

OVERVIEW

This reference manual describes the digital communications capabilities of the LT7170/LT7170-1, including the functionality of each LT7170/LT7170-1 PMBus command. Refer to these specifications for more information regarding the bus protocol details.

- ▶ PMBus Specification Revision 1.3.1
- ▶ SMBus Specification Revision 3.1

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REVISION HISTORY

1/2024—Revision A: Initial Version

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PMBUS/SMBUS/I²C

PMBUS/SMBUS/I²C CAPABILITIES

The LT7170/LT7170-1 serial interface is PMBus compliant and can operate at any frequency between 10 kHz and 1 MHz. The device address is configurable using the nonvolatile memory (NVM). The serial interface supports the following protocols defined in the PMBus and SMBus specifications:

- ▶ Send byte, write byte, write word, block write
- ▶ Read byte, read word, block read
- ▶ Alert response address
- ▶ PAGE_PLUS_READ, PAGE_PLUS_WRITE
- ▶ Zone write
- ▶ SMBALERT_MASK read and write

The LT7170/LT7170-1 pull the $\overline{\text{ALERT}}$ pin low to indicate conditions that may require attention. See the [Status](#) section in the [PMBus Command Details](#) section for more information.

SIMILARITIES BETWEEN PMBUS, SMBUS, AND I²C 2-WIRE INTERFACE

The PMBus 2-wire interface is an incremental extension of the SMBus. SMBus is built upon I²C with some minor differences in timing, DC parameters, and protocol. The PMBus/SMBus protocols are more robust than simple I²C byte commands because PMBus/SMBus provide timeouts to prevent persistent bus errors and optional packet error checking (PEC) to ensure data integrity. In general, a bus controller device that can be configured for I²C communication can be used for PMBus communication with little or no change to hardware or firmware. Repeat start (restart) is not supported by all I²C controllers but is required for SMBus/PMBus reads. If a general-purpose I²C controller is used, check that repeat start is supported.

For a description of the minor extensions and exceptions PMBus adds to SMBus, refer to *PMBus Specification* Part 1 Revision 1.3.1: Section 5: Transport.

For a description of the differences between SMBus and I²C, refer to *System Management Bus (SMBus) Specification* Version 3.1: Appendix B—Differences Between SMBus and I²C.

COMMUNICATION PROTECTION

All read operations return a valid PEC if the PMBus controller requests it. If Bit 2 of the MFR_CONFIG_ALL_LT7170 command is set, the PMBus write operations are not acted upon until a valid PEC is received by the LT7170/LT7170-1. If a PEC is included in a command write, that PEC must be valid or a PEC write error occurs, regardless of the value of Bit 2 of the MFR_CONFIG_ALL_LT7170 command.

If a PEC write error occurs, an attempt is made to access unsupported commands, or invalid data is written to supported commands, the LT7170/LT7170-1 ignore the command, set the communications, memory, and logic (CML) bit in the STATUS_BYTE and STATUS_WORD commands, set the appropriate bit in the STATUS_CML command, and pull the $\overline{\text{ALERT}}$ pin low.

ADDRESSING AND COMMUNICATIONS

DEVICE ADDRESSING

The LT7170/LT7170-1 offer addressing modes that provide flexible ways to control multiple channels at once or individually.

Device addressing is the standard way to communicate with a single instance of the LT7170/LT7170-1. The value of the device address is set by the MFR_ADDRESS command. Device addressing can be disabled by writing a value of 0x80 to the MFR_ADDRESS command. If MFR_ADDRESS cannot be read from NVM due to an NVM fault, the device address is set to 0x7C.

Global addressing provides a means to address all LT7170/LT7170-1 devices on the bus. The LT7170/LT7170-1 global addresses are fixed at 0x5A (7-bit notation) and 0x5B. They cannot be disabled. Do not read from global addresses because multiple devices may respond simultaneously. Other Analog Devices, Inc., device types may respond at one or both of these global addresses.

Rail addressing provides a means to control multiple channels simultaneously. While similar to global addressing, the rail address can be dynamically assigned with the MFR_RAIL_ADDRESS command, allowing any logical grouping of channels that may be required for reliable system control. Do not read from rail addresses because multiple devices may respond.

Zone write addressing provides a means to write to a set of channels. The set of channels can be distributed across multiple devices. Each channel is programmed to be part of a zone by programming the selected zone number to the ZONE_CONFIG command. This configuration only needs to be performed once. After zone configuration, the bus controller uses the ZONE_ACTIVE command to select the active zone. If the configured zone of a channel matches the active zone, or the active zone is set to all zone, the channel responds to subsequent ZONE_WRITE operations. A ZONE_WRITE operation is started when the bus controller uses the ZONE_WRITE address (0x37, 7-bit notation) as the device address in an SMBus write command.

All means of PMBus addressing require the user to employ disciplined planning to avoid addressing conflicts. Communication to LT7170/LT7170-1 devices at global and rail addresses are limited to command write operations.

COMMUNICATION RECOMMENDATIONS

If PMBus commands are received faster than they are being processed, the LT7170/LT7170-1 may become too busy to handle new commands. If a command is written when the LT7170/LT7170-1 are busy processing a command, the devices ignore that command, set Bit 7 of STATUS_BYTE, and pull the $\overline{\text{ALERT}}$ pin low. Bit 6 of MFR_COMMON sets to a 1 when the LT7170/LT7170-1 are ready to accept commands. This bit can be polled before writing commands. Alternatively, clock stretching can be enabled. Clock stretching is enabled by setting Bit 1 of MFR_CONFIG_ALL_LT7170.

NVM commands may take longer to process, including STORE_USER_ALL and MFR_COMPARE_USER_ALL. In these cases, either poll Bit 6 of MFR_COMMON or enable clock stretching to avoid a busy condition.

PMBUS COMMAND SUMMARY

Table 1 lists supported PMBus commands and manufacturer specific commands. A complete description of the included PMBus commands is found in the *PMBus Power System Management Protocol Specification*. Floating point values listed in the default value column are half-precision IEEE floating point numbers. All commands from 0xC0 through 0xFF not listed in Table 1 are implicitly reserved by the manufacturer. Users must avoid blind writes within this range of commands to avoid undesired operation of the LT7170/LT7170-1. All commands from 0x00 through 0xBF not listed in Table 1 are implicitly not supported by the manufacturer. Attempting to access unsupported or reserved commands results in a CML command fault event.

The LT7170/LT7170-1 contain additional manufacturer reserved commands not listed in Table 1. Reading these commands is harmless to the operation of the IC. However, the contents and meaning of these commands can change without notice.

Some of the unpublished commands are read only and generate a CML Bit 6 fault if written. Writing to commands not published in Table 1 is not permitted.

Table 1. Supported PMBus and MFR Commands¹

| Command Name ² | Command Code | Description | Type | Data Format | Unit | NVM ³ | Default Value |
|---------------------------|--------------|---|-----------|-------------|------|------------------|---------------|
| PAGE | 0x00 | Provides integration with multipage PMBUS devices. | R/W byte | Register | | No | 0x00 |
| OPERATION | 0x01 | Operating mode control. On/off, margin high, and margin low. | R/W byte | Register | | Yes | 0x80 |
| ON_OFF_CONFIG | 0x02 | RUN pin and PMBus bus on/off command configuration. | R/W byte | Register | | Yes | 0x1E |
| CLEAR_FAULTS | 0x03 | Clears any fault bits that have been set. | Send byte | | | | |
| PAGE_PLUS_WRITE | 0x05 | Writes a command directly to a specified page. | W block | | | | |
| PAGE_PLUS_READ | 0x06 | Reads a command directly from a specified page. | Block R/W | | | | |
| ZONE_CONFIG | 0x07 | Assigns current page to specified zone number for ZONE_WRITE operations. | W word | Register | | Yes | 0xFEFE |
| ZONE_ACTIVE | 0x08 | Selects active zone for ZONE_WRITE operations. | W word | Register | | No | 0xFEFE |
| WRITE_PROTECT | 0x10 | Level of protection provided by the device against accidental changes. | R/W byte | Register | | Yes | 0x00 |
| STORE_USER_ALL | 0x15 | Stores user operating memory to NVM. Can be written three times. | Send byte | | | | |
| RESTORE_USER_ALL | 0x16 | Restores user operating memory from NVM. | Send byte | | | | |
| CAPABILITY | 0x19 | Summary of PMBus optional communication protocols supported by this device. | R byte | Register | | No | 0xD8 |
| QUERY | 0x1A | Asks if a given command is supported, and what data formats are supported. | Block R/W | Register | | No | |
| SMBALERT_MASK | 0x1B | Masks ALERT activity. | Block R/W | Register | | Yes | |
| VOUT_MODE | 0x20 | Output voltage format and exponent. | R byte | Register | | No | 0x60 |
| VOUT_COMMAND | 0x21 | Nominal output voltage set point. | R/W word | IEEE | V | Yes | 0.5, 0x3800 |
| VOUT_MAX | 0x24 | Upper limit on the commanded output voltage. | R/W word | IEEE | V | Yes | 0.537, 0x384C |
| VOUT_MARGIN_HIGH | 0x25 | Margin high output voltage set point. | R/W word | IEEE | V | Yes | 0.525, 0x3833 |
| VOUT_MARGIN_LOW | 0x26 | Margin low output voltage set point. | R/W word | IEEE | V | Yes | 0.475, 0x3799 |
| VOUT_TRANSITION_RATE | 0x27 | Rates the output changes when V _{OUT} commanded to a new value. | R/W word | IEEE | V/ms | Yes | 0.25, 0x3400 |

PMBUS COMMAND SUMMARY

Table 1. Supported PMBus and MFR Commands¹ (Continued)

| Command Name ² | Command Code | Description | Type | Data Format | Unit | NVM ³ | Default Value |
|---------------------------|--------------|---|----------|-------------|------|------------------|----------------|
| FREQUENCY_SWITCH | 0x33 | Switching frequency of the regulator. | R/W word | IEEE | kHz | Yes | 1000.0, 0x63D0 |
| VIN_ON | 0x35 | Input voltage at which the unit must start power conversion. | R/W Word | IEEE | V | Yes | 1.4, 0x3D9A |
| VIN_OFF | 0x36 | Input voltage at which the unit must stop power conversion. | R/W word | IEEE | V | Yes | 1.35, 0x3D66 |
| IOUT_CAL_OFFSET | 0x39 | Offset for READ_IOUT. | R/W word | IEEE | A | Yes | 0.1, 0x2E66 |
| VOUT_OV_FAULT_LIMIT | 0x40 | Output overvoltage (OV) fault limit. | R/W word | IEEE | V | Yes | 0.55, 0x3866 |
| VOUT_OV_FAULT_RESPONSE | 0x41 | Action to be taken by the device when an output overvoltage fault is detected. | R/W byte | Register | | Yes | 0xB8 |
| VOUT_OV_WARN_LIMIT | 0x42 | Output overvoltage warning limit. | R/W word | IEEE | V | Yes | 0.537, 0x384C |
| VOUT_UV_WARN_LIMIT | 0x43 | Output undervoltage (UV) warning limit. | R/W word | IEEE | V | Yes | 0.467, 0x3779 |
| VOUT_UV_FAULT_LIMIT | 0x44 | Output undervoltage fault limit. | R/W word | IEEE | V | Yes | 0.465, 0x3770 |
| VOUT_UV_FAULT_RESPONSE | 0x45 | Action to be taken by the device when an output undervoltage fault is detected. | R/W byte | Register | | Yes | 0x00 |
| IOUT_OC_FAULT_RESPONSE | 0x47 | Action to be taken by the device when an output overcurrent fault is detected. | R/W byte | Register | | Yes | 0x00 |
| IOUT_OC_WARN_LIMIT | 0x4A | Output overcurrent warning limit. | R/W word | IEEE | A | Yes | 20.0, 0x4D00 |
| OT_FAULT_LIMIT | 0x4F | Internal overtemperature fault limit. | R/W word | IEEE | °C | Yes | 160.0, 0x5900 |
| OT_FAULT_RESPONSE | 0x50 | Action to be taken by the device when an internal overtemperature fault is detected. | R/W byte | Register | | Yes | 0xC0 |
| OT_WARN_LIMIT | 0x51 | Internal overtemperature warning limit. | R/W word | IEEE | °C | Yes | 140.0, 0x5860 |
| VIN_OV_FAULT_RESPONSE | 0x56 | Action to be taken by the device when an input overvoltage fault is detected. | R/W byte | Register | | Yes | 0xB8 |
| VIN_UV_WARN_LIMIT | 0x58 | Input supply undervoltage warning limit. | R/W word | IEEE | V | Yes | -1.0, 0xBC00 |
| TON_DELAY | 0x60 | Time from RUN and/or OPERATION on to output rail turn-on. | R/W word | IEEE | ms | Yes | 0.0, 0x0000 |
| TON_RISE | 0x61 | Time from when the output starts to rise until the output voltage reaches the V _{OUT} commanded value. | R/W word | IEEE | ms | Yes | 1.0, 0x3C00 |
| TON_MAX_FAULT_LIMIT | 0x62 | Maximum time from the start of TON_RISE for V _{OUT} to cross the VOUT_UV_FAULT_LIMIT. | R/W word | IEEE | ms | Yes | 5.0, 0x4500 |
| TON_MAX_FAULT_RESPONSE | 0x63 | Action to be taken by the device when a TON_MAX_FAULT event is detected. | R/W byte | Register | | Yes | 0x00 |
| TOFF_DELAY | 0x64 | Time from RUN and/or OPERATION off to the start of TOFF_FALL ramp. | R/W word | IEEE | ms | Yes | 0.0, 0x0000 |
| TOFF_FALL | 0x65 | Time from when the output starts to fall until the output reaches zero volts. | R/W word | IEEE | ms | Yes | 2.0, 0x4000 |
| TOFF_MAX_WARN_LIMIT | 0x66 | Maximum allowed time, after TOFF_FALL completed, for the unit to decay below MFR_DISCHARGE_THRESHOLD. | R/W word | IEEE | ms | Yes | 0.0, 0x0000 |
| STATUS_BYTE | 0x78 | One byte summary of the unit fault condition. | R/W byte | Register | | No | |

