

LT7184S PMBus/I<sup>2</sup>C Reference Manual

## OVERVIEW

LT7184S Power Management Bus (PMBus)/I<sup>2</sup>C Reference manual describes the digital communications capabilities of the **LT7184S**, including the functionality of each LT7184S PMBus command. Refer to the following specifications for more information regarding bus protocol details.

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

## PMBus/SMBus/I<sup>2</sup>C Capabilities

The LT7184S serial interface is PMBus compliant and can operate at any frequency between 10kHz and 1MHz. The device address is configurable using the electrically erasable programmable read-only memory (EEPROM) and/ or a configuration resistor on the ASEL pin. The serial interface supports the following protocols defined in the PMBus and System Management Bus (SMBus) specifications:

- ▶ Send Byte, Write Byte, Write Word, and Block Write.
- ▶ Read Byte, Read Word, and Block Read.
- ▶ Alert Response Address.
- ▶ PAGE\_PLUS\_READ, and PAGE\_PLUS\_WRITE.
- ▶ Zone Write.
- ▶ SMBALERT\_MASK Read and Write.

The LT7184S pulls 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.

## Similarity Between PMBus, SMBus and I<sup>2</sup>C 2-Wire Interfaces

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

To describe the minor extensions and exceptions PMBus makes to SMBus, refer to the PMBus Specification Part 1 Revision 1.3.1: Section 5: Transport.

To describe the differences between SMBus and I<sup>2</sup>C, refer to the SMBus Specification Version 3.1: Appendix B—Differences Between SMBus and I<sup>2</sup>C.

## Communication Protection

All read operations will return a valid PEC if the PMBus controller requests it. If Bit 2 of the MFR\_CONFIG\_ALL\_LT7184S command is set, the PMBus write operations will not be acted upon until a valid PEC has been received by the LT7184S. If a PEC is included in a command write, that PEC must be valid or a PEC write error will occur, regardless of the value of Bit 2 of the MFR\_CONFIG\_ALL\_LT7184S command.

If a PEC write error occurs, an attempt is made to access unsupported commands, or invalid data is written to supported commands, then the LT7184S ignores the command, sets the Communication, Memory, Logic (CML) bit in the STATUS\_BYTE and STATUS\_WORD commands, sets the appropriate bit in the STATUS\_CML command, and pulls the  $\overline{\text{ALERT}}$  pin low.

## Device Addressing

The LT7184S offers addressing modes that provide flexible ways to control multiple channels simultaneously and individually.

Device addressing is the standard way to communicate with a single instance of the LT7184S. The value of the device address is set by a combination of the ASEL configuration pin and the MFR\_ADDRESS command. Device addressing can be disabled by writing a value of 0x80 to the MFR\_ADDRESS. Individual channels are accessed using the PAGE command to select the desired channel, or by using the PMBus PAGE\_PLUS command. If MFR\_ADDRESS cannot be read from NVM due to an NVM fault, the device address will be set to 0x7C.

Global addressing provides a means to address all LT7184S devices on the bus. The LT7184S global addresses are fixed at 0x5A (7-bit notation) and 0x5B. They cannot be disabled. Commands sent to the 0x5A global address act the same as if PAGE is set to a value of 0xFF. Commands sent are written to both channels simultaneously. Global address 0x5B is paged and allows channel-specific commands for all LT7184S devices on the bus. Do not read from global addresses, as multiple devices may respond simultaneously. Other Analog devices' product types may respond at one or both global addresses.

Rail addressing provides a means to control multiple channels connected together to produce a single output voltage (PolyPhase®). While similar to global addressing, the rail address can be dynamically assigned with the paged MFR\_RAIL\_ADDRESS command, allowing for any logical grouping of channels that might be required for reliable system control. Do not read from rail addresses since multiple ADI devices may respond.

Zone write addressing provides a means to write to a set of channels. The set of channels may 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 for that page. 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 a channel's configured zone matches the active zone, or the active zone is set to the "All Zone", the channel will respond 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 LT7184S devices at global and rail addresses should be limited to command write operations.

## Communication Recommendations

If PMBus commands are received faster than they are being processed, the part may become too busy to handle new commands. If a command is written when the device is busy processing a command, the device will ignore that command, set bit 7 of STATUS\_BYTE, and pull the  $\overline{\text{ALERT}}$  pin low. MFR\_COMMON bit 6 will be set to a 1 when the device is ready to accept commands. This bit may be polled before writing commands. Alternatively, clock stretching may be enabled. Clock stretching is enabled by setting bit 1 of MFR\_CONFIG\_ALL\_LT7184S.

NVM commands may take longer to process, including STORE\_USER\_ALL, MFR\_COMPARE\_USER\_ALL, and MFR\_FAULT\_LOG\_CLEAR. When writing repeated VOUT\_MAX or MFR\_PWM\_MODE\_LT7184S commands to both channels simultaneously at bus speeds above 400kHz, the device may also become too busy to respond immediately. In these cases, either poll MFR\_COMMON bit 6 or enable clock stretching to avoid a busy condition.

[Table 1](#) lists the supported PMBus commands and manufacturer-specific commands. A complete description of the included PMBus commands can be found in the PMBus Power System Management Protocol Specification, Part II, Revision 1.3.1 Specification. Floating point values listed in the "DEFAULT VALUE" column are half-precision IEEE floating point numbers. If MFR\_CONFIG\_ALL is used to disable IEEE floating point mode, all floating point commands will read and write values using either Linear11 or ULinear16 format, as indicated by the DATA FORMAT column in [Table 1](#). See [Table 2](#) for data format details. All commands from 0xC0 through 0xFF not listed in [Table 1](#) are implicitly reserved by the manufacturer. Users should avoid blind writes within this range of commands to prevent the undesired operation of the part. All commands from 0x00 through 0xBF not listed in [Table 1](#) are implicitly not supported by the manufacturer. Attempting to access non-supported or reserved commands can result in a CML command fault event.

