 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 PROTECT 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 PROTECT bit corresponding to the STORE_USER_ALL command. 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 PROTECT 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.

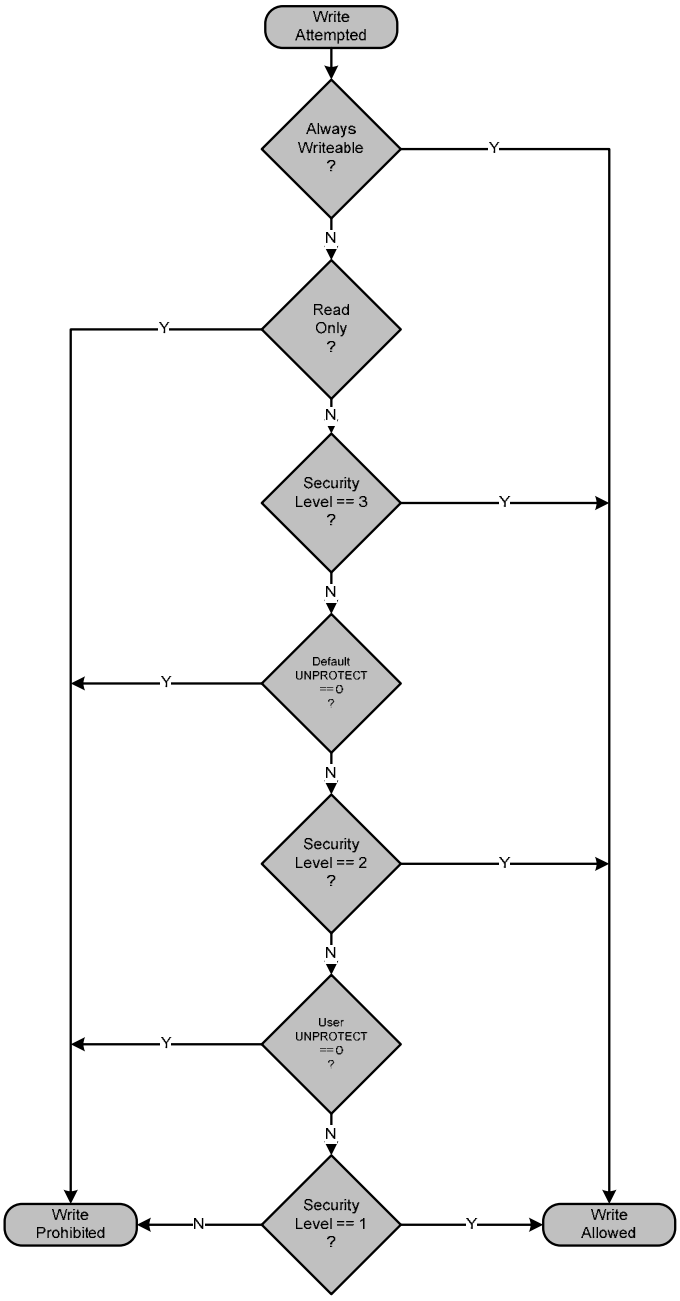

Figure 1. Algorithm used to determine when a command is writeable.

3. Glossary

Protectable: The data available in these commands are protectable. The PROTECT 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.

VOUT 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 VOUT mode with an exponent of -13. Thus the actual VOUT command value will be:

VOUT command voltage = (VOUT_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.