PMBUS COMMAND SUMMARY

Table 1. Supported PMBus and MFR Commands¹ (Continued)

| Command Name ² | Command Code | Description | Type | Data Format | Unit | NVM ³ | Default Value |
|-------------------------------|--------------|--|----------|-------------|------|------------------|--------------------|
| STATUS_WORD | 0x79 | Two byte summary of the unit fault condition. | R/W word | Register | | No | |
| STATUS_VOUT | 0x7A | Output voltage fault and warning status. | R/W byte | Register | | No | |
| STATUS_IOUT | 0x7B | Output current fault and warning status. | R/W byte | Register | | No | |
| STATUS_INPUT | 0x7C | Input supply fault and warning status. | R/W byte | Register | | No | |
| STATUS_TEMPERATURE | 0x7D | Internal temperature fault and warning status for READ_TEMPERATURE_1. | R/W byte | Register | | No | |
| STATUS_CML | 0x7E | Communication and memory fault and warning status. | R/W byte | Register | | No | |
| STATUS_MFR_SPECIFIC | 0x80 | Manufacturer specific fault and state information. | R/W byte | Register | | No | |
| READ_VIN | 0x88 | Measured input supply voltage. | R word | IEEE | V | No | |
| READ_VOUT | 0x8B | Measured output voltage. | R word | IEEE | V | No | |
| READ_IOUT | 0x8C | Measured output current. | R word | IEEE | A | No | |
| READ_TEMPERATURE_1 | 0x8D | Measured internal temperature. | R word | IEEE | °C | No | |
| READ_FREQUENCY | 0x95 | Measured PWM switching frequency. | R word | IEEE | | No | |
| PMBUS_REVISION | 0x98 | PMBus revision supported by this device. Current revision is 1.3. | R byte | Register | | No | 0x33 |
| MFR_ID | 0x99 | The manufacturer ID in ASCII. | R block | | | | ADI |
| MFR_SERIAL | 0x9E | Unique part serial number. | R block | | | | |
| IC_DEVICE_ID | 0xAD | Identification of the IC in ASCII. | R block | | | | LT7170 or LT7170-1 |
| IC_DEVICE_REV | 0xAE | Revision of the IC. | R block | | | | |
| MFR_NVM_UNLOCK | 0xBD | Contact factory. Only used for MFR_NVM_DATA bulk programming. | | | | | |
| MFR_NVM_USER_WRITES_REMAINING | 0xBE | Number of STORE_USER_ALL writes remaining. | R byte | Register | | No | |
| MFR_NVM_DATA | 0xBF | Contact factory. Used for bulk programming. Not needed for STORE_USER_ALL. | | | | | |
| MFR_USER_DATA_00 | 0xC9 | NVM word available for user. | R/W word | Register | | Yes | 0x0000 |
| MFR_USER_DATA_01 | 0xCA | NVM word available for user. | R/W word | Register | | Yes | 0x0000 |
| MFR_READ_EXTVCC | 0xCD | Measured EXTV _{CC} voltage, when enabled. | R word | IEEE | V | No | |
| MFR_READ_ITH | 0xCE | Measured I _{TH} voltage, when enabled. | R word | IEEE | V | No | |
| MFR_CHAN_CONFIG_LT7170 | 0xD0 | Configuration bits that are channel specific. | R/W word | Register | | Yes | 0x0240 |
| MFR_CONFIG_ALL_LT7170 | 0xD1 | General configuration bits. | R/W word | Register | | Yes | 0x0000 |
| MFR_PWM_MODE_LT7170 | 0xD4 | Configuration for the PWM engine. | R/W word | Register | | Yes | 0x0FDC |
| MFR_IOUT_PEAK | 0xD7 | Reports the maximum measured value of READ_IOUT since last MFR_CLEAR_PEAKS. | R word | IEEE | A | No | |
| MFR_ADC_CONTROL_LT7170 | 0xD8 | Configures the update rate of the measurements taken by the analog-to-digital converter (ADC). | R/W byte | Register | | Yes | 0x06 |
| MFR_RETRY_DELAY | 0xDB | Retries interval during fault retry mode. | R/W word | IEEE | ms | Yes | 10.0, 0x4900 |

PMBUS COMMAND SUMMARY

Table 1. Supported PMBus and MFR Commands¹ (Continued)

| Command Name ² | Command Code | Description | Type | Data Format | Unit | NVM ³ | Default Value |
|---------------------------|--------------|---|-----------|-------------|------|------------------|---------------|
| MFR_VOUT_PEAK | 0xDD | Maximum measured value of READ_VOUT since last MFR_CLEAR_PEAKS. | R/W word | IEEE | V | No | |
| MFR_VIN_PEAK | 0xDE | Maximum measured value of READ_VIN since last MFR_CLEAR_PEAKS. | R/W word | IEEE | V | No | |
| MFR_TEMPERATURE_1_PEAK | 0xDF | Maximum measured value of internal temperature (READ_TEMPERATURE_1) since last MFR_CLEAR_PEAKS. | R/W word | IEEE | °C | No | |
| MFR_READ_PWM_CFG | 0xE0 | Measured PWM_CFG resistor value. | R word | IEEE | kΩ | No | |
| MFR_READ_VOUT_CFG | 0xE1 | Measured VOUT_CFG resistor value. | R word | IEEE | kΩ | No | |
| MFR_CLEAR_PEAKS | 0xE3 | Clears all peak values. | Send byte | | | | |
| MFR_DISCHARGE_THRESHOLD | 0xE4 | Output voltage used to determine output has decayed sufficiently to reenable the channel. | R/W word | IEEE | | Yes | 0.2, 0x3266 |
| MFR_PADS_LT7170 | 0xE5 | Digital status of the I/O pads. | R word | Register | | No | |
| MFR_ADDRESS | 0xE6 | Sets the 7-bit I ² C address byte. | R/W word | Register | | Yes | 0x4F |
| MFR_SPECIAL_ID | 0xE7 | ID code used by manufacturer. | R word | Register | | No | 0x1C1D |
| MFR_COMMON | 0xEF | Manufacturer status bits that are common across multiple Analog Devices chips. | R byte | Register | | No | |
| MFR_COMPARE_USER_ALL | 0xF0 | Compares current command contents with NVM. | Send byte | | | | |
| MFR_CHANNEL_STATE | 0xF1 | Returns the state of the channel. | R byte | Register | | No | |
| MFR_PGOOD_DELAY | 0xF2 | Time output voltage must be between UV and OV before PGOOD pin transitions high. | R/W word | IEEE | ms | Yes | 1.0, 0x3C00 |
| MFR_NOT_PGOOD_DELAY | 0xF3 | Time output voltage must be below UV or above OV before PGOOD pin transitions low. | R/W word | IEEE | ms | Yes | 0.1, 0x2E66 |
| MFR_PWM_PHASE_LT7170 | 0xF5 | Sets PWM phase. | R/W byte | Register | | Yes | 0x00 |
| MFR_SYNC_CONFIG_LT7170 | 0xF6 | SYNC/PWM_CFG pin input/output configuration. | R/W byte | Register | | Yes | 0x00 |
| MFR_PIN_CONFIG_STATUS | 0xF7 | Pin configuration fault status. | R byte | Register | | No | |
| MFR_RAIL_ADDRESS | 0xFA | Common address to adjust common parameters. | R/W byte | Register | | Yes | 0x80 |
| MFR_DISABLE_OUTPUT | 0xFB | Disables regulator outputs until reset. | R/W byte | Register | | No | 0x00 |
| MFR_NVM_USER_WP | 0xFC | Disables commands that write user NVM. | R/W byte | Register | | Yes | 0x00 |
| MFR_RESET | 0xFD | Commanded reset without requiring a power-down. | Send byte | | | | |

¹ Empty cells mean not applicable.

² Do not assume compatibility of commands between different devices based upon command names. Always refer to the data sheet of the manufacturer for each device for a complete definition of the function of the command. Analog Devices strives to keep command functionality compatible between all Analog Devices devices. However, differences can be introduced to address specific product requirements.

³ Commands indicated with Y in the NVM column indicate that these commands are stored and restored using the STORE_USER_ALL and RESTORE_USER_ALL commands, respectively.

PMBUS COMMAND SUMMARY

Table 2. Abbreviations of Supported Data Formats¹

| | PMBus Terminology | PMBus Specification Reference | Definition | Example |
|----------|--|-------------------------------|--|--|
| Register | | | Per bit meaning defined in each command description. | PMBus STATUS_BYTE command |
| IEEE | IEEE 754 half-precision floating point | Rev 1.3.1 Part II 8.4.4 | Floating point 16-bit data: for normal values, $value = (-1)^S \times 2^{N-15} \times \left(1 + \frac{M}{1024}\right)$, where S = Bits[15], N = Bits[14:10], M = Bits[9:0]. | Bits[15:0] = 0x4580 = $(-1)^0 \times 2^{17-15} \times \left(1 + \frac{384}{1024}\right) = 5.5$ |

¹ Empty cells are left blank intentionally.

PMBUS COMMAND DETAILS

ADDRESSING AND WRITE PROTECTION

Table 3. Addressing and Write Protection Commands

| Command Name | Code | Description | Type | NVM | Default Value ¹ |
|------------------|------|---|-------------------|-----|----------------------------|
| PAGE | x00 | Channel (page) selected for any paged command. | R/W byte | No | 0x00 |
| PAGE_PLUS_WRITE | 0x05 | Writes a command directly to a specified page. | W block | No | N/A |
| PAGE_PLUS_READ | 0x06 | Reads a command directly from a specified page. | Block R/W process | No | N/A |
| ZONE_CONFIG | 0x07 | Specifies zone number for selected page. | R/W word | Yes | 0xFEFE |
| ZONE_ACTIVE | 0x08 | Sets active zone number. | R/W word | No | 0xFEFE |
| WRITE_PROTECT | 0x10 | Protects the device from unintended PMBus modifications. | R/W byte | Yes | 0x00 |
| MFR_ADDRESS | 0xE6 | Specifies right-justified 7-bit device address. | R/W byte | Yes | 0x4F |
| MFR_RAIL_ADDRESS | 0xFA | Specifies right-justified 7-bit address for channels to be controlled together. | R/W byte | Yes | 0x80 |

¹ N/A means not applicable.

PAGE

The PAGE command provides the ability to configure, control, and monitor multiple channels through only one physical address, either the device address or global address 0x5B (7-bit address).

The LT7170/LT7170-1 have only one channel, and the PAGE command can only be 0x00 or 0xFF. Both values have the same effect. PAGE 0xFF is used to select all channels in multichannel devices. The PAGE command is included only for compatibility with other PMBus devices.

PAGE_PLUS_WRITE

The PAGE_PLUS_WRITE command provides a way to select the page within the LT7170/LT7170-1, sends a command, and then sends the data for the command, all in one communication packet. Commands allowed by the present write protection level can be sent with PAGE_PLUS_WRITE.

The value stored in the PAGE command is not affected by PAGE_PLUS_WRITE. If PAGE_PLUS_WRITE is used to send a nonpaged command, the page number byte is ignored.

Note that PAGE_PLUS commands cannot be nested. A PAGE_PLUS command cannot be used to read or write another PAGE_PLUS command. If this is attempted, the LT7170/LT7170-1 refuse to acknowledge the entire PAGE_PLUS packet and issue a CML fault for invalid/unsupported data.

The PAGE_PLUS_WRITE command cannot be used to write the PAGE command.

If the PAGE_PLUS_WRITE command is sent during a ZONE_WRITE, the page field is used as the effective zone. The page field overrides the write zone of ZONE_ACTIVE for this PAGE_PLUS_WRITE only.

The LT7170/LT7170-1 have only one page, and the PAGE_PLUS_WRITE command is included only for compatibility with other PMBus devices.

PAGE_PLUS_READ

The PAGE_PLUS_READ command provides the ability to select the page within the LT7170/LT7170-1, sends a command, and then reads the data returned by the command, all in one communication packet.

The value stored in the PAGE command is not affected by PAGE_PLUS_READ. If PAGE_PLUS_READ is used to access data from a nonpaged command, the page number byte is ignored.

Note that PAGE_PLUS commands cannot be nested. A PAGE_PLUS command cannot be used to read or write another PAGE_PLUS command. If this is attempted, the LT7170/LT7170-1 refuse to acknowledge the entire PAGE_PLUS packet and issue a CML fault for invalid/unsupported data.

The PAGE_PLUS_READ command cannot be used to read the PAGE command.

The LT7170/LT7170-1 have only one page, and the PAGE_PLUS_READ command is included only for compatibility with other PMBus devices.

PMBUS COMMAND DETAILS

ZONE_CONFIG

The ZONE_CONFIG command is used to assign the currently selected channel to a specific zone number for ZONE_WRITE operations. Zone configuration only needs to be performed once, but zone numbers can be changed at any time.

The zone of the channel can be assigned to any zone number between 0x00 and 0x7F. It can also be set to 0xFE, which means no zone. Any channel programmed to no zone ignores ZONE_WRITE operations.

The ZONE_CONFIG command uses the SMBus word write and word read protocols.

Table 4. ZONE_CONFIG Bits and Meaning

| Bits | Meaning |
|--------|---------------|
| [15:8] | Must be 0xFE |
| [7:0] | Assigned zone |

ZONE_ACTIVE

The ZONE_ACTIVE command sets the active zone for ZONE_WRITE operations. When ZONE_WRITE is sent by the bus controller, the active zone controls which channels are affected by that write.

The active zone can be set to any zone number between 0x00 and 0x7F. The active zone can also be set to 0xFF, which means all zone. If a ZONE_WRITE is sent while the active zone is set to all zone, any channel not programmed to no zone via ZONE_CONFIG is affected by that write.

The ZONE_ACTIVE command must be sent using the ZONE_WRITE address (0x37) as a ZONE_WRITE operation. If the ZONE_ACTIVE command is sent to the global, device, or rail addresses, the invalid command bit is set in STATUS_CML.

Table 5. ZONE_ACTIVE Bits and Meaning

| Bits | Meaning |
|--------|--------------|
| [15:8] | Must be 0xFE |
| [7:0] | Active zone |

WRITE_PROTECT

The WRITE_PROTECT command is used to control writing to the LT7170/LT7170-1. When WRITE_PROTECT is set to 0x00, writes to all commands are enabled.

The PAGE_PLUS_WRITE command can be used to write any command that is not write protected. The PAGE_PLUS_READ command can be used to read any command.

Table 6. WRITE_PROTECT Byte and Meaning

| Byte | Meaning |
|------|---|
| 0x80 | Disable all writes except to the WRITE_PROTECT, PAGE, MFR_NVM_UNLOCK, and STORE_USER_ALL commands. |
| 0x40 | Disable all writes except to the WRITE_PROTECT, PAGE, MFR_NVM_UNLOCK, MFR_CLEAR_PEAKS, STORE_USER_ALL, OPERATION, and CLEAR_FAULTS commands. Individual fault bits can be cleared by writing a 1 to the respective bits in the STATUS registers. |
| 0x20 | Disable all writes except to the WRITE_PROTECT, OPERATION, MFR_NVM_UNLOCK, MFR_CLEAR_PEAKS, CLEAR_FAULTS, PAGE, ON_OFF_CONFIG, VOUT_COMMAND, and STORE_USER_ALL commands. Individual fault bits can be cleared by writing a 1 to the respective bits in the STATUS registers. |
| 0x10 | Reserved, must be 0. |
| 0x08 | Reserved, must be 0. |
| 0x04 | Reserved, must be 0. |
| 0x02 | Reserved, must be 0. |
| 0x01 | Reserved, must be 0. |

PMBUS COMMAND DETAILS

MFR_ADDRESS

The MFR_ADDRESS command byte sets the seven bits of the PMBus device address.

Setting this command to a value of 0x80 disables device addressing. The global device addresses, Address 0x5A and Address 0x5B, cannot be deactivated.

Table 7. Illegal Values for MFR_ADDRESS

| Address | Other Use |
|---------|-------------------------|
| 0x0C | ARA protocol address |
| 0x37 | Zone write |
| 0x5A | Global all rail address |
| 0x5B | Global address |

Attempting to set the MFR_ADDRESS command to illegal values sets a CML invalid data fault.