## TABLE OF CONTENTS

OVERVIEW .....	1	Output Voltage and Limits .....	27
PMBus/SMBus/I <sup>2</sup> C Capabilities .....	1	VOUT_MODE .....	28
Similarity Between PMBus, SMBus and I <sup>2</sup> C 2-Wire Interfaces .....	1	VOUT_COMMAND .....	28
Communication Protection .....	1	VOUT_MAX .....	28
Device Addressing .....	1	VOUT_MARGIN_HIGH .....	28
Communication Recommendations .....	2	VOUT_MARGIN_LOW .....	29
Revision History .....	5	VOUT_OV_FAULT_LIMIT .....	29
PMBus Command Summary .....	6	VOUT_OV_WARN_LIMIT .....	29
PMBus Command Details .....	14	VOUT_UV_WARN_LIMIT .....	30
Addressing and Write Protect .....	14	VOUT_UV_FAULT_LIMIT .....	30
PAGE .....	14	MFR_DISCHARGE_THRESHOLD .....	30
PAGE_PLUS_WRITE .....	15	MFR_PGOOD_DELAY .....	31
PAGE_PLUS_READ .....	15	MFR_NOT_PGOOD_DELAY .....	31
ZONE_CONFIG .....	15	Input Current Limits .....	31
ZONE_ACTIVE .....	15	IIN_OC_WARN_LIMIT .....	31
WRITE_PROTECT .....	16	Output Current Limits .....	32
MFR_ADDRESS .....	17	IOUT_OC_WARN_LIMIT .....	32
MFR_RAIL_ADDRESS .....	18	Temperature .....	32
General Configuration .....	18	OT_FAULT_LIMIT .....	32
MFR_CHAN_CONFIG_LT7184S .....	19	OT_WARN_LIMIT .....	33
MFR_CONFIG_ALL_LT7184S .....	20	Timing .....	33
OPERATION .....	21	Sequencing On .....	33
ON_OFF_CONFIG .....	21	VOUT_TRANSITION_RATE .....	33
MFR_RESET .....	21	TON_DELAY .....	34
PWM Configuration .....	22	TON_RISE .....	34
FREQUENCY_SWITCH .....	22	TON_MAX_FAULT_LIMIT .....	34
MFR_PWM_MODE_LT7184S .....	23	Sequencing Off .....	35
MFR_PWM_PHASE_LT7184S .....	24	TOFF_DELAY .....	35
MFR_SYNC_CONFIG_LT7184S .....	25	TOFF_FALL .....	35
Input Voltage and Limits .....	25	TOFF_MAX_WARN_LIMIT .....	36
VIN_ON .....	26	Restarting .....	36
VIN_OFF .....	26	MFR_RESTART_DELAY .....	36
VIN_UV_WARN_LIMIT .....	26	Fault Response .....	37
		All Faults .....	37

MFR_RETRY_DELAY.....	37	READ_VIN .....	54
Input Voltage.....	37	READ_VOUT .....	54
VIN_OV_FAULT_RESPONSE .....	37	READ_IIN .....	55
Output Voltage.....	38	READ_IOUT .....	55
VOUT_OV_FAULT_RESPONSE .....	39	READ_TEMPERATURE_1 .....	55
VOUT_UV_FAULT_RESPONSE.....	40	READ_FREQUENCY .....	55
TON_MAX_FAULT_RESPONSE .....	41	READ_POUT .....	55
Output Current.....	42	MFR_READ_EXTVCC .....	55
Temperature .....	43	MFR_READ_ITH.....	55
OT_FAULT_RESPONSE .....	43	MFR_IOUT_PEAK .....	56
Fault Sharing Commands.....	44	MFR_ADC_CONTROL_LT7184S.....	56
MFR_FAULT_PROPAGATE_LT7184S.....	44	MFR_VOUT_PEAK .....	56
MFR_FAULT_RESPONSE.....	45	MFR_VIN_PEAK.....	56
Identification .....	45	MFR_TEMPERATURE_1_PEAK .....	56
Status .....	45	MFR_CLEAR_PEAKS.....	56
CLEAR_FAULTS .....	48	NVM Commands.....	57
SMBALERT_MASK .....	48	STORE_USER_ALL .....	57
STATUS_BYTE .....	49	RESTORE_USER_ALL.....	57
STATUS_WORD .....	49	MFR_COMPARE_USER_ALL .....	57
STATUS_VOUT .....	50	MFR_USER_DATA_00, MFR_USER_DATA_01, MFR_USER_DATA_02, and MFR_USER_DATA_03 .....	58
STATUS_IOUT .....	50	MFR_DISABLE_OUTPUT.....	58
STATUS_INPUT .....	50	MFR_EE_USER_WP.....	58
STATUS_TEMPERATURE .....	51	FAULT Logging .....	58
STATUS_CML.....	51	MFR_FAULT_LOG_TIMESTAMP_MSBS, and MFR_FAULT_LOG_TIMESTAMP_LSBS.....	59
STATUS_MFR_SPECIFIC .....	51	MFR_FAULT_LOG_STORE .....	59
MFR_PIN_CONFIG_STATUS .....	52	MFR_FAULT_LOG_CLEAR.....	59
MFR_PADS_LT7184S.....	52	MFR_FAULT_LOG.....	59
MFR_COMMON.....	53	Example Event .....	63
MFR_CHANNEL_STATE.....	53		
Telemetry.....	54		