4. Application Note List

AN2015 – ZL2005 Current Protection and Reporting Techniques

AN2016 – ZL2005 Digital Control Loop Compensation

5. Quick Reference Table

PMBus Command	Command Code	Data Bytes	PMBus Data Format	Data Units	Type	Factory Value	AN2013 Section
OPERATION	0x01	1	CUSTOM		R/W byte	n/a	2.1.1
ON_OFF_CONFIG	0x02	1	CUSTOM		R/W byte	0x16	2.1.2
CLEAR_FAULTS	0x03	0	n/a		R/W byte	n/a	2.6.1
STORE_DEFAULT_ALL	0x11	0	n/a		R/W byte	n/a	2.11.1
RESTORE_DEFAULT_ALL	0x12	0	n/a		R/W byte	n/a	2.11.2
STORE_USER_ALL	0x15	0	n/a		R/W byte	n/a	2.11.3
RESTORE_USER_ALL	0x16	0	n/a		R/W byte	n/a	2.11.4
VOUT_MODE	0x20	1	CUSTOM		Read byte	0x13	2.2.1
VOUT_COMMAND	0x21	2	VOUT LINEAR	V	R/W word	V1:V0 pins ZL2005P: V1:V0 pins or VADJ pin	2.2.2
VOUT_TRIM	0x22	2	SIGNED VOUT LINEAR	V	R/W word	0x0000 (0)	2.2.3
VOUT_GAIN	0x23	2	SIGNED VOUT LINEAR	V	R/W word	0x0000 (0)	2.2.4
VOUT_MAX	0x24	2	VOUT LINEAR	V	R/W word	1.1 x VOUT_COMMAND	2.2.5
VOUT_MARGIN_HIGH	0x25	2	VOUT LINEAR	V	R/W word	1.05 x VOUT_COMMAND	2.2.6
VOUT_MARGIN_LOW	0x26	2	VOUT LINEAR	V	R/W word	0.95 x VOUT_COMMAND	2.2.7
VOUT_TRANSITION_RATE	0x27	2	LINEAR	V/ms	R/W word	0xBA00 (1.0)	2.2.8
VOUT_DROOP	0x28	2	LINEAR	mV/A	R/W word	0x0000 (0)	2.2.9
MAX_DUTY	0x32	2	LINEAR	%	R/W word	0xEAF8 (95)	2.2.10
FREQUENCY_SWITCH	0x33	2	LINEAR	kHz	R/W word	SYNC pin	2.2.11
INTERLEAVE	0x37	2	CUSTOM		R/W word	0x01 (SA1:SA0)	2.10.1
IOUT_CAL_GAIN (formerly IOUT_SCALE)	0x38	2	LINEAR	mV/A	R/W word	ZL2005: 0xC200 (2) ZL2005P: 0xC200 (2) ZL2105: 0xEBC0 (120)	2.2.12
IOUT_CAL_OFFSET	0x39	2	LINEAR	A	R/W word	0	2.2.13
VOUT_OV_FAULT_LIMIT	0x40	2	VOUT LINEAR	V	R/W word	1.15 x VOUT_COMMAND	2.3.2
VOUT_OV_FAULT_RESPONSE	0x41	1	CUSTOM		R/W byte	0xBF	2.4.1
VOUT_UV_FAULT_LIMIT	0x44	2	VOUT LINEAR	V	R/W word	0.85 x VOUT_COMMAND	2.3.3