After changing the device address, leave at least 10 μ s for the new address to take effect before starting a new PMBus transaction.

The LT7170/LT7170-1 always respond to the global addresses, Address 0x5A and Address 0x5B. Writes to Address 0x5A affect all pages, and reads target Page 0, as if PAGE = 0xFF.

MFR_RAIL_ADDRESS

The MFR_RAIL_ADDRESS command enables direct device address access to the currently selected channel. Writing this command sets the rail address for the currently selected channel. The value of this command is common to all devices attached to a single power supply rail.

Setting this command to a value of 0x80 disables rail device addressing for the selected channel.

Attempting to set MFR_RAIL_ADDRESS to an illegal address, as defined in the [MFR_ADDRESS](#) section, sets a CML invalid data fault.

Writing the PAGE_PLUS_READ or PAGE_PLUS_WRITE command to the rail address sets a CML invalid command fault.

Reading from the rail address results in a CML other fault.

After changing the rail address, leave at least 10 μ s for the new address to take effect before starting a new PMBus transaction.

GENERAL CONFIGURATION

Table 8. General Configuration Commands

| Command Name | Code | Description | Type | NVM | Default Value |
|------------------------|------|---|----------|-----|---------------|
| MFR_CHAN_CONFIG_LT7170 | 0xD0 | Configuration bits that are channel specific. | R/W word | Yes | 0x0240 |
| MFR_CONFIG_ALL_LT7170 | 0xD1 | Configuration bits common to all channels. | R/W word | Yes | 0x0000 |

MFR_CHAN_CONFIG_LT7170

The MFR_CHAN_CONFIG_LT7170 command sets various per channel configuration bits.

Table 9. MFR_CHAN_CONFIG_LT7170 Bits

| Bits | Default | Meaning |
|---------|---------|--|
| [15:11] | 00000 | Reserved. |
| 10 | 0 | Reserved. |
| 9 | 1 | 0 = Top switch drive strength normal. 1 = Top switch drive strength high. |
| 8 | 0 | Reserved. |
| 7 | 0 | Reserved. |
| 6 | 1 | Reserved. Must be 1. |
| [5:3] | 000 | Reserved. |

PMBUS COMMAND DETAILS

Table 9. MFR_CHAN_CONFIG_LT7170 Bits (Continued)

| Bits | Default | Meaning | | | | | | | | | | | | | | | |
|--------------------|---|---|-------|------------------------|---|---|---------|-------|---|--------|-------|---|-------|-------|---|---|--|
| [2:1] ¹ | 0 | Output voltage range. | | | | | | | | | | | | | | | |
| | | <table border="1"> <thead> <tr> <th>Value</th> <th>Maximum Output Voltage</th> <th>Minimum Recommended Output Voltage²</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>1.375 V</td> <td>0.4 V</td> </tr> <tr> <td>1</td> <td>2.75 V</td> <td>0.8 V</td> </tr> <tr> <td>2</td> <td>5.5 V</td> <td>1.6 V</td> </tr> <tr> <td>3</td> <td colspan="2">Invalid; writing this causes CML invalid data</td> </tr> </tbody> </table> | Value | Maximum Output Voltage | Minimum Recommended Output Voltage ² | 0 | 1.375 V | 0.4 V | 1 | 2.75 V | 0.8 V | 2 | 5.5 V | 1.6 V | 3 | Invalid; writing this causes CML invalid data | |
| Value | Maximum Output Voltage | Minimum Recommended Output Voltage ² | | | | | | | | | | | | | | | |
| 0 | 1.375 V | 0.4 V | | | | | | | | | | | | | | | |
| 1 | 2.75 V | 0.8 V | | | | | | | | | | | | | | | |
| 2 | 5.5 V | 1.6 V | | | | | | | | | | | | | | | |
| 3 | Invalid; writing this causes CML invalid data | | | | | | | | | | | | | | | | |
| 0 | 0 | Reserved. | | | | | | | | | | | | | | | |

¹ Bit 2 and Bit 1 cannot be set to a value that makes the value in VOUT_COMMAND, VOUT_MARGIN_HIGH, or VOUT_MARGIN_LOW become greater than the maximum value for the selected range.

² Setting the output voltage lower than the minimum recommended output voltage will result in reduced performance.

MFR_CONFIG_ALL_LT7170

The MFR_CONFIG_ALL_LT7170 command sets various global configuration bits.

Table 10. MFR_CONFIG_ALL_LT7170 Bits

| Bits | Default | Meaning |
|--------|---------|---|
| [15:7] | 0000000 | Reserved. |
| 6 | 0 | 0 = Configuration resistors are measured and used to configure the LT7170/LT7170-1 during initialization. 1 = CFG pin configuration resistors are ignored on VOUT_CFG and PWM_CFG pins. |
| [5:3] | 000 | Reserved. |
| 2 | 0 | 0 = Valid PEC not required. 1 = Valid PEC required. |
| 1 | 0 | 0 = Disable PMBus clock stretching. If the LT7170/LT7170-1 are too busy to process a command, the devices refuse to acknowledge the command and set Bit 7 in STATUS_BYTE and STATUS_WORD. 1 = Enable PMBus clock stretching. |
| 0 | 0 | Reserved. |

On, Off, and Margin

Table 11. On, Off, and Margin Commands¹

| Command Name | Code | Description | Type | NVM | Default Value |
|---------------|------|--|-----------|-----|---------------|
| OPERATION | 0x01 | Operating mode control. On/off, margin high, and margin low. | R/W byte | Yes | 0x80 |
| ON_OFF_CONFIG | 0x02 | RUN pin and PMBus OPERATION command configuration. | R/W byte | Yes | 0x1E |
| MFR_RESET | 0xFD | Commanded reset. | Send byte | | |

¹ Empty cells are left blank intentionally.

Operation

The OPERATION command is used to turn the channel on or off in conjunction with the RUN pin, based on the configuration defined in ON_OFF_CONFIG. It is also used to set the output voltage to VOUT_MARGIN_HIGH or VOUT_MARGIN_LOW.

Disabling and then reenabling the channel causes all latched faults and status bits to be cleared.

Table 12 details the OPERATION values supported by the LT7170/LT7170-1.

Table 12. Operation Values

| Function | Value |
|----------------------|-------|
| Turn off immediately | 0x00 |
| Turn on | 0x80 |
| Margin low | 0x98 |

PMBUS COMMAND DETAILS

Table 12. Operation Values (Continued)

| Function | Value |
|--------------|-------|
| Margin high | 0xA8 |
| Sequence off | 0x40 |

ON_OFF_CONFIG

The ON_OFF_CONFIG command configures the combination of the RUN pin input and serial bus commands required to turn the channel on and off.

The only bits allowed to be changed are as follows:

- ▶ Bit 3: when high, the channel only provides output power if the on/off portion of OPERATION is set.
- ▶ Bit 2: when high, the channel only provides output power if the RUN pin is high.
- ▶ Bit 0: when high, the channel performs an immediate shutdown when the RUN pin is deasserted. Bit 0 only has an effect when Bit 2 is also set.

Bit 4 and Bit 1 must both be 1. Setting Bit 4 or Bit 1 to 0 generates a CML fault.

If Bit 2 and Bit 3 of the ON_OFF_CONFIG command are both set to 1 (which is the factory default), the channel only turns on if the RUN pin is high and the OPERATION command is set to enable (on, margin low, or margin high).

MFR_RESET

The MFR_RESET command causes the LT7170/LT7170-1 to reset.

Reading the MFR_RESET command also causes the LT7170/LT7170-1 to reset.

PWM CONFIGURATION

Table 13. PWM Configuration Commands

| Command Name | Code | Description | Type | Unit ¹ | NVM | Default Value |
|------------------------|------|---------------------------------------|----------|-------------------|-----|---------------|
| FREQUENCY_SWITCH | 0x33 | Controller switching frequency | R/W word | kHz | Yes | 1000.0 |
| MFR_PWM_MODE_LT7170 | 0xD4 | PWM configuration, including PWM mode | R/W word | N/A | Yes | 0x0FDC |
| MFR_PWM_PHASE_LT7170 | 0xF5 | Sets PWM phase | R/W word | N/A | Yes | 0x00 |
| MFR_SYNC_CONFIG_LT7170 | 0xF6 | SYNC pin configuration | R/W byte | N/A | Yes | 0x00 |

¹ N/A means not applicable.

FREQUENCY_SWITCH

The FREQUENCY_SWITCH command selects the internal oscillator frequency in 50 kHz steps. The valid range is from 400 kHz to 4 MHz. If the commanded frequency is not a multiple of 50 kHz, the nearest multiple is used.

Regardless of the value of FREQUENCY_SWITCH, if an external clock is present on the SYNC/PWM_CFG pin, the LT7170/LT7170-1 attempt to synchronize the PWM to the external clock, unless Bit 1 or Bit 0 in the MFR_SYNC_CONFIG_LT7170 command is set. If an external clock is to be used for synchronization, it is recommended to program FREQUENCY_SWITCH to the same frequency as the external clock.

The FREQUENCY_SWITCH command has two data bytes encoded in half-precision floating point format.

When Bit 6 of the MFR_CONFIG_ALL_LT7170 command is 0, a configuration resistor on the SYNC/PWM_CFG pin can override stored NVM values for the FREQUENCY_SWITCH command at power-up.

MFR_PWM_MODE_LT7170

Table 14. MFR_PWM_MODE_LT7170 Bits

| Bits | Default | Meaning |
|---------|---------|---|
| [15:11] | 0b00001 | Error Amplifier Transconductance (g_{MEA}) 0.4 V to 1.375 V V_{OUT} range: $g_{MEA} = (\text{Value} + 1) \times 150 \mu\text{S}$ |

PMBUS COMMAND DETAILS

Table 14. MFR_PWM_MODE_LT7170 Bits (Continued)

| Bits | Default | Meaning | | | | | | | | | | | | | | | | | | |
|--------|--|--|-------|--|--|---------------|---------|---------------|---|---------------|--------|---------------|---------|---------------|---|---------------|--------|--------------|---|--------------|
| | | 0.8 V to 2.75 V V_{OUT} range: $g_{MEA} = (Value + 1) \times 75 \mu S$ 1.6 V to 5.5 V V_{OUT} range: $g_{MEA} = (Value + 1) \times 37.5 \mu S$ | | | | | | | | | | | | | | | | | | |
| [10:9] | 0b11 | Current Limit Selection ¹ | | | | | | | | | | | | | | | | | | |
| | | <table border="1"> <thead> <tr> <th>Value</th> <th>Positive Valley Current Limit, $I_{LIM-POS}$ (Typical)</th> <th>Negative Valley Current Limit, $I_{LIM-NEG}$ (Typical)</th> </tr> </thead> <tbody> <tr> <td>3</td> <td>+21.4 A</td> <td>-12.0 A</td> </tr> <tr> <td>2</td> <td>+15.6 A</td> <td>-9.4 A</td> </tr> <tr> <td>1</td> <td>+13.0 A</td> <td>-7.6 A</td> </tr> <tr> <td>0</td> <td>+9.0 A</td> <td>-6.0 A</td> </tr> </tbody> </table> | Value | Positive Valley Current Limit, $I_{LIM-POS}$ (Typical) | Negative Valley Current Limit, $I_{LIM-NEG}$ (Typical) | 3 | +21.4 A | -12.0 A | 2 | +15.6 A | -9.4 A | 1 | +13.0 A | -7.6 A | 0 | +9.0 A | -6.0 A | | | |
| Value | Positive Valley Current Limit, $I_{LIM-POS}$ (Typical) | Negative Valley Current Limit, $I_{LIM-NEG}$ (Typical) | | | | | | | | | | | | | | | | | | |
| 3 | +21.4 A | -12.0 A | | | | | | | | | | | | | | | | | | |
| 2 | +15.6 A | -9.4 A | | | | | | | | | | | | | | | | | | |
| 1 | +13.0 A | -7.6 A | | | | | | | | | | | | | | | | | | |
| 0 | +9.0 A | -6.0 A | | | | | | | | | | | | | | | | | | |
| [8:6] | 0b111 | Internal Compensation Capacitor Value, C_{ITH} | | | | | | | | | | | | | | | | | | |
| | | <table border="1"> <thead> <tr> <th>Value</th> <th>C_{ITH} Capacitor Value</th> </tr> </thead> <tbody> <tr> <td>7</td> <td>320 pF</td> </tr> <tr> <td>6</td> <td>280 pF</td> </tr> <tr> <td>5</td> <td>240 pF</td> </tr> <tr> <td>4</td> <td>200 pF</td> </tr> <tr> <td>3</td> <td>160 pF</td> </tr> <tr> <td>2</td> <td>120 pF</td> </tr> <tr> <td>1</td> <td>80 pF</td> </tr> <tr> <td>0</td> <td>40 pF</td> </tr> </tbody> </table> | Value | C_{ITH} Capacitor Value | 7 | 320 pF | 6 | 280 pF | 5 | 240 pF | 4 | 200 pF | 3 | 160 pF | 2 | 120 pF | 1 | 80 pF | 0 | 40 pF |
| Value | C_{ITH} Capacitor Value | | | | | | | | | | | | | | | | | | | |
| 7 | 320 pF | | | | | | | | | | | | | | | | | | | |
| 6 | 280 pF | | | | | | | | | | | | | | | | | | | |
| 5 | 240 pF | | | | | | | | | | | | | | | | | | | |
| 4 | 200 pF | | | | | | | | | | | | | | | | | | | |
| 3 | 160 pF | | | | | | | | | | | | | | | | | | | |
| 2 | 120 pF | | | | | | | | | | | | | | | | | | | |
| 1 | 80 pF | | | | | | | | | | | | | | | | | | | |
| 0 | 40 pF | | | | | | | | | | | | | | | | | | | |
| [5:3] | 0b011 | Internal Compensation Lead Resistor Value, R_{ITH} | | | | | | | | | | | | | | | | | | |
| | | <table border="1"> <thead> <tr> <th>Value</th> <th>R_{ITH} Resistor Value</th> </tr> </thead> <tbody> <tr> <td>7</td> <td>60 kΩ</td> </tr> <tr> <td>6</td> <td>42 kΩ</td> </tr> <tr> <td>5</td> <td>29 kΩ</td> </tr> <tr> <td>4</td> <td>20 kΩ</td> </tr> <tr> <td>3</td> <td>14 kΩ</td> </tr> <tr> <td>2</td> <td>10 kΩ</td> </tr> <tr> <td>1</td> <td>7 kΩ</td> </tr> <tr> <td>0</td> <td>5 kΩ</td> </tr> </tbody> </table> | Value | R_{ITH} Resistor Value | 7 | 60 k Ω | 6 | 42 k Ω | 5 | 29 k Ω | 4 | 20 k Ω | 3 | 14 k Ω | 2 | 10 k Ω | 1 | 7 k Ω | 0 | 5 k Ω |
| Value | R_{ITH} Resistor Value | | | | | | | | | | | | | | | | | | | |
| 7 | 60 k Ω | | | | | | | | | | | | | | | | | | | |
| 6 | 42 k Ω | | | | | | | | | | | | | | | | | | | |
| 5 | 29 k Ω | | | | | | | | | | | | | | | | | | | |
| 4 | 20 k Ω | | | | | | | | | | | | | | | | | | | |
| 3 | 14 k Ω | | | | | | | | | | | | | | | | | | | |
| 2 | 10 k Ω | | | | | | | | | | | | | | | | | | | |
| 1 | 7 k Ω | | | | | | | | | | | | | | | | | | | |
| 0 | 5 k Ω | | | | | | | | | | | | | | | | | | | |
| 2 | 1 | Reserved. | | | | | | | | | | | | | | | | | | |
| 1 | 0 | Reserved. | | | | | | | | | | | | | | | | | | |
| 0 | 0 | Reserved. | | | | | | | | | | | | | | | | | | |

¹ The LT7170-1 per-phase current limits are half of the LT7170 current limit settings. For example, for current limit 0, the LT7170-1 positive current limit is 4.5 A per phase, for a total of 9 A.