**REVISION HISTORY**

REVISION NUMBER	REVISION DATE	DESCRIPTION	UNITS
0	11/24	Initial release	—

## PMBUS COMMAND SUMMARY

**Table 1. PMBus Command Summary**

COMMAND NAME	CMD CODE	DESCRIPTION	TYPE	PAGED	DATA FORMAT	UNITS	EEPROM	DEFAULT VALUE
PAGE	0x00	Provides integration with multiple PMBus devices.	R/W Byte	N	Register			0x00
OPERATION	0x01	Operating mode control. On/Off, margin high, and margin low.	R/W Byte	Y	Register		Y	0x80
ON_OFF_CONFIG	0x02	RUNN pin and PMBus bus On/Off command configuration.	R/W Byte	Y	Register		Y	0x1E
CLEAR_FAULTS	0x03	Clear any fault bits that have been set.	Send Byte	N				
PAGE_PLUS_WRITE	0x05	Write a command directly to a specified page.	W Block	N				
PAGE_PLUS_READ	0x06	Read a command directly from a specified page.	Block R/W	N				
ZONE_CONFIG	0x07	Assigns the current page to the specified zone number for ZONE_WRITE operations.	W Word	Y	Register		Y	0xFEFE
ZONE_ACTIVE	0x08	Selects the active zone for ZONE_WRITE operations.	W Word		Register			0xFEFE
WRITE_PROTECT	0x10	Level of protection provided by the device against accidental changes.	R/W Byte	N	Register		Y	0x00
STORE_USER_ALL	0x15	Store user operating memory to EEPROM.	Send Byte	N				
RESTORE_USER_ALL	0x16	Restore user operating memory from EEPROM.	Send Byte	N				
CAPABILITY	0x19	Summary of PMBus optional communication protocols supported by this device.	R Byte	N	Register			0xD8
QUERY	0x1A	Asks if a given command is supported, and what data formats are supported.	Block R/W	N	Register			
SMBALERT_MASK	0x1B	Masks $\overline{\text{ALERT}}$ activity.	Block R/W	Y	Register		Y	
VOUT_MODE	0x20	Output voltage format and exponent.	R Byte	N	Register			0x60

COMMAND NAME	CMD CODE	DESCRIPTION	TYPE	PAGED	DATA FORMAT	UNITS	EEPROM	DEFAULT VALUE
VOUT_COMMAND	0x21	Nominal output voltage set point.	R/W Word	Y	IEEE/UL16	V	Y	0.5V (0x3800)
VOUT_MAX	0x24	The upper limit on the commanded output voltage.	R/W Word	Y	IEEE/UL16	V	Y	0.537V (0x384C)
VOUT_MARGIN_HIGH	0x25	Margin high output voltage set point.	R/W Word	Y	IEEE/UL16	V	Y	0.525V (0x3833)
VOUT_MARGIN_LOW	0x26	Margin low output voltage set point.	R/W Word	Y	IEEE/UL16	V	Y	0.475V (0x379A)
VOUT_TRANSITION_RATE	0x27	Rate the output changes when $V_{OUT}$ is commanded to a new value.	R/W Word	Y	IEEE/L11	V/ms	Y	0.25V/ms (0x3400)
FREQUENCY_SWITCH	0x33	Switching frequency of the regulator.	R/W Word	N	IEEE/L11	kHz	Y	1000 (0x63D0)
VIN_ON	0x35	Input voltage at which the unit should start power conversion.	R/W Word	Y	IEEE/L11	V	Y	Ch.0: 1.5V (0x3E00) Ch.1: 1.4V (0x3D9A)
VIN_OFF	0x36	Input voltage at which the unit should stop power conversion.	R/W Word	Y	IEEE/L11	V	Y	Ch.0: 1.45V (0x3DCD) Ch.1: 1.35V (0x3D66)
VOUT_OV_FAULT_LIMIT	0x40	Output overvoltage fault limit.	R/W Word	Y	IEEE/L11	V	Y	0.55V (0x3866)
VOUT_OV_FAULT_RESPONSE	0x41	Action to be taken by the device when an output overvoltage fault is detected.	R/W Byte	Y	Reg		Y	0xB8
VOUT_OV_WARN_LIMIT	0x42	Output overvoltage warning limit.	R/W Word	Y	IEEE/L11	V	Y	0.537V (0x384C)
VOUT_UV_WARN_LIMIT	0x43	Output undervoltage warning limit.	R/W Word	Y	IEEE/L11	V	Y	0.467V (0x3779)
VOUT_UV_FAULT_LIMIT	0x44	Output undervoltage fault limit.	R/W Word	Y	IEEE/L11	V	Y	0.465V (0x3771)
VOUT_UV_FAULT_RESPONSE	0x45	Action to be taken by the device when an output undervoltage fault is detected.	R/W Byte	Y	Register		Y	0x00
IOUT_OC_FAULT_RESPONSE	0x47	Action to be taken by the device when an output overcurrent fault is detected.	R/W Byte	Y	Register		Y	0x00

COMMAND NAME	CMD CODE	DESCRIPTION	TYPE	PAGED	DATA FORMAT	UNITS	EEPROM	DEFAULT VALUE
IOUT_OC_WARN_LIMIT	0x4A	Output overcurrent warning limit.	R/W Word	Y	IEEE/L11	A	Y	11.0A (0x4980)
OT_FAULT_LIMIT	0x4F	Internal overtemperature fault limit.	R/W Word	N	IEEE/L11	C	Y	160.0C (0x5900)
OT_FAULT_RESPONSE	0x50	Action to be taken by the device when an overtemperature fault is detected.	R/W Byte	N	Register		Y	0xC0
OT_WARN_LIMIT	0x51	Internal overtemperature warning limit.	R/W Word	N	IEEE/L11	C	Y	140.0C (0x5860)
VIN_OV_FAULT_RESPONSE	0x56	Action to be taken by the device when an input overvoltage fault is detected.	R/W Byte	Y	Register		Y	0xB8
VIN_UV_WARN_LIMIT	0x58	Input supply undervoltage warning limit.	R/W Word	Y	IEEE/L11	V	Y	-1.0V (0xBC00)
IIN_OC_WARN_LIMIT	0x5D	Input supply overcurrent warning limit.	R/W Word	Y	IEEE/L11	A	Y	9.0A (0x4880)
TON_DELAY	0x60	Time from RUNN and/or Operation on to output rail turn-on.	R/W Word	Y	IEEE/L11	ms	Y	0.0ms (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	Y	IEEE/L11	ms	Y	1.0ms (0x3C00)
TON_MAX_FAULT_LIMIT	0x62	Maximum time from the start of TON_RISE for $V_{OUT}$ to cross the $V_{OUT\_UV\_FAULT\_LIMIT}$	R/W Word	Y	IEEE/L11	ms	Y	5.0ms (0x4500)
TON_MAX_FAULT_RESPONSE	0x63	Action to be taken by the device when a TON_MAX_FAULT event is detected.	R/W Byte	Y	Register		Y	0x00
TOFF_DELAY	0x64	Time from RUNN and/or Operation off to the start of TOFF_FALL ramp.	R/W Word	Y	IEEE/L11	ms	Y	0.0 0x0000
TOFF_FALL	0x65	Time from when the output starts to fall until the output reaches zero volts.	R/W Word	Y	IEEE/L11	ms	Y	2.0ms (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	Y	IEEE/L11	ms	Y	0.0ms (0x0000)