PMBus Command	Command Code	Data Bytes	PMBus Data Format	Data Units	Type	Factory Value	AN2013 Section
OPERATION	0x01	1	CUSTOM		R/W byte	n/a	2.1.1
VOUT_UV_FAULT_RESPONSE	0x45	1	CUSTOM		R/W byte	0xBF	2.4.2
IOUT_OC_FAULT_LIMIT	0x46	2	LINEAR	A	R/W word	ILIM pin(s)	2.3.4
IOUT_UC_FAULT_LIMIT	0x4B	2	LINEAR	A	R/W word	-1 x IOUT_OC_FAULT_LIMIT	2.3.6
OT_FAULT_LIMIT	0x4F	2	LINEAR	C	R/W word	0xEBE8 (125)	2.3.8
OT_FAULT_RESPONSE	0x50	1	CUSTOM		R/W byte	0xBF	2.4.5
OT_WARN_LIMIT	0x51	2	LINEAR	C	R/W word	0xEB70 (110)	2.3.9
UT_WARN_LIMIT	0x52	2	LINEAR	C	R/W word	0xDC40 (-30)	2.3.10
UT_FAULT_LIMIT	0x53	2	LINEAR	C	R/W word	0xE530 (-45)	2.3.11
UT_FAULT_RESPONSE	0x54	1	CUSTOM		R/W byte	0xBF	2.4.6
VIN_OV_FAULT_LIMIT	0x55	2	LINEAR	V	R/W word	0xD380 (14)	2.3.12
VIN_OV_FAULT_RESPONSE	0x56	1	CUSTOM		R/W byte	0xBF	2.4.7
VIN_OV_WARN_LIMIT	0x57	2	LINEAR	V	R/W word	0xD360 (13.5)	2.3.13
VIN_UV_WARN_LIMIT	0x58	2	LINEAR	V	R/W word	1.03 x VIN_UV_FAULT_LIMIT	2.3.14
VIN_UV_FAULT_LIMIT	0x59	2	LINEAR	V	R/W word	UVLO	2.3.15
VIN_UV_FAULT_RESPONSE	0x5A	1	CUSTOM		R/W byte	0xBF	2.4.8
POWER_GOOD_ON	0x5E	2	VOUT LINEAR	V	R/W word	0.9 x VOUT_COMMAND	2.3.1
TON_DELAY	0x60	2	LINEAR	ms	R/W word	DLY pin(s)	2.5.1
TON_RISE	0x61	2	LINEAR	ms	R/W word	SS pin(s)	2.5.2
TOFF_DELAY	0x64	2	LINEAR	ms	R/W word	1 x TON_DELAY	2.5.3
TOFF_FALL	0x65	2	LINEAR	ms	R/W word	1 x TON_RISE	2.5.4
STATUS_BYTE	0x78	1	CUSTOM		Read byte	n/a	2.6.2
STATUS_WORD	0x79	2	CUSTOM		Read word	n/a	2.6.3
STATUS_VOUT	0x7A	1	CUSTOM		Read byte	n/a	2.6.4
STATUS_IOUT	0x7B	1	CUSTOM		Read byte	n/a	2.6.5
STATUS_INPUT	0x7C	1	CUSTOM		Read byte	n/a	2.6.6
STATUS_TEMPERATURE	0x7D	1	CUSTOM		Read byte	n/a	2.6.7
STATUS_CML	0x7E	1	CUSTOM		Read byte	n/a	2.6.8
READ_VIN	0x88	2	LINEAR	V	Read word	n/a	2.7.1
READ_VOUT	0x8B	2	VOUT LINEAR	V	Read word	n/a	2.7.2

PMBus Command	Command Code	Data Bytes	PMBus Data Format	Data Units	Type	Factory Value	AN2013 Section
OPERATION	0x01	1	CUSTOM		R/W byte	n/a	2.1.1
READ_IOUT	0x8C	2	LINEAR	A	Read word	n/a	2.7.3
READ_TEMPERATURE_1	0x8D	2	LINEAR	C	Read word	n/a	2.7.4
READ_TEMPERATURE_2	0x8E	2	LINEAR	C	Read word	n/a	2.7.5
READ_FAN_SPEED_1	0x90	2	LINEAR	RPM	Read word	n/a	2.7.6
READ_DUTY_CYCLE	0x94	2	LINEAR	%	Read word	n/a	2.7.7
READ_FREQUENCY	0x95	2	LINEAR	kHz	Read word	n/a	2.7.8
PMBUS_REVISION	0x98	1	HEX		Read byte	0x01	2.8.2
MFR_ID	0x99		ASCII		Block R/W	<null>	2.8.3
MFR_MODEL	0x9A		ASCII		Block R/W	<null>	2.8.4
MFR_REVISION	0x9B		ASCII		Block R/W	<null>	2.8.5
MFR_LOCATION	0x9C		ASCII		Block R/W	<null>	2.8.6
MFR_DATE	0x9D		ASCII		Block R/W	<null>	2.8.7
MFR_SERIAL	0x9E		ASCII		Block R/W	<null>	2.8.8
USER_DATA_00	0xB0		ASCII		Block R/W	<null>	2.8.9
MFR_CONFIG	0xD0	2	CUSTOM		R/W word	ZL2005: ILIM1 pin ZL2005P: ILIM1 pin ZL2105: 0x8001	2.9.1
USER_CONFIG	0xD1	2	CUSTOM		R/W word	CFG pin	2.9.2
ISHARE_CONFIG	0xD2	2	CUSTOM		R/W word	0x0000	2.10.6
DDC_CONFIG	0xD3	2	CUSTOM		R/W word	5-bit LSB of SMBus Address	2.10.4
POWER_GOOD_DELAY	0xD4	2	LINEAR	ms	R/W word	SS pins(s) (TON_RISE)	2.5.5