When Bit 6 of the MFR_CONFIG_ALL_LT7170 command is 0, configuration resistors, if populated, override stored NVM values for the MFR_PWM_MODE_LT7170 command at power-up.

MFR_PWM_PHASE_LT7170

The MFR_PWM_PHASE_LT7170 command sets the channel PWM phase.

Table 15. MFR_PWM_PHASE_LT7170 Value and Phase

| Value | Phase |
|-------|-------|
| 0x00 | 0° |
| 0x01 | 15° |
| 0x02 | 30° |
| 0x03 | 45° |
| 0x04 | 60° |

PMBUS COMMAND DETAILS

Table 15. MFR_PWM_PHASE_LT7170 Value and Phase (Continued)

| Value | Phase |
|-------|-------|
| 0x05 | 75° |
| 0x06 | 90° |
| 0x07 | 105° |
| 0x08 | 120° |
| 0x09 | 135° |
| 0x0a | 150° |
| 0x0b | 165° |
| 0x0c | 180° |
| 0x0d | 195° |
| 0x0e | 210° |
| 0x0f | 225° |
| 0x10 | 240° |
| 0x11 | 255° |
| 0x12 | 270° |
| 0x13 | 285° |
| 0x14 | 300° |
| 0x15 | 315° |
| 0x16 | 330° |
| 0x17 | 345° |

When Bit 6 of the MFR_CONFIG_ALL_LT7170 command is 0, configuration resistors, if populated, override stored NVM values for the MFR_PWM_PHASE_LT7170 command at power-up.

MFR_SYNC_CONFIG_LT7170

Table 16. MFR_SYNC_CONFIG_LT7170 Bits

| Bits | Default | Meaning |
|-------|---------|--|
| [7:2] | 000000 | Must be 0. |
| 1 | 0 | 0 = SYNC clock input is used if applied. 1 = Ignore SYNC clock input. Note that the SYNC clock input is always ignored if the SYNC output is enabled (Bit 0 high). Note that even if Bit 1 is set, an external clock on SYNC may not be ignored during reset. If an external clock is applied to SYNC at POR and the configuration resistor function has not been disabled (that is, Bit 6 of the MFR_CONFIG_ALL_LT7170 command is set to its factory default value of 0 in NVM), the LT7170/LT7170-1 configure internal settings as described in the Theory of Operation section of the main data sheet. |
| 0 | 0 | 0 = Disable SYNC output clock. 1 = Enable SYNC output clock (after V_{IN} has risen above V_{IN_ON} for the first time after power is applied). |

When Bit 6 of MFR_CONFIG_ALL_LT7170 is 0, configuration resistors may override stored NVM values for the MFR_SYNC_CONFIG_LT7170 command at power-up.

INPUT VOLTAGE AND LIMITS

Table 17. Input Voltage and Limits Commands

| Command Name | Code | Description | Type | Unit | NVM | Default Value |
|-------------------|------|---|----------|------|-----|---------------|
| VIN_ON | 0x35 | Input voltage at which channel starts power conversion. | R/W word | V | Yes | 1.4 |
| VIN_OFF | 0x36 | Input voltage at which channel stops power conversion. | R/W word | V | Yes | 1.35 |
| VIN_UV_WARN_LIMIT | 0x58 | Input supply undervoltage warning limit. | R/W word | V | Yes | -1.0 |

VIN_ON

The VIN_ON command sets the value of the V_{IN} voltage, in volts, at which the LT7170/LT7170-1 start power conversion.

Note that the LT7170/LT7170-1 regulator does not start unless either $EXTV_{CC}$ or V_{IN} is more than 2.9 V.

PMBUS COMMAND DETAILS

This command has two data bytes encoded in half-precision floating point format.

- ▶ Maximum = 16.0 V
- ▶ Minimum = 1.4 V

VIN_OFF

The VIN_OFF command sets the value of the V_{IN} voltage, in volts, at which the LT7170/LT7170-1 stop power conversion.

This command has two data bytes encoded in half-precision floating point format.

- ▶ Maximum = 16.0 V
- ▶ Minimum = 1.35 V

VIN_UV_WARN_LIMIT

The VIN_UV_WARN_LIMIT command sets the value of the input voltage that causes an input voltage low warning.

This alarm is masked until the input exceeds the warning limit at least one time since the LT7170/LT7170-1 have been powered.

In response to the VIN_UV_WARN_LIMIT being exceeded, the device also does the following:

- ▶ Sets the NONE_OF_THE_ABOVE bit in the STATUS_BYTE command
- ▶ Sets the INPUT bit in the STATUS_WORD command
- ▶ Sets the VIN undervoltage warning bit in the STATUS_INPUT command
- ▶ Notifies the host by asserting \overline{ALERT} pin low, unless masked

This VIN_UV_WARN_LIMIT command has two data bytes encoded in half-precision floating point format.

- ▶ Maximum = 22.0 V
- ▶ Minimum = -1.0 V

The input voltage low warning is detected by the ADC. Typical response time is less than 5 ms in continuous monitor mode and is less than 100 ms in low power mode. Note that this response delay occurs even when the previous ADC measurement is under the new VIN_UV_WARN_LIMIT command.

OUTPUT VOLTAGE AND LIMITS

Table 18. Output Voltage and Limits Commands

| Command Name | Code | Description | Type | Unit ¹ | NVM | Default Value |
|-------------------------|------|--|----------|-------------------|-----|---------------|
| VOUT_MODE | 0x20 | Output voltage format and exponent. | R byte | N/A | No | 0x60 |
| VOUT_COMMAND | 0x21 | Nominal output voltage set point. | R/W word | V | Yes | 0.5 |
| VOUT_MAX | 0x24 | Upper limit on the commanded output voltage. | R/W word | V | Yes | 0.537 |
| VOUT_MARGIN_HIGH | 0x25 | Margin high output voltage set point. | R/W word | V | Yes | 0.525 |
| VOUT_MARGIN_LOW | 0x26 | Margin low output voltage set point. | R/W word | V | Yes | 0.475 |
| VOUT_OV_FAULT_LIMIT | 0x40 | Output overvoltage fault limit. | R/W word | V | Yes | 0.55 |
| VOUT_OV_WARN_LIMIT | 0x42 | Output overvoltage warning limit. | R/W word | V | Yes | 0.537 |
| VOUT_UV_WARN_LIMIT | 0x43 | Output undervoltage warning limit. | R/W word | V | Yes | 0.467 |
| VOUT_UV_FAULT_LIMIT | 0x44 | Output undervoltage fault limit. | R/W word | V | Yes | 0.465 |
| MFR_DISCHARGE_THRESHOLD | 0xE4 | Voltage threshold that determines output has decayed sufficiently. | R/W word | V | Yes | 0.2 |
| MFR_PGOOD_DELAY | 0xF2 | Time output voltage must be between UV and OV before PGOOD transitions high. | R/W word | ms | Yes | 1.0 |
| MFR_NOT_PGOOD_DELAY | 0xF3 | Time output voltage must be below UV or above OV before PGOOD transitions low. | R/W word | ms | Yes | 0.1 |

¹ N/A means not applicable.

PMBUS COMMAND DETAILS

VOUT_MODE

The read-only VOUT_MODE command returns 0x60, indicating that the output voltage commands use IEEE half-precision floating point format.

VOUT_COMMAND

The VOUT_COMMAND command sets the output voltage when the OPERATION command has selected VOUT_COMMAND, and uses half-precision floating point format.

If OPERATION is set to 0x80 (turn on the output with the target voltage of VOUT_COMMAND) and VOUT_COMMAND is a greater than VOUT_MAX, the target output voltage is limited to VOUT_MAX. When VOUT_COMMAND is commanded to a value greater than VOUT_MAX, a VOUT_MAX warning occurs.

When Bit 6 of MFR_CONFIG_ALL_LT7170 is 0, configuration resistors may override stored NVM values for this command at power-up.

Bits[2:1] of MFR_CHAN_CONFIG_LT7170 select the output voltage range. See Table 9 for the recommended minimum output voltage for each voltage range.

Table 19. Output Voltage Range Maximums and Minimums

| 1.375 V V _{OUT} Range | 2.75 V V _{OUT} Range | 5.5 V V _{OUT} Range |
|--------------------------------|-------------------------------|------------------------------|
| 1.375 V maximum | 2.75 V maximum | 5.5 V maximum |
| 0.4 V minimum | 0.4 V minimum | 0.4 V minimum |

VOUT_MAX

The VOUT_MAX command sets an upper limit on the commanded voltage. It applies to VOUT_COMMAND, VOUT_MARGIN_HIGH, and VOUT_MARGIN_LOW. If the output voltage is commanded to a value greater than VOUT_MAX, the target output voltage is limited to VOUT_MAX. When VOUT_MAX is lower than VOUT_COMMAND, VOUT_MARGIN_HIGH, or VOUT_MARGIN_LOW, a VOUT_MAX warning occurs.

The VOUT_MAX command uses half-precision floating point format.

- ▶ Maximum = 5.5 V
- ▶ Minimum = 0.4 V

When Bit 6 of MFR_CONFIG_ALL_LT7170 is 0, configuration resistors may override stored NVM values for this command at power-up.

VOUT_MARGIN_HIGH

The VOUT_MARGIN_HIGH command loads the LT7170/LT7170-1 with the voltage to which the output is to be regulated when the OPERATION command is set to 0xA8 (margin high). When OPERATION is set to 0xA8 and VOUT_MARGIN_HIGH is greater than VOUT_MAX, the output voltage is limited to VOUT_MAX. When VOUT_MARGIN_HIGH is commanded to a value greater than VOUT_MAX, a VOUT_MAX warning occurs.

The VOUT_MARGIN_HIGH command uses half-precision floating point format.

When Bit 6 of MFR_CONFIG_ALL_LT7170 is 0, configuration resistors may override stored NVM values for the VOUT_MARGIN_HIGH command at power-up.

Bits[2:1] of MFR_CHAN_CONFIG_LT7170 select the output voltage range.

Table 20. Output Voltage Range Maximums and Minimums

| 1.375 V V _{OUT} Range | 2.75 V V _{OUT} Range | 5.5 V V _{OUT} Range |
|--------------------------------|-------------------------------|------------------------------|
| 1.375 V maximum | 2.75 V maximum | 5.5 V maximum |
| 0.4 V minimum | 0.4 V minimum | 0.4 V minimum |

VOUT_MARGIN_LOW

The VOUT_MARGIN_LOW command loads the LT7170/LT7170-1 with the voltage to which the output is to be changed when the OPERATION command is set to 0x98 (margin low). When OPERATION is set to 0x98 and VOUT_MARGIN_LOW is greater than VOUT_MAX, the output

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voltage is VOUT_MAX. When VOUT_MARGIN_LOW is commanded to a value greater than VOUT_MAX, the VOUT_MAX_WARNING bit in VOUT_STATUS is set.

The VOUT_MARGIN_LOW command uses half-precision floating point format.

When Bit 6 of MFR_CONFIG_ALL_LT7170 is 0, configuration resistors may override stored NVM values for this command at power-up.

Bits[2:1] MFR_CHAN_CONFIG_LT7170 select the output voltage range.

Table 21. Output Voltage Range Maximums and Minimums

| 1.375 V V _{OUT} Range | 2.75 V V _{OUT} Range | 5.5 V V _{OUT} Range |
|--------------------------------|-------------------------------|------------------------------|
| 1.375 V maximum | 2.75 V maximum | 5.5 V maximum |
| 0.4 V minimum | 0.4 V minimum | 0.4 V minimum |

VOUT_OV_FAULT_LIMIT

The VOUT_OV_FAULT_LIMIT command sets the value of the output voltage measured at the VSENSE pins, which causes an output overvoltage fault.

The VOUT_OV_FAULT_LIMIT command uses half-precision floating point format.

- ▶ Maximum = 6.0 V
- ▶ Minimum = 0.4 V

The value must be greater than VOUT_UV_WARN_LIMIT, VOUT_UV_FAULT_LIMIT, and MFR_DISCHARGE_THRESHOLD, or an invalid data error occurs.

When Bit 6 of MFR_CONFIG_ALL_LT7170 is 0, configuration resistors may override stored NVM values for this command at power-up.

VOUT_OV_WARN_LIMIT

The VOUT_OV_WARN_LIMIT command sets the value of the output voltage measured at the VSENSE pins, which causes an output overvoltage warning.

In response to the VOUT_OV_WARN_LIMIT being exceeded, the LT7170/LT7170-1 also do the following:

- ▶ Set the NONE_OF_THE_ABOVE bit in the STATUS_BYTE command.
- ▶ Set the VOUT bit in the STATUS_WORD command.
- ▶ Set the VOUT overvoltage warning bit in the STATUS_VOUT command.
- ▶ Notify the host by asserting the $\overline{\text{ALERT}}$ pin low, unless masked.

The VOUT_OV_WARN_LIMIT command uses half-precision floating point format.

- ▶ Maximum = 6.0 V
- ▶ Minimum = 0.0 V

The value must be greater than VOUT_UV_WARN_LIMIT, VOUT_UV_FAULT_LIMIT, and MFR_DISCHARGE_THRESHOLD, or an invalid data error occurs.

When Bit 6 of MFR_CONFIG_ALL_LT7170 is 0, configuration resistors may override stored NVM values for this command at power-up.

VOUT_UV_WARN_LIMIT

The VOUT_UV_WARN_LIMIT command sets the value of the output voltage measured at the VSENSE pins, which causes an output undervoltage warning.

In response to VOUT_UV_WARN_LIMIT being exceeded, the LT7170/LT7170-1 also do the following:

- ▶ Set the NONE_OF_THE_ABOVE bit in the STATUS_BYTE.
- ▶ Set the VOUT bit in the STATUS_WORD.
- ▶ Set the VOUT undervoltage warning bit in the STATUS_VOUT command.

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- ▶ Notify the host by asserting the $\overline{\text{ALERT}}$ pin low, unless masked.

The `VOUT_UV_WARN_LIMIT` command uses half-precision floating point format.

- ▶ Maximum = 5.5 V
- ▶ Minimum = 0.0 V

The value must be less than `VOUT_OV_WARN_LIMIT` and `VOUT_OV_FAULT_LIMIT`, or an invalid data error occurs.