COMMAND NAME	CMD CODE	DESCRIPTION	TYPE	PAGED	DATA FORMAT	UNITS	EEPROM	DEFAULT VALUE
STATUS_BYTE	0x78	One-byte summary of the unit's fault condition.	R/W Byte	Y	Register			
STATUS_WORD	0x79	Two-byte summary of the unit's fault condition.	R/W Word	Y	Register			
STATUS_VOUT	0x7A	Output voltage fault and warning status.	R/W Byte	Y	Register			
STATUS_IOUT	0x7B	Output current fault and warning status.	R/W Byte	Y	Register			
STATUS_INPUT	0x7C	Input supply fault and warning status.	R/W Byte	Y	Register			
STATUS_TEMPERATURE	0x7D	Internal temperature fault and warning status for READ_TEMPERATURE_1.	R/W Byte	N	Register			
STATUS_CML	0x7E	Communication and memory fault and warning status.	R/W Byte	N	Register			
STATUS_MFR_SPECIFIC	0x80	Manufacturer-specific fault and state information.	R/W Byte	Y	Register			
READ_VIN	0x88	Measured input supply voltage.	R Word	Y	IEEE/L11	V		
READ_IIN	0x89	Calculated input supply current.	R Word	Y	IEEE/L11	A		
READ_VOUT	0x8B	Measured output voltage.	R Word	Y	IEEE/UL16	V		
READ_IOUT	0x8C	Measured output current.	R Word	Y	IEEE/L11	A		
READ_TEMPERATURE_1	0x8D	Measured internal temperature.	R Word	N	IEEE/L11	C		
READ_FREQUENCY	0x95	Measured PWM switching frequency.	R Word	Y	IEEE/L11			
READ_POUT	0x96	Calculated output power.	R Word	Y	IEEE/L11			
PMBUS_REVISION	0x98	PMBus revision supported by this device. Current revision is 1.3.	R Byte	N	Register			0x33
MFR_ID	0x99	The manufacturer ID in ASCII.	R Block	N				Analog Devices
MFR_MODEL	0x9A	The part number in ASCII.	R Block	N				LT7184S

COMMAND NAME	CMD CODE	DESCRIPTION	TYPE	PAGED	DATA FORMAT	UNITS	EEPROM	DEFAULT VALUE
MFR_REVISION	0x9B	Part revision number.	R Block	N				
MFR_SERIAL	0x9E	Unique part serial number.	R Block	N				
IC_DEVICE_ID	0xAD	Identification of the IC in ASCII.	R Block	N				LT7184S
IC_DEVICE_REV	0xAE	Revision of the IC.	R Block	N				
MFR_EE_UNLOCK	0xBD	Contact factory.						
MFR_EE_ERASE	0xBE	Contact factory.						
MFR_EE_DATA	0xBF	Contact factory.						
MFR_USER_DATA_00	0xC9	EEPROM word available for the user.	R/W Word	N	Register		Y	0x0000
MFR_USER_DATA_01	0xCA	EEPROM word available for the user.	R/W Word	N	Register		Y	0x0000
MFR_USER_DATA_02	0xCB	EEPROM word available for the user.	R/W Word	N	Register		Y	0x0000
MFR_USER_DATA_03	0xCC	EEPROM word available for the user.	R/W Word	N	Register		Y	0x0000
MFR_READ_EXTVCC	0xCD	Measured $EXTV_{CC}$ voltage, when enabled.	R Word	N	IEEE/L11	V		
MFR_READ_ITH	0xCE	Measured $I_{TH}$ voltage, when enabled.	R Word	Y	IEEE/L11	V		
MFR_CHAN_CONFIG_LT7184S	0xD0	Configuration bits that are channel-specific.	R/W Word	Y	Register		Y	Ch. 0: 0x08D6 Ch. 1: 0x0856
MFR_CONFIG_ALL_LT7184S	0xD1	General configuration bits.	R/W Word	N	Register		Y	0x0100
MFR_FAULT_PROPAGATE_LT7184S	0xD2	Configuration that determines which faults are propagated to the $\overline{FAULTN}$ pin.	R/W Word	Y	Register		Y	0xE0D7
MFR_PWM_MODE_LT7184S	0xD4	Configuration for the PWM engine.	R/W Word	Y	Register		Y	0x0DD8
MFR_FAULT_RESPONSE	0xD5	Action to be taken by the device when the $\overline{FAULTN}$ pin is externally asserted low.	R/W Byte	Y	Register		Y	0xC0
MFR_IOUT_PEAK	0xD7	Report the maximum measured value of $READ_{IOUT}$ since last $MFR\_CLEAR\_PEAKS$ .	R Word	Y	IEEE/L11	A		