PMBus Command	Command Code	Data Bytes	PMBus Data Format	Data Units	Type	Factory Value	AN2013 Section
OPERATION	0x01	1	CUSTOM		R/W byte	n/a	2.1.1
Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006 Command Code: 0xD1 Data Length in Bytes: 2 Data Format: Custom Factory Value: Pin-strap setting value (CFG) Units: n/a Type: R/W word - Protectable Reference: Definition: Configures several user-level features. The data field is defined in the following table. This command overrides the CONFIG pin settings.	0xD5	9	CUSTOM		Block R/W	FC pin(s)	0

USER_CONFIG format for ZL2005, ZL2105, and ZL2005P

Field	Purpose	Value	Description
15:12	Reserved	-	Reserved
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 Control	0	Received faults are ignored
		1	Received faults cause a shut-down
7	SMBus Master Clock Rate	0	Operate at 100 kHz in master mode
		1	Operate at 400 kHz in master mode
6	SYNC utilization control	0	Auto-configure using the SYNC pin and FREQUENCY_SWITCH parameter
		1	Switch using the SYNC input (device waits for external sync signal before regulation)
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

PMBus Command	Command Code	Data Bytes	PMBus Data Format	Data Units	Type	Factory Value	AN2013 Section
OPERATION	0x01	1	CUSTOM		R/W byte	n/a	2.1.1

4	**SMBus** Transmit Inhibit	**0**	**SMBus** master transmissions are allowed
		1	**SMBus** master transmissions are not allowed
3	SMBus Timeout Inhibit	0	SMBus Idle and Fault timeouts are enabled
		1	SMBus Idle and Fault timeouts are inhibited
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
		01	Monitor for faults when device is disabled
		10	Reserved
		11	Monitor for faults using pulsed mode.

USER_CONFIG format for ZL2004 and ZL2006

Field	Purpose	Value	Description
15:14	Minimum Duty Cycle	N	Sets the minimum duty cycle ((N+1) / (2^8)) out of the PID during ramps if the Set Minimum Duty Cycle is Enabled. For example, if Minimum Duty Cycle input N is set to 3, the minimum duty cycle is (3+1) / (2^8) = (4 / 256) = (1 / 64) %.
13	Minimum Duty Cycle Enable	0	Minimum Duty Cycle Shelf is Disabled
		1	Minimum Duty Cycle Shelf is Enabled
12	Ramp Down Minimum Step	0	Ramps are terminated when reference logic determines that ramp is done
		1	Ramps are terminated when minimum duty cycle flag is tripped
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