When Bit 6 of `MFR_CONFIG_ALL_LT7170` is 0, configuration resistors may override stored NVM values for the `VOUT_UV_WARN_LIMIT` command at power-up.

VOUT_UV_FAULT_LIMIT

The `VOUT_UV_FAULT_LIMIT` command sets the value of the output voltage measured at the `VSENSE` pins, which causes an output undervoltage fault.

The `VOUT_UV_FAULT_LIMIT` command uses half-precision floating point format.

- ▶ Maximum = 5.5 V
- ▶ Minimum = 0.36 V

The value must be less than `VOUT_OV_WARN_LIMIT` and `VOUT_OV_FAULT_LIMIT`, or an invalid data error occurs.

When Bit 6 of `MFR_CONFIG_ALL_LT7170` is 0, configuration resistors may override stored NVM values for the `VOUT_UV_FAULT_LIMIT` command at power-up.

MFR_DISCHARGE_THRESHOLD

The `MFR_DISCHARGE_THRESHOLD` command specifies the output voltage threshold below which the output voltage must decay to enable the channel if the discharge threshold feature is enabled (Bit 0 of `MFR_CHAN_CONFIG_LT7170` is 0).

If the discharge threshold is enabled, when automatically retrying after a fault, the device also waits for V_{OUT} to be less than the discharge threshold after waiting `MFR_RETRY_DELAY`.

The value must be less than `VOUT_OV_WARN_LIMIT` and `VOUT_OV_FAULT_LIMIT`, or an invalid data error occurs.

This command uses half-precision floating-point format.

- ▶ Maximum = 2.2 V
- ▶ Minimum = 0.1 V

MFR_PGOOD_DELAY

The `MFR_PGOOD_DELAY` command sets the time in milliseconds, rounded to the nearest 10 μs , that the output voltage must be between `VOUT_OV_FAULT_LIMIT` and `VOUT_UV_FAULT_LIMIT` before the `PGOOD` pin transitions high. If the output voltage moves to less than the undervoltage limit or more than the overvoltage limit before `PGOOD` pin transitions high, the delay timer resets to zero. Note that `PGOOD` is always held low when the channel is off and during `TON_RISE`, regardless of whether V_{OUT} is within the limits.

This command uses half-precision floating-point format.

- ▶ Maximum = 64,000 ms
- ▶ Minimum = 0 ms

MFR_NOT_PGOOD_DELAY

The `MFR_NOT_PGOOD_DELAY` command sets the time in milliseconds, rounded to the nearest 10 μs , that the output voltage must be between `VOUT_OV_FAULT_LIMIT` and `VOUT_UV_FAULT_LIMIT` before the `PGOOD` pin is pulled low. If the output voltage is between the undervoltage and overvoltage limits before `PGOOD` transitions low, the delay timer resets to zero. Note that the `MFR_NOT_PGOOD_DELAY` command only applies when the channel is enabled. If the channel is disabled by the `MFR_NOT_PGOOD_DELAY` command, the `RUN` pin, or a fault condition set to disable the output, the `PGOOD` pin is pulled low immediately.

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This command uses half-precision floating-point format.

- ▶ Maximum = 100 ms
- ▶ Minimum = 0 ms

OUTPUT CURRENT LIMITS

Table 22. Output Current Limits Commands

| Command Name | Code | Description | Type | Unit | NVM | Default Value |
|--------------------|------|----------------------------------|----------|------|-----|---------------|
| IOUT_OC_WARN_LIMIT | 0x4A | Output overcurrent warning limit | R/W word | A | Yes | 20.0 |

IOUT_OC_WARN_LIMIT

The IOUT_OC_WARN_LIMIT command sets the value of the output current that causes an output overcurrent warning in amperes. This value is the total current limit, not per phase.

In response to the IOUT_OC_WARN_LIMIT being exceeded, the LT7170/LT7170-1 do the following:

- ▶ Set the NONE_OF_THE_ABOVE bit in the STATUS_BYTE command.
- ▶ Set the IOUT bit in the STATUS_WORD command.
- ▶ Set the I_{OUT} overcurrent warning bit in the STATUS_IOUT command.
- ▶ Notify the host by asserting the $\overline{\text{ALERT}}$ pin low, unless masked.

The IOUT_OC_WARN_LIMIT command uses half-precision floating point format.

- ▶ Maximum = 20 A
- ▶ Minimum = 0.0 A

The output overcurrent warning is detected by the ADC. Typical response time is less than 5 ms in continuous monitor mode and is less than 100 ms in low power mode.

The IOUT_OC_WARN_LIMIT command is ignored during TON_RISE.

TEMPERATURE

Table 23. Temperature Commands

| Command Name | Code | Description | Type | Unit | NVM | Default Value |
|----------------|------|-------------------------------|----------|------|-----|---------------|
| OT_FAULT_LIMIT | 0x4F | Overtemperature fault limit | R/W word | °C | Yes | 160 |
| OT_WARN_LIMIT | 0x51 | Overtemperature warning limit | R/W word | °C | Yes | 140 |

OT_FAULT_LIMIT

The OT_FAULT_LIMIT command sets the value of the internal die temperature, in degrees Celsius, which causes an overtemperature fault.

This command uses half-precision floating point format.

- ▶ Maximum = +160°C
- ▶ Minimum = -60°C

OT_WARN_LIMIT

The OT_WARN_LIMIT command sets the value of the internal die temperature, in degrees Celsius, which causes an overtemperature warning.

In response to the OT_WARN_LIMIT being exceeded, the LT7170/LT7170-1 do the following:

- ▶ Set the TEMPERATURE bit in the STATUS_BYTE command.
- ▶ Set the overtemperature warning bit in the STATUS_TEMPERATURE command.
- ▶ Notify the host by asserting the $\overline{\text{ALERT}}$ pin low, unless masked.

The OT_WARN_LIMIT command uses half-precision floating point format.

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- ▶ Maximum = +160°C
- ▶ Minimum = -60°C

The overtemperature warning is detected by the ADC. Typical response time is less than 5 ms in continuous monitor mode and is less than 100 ms in low power mode.

TIMING

Sequencing On

Table 24. Sequencing On Commands

| Command Name | Code | Description | Type | Unit | NVM | Default Value |
|----------------------|------|--|----------|------|-----|---------------|
| VOUT_TRANSITION_RATE | 0x27 | Rates the output changes when commanded to a new value. | R/W word | V/ms | Yes | 0.25 |
| TON_DELAY | 0x60 | Time from RUN or OPERATION on to output turn-on. | R/W word | ms | Yes | 0 |
| TON_RISE | 0x61 | Time from output turn-on to reach the commanded value. | R/W word | ms | Yes | 1.0 |
| TON_MAX_FAULT_LIMIT | 0x62 | Maximum time from start of TON_RISE for V _{OUT} to cross VOUT_UV_FAULT_LIMIT. | R/W word | ms | Yes | 5.0 |

VOUT_TRANSITION_RATE

When a PMBus device receives either a VOUT_COMMAND, OPERATION, VOUT_MARGIN_HIGH, VOUT_MARGIN_LOW, or VOUT_MAX command that causes the output voltage to change, VOUT_TRANSITION_RATE sets the rate (in V/ms) at which the output voltage changes. This commanded rate of change does not apply when the unit is commanded on or off.

Values of greater than 0.05 V/ms are recommended for optimal performance. At smaller sizes, the transition step size quantization error may be undesirable.

The VOUT_TRANSITION_RATE command uses half-precision floating point format.

- ▶ Maximum = 25 V/ms (While the VOUT_TRANSITION_RATE can be commanded up to 25 V/ms, the actual achievable output voltage transition rate may be limited by other factors, including output capacitance, current limit, and compensation.)
- ▶ Minimum = 0.01 V/ms

TON_DELAY

The TON_DELAY command sets the time, in milliseconds, from when a start condition is received until the output voltage starts to rise. The time is internally rounded down to the nearest 10 μs.

This command uses half-precision floating-point format.

- ▶ Maximum = 64,000 ms
- ▶ Minimum = 0 ms

TON_RISE

The TON_RISE command sets the time, in milliseconds, from the time the output starts to rise to the time the output enters the regulation band. The time is internally rounded to the nearest 10 μs. The channel is set to pulse skipping mode during TON_RISE events. The maximum rise rate of the digital ramp controller is 25 V/ms. If the commanded output voltage divided by TON_RISE is more than 25 V/ms, the digital control ramps at this rate. The minimum output voltage rise time is further limited by analog behavior of the switcher, which is affected by several factors including output capacitance, current limit selection, and loop compensation.

When TON_RISE is commanded to change during TON ramp-up, the LT7170/LT7170-1 act on the command as soon as possible. However, the new ramp rate is calculated for a full ramp from 0 V. Because the output is partially ramped and time has already passed, the actual total ramp time differs from the new value for TON_RISE.

The TON_RISE command uses half-precision floating-point format.

- ▶ Maximum = 63 ms

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- ▶ Minimum = 0 ms

TON_MAX_FAULT_LIMIT

The TON_MAX_FAULT_LIMIT command sets the value, in milliseconds, that determines how long the LT7170/LT7170-1 can attempt to power up the output without reaching the output undervoltage fault limit. The time is internally rounded down to the nearest 10 μ s. A data value of 0 ms means that there is no limit and that the unit can attempt to bring up the output voltage indefinitely.

The TON_MAX_FAULT_LIMIT time is started after TON_DELAY has finished and a soft-start sequence is started. The resolution of the TON_MAX_FAULT_LIMIT is 10 μ s. If the VOUT_UV_FAULT_LIMIT is not reached within the TON_MAX_FAULT_LIMIT time, the response of this fault is determined by the value of the TON_MAX_FAULT_RESPONSE command value.

The TON_MAX_FAULT_LIMIT command uses half-precision floating-point format.

- ▶ Maximum = 64,000 ms
- ▶ Minimum (disabled) = 0 ms

Sequencing Off

Table 25. Sequencing Off Commands

| Command Name | Code | Description | Type | Unit | NVM | Default Value |
|---------------------|------|--|----------|------|-----|---------------|
| TOFF_DELAY | 0x64 | Time from RUN and/or OPERATION off to the start of TOFF_FALL | R/W word | ms | Yes | 0.0 |
| TOFF_FALL | 0x65 | Time from when the output starts to fall until the output reaches 0 V | R/W word | ms | Yes | 2.0 |
| TOFF_MAX_WARN_LIMIT | 0x66 | Maximum allowed time, after TOFF_FALL completed, for output to decay below MFR_DISCHARGE_THRESHOLD | R/W word | ms | Yes | 0.0 |

TOFF_DELAY

The TOFF_DELAY command sets the time, in milliseconds, from when a stop condition is received until the output voltage starts to fall. The time is internally rounded down to the nearest 10 μ s.

This command uses half-precision floating-point format.

- ▶ Maximum = 64,000 ms
- ▶ Minimum = 0 ms

TOFF_FALL

The TOFF_FALL command sets the time, in milliseconds, from the end of the turn-off delay time until the output voltage is commanded to zero. The time is internally rounded to the nearest 10 μ s. It is the ramp time of the V_{OUT} DAC.

During V_{OUT} ramp-down, the LT7170/LT7170-1 use continuous conduction mode if either Bit 2 of MFR_PWM_MODE_LT7170 is set to 1, or Bit 0 of MFR_PWM_MODE_LT7170 is set to 0. Otherwise, V_{OUT} decays only due to the external load (and the 200 Ω internal pull-down if Bit 6 of MFR_CHAN_CONFIG_LT7170 is set to 1). For defined TOFF_FALL times, it is recommended to set Bit 2 of MFR_PWM_MODE_LT7170 to 1. The maximum fall rate of the digital ramp controller is 25 V/ms. If the commanded output voltage divided by TOFF_FALL is more than 25 V/ms, the digital control ramps down at this rate. The minimum V_{OUT} fall time is further limited by analog behavior of the switcher, which is affected by several factors including output load, output capacitance, PWM mode selection (forced continuous vs. pulse skip), and current-limit selection. After the digital ramp-down is completed, the switching regulator is disabled. If the V_{OUT} fall rate is limited by analog behavior, the regulator becomes disabled before the ramp-down is complete, and the output is not forced all the way to zero. Setting TOFF_FALL to 2 ms or greater ensures that V_{OUT} ramps to zero during TOFF_FALL.

The TOFF_FALL command uses half-precision floating-point format.

- ▶ Maximum = 63 ms
- ▶ Minimum = 0 ms

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TOFF_MAX_WARN_LIMIT

The TOFF_MAX_WARN_LIMIT command sets the value, in milliseconds, that determines how long the LT7170/LT7170-1 can attempt to turn off the output until a warning is asserted. The time is internally rounded to the nearest 1 ms. The output is considered off when the V_{OUT} voltage is less than MFR_DISCHARGE_THRESHOLD. The calculation begins after TOFF_FALL is complete. TOFF_MAX_WARN is not enabled if the discharge requirement is disabled (Bit 0 of MFR_CHAN_CONFIG_LT7170 set to 1).

In response to the TOFF_MAX_WARN_LIMIT being exceeded, the LT7170/LT7170-1 also do the following:

- ▶ Set the NONE_OF_THE_ABOVE bit in the STATUS_BYTE command.
- ▶ Set the VOUT bit in the STATUS_WORD command.
- ▶ Set the TOFF maximum warning bit in the STATUS_VOUT command.
- ▶ Notify the host by asserting the $\overline{\text{ALERT}}$ pin low, unless masked.

The special data value of 0 ms means that there is no limit and that the LT7170/LT7170-1 can attempt to turn off the output voltage indefinitely.

The TOFF_MAX_WARN_LIMIT command uses half-precision floating-point format.

- ▶ Maximum = 64,000 ms
- ▶ Minimum = 10.0 ms
- ▶ Disabled = 0.0 ms

FAULT RESPONSE

All Faults

Table 26. All Faults Commands

| Command Name | Code | Description | Type | Unit | NVM | Default Value |
|-----------------|------|-----------------------------------|----------|------|-----|---------------|
| MFR_RETRY_DELAY | 0xDB | Retry interval during fault retry | R/W word | ms | Yes | 10.0 |

MFR_RETRY_DELAY

The MFR_RETRY_DELAY command sets the time in milliseconds between restarts if the fault response is to retry the controller at specified intervals. The time is internally rounded down to the nearest 10 μ s. This command value is used for all fault responses that require retry. The retry time starts when a fault has been detected by the offending channel.

Note that the retry delay time is set by either the MFR_RETRY_DELAY command or the time required for the regulated output to decay below MFR_DISCHARGE_THRESHOLD, whichever is longer. If the natural decay time of the output is too long, it is possible to remove the voltage requirement of the MFR_RETRY_DELAY command by asserting Bit 0 of MFR_CHAN_CONFIG_LT7170.

The MFR_RETRY_DELAY command uses half-precision floating point format.

- ▶ Maximum = 64,000 ms
- ▶ Minimum = 0.02 ms

Input Voltage

Input voltage faults only cause a configured fault response when the associated channel is on. However, the $\overline{\text{ALERT}}$ pin is asserted low unless masked by SMBALERT_MASK.