COMMAND NAME	CMD CODE	DESCRIPTION	TYPE	PAGED	DATA FORMAT	UNITS	EEPROM	DEFAULT VALUE
MFR_ADC_CONTROL_LT7184S	0xD8	Configures the update rate of the measurements taken by the ADC.	R/W Byte	N	Register		Y	0x00
MFR_RETRY_DELAY	0xDB	Retry interval during fault retry mode.	R/W Word	Y	IEEE/L11	ms	Y	10.0ms (0x4900)
MFR_RESTART_DELAY	0xDC	The minimum time the RUNN pin is held low by the LT7184S.	R/W Word	Y	IEEE/L11	ms	Y	10.0ms (0x4900)
MFR_VOUT_PEAK	0xDD	The maximum measured value of READ_VOUT since last MFR_CLEAR_PEAKS.	R/W Word	Y	IEEE/UL16	V		
MFR_VIN_PEAK	0xDE	The maximum measured value of READ_VIN since last MFR_CLEAR_PEAKS.	R/W Word	Y	IEEE/L11	V		
MFR_TEMPERATURE_1_PEAK	0xDF	The maximum measured value of internal temperature (READ_TEMPERATURE_1) since last MFR_CLEAR_PEAKS.	R/W Word	N	IEEE/L11	C		
MFR_CLEAR_PEAKS	0xE3	Clears all peak values.	Send Byte	N				
MFR_DISCHARGE_THRESHOLD	0xE4	The output voltage used to determine output has decayed sufficiently to re-enable the channel	R/W Word	Y	IEEE/UL16	V	Y	0.2V (0x3266)
MFR_PADS_LT7184S	0xE5	Digital status of the I/O pads.	R Word	N	Register			
MFR_ADDRESS	0xE6	Sets the 7-bit I <sup>2</sup> C address byte.	R/W Word	N	Register		Y	0x4F
MFR_SPECIAL_ID	0xE7	ID code used by manufacturer.	R Word	N	Register			0x1C1D
MFR_FAULT_LOG_TIME_STAMP_MSBS	0xE8	Sets the fault log timestamp upper 13 bits, clears lower 32 (read and write first)	R/W 32	N				
MFR_FAULT_LOG_TIME_STAMP_LSBS	0xE9	Sets the fault log timestamp lower 32 bits.	R/W 32	N				
MFR_FAULT_LOG_STORE	0xEA	Force a fault log entry to be written.	Send Byte	N				
MFR_FAULT_LOG_CLEAR	0xEC	Erases all fault log entries, if any.	Send Byte	N				
MFR_FAULT_LOG	0xEE	Read contents of fault log, if any.	R Block	N	Register			

COMMAND NAME	CMD CODE	DESCRIPTION	TYPE	PAGED	DATA FORMAT	UNITS	EEPROM	DEFAULT VALUE
MFR_COMMON	0xEF	Manufacturer status bits that are common across multiple ADI chips.	R Byte	N	Register			
MFR_COMPARE_USER_ALL	0xF0	Compares current command contents with EEPROM.	Send Byte	N				
MFR_CHANNEL_STATE	0xF1	Returns the state of the channel.	R Byte	Y	Register			
MFR_PGOOD_DELAY	0xF2	Time output voltage must be between UV and OV before PGOODN transitions high.	R/W Word	Y	IEEE/L11	ms	Y	1.0ms (0x3C00)
MFR_NOT_PGOOD_DELAY	0xF3	Time output voltage must be below UV or above OV before PGOODN transitions low.	R/W Word	Y	IEEE/L11	ms	Y	0.1ms (0x2E66)
MFR_PWM_PHASE_LT7184S	0xF5	Set PWM phase.	R/W Word	Y	IEEE/L11	Degrees	Y	Ch. 0: 0° (0x0000) Ch. 1: 180° 0x59A0
MFR_SYNC_CONFIG_LT7184S	0xF6	SYNC pin input/output configuration.	R/W Byte	N	Register		Y	0x00
MFR_PIN_CONFIG_STATUS	0xF7	Pin configuration fault status.	R Byte	N	Register			
MFR_RAIL_ADDRESS	0xFA	Common address for PolyPhase outputs to adjust common parameters.	R/W Byte	Y	Register		Y	0x80
MFR_DISABLE_OUTPUT	0xFB	Disables regulator outputs until reset.	R/W Byte	N	Register			0x00
MFR_EE_USER_WP	0xFC	Disables commands that write user NVM.	R/W Byte	N	Register		Y	0x00
MFR_RESET	0xFD	Commanded reset without requiring a power down.	Send Byte	N				

**Note 1:** Commands indicated with Y in the EEPROM column indicate that these commands are stored and restored using the STORE\_USER\_ALL and RESTORE\_USER\_ALL commands, respectively.

**Note 2:** The LT7184S contains additional reserved commands not listed in this table. Reading these commands is harmless to the operation of the IC; however, the contents and meaning of these commands can change without notice. Writing to commands not published in this table is not permitted.

**Note 3:** Some unpublished commands are read-only and will generate a CML bit 6 fault if written.

**Note 4:** The user should not assume compatibility of commands between different parts based on command names. Always refer to the manufacturer's data sheet for each part for a complete definition of a command's function. Analog Devices strives to keep command functionality compatible with all Analog Devices' products, but differences may be introduced to address specific product requirements.

**Table 2. Abbreviations of Supported Data Formats**

	PMBus		DEFINITION <sup>1</sup>	EXAMPLES <sup>2</sup>
	TERMINOLOGY	SPECIFICATION REFERENCE		
L11	Linear11	Rev 1.3.1 Part II 7.3	Floating point 16-bit data: $Y \times 2^{(N)}$ , where the exponent $N = b[15:11]$ and the value $Y = b[10:0]$ , both the two's complement binary integers.	$b[15:0] = 0x9807 = 7 \times 2^{-13} = 8.54 \times 10^{-4}$ $b[15:0] = 0xB7D0 = -48 \times 2^{-10} = -4.69 \times 10^{-3}$ $b[15:0] = 0xE058 = 88 \times 2^{-4} = 5.50$
UL16	ULinear16	Rev 1.3.1 Part II 8.4.1.1	Fixed point 16-bit data: $Y \times 2^{(-12)}$ , where value $Y = b[15:0]$ is an unsigned integer multiplied by 2 raised to the fixed exponent of -12.	$b[15:0] = 0x4C00 = 19456 \times 2^{-12} = 4.75$ $b[15:0] = 0x0600 = 1536 \times 2^{-12} = 3.75 \times 10^{-1}$
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	IEEE Floating point 16-bit data: $(-1)^S \times 2^{(N)} \times \left( P + \frac{M}{1024} \right)$ where the sign bit $S = b[15]$ . The bias encoding exponent $N$ and factor $P$ are coded from $b[14:10]$ as: if $(b[14:10] = 0)$ , $N = -14$ $P = 0$ else, $N = \text{decimal}(b[14:10]) - 15$ $P = 1$ endif. and $M = \text{decimal}(b[9:0])$ .	$b[15:0] = 0x4580$ $(-1)^0 \times 2^{(17-15)} \times \left( 1 + \frac{384}{1024} \right) = 5.50$ $b[15:0] = 0x3A66$ $(-1)^0 \times 2^{(16-15)} \times \left( 1 + \frac{614}{1024} \right) = 0.80$ $b[15:0] = 0x8008$ $(-1)^1 \times 2^{(-14)} \times \left( 0 + \frac{8}{1024} \right) = -4.77 \times 10^{-7}$