PMBus Command				Command Code	Data Bytes	PMBus Data Format	Data Units	Type	Factory Value	AN2013 Section
OPERATION				0x01	1	CUSTOM		R/W byte	n/a	2.1.1
8	Fault Spreading Control	0	Received faults are ignored							
		1	Received faults cause a shut-down							
7	SMBus Master Clock Rate	0	Operate at 100 kHz in master mode							
		1	Operate at 400 kHz in master mode							
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 master transmissions are allowed							
		1	SMBus master transmissions are not allowed							
3	SMBus Timeout Inhibit	0	SMBus Idle and Fault timeouts are enabled							
		1	SMBus Idle and Fault timeouts are inhibited							
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							
		01	Monitor for faults when device is disabled							
		10	Reserved							
		11	Monitor for faults using pulsed mode.							
PID_TAPS										
POLA_VADJ_CONFIG				0xD6	1	CUSTOM		R/W byte	V0 pin	2.9.8
NLR_CONFIG				0xD7	2	CUSTOM		R/W word	ZL2005: FC1 ZL2005P: FC1 ZL2105: 0xA2A0	2.9.4
OVUV_CONFIG				0xD8	1	CUSTOM		R/W byte	0x80	2.4.9
XTEMP_SCALE				0xD9	2	LINEAR	C	R/W word	0xBA00 (1)	2.2.14
XTEMP_OFFSET				0xDA	2	LINEAR	C	R/W word	0x0000 (0)	2.2.15
Devices: ZL2005, ZL2105, ZL2005P, ZL2004, ZL2006 Command Code: 0xD7 Data Length in Bytes: 2 Data Format: Custom				0xDC	1	CUSTOM		R/W byte	ZL2005: 0x2C ZL2005P: 0x2C ZL2105: 0x00	0

PMBus Command	Command Code	Data Bytes	PMBus Data Format	Data Units	Type	Factory Value	AN2013 Section
OPERATION	0x01	1	CUSTOM		R/W byte	n/a	2.1.1

Factory Value:
ZL2005: Pin-strap setting value (FC1)
ZL2105: 0xA2A0
Units: n/a
Type: R/W word - Protectable
Reference:
Definition: Configures the non-linear response (NLR) control algorithm. The 2-byte data field is defined in the following table.

NLR_CONFIG Command Format for ZL2005, ZL2105, and ZL2005P

Field	Purpose	Value	Description
15	Controls the NLR enable	0	The NLR feature is disabled
		1	The NLR feature is enabled
14:12	Sets the high-side (control FET) NLR threshold	HT	Sets the high-side comparator threshold to approximately 0.005 x (HT+1) x Vout
11	Controls the outer NLR comparators	0	The outer NLR comparators are disabled
		1	The outer NLR comparators are enabled
10:8	Sets the low-side (sync FET) NLR threshold	LT	Sets the low-side comparator threshold to approximately 0.005 x (LT+1) x Vout
7:6	Sets the maximum high-side correction time	HC	Sets the maximum high-side correction time to Tsw x ((2*HC) +1)/64
5:4	Sets the maximum low-side correction time	LC	Sets the maximum low-side correction time to Tsw x ((2*LC) +1)/64
3:0	NLR Blanking time control	B	Adds to the NLR blanking time by B x Tsw / 64.