Table 27. Input Voltage Commands

| Command Name | Code | Description | Type | NVM | Default Value |
|-----------------------|------|---|----------|-----|---------------|
| VIN_OV_FAULT_RESPONSE | 0x56 | Action to be taken when an input overvoltage fault is detected. | R/W byte | Yes | 0xB8 |

VIN_OV_FAULT_RESPONSE

The VIN_OV_FAULT_RESPONSE command sets the action the LT7170/LT7170-1 take in response to an input overvoltage fault.

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The LT7170/LT7170-1 also do the following:

- ▶ Set the NONE_OF_THE_ABOVE bit in the STATUS_BYTE command.
- ▶ Set the INPUT bit in the upper byte of the STATUS_WORD command.
- ▶ Set the VIN OV fault bit in the STATUS_INPUT command.
- ▶ Notify the host by asserting the $\overline{\text{ALERT}}$ pin low, unless masked.

Table 28. Data Byte Contents: VIN_OV_FAULT_RESPONSE

| Bits | Description | Value | Meaning |
|-------|---|---------------|---|
| [7:6] | Response. For all values of Bits[7:6], the LT7170/LT7170-1 set the VIN OV fault bit in the STATUS commands and pull the $\overline{\text{ALERT}}$ pin low, unless masked. | 00 | Not supported. Writing this value generates a CML fault. |
| | | 01 | Not supported. Writing this value generates a CML fault. |
| | | 10 (default) | The LT7170/LT7170-1 shut down immediately (disables the output) and respond according to the retry setting in Bits[5:3]. |
| | | 11 | Not supported. Writing this value generates a CML fault. |
| [5:3] | Retry setting. | 000-110 | The LT7170/LT7170-1 do not attempt to restart. The output remains disabled until the devices are commanded off or bias power is removed by removing V_{IN} and EXTV_{CC} . |
| | | 111 (default) | The LT7170/LT7170-1 attempt to restart continuously, without limitation, until the devices are commanded off (by the RUN pin or OPERATION command or both), bias power is removed, or another fault condition causes the unit to shut down without retry. Note that the retry interval is set by the MFR_RETRY_DELAY command. |
| [2:0] | Delay time. | 000 (default) | Must be 0. Writing this to nonzero generates a CML fault. |

Output Voltage

Output voltage faults only cause a configured fault response when the associated channel is on. However, the $\overline{\text{ALERT}}$ pin is asserted low unless masked by SMBALERT_MASK.

Table 29. Output Voltage Commands

| Command Name | Code | Description | Type | NVM | Default Value |
|------------------------|------|--|----------|-----|---------------|
| VOUT_OV_FAULT_RESPONSE | 0x41 | Action to be taken when an output overvoltage fault is detected | R/W byte | Yes | 0xB8 |
| VOUT_UV_FAULT_RESPONSE | 0x45 | Action to be taken when an output undervoltage fault is detected | R/W byte | Yes | 0x00 |
| TON_MAX_FAULT_RESPONSE | 0x63 | Action to be taken when a TON_MAX_FAULT event is detected | R/W byte | Yes | 0x00 |

VOUT_OV_FAULT_RESPONSE

The VOUT_OV_FAULT_RESPONSE command sets the action the LT7170/LT7170-1 take in response to an output overvoltage fault.

The LT7170/LT7170-1 also do the following:

- ▶ Set the VOUT_OV bit in the STATUS_BYTE.
- ▶ Set the VOUT bit in the STATUS_WORD.
- ▶ Set the VOUT OV fault bit in the STATUS_VOUT command.
- ▶ Set the VOUT OV warning bit in the STATUS_VOUT command.
- ▶ Notify the host by asserting the $\overline{\text{ALERT}}$ pin low, unless masked.

Table 30. Data Byte Contents: VOUT_OV_FAULT_RESPONSE

| Bits | Description | Value | Meaning |
|-------|---|-------|--|
| [7:6] | Response. For all values of Bits[7:6], the LT7170/LT7170-1 set the VOUT OV fault and warning bits in the status commands and pull the $\overline{\text{ALERT}}$ pin low, unless masked. | 00 | The LT7170/LT7170-1 operate in continuous mode while the fault is active, attempting to regulate to the programmed voltage. |
| | | 01 | The LT7170/LT7170-1 continue operation for the delay time specified by Bits[2:0] and the delay time unit specified for that particular fault. If the fault |

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Table 30. Data Byte Contents: VOUT_OV_FAULT_RESPONSE (Continued)

| Bits | Description | Value | Meaning |
|-------|----------------|------------------|---|
| | | | condition is still present at the end of the delay time, the devices respond as programmed in the retry setting (Bits[5:3]). |
| | | 10 (default) | The LT7170/LT7170-1 shut down immediately (disables the output) and respond according to the retry setting in Bits[5:3]. |
| | | 11 | Not supported. Writing this value generates a CML fault. |
| [5:3] | Retry setting. | 000 to 110 | The LT7170/LT7170-1 do not attempt to restart. The output remains disabled until the LT7170/LT7170-1 are commanded off or bias power is removed by removing V_{IN} and $EXTV_{CC}$. |
| | | 111 (default) | The LT7170/LT7170-1 attempt to restart continuously, without limitation, until the devices are commanded off (by the RUN pin or OPERATION command or both), bias power is removed, or another fault condition causes the unit to shut down without retry. Note that the retry interval is set by the MFR_RETRY_DELAY command. |
| [2:0] | Delay time. | XXX ¹ | The delay time in 10 μ s increments. This delay time determines how long the channel continues operating after a fault is detected. 000 is default. |

¹ X means don't care.

VOUT_UV_FAULT_RESPONSE

The VOUT_UV_FAULT_RESPONSE command sets the action the LT7170/LT7170-1 take in response to an output undervoltage fault. The LT7170/LT7170-1 also do the following:

- ▶ Set the NONE_OF_THE_ABOVE bit in the STATUS_BYTE command.
- ▶ Set the VOUT bit in the STATUS_WORD command.
- ▶ Set the VOUT UV fault bit in the STATUS_VOUT command.
- ▶ Set the VOUT UV warning bit in the STATUS_VOUT command.
- ▶ Notify the host by asserting the \overline{ALERT} pin low, unless masked.

The UV fault and warn are masked until the following criteria are achieved:

- ▶ The TON_MAX_FAULT_LIMIT is reached.
- ▶ The TON_DELAY sequence completes.
- ▶ The TON_RISE sequence completes.
- ▶ The VOUT_UV_FAULT_LIMIT threshold is reached.
- ▶ The IOUT_OC_FAULT_LIMIT is not present.

The UV fault and warn are masked whenever the channel is not active.

The UV fault and warn are masked during TON_RISE and TOFF_FALL sequencing.

Table 31. Data Byte Contents: VOUT_UV_FAULT_RESPONSE

| Bits | Description | Value | Meaning |
|-------|--|----------------------|---|
| 7:6 | Response. For all values of Bits[7:6], the LT7170/LT7170-1 set the VOUT UV fault and warning bits in the STATUS commands and pull the \overline{ALERT} pin low, unless masked. | 00 (default) | The LT7170/LT7170-1 continue operation without interruption. |
| | | 01 | The LT7170/LT7170-1 continue operation for the delay time 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 devices respond as programmed in the retry setting (Bits[5:3]). |
| | | 10 | The LT7170/LT7170-1 shut down immediately (disables the output) and respond according to the retry setting in Bits[5:3]. |
| | | 11 | Not supported. Writing this value generates a CML fault. |
| [5:3] | Retry setting. | 000 (default) to 110 | The LT7170/LT7170-1 do not attempt to restart. The output remains disabled until the devices are commanded off or bias power is removed by removing V_{IN} and $EXTV_{CC}$. |

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Table 31. Data Byte Contents: VOUT_UV_FAULT_RESPONSE (Continued)

| Bits | Description | Value | Meaning |
|-------|-------------|------------------|--|
| | | 111 | The LT7170/LT7170-1 attempt to restart continuously, without limitation, until the devices are commanded off (by the RUN pin or OPERATION command or both), bias power is removed, or another fault condition causes the devices to shut down without retry. Note that the retry interval is set by the MFR_RETRY_DELAY command. |
| [2:0] | Delay time. | XXX ¹ | The delay time in 10 μ s increments. This delay time determines how long the channel continues operating after a fault is detected. 000 is the default. |

¹ X means don't care.

TON_MAX_FAULT_RESPONSE

The TON_MAX_FAULT_RESPONSE command sets the action the LT7170/LT7170-1 take in response to a TON MAX fault.

The LT7170/LT7170-1 also do the following:

- ▶ Set the NONE_OF_THE_ABOVE bit in the STATUS_BYTE command.
- ▶ Set the VOUT bit in the STATUS_WORD command.
- ▶ Set the TON MAX fault bit in the STATUS_VOUT command.
- ▶ Notify the host by asserting the $\overline{\text{ALERT}}$ pin low, unless masked.

A value of 0 disables the TON_MAX_FAULT_RESPONSE command. It is not recommended to use 0.

Table 32. Data Byte Contents: TON_MAX_FAULT_RESPONSE

| Bits | Description | Value | Meaning |
|-------|--|----------------------|--|
| [7:6] | Response. For all values of Bits[7:6], the LT7170/LT7170-1 set the TON MAX fault bit in the STATUS commands and pull the $\overline{\text{ALERT}}$ pin low, unless masked. | 00 (default) | The LT7170/LT7170-1 continue operation without interruption. |
| | | 01 | Not supported. Writing this value generates a CML fault. |
| | | 10 | The LT7170/LT7170-1 shut down immediately (disables the output) and respond according to the retry setting in Bits[5:3]. |
| | | 11 | Not supported. Writing this value generates a CML fault. |
| [5:3] | Retry setting. | 000 (default) to 110 | The LT7170/LT7170-1 do not attempt to restart. The output remains disabled until the devices are commanded off or bias power is removed by removing V_{IN} and EXTV_{CC} . |
| | | 111 | The LT7170/LT7170-1 attempt to restart continuously, without limitation, until the devices are commanded off (by the RUN pin or OPERATION command or both), bias power is removed, or another fault condition causes the devices to shut down without retry. Note that the retry interval is set by the MFR_RETRY_DELAY command. |
| [2:0] | Delay time. | XXX ¹ | Must be 0. Writing this to nonzero generates a CML fault. 000 is default. |

¹ X means don't care.

Output Current

Table 33. Output Current Commands

| Command Name | Code | Description | Type | NVM | Default Value |
|------------------------|------|---|----------|-----|---------------|
| IOUT_OC_FAULT_RESPONSE | 0x47 | Action to be taken when an output overcurrent fault is detected | R/W byte | Yes | 0x00 |

PMBUS COMMAND DETAILS

IOUT_OC_FAULT_RESPONSE

Table 34. Data Byte Contents: IOUT_OC_FAULT_RESPONSE

| Bits | Description | Value | Meaning |
|-------|--|----------------------|--|
| [7:6] | Response. For all values of Bits[7:6], the LT7170/LT7170-1 set the IOUT_OC fault bit in the status commands and pull the ALERT pin low, unless masked. | 00 (default) | The LT7170/LT7170-1 continue operation indefinitely while maintaining the output current set by MFR_PWM_MODE_LT7170 without regard to the output voltage (known as constant-current or brick wall limiting). |
| | | 01 | Not supported. Writing this value generates a CML fault. |
| | | 10 | The LT7170/LT7170-1 continue operation for the delay time 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 devices respond as programmed in the retry setting (Bits[5:3]). |
| | | 11 | The LT7170/LT7170-1 shut down immediately (disables the output) and respond according to the retry setting in Bits[5:3]. |
| [5:3] | Retry setting. | 000 (default) to 110 | The LT7170/LT7170-1 do not attempt to restart. The output remains disabled until the devices are commanded off or bias power is removed by removing V _{IN} and EXT _{VCC} . |
| | | 111 | The LT7170/LT7170-1 attempt to restart continuously, without limitation, until the devices are commanded off (by the RUN pin or OPERATION command or both), bias power is removed, or another fault condition causes the units to shut down without retry. Note that the retry interval is set by the MFR_RETRY_DELAY command. |
| [2:0] | Delay time. | XXX ¹ | The delay time in 10 μs increments. This delay time determines how long the channel continues operating after a fault is detected. 000 is the default. |

¹ X means don't care.

Temperature

Internal temperature faults only cause a configured fault response when the associated channel is on. However, the $\overline{\text{ALERT}}$ pin is asserted low unless masked by SMBALERT_MASK.

Table 35. Temperature Command

| Command Name | Code | Description | Type | NVM | Default Value |
|-------------------|------|---|----------|-----|---------------|
| OT_FAULT_RESPONSE | 0x50 | Action to be taken when an internal overtemperature fault is detected | R/W Byte | Yes | 0xC0 |

OT_FAULT_RESPONSE

The OT_FAULT_RESPONSE command sets the action the LT7170/LT7170-1 take in response to an internal overtemperature fault.

The LT7170/LT7170-1 also do the following:

- ▶ Set the MFR bit in the STATUS_WORD command.
- ▶ Set the OT fault bit in the STATUS_TEMPERATURE command.
- ▶ Notify the host by asserting the $\overline{\text{ALERT}}$ pin low, unless masked.

Table 36. Data Byte Contents: OT_FAULT_RESPONSE

| Bits | Description | Value | Meaning |
|-------|---|--------------|--|
| [7:6] | Response. For all values of Bits[7:6], the LT7170/LT7170-1 set the OT fault bit in the STATUS commands and pull the $\overline{\text{ALERT}}$ pin low, unless masked. | 00 | Not supported. Writing this value generates a CML fault. |
| | | 01 | Not supported. Writing this value generates a CML fault. |
| | | 10 | The LT7170/LT7170-1 shut down immediately (disables the output) and respond according to the retry setting in Bits[5:3]. |
| | | 11 (default) | The output of the LT7170/LT7170-1 is disabled while the fault is present. Operation resumes and the output is enabled when the fault condition no longer exists. |

PMBUS COMMAND DETAILS

Table 36. Data Byte Contents: OT_FAULT_RESPONSE (Continued)

| Bits | Description | Value | Meaning |
|-------|----------------|----------------------|--|
| [5:3] | Retry setting. | 000 (default) to 110 | The LT7170/LT7170-1 do not attempt to restart. The output remains disabled until the LT7170/LT7170-1 are commanded off or bias power is removed by removing V_{IN} and $EXTV_{CC}$. |
| | | 111 | Not supported. Writing this value generates a CML fault. |
| [2:0] | Ignored. | XXX ¹ | Ignored. 000 is the default. |

¹ X means don't care.

IDENTIFICATION

Table 37. Identification Commands¹

| Command Name | Code | Description | Type | NVM | Default Value |
|----------------|------|---|---------|-----|---------------|
| CAPABILITY | 0x19 | PMBus optional communication protocols supported. | R byte | No | 0xD8 |
| PMBUS_REVISION | 0x98 | PMBus revision supported, currently 1.3. | R byte | No | 0x33 |
| MFR_ID | 0x99 | Returns ADI. | R block | No | ADI |
| MFR_SERIAL | 0x9E | Unit specific unique serial number. | R block | No | N/A |
| IC_DEVICE_ID | 0xAD | Returns LT7170 or LT7170-1. | R block | No | N/A |
| IC_DEVICE_REV | 0xAE | Manufacturer revision number. | R block | No | N/A |
| MFR_SPECIAL_ID | 0xE7 | Manufacturer code. | R word | No | 0x1C1D |

¹ N/A means not applicable.