**Note 1:** Refer to the PMBus Specification Reference for the definition.

**Note 2:** Examples are rounded to 2 significant digits.

## PMBus COMMAND DETAILS

### Addressing and Write Protect

**Table 3. Addressing and Write Protection Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	NVM	DEFAULT
PAGE	0x00	Channel (page) selected for any paged command.	R/W Byte	N		0x00
PAGE_PLUS_WRITE	0x05	Write a command directly to a specified page.	W Block	N		
PAGE_PLUS_READ	0x06	Read a command directly from a specified page.	Block R/W Process	N		
ZONE_CONFIG	0x07	Specify the zone number for the selected page.	R/W Word	Y	Y	0xFEFE
ZONE_ACTIVE	0x08	Sets active zone number.	R/W Word	N		0xFEFE
WRITE_PROTECT	0x10	Protect the device from unintended PMBus modifications.	R/W Byte	N	Y	0x00
MFR_ADDRESS	0xE6	Specify the right-justified 7-bit device address.	R/W Byte	N	Y	0x4F
MFR_RAIL_ADDRESS	0xFA	Specify the right-justified 7-bit address for channels comprising a PolyPhase output.	R/W Byte	Y	Y	0x80

#### PAGE

The PAGE command provides the ability to configure, control, and monitor both channels through only one physical address, either the device address or global address 0x5B (7-bit address). Each PAGE contains the operating commands for one channel.

Pages 0x00 and 0x01 correspond to channel 0 and channel 1, respectively, in this device.

Setting PAGE to 0xFF applies any following paged commands to both outputs. With PAGE set to 0xFF, the device will respond to read commands as if PAGE were set to 0x00 (channel 0 results).

### PAGE\_PLUS\_WRITE

The PAGE\_PLUS\_WRITE command provides a way to select the page within a device, send a command, and then send the data for the command, an all-in-one communication packet. Commands allowed by the present write protection level may 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 non-paged command, the Page Number byte is ignored.

**Note:** 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 device will NACK 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 will be used as the effective ZONE. The page field will override the write zone of ZONE\_ACTIVE for this PAGE\_PLUS\_WRITE only.

### PAGE\_PLUS\_READ

The PAGE\_PLUS\_READ command provides the ability to select the page within a device, send a command, and then read the data returned by the command, an 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 non-paged command, the Page Number byte is ignored.

**Note:** 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 device will NACK 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.

### ZONE\_CONFIG

The ZONE\_CONFIG command assigns the selected channel to a specific zone number for ZONE\_WRITE operations. Zone configuration only needs to be performed once, but zone numbers change any time.

A channel's zone may be assigned to any zone number between 0x00 and 0x7F. It may also be set to 0xFE, which means "No Zone". Any channel programmed to "No Zone" will ignore ZONE\_WRITE operations.

The ZONE\_CONFIG command uses the SMBus word write and word read protocols.

**Table 4. Data Byte Contents for ZONE\_CONFIG**

BITS	DESCRIPTION
15-8	Must be 0xFE
7-0	Assigned zone

### ZONE\_ACTIVE

The ZONE\_ACTIVE command sets the active zone for ZONE\_WRITE operations. When a ZONE\_WRITE is sent by the bus controller, the active zone controls which channels are affected by that write.

The active zone may be set to any zone number between 0x00 and 0x7F. The active zone may 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 will be 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 will be set in STATUS\_CML.

**Table 5. Data Byte Contents for ZONE\_ACTIVE**

BITS	DESCRIPTION
15:8	Must be 0xFE
7:0	Active zone

## WRITE\_PROTECT

The WRITE\_PROTECT command is used to control writing to the device. This command does not indicate the status of the WP pin, which is defined in the MFR\_COMMON command. The WP pin takes precedence over the value of this command.

If the WP pin is high, only the PAGE, OPERATION, MFR\_EE\_UNLOCK, and CLEAR\_FAULTS commands are writable. Individual fault bits can be cleared by writing a 1 to the respective bits in the STATUS commands.

When WRITE\_PROTECT is set to 0x00, writes to all commands are enabled.

PAGE\_PLUS\_WRITE may be used to write any command that is not write protected. PAGE\_PLUS\_READ may be used to read any command.

**Table 6. Data Byte Contents for WRITE\_PROTECT**

BYTE	DESCRIPTION
0x80	Disable all writes except to the WRITE_PROTECT, PAGE, MFR_EE_UNLOCK and STORE_USER_ALL command.
0x40	Disable all writes except to the WRITE_PROTECT, PAGE, MFR_EE_UNLOCK, MFR_CLEAR_PEAKS, STORE_USER_ALL, OPERATION, and CLEAR_FAULTS command. 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_EE_UNLOCK, MFR_CLEAR_PEAKS, CLEAR_FAULTS, PAGE, ON_OFF_CONFIG, VOUT_COMMAND, and STORE_USER_ALL. 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.



**MFR\_ADDRESS**

The MFR\_ADDRESS command byte and the ASEL pin set the 7 bits of the PMBus device address.

Setting this command to a value of 0x80 disables device addressing. The GLOBAL device address, 0x5A and 0x5B, cannot be deactivated. If the ASEL pin is floating or connected to  $V_{DD18}$ , the device will use the full MFR\_ADDRESS value. If a resistor is connected to the ASEL pin according to the table below, the four LSBs of the device address will be determined by the ASEL resistor value.