PMBus Command	Command Code	Data Bytes	PMBus Data Format	Data Units	Type	Factory Value	AN2013 Section
OPERATION	0x01	1	CUSTOM		R/W byte	n/a	2.1.1
NLR_CONFIG **Command Format for ZL2004 and ZL2006** Field / Purpose / Value / Description 15 / Controls the NLR Enable / 0 / NLR feature is disabled 15 / Controls the NLR Enable / 1 / NLR feature is enabled 14:12 / Sets the high- / HT / Sets the high-side 11:8 / Sets the low- / LT / Sets the low-side 7:5 / Sets the / HC / Sets the maximum 4:2 / Sets the / LC / Sets the maximum low- 1:0 / NLR Blanking / B / Sets the NLR blanking TEMPCO_CONFIG							
DEADTIME	0xDD	2	LINEAR	ns	R/W word	ZL2005: 0x3C3C ZL2005P: 0x3C20 ZL2105: 0x3C20	2.9.6
DEADTIME_CONFIG	0xDE	2	CUSTOM		R/W word	ZL2005: 0x0505 ZL2005P: 0x0484 ZL2105: 0x0484	2.9.7
SEQUENCE	0xE0	2	CUSTOM		R/W word	CFG pin	2.10.2
TRACK_CONFIG	0xE1	1	CUSTOM		R/W byte	ZL2005: SS1 pin ZL2005P: SS1 pin ZL2105: SS pin	2.10.3
DDC_GROUP	0xE2	4	CUSTOM		Block R/W	0x00000000	2.10.5
DEVICE_ID	0xE4	16	ASCII		Block read	n/a	2.8.1
MFR_IOUT_OC_FAULT_RESPONSE	0xE5	1	CUSTOM		R/W byte	0xBF	2.4.3
MFR_IOUT_UC_FAULT_RESPONSE	0xE6	1	CUSTOM		R/W byte	0xBF	2.4.4
IOUT_AVG OC_FAULT_LIMIT	0xE7	2	LINEAR	A	R/W word	IOUT_OC_FAULT_LIMIT	2.3.5
IOUT_AVG UC_FAULT_LIMIT	0xE8	2	LINEAR	A	R/W word	IOUT_UC_FAULT_LIMIT	2.3.7
MISC_CONFIG	0xE9	2	CUSTOM		R/W word		2.9.9
PHASE_CONTROL	0xF0	1	CUSTOM		R/W byte		2.10.7
RESTORE_FACTORY	0xF4	0	n/a		R/W byte	n/a	2.11.5
MFR_VMON_OV_FAULT_LIMIT	0xF5	2	LINEAR	V	R/W word	12	2.3.16
MFR_VMON_UV_FAULT_LIMIT	0xF6	2	LINEAR	V	R/W word	5	2.3.17

PMBus Command	Command Code	Data Bytes	PMBus Data Format	Data Units	Type	Factory Value	AN2013 Section
OPERATION	0x01	1	CUSTOM		R/W byte	n/a	2.1.1
MFR_READ_VMON	0xF7	2	LINEAR	V	R/W word	n/a	2.7.9
VMON_OV_FAULT_RESPONSE	0xF8	1	CUSTOM		R/W byte	0xBF	2.4.9
VMON_UV_FAULT_RESPONSE	0xF9	1	CUSTOM		R/W byte	0xBF	2.4.10
SECURITY_LEVEL	0xFA	1	HEX		Read byte	n/a	2.11.9
PRIVATE_PASSWORD	0xFB	9	ASCII		Block R/W	0x00…00	2.11.6
PUBLIC_PASSWORD	0xFC	4	ASCII		Block R/W	0x00000000	2.11.7
UNPROTECT	0xFD	32	CUSTOM		Block R/W	0xFF…FF	2.11.8

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

Revision History

Date	Rev. #	
12/15/05	1.0	Initial Release
5/24/06	2.0	Updated STORE/RESTORE command definitions
10/11/06	3.0	Updated default values; Added device compatibility listing
5/2/07	3.2	Updated commands and formats to match PMBus 1.1 spec; Updated NLR_CONFIG
10/19/07	3.3	Updated commands for ZL2005P, ZL2105 Updated TEMPCO_CONFIG
11/6/07	3.4	Page 30, Added note on MFR_CONFIG for current sense delay on ZL2105
12/12/07	3.5	Added commands related to the ZL2004 and Zl2006
4/30/09	AN2013.0	Assigned file number AN2013 to app note as this will be the first release with an Intersil file number. Replaced header and footer with Intersil header and footer. Updated disclaimer information to read “Intersil and it’s subsidiaries including Zilker Labs, Inc.” No changes to app note content.

Notes

Zilker Labs, Inc.
4301 Westbank Drive
Building A-100
Austin, TX 78746

Tel: 512-382-8300
Fax: 512-382-8329