STATUS

Figure 1 summarizes the internal LT7170/LT7170-1 status registers accessible by the PMBus command. These status registers contain indication of various faults, warnings, and other important operating conditions. As shown in Figure 1, the STATUS_BYTE and STATUS_WORD commands summarize contents of other status registers.

The NONE OF THE ABOVE bit in STATUS_BYTE indicates that one or more of the bits in the most significant nibble of STATUS_WORD are also set.

Unless masked by SMBALERT_MASK, any asserted bit in a STATUS_x register (including any fault or warning) also pulls the \overline{ALERT} pin low.

With some exceptions, the SMBALERT_MASK command can be used to prevent the LT7170/LT7170-1 from pulling the \overline{ALERT} pin low for bits in these registers on a bit by bit basis. These mask settings apply to STATUS_WORD and STATUS_BYTE in the same fashion as the status bits themselves. For example, if \overline{ALERT} is masked for all bits in Channel 0 STATUS_VOUT, \overline{ALERT} is effectively masked for the VOUT bit in STATUS_WORD for Page 0.

Status information contained in MFR_COMMON and MFR_PADS can be used to further debug or clarify the contents of STATUS_BYTE or STATUS_WORD as shown in Figure 1. However, the contents of MFR_COMMON and MFR_PADS do not directly affect the state of the \overline{ALERT} pin.

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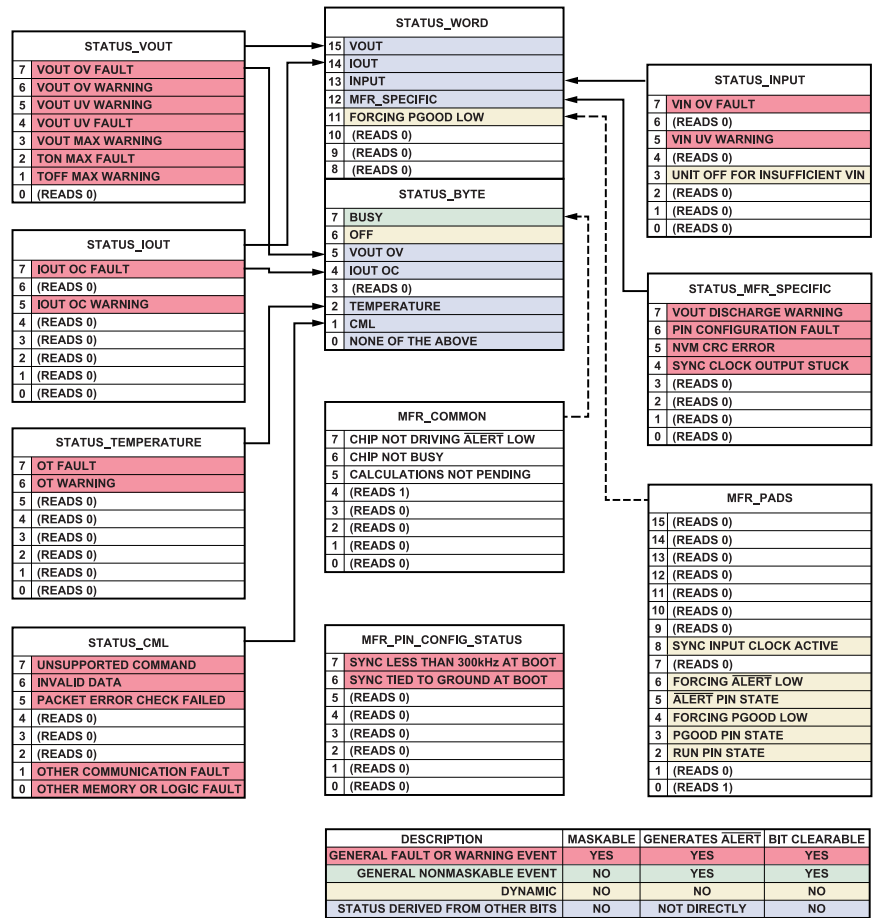


Figure 1. Status Register Summary

Table 38. Status Commands

| Command Name | Code | Description | Type | NVM |
|-----------------------|------|--|-----------|-----|
| CLEAR_FAULTS | 0x03 | Clear all fault bits | Send byte | No |
| SMBALERT_MASK | 0x1B | Mask ALERT pin | Block R/W | Yes |
| STATUS_BYTE | 0x78 | One-byte summary of the faults and warnings of the LT7170/LT7170-1 | R/W byte | No |
| STATUS_WORD | 0x79 | One-word summary of the faults and warnings of the LT7170/LT7170-1 | R/W word | No |
| STATUS_VOUT | 0x7A | Output voltage faults and warnings | R/W byte | No |
| STATUS_IOUT | 0x7B | Output current faults and warnings | R/W byte | No |
| STATUS_INPUT | 0x7C | Input supply faults and warnings | R/W byte | No |
| STATUS_TEMPERATURE | 0x7D | Internal temperature faults and warnings | R/W byte | No |
| STATUS_CML | 0x7E | Communications, memory, and logic faults and warnings | R/W byte | No |
| STATUS_MFR_SPECIFIC | 0x80 | Manufacturer specific faults and warnings | R/W byte | No |
| MFR_PADS_LT7170 | 0xE5 | Digital status of I/O pads | R word | No |
| MFR_COMMON | 0xEF | Manufacturer status bits common across multiple Analog Devices devices | R/W byte | No |
| MFR_CHANNEL_STATE | 0xF1 | Returns the state of the channel | R byte | No |
| MFR_PIN_CONFIG_STATUS | 0xF7 | Indicates source of pin configuration fault | R byte | No |

PMBUS COMMAND DETAILS

CLEAR_FAULTS

The CLEAR_FAULTS command is used to clear any fault bits that have been set. This command clears all bits in all STATUS commands simultaneously. The CLEAR_FAULTS command also deasserts the $\overline{\text{ALERT}}$ pin. If the fault is still present when the bit is cleared, the fault bit remains set and the host is notified by asserting the $\overline{\text{ALERT}}$ pin low.

The CLEAR_FAULTS command does not cause the LT7170/LT7170-1 that have latched off for a fault condition to restart. The LT7170/LT7170-1 devices that have shut down for a fault condition are restarted only when the following situations occur:

- ▶ The output is commanded to turn off and then to turn back on via the RUN pin and/or the OPERATION command.
- ▶ The MFR_RESET command is issued.
- ▶ The V_{IN} and EXTV_{CC} bias power are removed and reapplied to the LT7170/LT7170-1.

Reading the CLEAR_FAULTS command also clears all bits in all STATUS commands and deasserts the $\overline{\text{ALERT}}$ pin.

SMBALERT_MASK

The SMBALERT_MASK command can be used to prevent chosen status bits from asserting $\overline{\text{ALERT}}$ low as they are asserted. Only supported bits can be masked.

The bits in the mask byte align with bits in the specified status register. For example, if the STATUS_TEMPERATURE command code is sent in the first data byte, and the mask byte contains 0x40, a subsequent overtemperature warning is still set, Bit 6 of STATUS_TEMPERATURE, but not assert $\overline{\text{ALERT}}$ low. All other supported STATUS_TEMPERATURE bits continue to assert $\overline{\text{ALERT}}$ low if set.

SMBALERT_MASK cannot be applied to the derived bits in STATUS_BYTE or STATUS_WORD. Bit 7, the busy fault bit, of STATUS_BYTE can be masked. The STATUS_WORD is not supported for SMBALERT_MASK.

Providing an unsupported command code to SMBALERT_MASK generates a CML for invalid and/or unsupported data.

Table 39. Factory Default SMBALERT_MASK Settings

| Status Register | Mask Value | Masked Bits |
|---------------------|------------|---------------|
| STATUS_BYTE | 0x00 | None |
| STATUS_VOUT | 0x00 | None |
| STATUS_IOUT | 0x80 | IOUT OC fault |
| STATUS_TEMPERATURE | 0x00 | None |
| STATUS_CML | 0x00 | None |
| STATUS_INPUT | 0x00 | None |
| STATUS_MFR_SPECIFIC | 0x00 | None |

STATUS_BYTE

The STATUS_BYTE command returns a one-byte summary of the most critical faults. Bit 7 can be cleared by writing a 1 to its position.

Table 40. STATUS_BYTE Contents

| Bit | Name | Description |
|-----|-------------------|--|
| 7 | BUSY | A fault is declared because the LT7170/LT7170-1 fail to respond to a command. |
| 6 | OFF | This bit is set if the channel is not providing power to its output, regardless of the reason, including simply not being enabled. |
| 5 | VOUT OV | An output overvoltage fault has occurred. |
| 4 | IOUT OC | An output overcurrent fault has occurred. |
| 3 | Unsupported | Not supported (device returns 0). |
| 2 | TEMPERATURE | A temperature fault or warning has occurred. |
| 1 | CML | A communication, memory, or logic fault has occurred. |
| 0 | NONE OF THE ABOVE | A fault or warning not listed in Bits[7:1] has occurred. |

PMBUS COMMAND DETAILS

STATUS_WORD

The STATUS_WORD command returns a two-byte summary of the channel fault condition. The low byte of the STATUS_WORD command is the same as the STATUS_BYTE command. Bit 7 can be cleared by writing a 1 to its position.

Table 41. STATUS_WORD Contents

| Bits | Name | Description |
|--------|----------------|---|
| 15 | VOUT | An output voltage fault or warning has occurred. |
| 14 | IOUT | An output current fault or warning has occurred. |
| 13 | INPUT | An input voltage fault or warning has occurred. |
| 12 | MFR_SPECIFIC | A fault or warning specific to the LT7170/LT7170-1 has occurred. |
| 11 | POWER NOT GOOD | This bit is set when the LT7170/LT7170-1 are forcing the PGOOD pin low. |
| [10:8] | Unsupported | Not supported (device returns 0). |

STATUS_VOUT

The STATUS_VOUT command returns one byte of V_{OUT} status information. An individual bit can be cleared by writing a 1 to its position.

Table 42. STATUS_VOUT Contents

| Bits | Name | Description |
|------|------------------|--|
| 7 | VOUT OV FAULT | V_{OUT} overvoltage fault. |
| 6 | VOUT OV WARNING | V_{OUT} overvoltage warning. |
| 5 | VOUT UV WARNING | V_{OUT} undervoltage warning. |
| 4 | VOUT UV FAULT | V_{OUT} undervoltage fault. |
| 3 | VOUT MAX WARNING | Warning that the LT7170/LT7170-1 are commanded to exceed VOUT MAX. |
| 2 | TON MAX FAULT | TON MAX fault. |
| 1 | TOFF MAX WARNING | TOFF MAX warning. |
| 0 | Unsupported | Not supported (device returns 0). |

STATUS_IOUT

The STATUS_IOUT command returns one byte of I_{OUT} status information. An individual bit can be cleared by writing a 1 to its position.

Table 43. STATUS_IOUT Contents

| Bit | Name | Description |
|-------|-----------------|-----------------------------------|
| 7 | IOUT OC FAULT | I_{OUT} overcurrent fault. |
| 6 | Unsupported | Not supported (device returns 0). |
| 5 | IOUT OC WARNING | I_{OUT} overcurrent warning. |
| [4:0] | Unsupported | Not supported (device returns 0). |

STATUS_INPUT

The STATUS_INPUT command returns one byte of input voltage status information. An individual bit can be cleared by writing a 1 to its position.

Table 44. STATUS_INPUT Contents

| Bit | Name | Description |
|-----|-------------------------------|--|
| 7 | VIN OV FAULT | V_{IN} overvoltage fault. |
| 6 | Unsupported | Not supported (device returns 0). |
| 5 | VIN UV WARNING | V_{IN} undervoltage warning. |
| 4 | Unsupported | Not supported (device returns 0). |
| 3 | UNIT OFF FOR INSUFFICIENT VIN | Unit is off due to insufficient input voltage. |
| 2 | Unsupported | Not supported (device returns 0). |
| 1 | Unsupported | Not supported (device returns 0). |

PMBUS COMMAND DETAILS

Table 44. STATUS_INPUT Contents (Continued)

| Bit | Name | Description |
|-----|-------------|-----------------------------------|
| 0 | Unsupported | Not supported (device returns 0). |

STATUS_TEMPERATURE

The STATUS_TEMPERATURE command returns one byte of sensed internal temperature status information. An individual bit can be cleared by writing a 1 to its position.

Table 45. STATUS_TEMPERATURE Contents

| Bit | Name | Description |
|-------|-------------|-----------------------------------|
| 7 | OT FAULT | Internal overtemperature fault. |
| 6 | OT WARNING | Internal overtemperature warning. |
| [5:0] | Unsupported | Not supported (device returns 0). |

STATUS_CML

The STATUS_CML command returns one byte of status information regarding PMBus communication, internal memory, and logic. An individual bit can be cleared by writing a 1 to its position.

Table 46. STATUS_CML Contents

| Bit | Description |
|-----|--|
| 7 | Invalid or unsupported command received. |
| 6 | Invalid or unsupported data received. |
| 5 | Packet error check failed. |
| 4 | Not supported (device returns 0). |
| 3 | Not supported (device returns 0). |
| 2 | Not supported (device returns 0). |
| 1 | Other communication fault. |
| 0 | Other memory or logic fault. |

STATUS_MFR_SPECIFIC

The STATUS_MFR_SPECIFIC command returns one byte with the manufacturer specific status information. Bit 4 and Bit 5 are not page specific. An individual bit can be cleared by writing a 1 to its position.

Table 47. STATUS_MFR_SPECIFIC Contents

| Bit | Description |
|-----|--|
| 7 | V _{OUT} turned on when output voltage above discharge threshold. |
| 6 | Pin configuration fault (see the MFR_PIN_CONFIG_STATUS section for more information). |
| 5 | NVM fault. Either the CRC does not match or error correction indicates an uncorrectable error. |
| 4 | Sync stuck low while SYNC pin is configured as a clock output (MFR_SYNC_CONFIG_LT7170, Bit 0 is set to 1). |
| 3 | Not supported (device returns 0). |
| 2 | Not supported (device returns 0). |
| 1 | Not supported (device returns 0). |
| 0 | Not supported (device returns 0). |

MFR_PIN_CONFIG_STATUS

During initialization, the LT7170/LT7170-1 check for various illegal pin configurations. If a pin configuration fault is detected, the LT7170/LT7170-1 pull down the PGOOD pin and set Bit 6 of STATUS_MFR_SPECIFIC. The regulator outputs are also locked off until the LT7170/LT7170-1 are reset. The MFR_PIN_CONFIG_STATUS commands returns one read-only byte indicating what type of pin configuration fault has been detected.