Reading MFR\_ADDRESS always returns the value loaded from EEPROM or written via PMBus write. The value read from MFR\_ADDRESS is not affected by the ASEL pin.

LT7184S does not ignore ASEL, even when bit 6 of MFR\_CONFIG\_ALL\_LT7184S is set to ignore the other resistor configuration pins. The three MSBs 6:4 of the device address are always determined by bits 6:4 of MFR\_ADDRESS.

**Table 7. ASEL Configuration Resistor and LSBs of Device Address**

ASEL RESISTOR VALUE ( $\pm 1\%$ )	VALUE OF PMBus DEVICE ADDRESS LSBs 3:0
Floating or $V_{DD18}$	EEPROM value of MFR_ADDRESS
124k $\Omega$	0xF
107k $\Omega$	0xE
93.1k $\Omega$	0xD
80.6k $\Omega$	0xC
69.8k $\Omega$	0xB
60.4k $\Omega$	0xA
51.1k $\Omega$	0x9
43.2k $\Omega$	0x8
36.5k $\Omega$	0x7
30.9k $\Omega$	0x6
25.5k $\Omega$	0x5
21.0k $\Omega$	0x4
16.5k $\Omega$	0x3
11.8k $\Omega$	0x2
6.65k $\Omega$	0x1
0 $\Omega$ (Grounded)	0x0

**Table 8. Illegal Values for MFR\_ADDRESS**

ADDRESS	USE
0x0C	ARA protocol address
0x37	Zone write
0x5A	Global all rail address
0x5B	Global address

Attempting to set this command to illegal values will set a CML invalid data fault. The current value of ASEL will be considered for this error check. During power on, if the MFR\_ADDRESS read from NVM and the current value of ASEL makes an illegal address, the address will be set to 0x7C.

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

The device will always respond to the global addresses 0x5A and 0x5B. Writes to address 0x5A will affect all pages, and reads will 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 should be 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 above in MFR\_ADDRESS, will set a CML invalid data fault.

Writing PAGE\_PLUS\_READ or PAGE\_PLUS\_WRITE commands to the rail address will set a CML invalid command fault.

Reading from the rail address will result in a CML other fault.

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

## General Configuration

**Table 9. General Configuration Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	NVM	DEFAULT
MFR_CHAN_CONFIG_LT7184S	0xD0	Configuration bits that are channel specific.	R/W Word	Y	Y	Ch. 0: 0x08D6 Ch. 1: 0x0856
MFR_CONFIG_ALL_LT7184S	0xD1	Configuration bits common to all channels.	R/W Word	N	Y	0x0100

**MFR\_CHAN\_CONFIG\_LT7184S**

This command sets various global configuration bits.

**Table 10. Data Byte Contents for MFR\_CHAN\_CONFIG\_LT7184S**

BITS	DEFAULT		DESCRIPTION
	Ch 0	Ch 1	
15:12	0000	0000	Reserved
11	1	1	Fast-rising edge slew mode
10	0	0	0 = PGOODN Pull-down is disabled when VOUT_OV_FAULT_LIMIT is exceeded. 1 = PGOODN Pull-down remains active when VOUT_OV_FAULT_LIMIT is exceeded.
9	0	0	0 = PGOODN Pull-down is disabled during output transitions. 1 = PGOODN Pull-down is enabled during output transitions.
8	0	0	0 = Default single-phase application or polyphase leader operation. 1 = Polyphase follower mode. All but one channel in polyphase applications should be set to follower mode. Internal compensation cannot be used in PolyPhase operations. The channel operates in forced continuous conduction mode.
7	1	0	0 = Device will not pull SHARE_CLK down due to PV <sub>INN</sub> voltage level. 1 = Enable SHARE_CLK pull-down until PV <sub>INN</sub> exceeds VIN_ON, or if PV <sub>INN</sub> falls below VIN_OFF.
6	1	1	Reserved must be 1.
5	0	0	0 = $\overline{\text{FAULTN}}$ pin will be logged as a subevent when externally pulled low. 1 = $\overline{\text{FAULTN}}$ pin will be logged as an event when externally pulled low.
4	1	1	0 = RUNN will pulse low when OPERATION is written to turn off the channel. 1 = RUNN will not pulse low when OPERATION is written to turn off the channel.
3	0	0	0 = Disable detection of channel disabled for insufficient time to complete shutdown sequence. 1 = Enable detection of channel disabled for insufficient time to complete shutdown sequence. See Note 2.
2	1	1	0 = Channel output remains active if SHARE_CLK is held low. 1 = Channel output is disabled if SHARE_CLK is held low.
1	1	1	0 = If $\overline{\text{FAULTN}}$ pin is externally asserted, it will be logged, and STATUS_MFR_SPECIFIC bit 0 will be set. 1 = If $\overline{\text{FAULTN}}$ pin is externally asserted, it will not be logged, and STATUS_MFR_SPECIFIC bit 0 will not be set. Therefore, the $\overline{\text{ALERT}}$ pin is also not asserted due to $\overline{\text{FAULTN}}$ pin's external assertion.
0	0	0	Reserved.

**Note 1:** (bit 4). When this bit is cleared to a 0, the RUNN pin will be pulled down whenever the channel is commanded off with the OPERATION command for a duration set by MFR\_RESTART\_DELAY.

**Note 2:** (bit 3). A Short Shutdown Cycle event occurs whenever the channel is turned off and commanded back on before the TOFF\_DELAY plus TOFF\_FALL time has elapsed. If a Short Shutdown Cycle event occurs and bit 3 of MFR\_CHAN\_CONFIG\_LT7184S is set to a 1, the output rail will stop delivering power immediately and restart with a 20μs delay. If the Short Shutdown Cycle event occurs and this bit is set to a 0, the TOFF\_DELAY plus TOFF\_FALL times will be honored as a normal sequence-off event, and the part will restart after an additional 20μs delay.

**Note 3:** (bit 8) When bit 6 of MFR\_CONFIG\_ALL\_LT7184S is 0, configuration resistors may override the stored NVM value for this bit at power-up.

### MFR\_CONFIG\_ALL\_LT7184S

This command sets various global configuration bits.