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Table 48. MFR_PIN_CONFIG_STATUS Bit Descriptions

| Bits | Description |
|-------|--|
| 7 | A frequency of less than 300 kHz is detected on the SYNC/PWM_CFG pin during initialization. This may occur if a higher frequency clock starts in the middle of the initialization process. If an external clock is to be applied to the SYNC/PWM_CFG pin, it must start before the LT7170/LT7170-1 initialization begins, or after initialization is complete. |
| [6:0] | Not supported (device returns 0). |

MFR_PADS_LT7170

The read-only MFR_PADS_LT7170 command returns the digital status of the listed pins.

Table 49. MFR_PADS_LT7170 Bit Descriptions

| Bits | Description |
|---------|-----------------------------------|
| [15:10] | Not supported (device returns 0). |
| 9 | Not supported (device returns 0). |
| 8 | Sync input clock active. |
| 7 | Not supported (device returns 0). |
| 6 | Device driving ALERT low. |
| 5 | ALERT. |
| 4 | Device driving PGOOD low. |
| 3 | PGOOD. |
| 2 | RUN. |
| 1 | Not supported (device returns 0). |
| 0 | Not supported (device returns 1). |

MFR_COMMON

The MFR_COMMON command contains bits that are common to all Analog Devices digital power and telemetry products. This command cannot cause the ALERT pin to be asserted.

Table 50. MFR_COMMON Bit Description

| Bit | Description |
|-----|-----------------------------|
| 7 | Chip not driving ALERT low |
| 6 | Chip not busy |
| 5 | Calculations not pending |
| 4 | Reserved (device returns 1) |
| 3 | Reserved (device returns 0) |
| 2 | Reserved (device returns 0) |
| 1 | Reserved (device returns 0) |
| 0 | Reserved (device returns 0) |

MFR_CHANNEL_STATE

The MFR_CHANNEL_STATE command returns the state of the channel.

Table 51. MFR_CHANNEL_STATE Values

| Value | Description |
|-------|---------------------------------|
| 0, 7 | Off |
| 2 | Waiting for TON_DELAY |
| 3 | Power-on ramp up (TON_RISE) |
| 4, 5 | On |
| 6 | Waiting for TOFF_DELAY |
| 8 | Power-off ramp down (TOFF_FALL) |

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TELEMETRY

Table 52. Telemetry Commands

| Command Name | Code | Description | Type | Unit ¹ | NVM | Default Value ¹ |
|------------------------|------|--|-----------|-------------------|-----|----------------------------|
| IOUT_CAL_OFFSET | 0x39 | Offset for READ_IOUT. | R/W word | A | Yes | 0.1 |
| READ_VIN | 0x88 | Measured input supply voltage. | R word | V | No | N/A |
| READ_VOUT | 0x8B | Measured output voltage. | R word | V | No | N/A |
| READ_IOUT | 0x8C | Measured output current. | R word | A | No | N/A |
| READ_TEMPERATURE_1 | 0x8D | Measured internal temperature. | R word | C | No | N/A |
| READ_FREQUENCY | 0x95 | Frequency of top gate. | R word | kHz | No | N/A |
| MFR_READ_EXTVCC | 0xCD | Measured EXT _{VCC} pin voltage. | R word | V | No | N/A |
| MFR_READ_ITH | 0xCE | Measured I _{TH} pin voltage. | R word | V | No | N/A |
| MFR_IOUT_PEAK | 0xD7 | Maximum READ_IOUT. | R word | A | No | N/A |
| MFR_ADC_CONTROL_LT7170 | 0xD8 | ADC configuration. | R/W byte | N/A | Yes | 0x06 |
| MFR_VOUT_PEAK | 0xDD | Maximum READ_VOUT. | R word | V | No | N/A |
| MFR_VIN_PEAK | 0xDE | Maximum READ_VIN. | R word | V | No | N/A |
| MFR_TEMPERATURE_1_PEAK | 0xDF | Maximum READ_TEMPERATURE_1. | R word | C | No | N/A |
| MFR_READ_PWM_CFG | 0xE0 | Measured PWM_CFG resistor value. | R word | kΩ | No | N/A |
| MFR_READ_VOUT_CFG | 0xE1 | Measured VOUT_CFG resistor value. | R word | kΩ | No | N/A |
| MFR_CLEAR_PEAKE | 0xE3 | Clears all recorded peak values. | Send byte | N/A | No | N/A |

¹ N/A means not applicable.

IOUT_CAL_OFFSET

The IOUT_CAL_OFFSET command sets an offset for READ_IOUT in amperes. See the [READ_IOUT](#) section for details.

This command uses half-precision floating point format.

READ_VIN

The READ_VIN command returns the measured input voltage.

This command uses half-precision floating point format.

READ_VOUT

The READ_VOUT command returns the measured output voltage.

This command uses half-precision floating point format.

READ_IOUT

The READ_IOUT command returns the output current, averaged over the measurement time determined by the I_{OUT} aperture control. See the [MFR_ADC_CONTROL_LT7170](#) section for details about the I_{OUT} aperture control.

The value returned by READ_IOUT is the measured output current offset by the value of IOUT_CAL_OFFSET. A dominant source of READ_IOUT error is systematic offset, which is largely a function of switching frequency, input voltage, output voltage, and inductor selection. To improve the accuracy of READ_IOUT, record the value reported by READ_IOUT in typical application conditions at zero load with IOUT_CAL_OFFSET set to zero. Then write IOUT_CAL_OFFSET to the negation of the recorded READ_IOUT value at no load. This value of IOUT_CAL_OFFSET can be systematically stored in NVM for all devices and does not need to be calibrated for every LT7170/LT7170-1 individually.

The READ_IOUT command uses half-precision floating point format.

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READ_TEMPERATURE_1

The READ_TEMPERATURE_1 command returns the internal device temperature.

This command uses half-precision floating point format.

READ_FREQUENCY

The READ_FREQUENCY command returns the top switch switching frequency in kilohertz (kHz).

This command uses half-precision floating point format.

MFR_READ_EXTVCC

The MFR_READ_EXTVCC command returns the measured voltage on the EXTV_{CC} pin.

This command is only updated if Bit 0 of MFR_ADC_CONTROL_LT7170 is set to 1 to enable debug telemetry measurements.

The MFR_READ_EXTVCC command uses half-precision floating point format.

MFR_READ_ITH

The MFR_READ_ITH command returns the measured voltage at the internal switching regulator compensation point.

This command is only updated if Bit 0 of MFR_ADC_CONTROL_LT7170 is set to 1 to enable debug telemetry measurements.

The reported voltage corresponds to the valley current operating point, scaled by the current sense transconductance ($\Delta I_{OUT}/\Delta V_{ITH}$). See the [LT7170/LT7170-1](#) data sheet for more information about the programmable current limit. The compensation point voltage is measured differentially with respect to the internal zero valley current reference voltage of approximately 935 mV.

The MFR_READ_ITH command uses half-precision floating point format.

MFR_IOUT_PEAK

The MFR_IOUT_PEAK command reports the highest output current measured.

This command is cleared using the MFR_CLEAR_PEAKS command.

The MFR_IOUT_PEAK command uses half-precision floating point format.

MFR_ADC_CONTROL_LT7170

The MFR_ADC_CONTROL_LT7170 command controls adjustable features of the telemetry loop.

Bit 4 enables the I_{OUT} scope mode where the output current measurement is updated more frequently. The update rate for all other measurements is decreased when the I_{OUT} scope mode is enabled.

Bits[3:2] select the aperture time for the I_{OUT} measurement. A longer aperture time provides more precise output current measurements but increases the time required for the I_{OUT} measurement and the overall telemetry loop. A shorter aperture time provides a faster measurement but with less precision.

Table 53. Mode, I_{OUT} Oversample Ratio (OSR), and Update Times for MFR_ADC_CONTROL_LT7170

| Mode | I _{OUT} OSR | Update Time for I _{OUT} Measurement (ms) | Update Time for Other Measurements (ms) |
|------------------------|----------------------|---|---|
| Standard | 3 | 8.1 | 8.1 |
| | 2 | 6.3 | 6.3 |
| | 1 | 5.5 | 5.5 |
| | 0 | 5.1 | 5.1 |
| I _{OUT} Scope | 3 | 5 | 19.4 |
| | 2 | 3.3 | 12.4 |
| | 1 | 2.5 | 9 |
| | 0 | 2.1 | 7.2 |

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Bit 1 enables lower-frequency telemetry measurements in order to reduce input supply quiescent current. When this bit is set, the telemetry runs with a typical period of 110 ms (compared to a typical period of 5.5 ms when this bit is zero).

Bit 0 enables the debug telemetry measurements: MFR_READ_EXTVCC, MFR_READ_ITH. When this bit is 1, the other measurements update at a slower rate.

Table 54. MFR_ADC_CONTROL_LT7170 Bit Descriptions

| Bits | Default Value | Description |
|-------|---------------|---|
| 4 | 0 | Enable scope mode for the I _{OUT} measurement. |
| [3:2] | 1 | I _{OUT} measurement aperture time. |
| 1 | 1 | Enable low frequency telemetry (110 ms typical period, 2 mA typical supply current reduction). |
| 0 | 0 | 0 = standard telemetry measurements. 1 = debug telemetry measurements: standard + EXTV _{CC} + I _{TH} . |

MFR_VOUT_PEAK

The MFR_VOUT_PEAK command reports the highest output voltage measured.

This command is cleared using the MFR_CLEAR_PEAKS command.

The MFR_VOUT_PEAK command uses half-precision floating point format.

MFR_VIN_PEAK

The MFR_VIN_PEAK command reports the highest input voltage measured.

This command is cleared using the MFR_CLEAR_PEAKS command.

The MFR_VIN_PEAK command uses half-precision floating point format.

MFR_TEMPERATURE_1_PEAK

The MFR_TEMPERATURE_1_PEAK command reports the highest internal temperature measured.

This command is cleared using the MFR_CLEAR_PEAKS command.

The MFR_TEMPERATURE_1_PEAK command uses half-precision floating point format.

MFR_READ_PWM_CFG

The MFR_READ_PWM_CFG command returns the measured PWM_CFG pin resistor value.

If the PWM_CFG pin is left floating or is tied to V_{DD18}, MFR_READ_PWM_CFG returns a large value.

If Bit 6 of MFR_CONFIG_ALL_LT7170 is set to disable the resistor configuration during initialization, MFR_READ_PWM_CFG returns 0.

The MFR_READ_PWM_CFG command uses half-precision floating point format.

MFR_READ_VOUT_CFG

The MFR_READ_VOUT_CFG command returns the measured VOUT_CFG pin resistor value.

If the VOUT_CFG pin is left floating or is tied to V_{DD18}, MFR_READ_VOUT_CFG returns a large value.

If Bit 6 of MFR_CONFIG_ALL_LT7170 is set to disable the resistor configuration during initialization, MFR_READ_VOUT_CFG returns 0.

The MFR_READ_VOUT_CFG command uses half-precision floating point format.

MFR_CLEAR_PEAKS

The MFR_CLEAR_PEAKS command clears the MFR_x_PEAK data values. These values are also cleared at reset or power-up.

PMBUS COMMAND DETAILS

NVM COMMANDS

Most NVM access commands take milliseconds to complete.

Store/Restore

Table 55. Store/Restore Commands¹

| Command | Code | Description | Type | NVM | Default Value |
|-------------------------------|------|---|-----------|-----|---------------|
| STORE_USER_ALL | 0x15 | Stores user operating memory to NVM. Can only be written three times. | Send byte | No | N/A |
| RESTORE_USER_ALL | 0x16 | Restores user operating memory from NVM. | Send byte | No | N/A |
| MFR_COMPARE_USER_ALL | 0xF0 | Compares current command contents with NVM. | Send byte | No | N/A |
| MFR_USER_DATA_00 | 0xC9 | NVM word available for the user. | R/W word | Yes | 0x0000 |
| MFR_USER_DATA_01 | 0xCA | NVM word available for the user. | R/W word | Yes | 0x0000 |
| MFR_DISABLE_OUTPUT | 0xFB | Disables regulator outputs until reset. | R/W byte | No | 0x00 |
| MFR_NVM_USER_WRITES_REMAINING | 0xBE | Number of STORE_USER_ALL writes remaining. | R byte | No | N/A |
| MFR_NVM_USER_WP | 0xFC | Disables commands that write user NVM. | R/W byte | Yes | 0x00 |

¹ N/A means not applicable.

STORE_USER_ALL

The STORE_USER_ALL command instructs the LT7170/LT7170-1 to copy the contents of the operating memory to nonvolatile memory. All commands designated as NVM backed commands are stored in nonvolatile memory by the STORE_USER_ALL command.

STORE_USER_ALL may only be written three times during the life of the LT7170/LT7170-1.

Throughout the STORE_USER_ALL operation, the device junction temperature must be maintained between -40°C and 125°C , and V_{IN} must be maintained at more than 9.6 V.

If a nonvolatile memory write fails, Bit 5 is set in STATUS_MFR_SPECIFIC, indicating that a nonvolatile memory fault has occurred. If the LT7170/LT7170-1 are reset or bias power is removed while a nonvolatile memory fault is present, the devices address is set to 0x7C on the next power-up.

Reading the STORE_USER_ALL command also instructs the LT7170/LT7170-1 to copy the contents of the operating memory to nonvolatile memory.

RESTORE_USER_ALL

The RESTORE_USER_ALL command provides a means by which the user can perform a reset of the LT7170/LT7170-1.

Reading the RESTORE_USER_ALL command also causes the LT7170/LT7170-1 to reset.

MFR_COMPARE_USER_ALL

The MFR_COMPARE_USER_ALL command instructs the LT7170/LT7170-1 to compare current command contents with what is stored in nonvolatile memory. If the compare operation detects differences, a CML Bit 0 fault is generated.

Reading the MFR_COMPARE_USER_ALL command also instructs the LT7170/LT7170-1 to compare current command contents with what is stored in nonvolatile memory.

MFR_USER_DATA_00 and MFR_USER_DATA_01

The MFR_USER_DATA_xx commands can be used by the user to store any data. Each of these commands stores one 16-bit word. This data is written to the NVM when the STORE_USER_ALL command is written.

PMBUS COMMAND DETAILS

MFR_DISABLE_OUTPUT

When written to 0xFF, the MFR_DISABLE_OUTPUT command disables the regulator outputs until reset. The value of MFR_DISABLE_OUTPUT is not stored in NVM, which allows anything to be programmed into ON_OFF_CONFIG, OPERATION, and so forth, without powering up the output. MFR_DISABLE_OUTPUT also allows all NVM stored commands to be configured and written to NVM with STORE_USER_ALL without powering up the output. The MFR_DISABLE_OUTPUT command can be read to determine the state of the output disable function.

MFR_NVM_USER_WRITES_REMAINING

When read, MFR_NVM_USER_WRITES_REMAINING returns the number of times STORE_USER_ALL can be written.

MFR_NVM_USER_WP

When written to 0xFF, the MFR_NVM_USER_WP command disables the commands that can be used to write to the user NVM space: STORE_USER_ALL and MFR_NVM_DATA writes. The MFR_NVM_USER_WP command can only be written to 0xFF.

NOTES

I²C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).

**ESD Caution**

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

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