**Table 11. Data Byte Contents for MFR\_CONFIG\_ALL\_LT7184S**

BITS	DEFAULT	DESCRIPTION
15-9	0000000	Reserved
8	1	0 = Linear11 and ULinear16 formats selected, depending on the command. 1 = IEEE half-precision floating point format selected.
7	0	0 = Fault log is disabled. 1 = Fault log is enabled.
6	0	0 = CFG Configuration resistors will be measured and used to configure the device during initialization. If external compensation is detected, $g_{MEA}$ is set to code 7. 1 = CFG pin configuration resistors will be ignored on pins VOUT0_CFG, VOUT1_CFG/POLYPHASE_CONFIG, and PWM_CFG. Note that the ASEL cannot be ignored and is always measured during initialization and used for device address (see <a href="#">MFR_ADDRESS</a> ). The two $I_{TH}$ pins are also always measured at startup, and if not pulled up to $INTV_{CC}$ , the device is configured for external compensation.
5	0	0 = Enable CML fault for quick command read message. See Note 1. 1 = Disable CML fault for quick command read message.
4	0	Reserved
3	0	Reserved
2	0	0 = Valid PEC not required. 1 = Valid PEC required.
1	0	0 = Disable PMBus clock stretching. If the device is too busy to process a command, the device will NACK the command and set bit 7 in STATUS_BYTE and STATUS_WORD. 1 = Enable PMBus clock stretching.
0	0	0 = When a channel is enabled, only the status bits affecting that channel will be cleared, including global status bits. 1 = All fault and warning status bits will be cleared when either channel is enabled.

**Note 1:** (bit 5). The PMBus specification indicates that PMBus devices should indicate a fault has occurred if a command starts with the read bit set in the address byte. When bit 5 of MFR\_CONFIG\_ALL\_LT7184S is set, this device will not indicate a fault.

**Table 12. On, Off, and Margin Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	NVM	DEFAULT
OPERATION	0x01	Operating mode control. On/off, margin high, and margin low.	R/W Byte	Y	Y	0x80
ON_OFF_CONFIG	0x02	RUNN pin and PMBus OPERATION command configuration.	R/W Byte	Y	Y	0x1E
MFR_RESET	0xFD	Commanded reset.	Send Byte	N		

**OPERATION**

The OPERATION command turns the channels on or off in conjunction with the RUNN pins, 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 re-enabling a channel will cause all latched faults and status bits to be cleared for that channel. Overtemperature and internal reference faults are shared between both channels. Disabling and reenabling either channel will clear the latched condition for overtemperature and internal reference faults for both channels.

[Table 13](#) shows the values of OPERATION supported by the LT7184S.

**Table 13. OPERATION Command Values**

FUNCTION	VALUE
Turn off immediately	0x00
Turn on	0x80
Margin low	0x98
Margin high	0xA8
Sequence off	0x40

**ON\_OFF\_CONFIG**

The ON\_OFF\_CONFIG command configures the combination of RUNN pin input and serial bus commands required to turn the channel on and off.

The bits that are allowed to be changed are as follows:

Bit 3: When high, the channel will only provide output power if the on/off portion of OPERATION is set.

Bit 2: When high, the channel will only provide output power if the corresponding RUNN pin is high.

Bit 0: When high, the channel will perform an immediate shutdown when the RUNN pin is deasserted. Bit 0 only has an effect when bit 2 is also set.

Bit 1 and Bit 4 must both be 1. Setting bits 1 or 4 to 0 will generate a CML fault.

If ON\_OFF\_CONFIG bits 2 and 3 are both set to 1 (which is the factory default), the channel will only turn on if the RUNN pin is high and the OPERATION command is set to enable (on, margin low, or margin high).

**MFR\_RESET**

MFR\_RESET causes the device to reset.

## PWM Configuration

**Table 14. Configuration Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	UNITS	NVM	DEFAULT
FREQUENCY_SWITCH	0x33	Controller switching frequency	R/W Word	N	kHz	Y	1000.0
MFR_PWM_MODE_LT7184S	0xD4	Paged PWM config, including PWM mode	R/W Word	Y		Y	0x0DD8
MFR_PWM_PHASE_LT7184S	0xF5	Set PWM phase	R/W Word	Y	Degrees	Y	Ch. 0: 0.0 Ch 1: 180.0
MFR_SYNC_CONFIG_LT7184S	0xF6	SYNC pin config for all pages	R/W Byte	N		Y	0x00

### FREQUENCY\_SWITCH

The FREQUENCY\_SWITCH command selects the internal oscillator frequency in 50kHz steps. The valid range is 500kHz to 4MHz.

Regardless of the value of FREQUENCY\_SWITCH, if an external clock is present on the SYNC pin, the LT7184S will attempt to synchronize the PWM to the external clock, unless bit 1 or 0 in MFR\_SYNC\_CONFIG\_LT7184S 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.

This command has two data bytes encoded in either Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

If MFR\_PWM\_MODE\_LT7184S bit 15 is set indicating, that a channel is using double the switching frequency, then FREQUENCY\_SWITCH must be less than or equal to 2MHz. If either channel has MFR\_PWM\_MODE\_LT7184S bit 15 set, then FREQUENCY\_SWITCH cannot be set higher than 2MHz.

## MFR\_PWM\_MODE\_LT7184S

Table 15. Data Byte Contents for MFR\_PWM\_MODE\_LT7184S

BITS	DEFAULT	DESCRIPTION		
15	0	Double the switching frequency for this channel.		
14	0	Must be 0.		
13:11	0b001	Error Amplifier Transconductance ( $g_{MEA}$ ).		
		Value	Standard Mode (MFR_PWM_MODE_LT7184S Bit 1 Set to 0)	High-Performance Low- $V_{OUT}$ Mode (MFR_PWM_MODE_LT7184S Bit 1 Set to 1)
		7	1240 $\mu$ S	5000 $\mu$ S
		6	1085 $\mu$ S	4375 $\mu$ S
		5	930 $\mu$ S	3750 $\mu$ S
		4	775 $\mu$ S	3125 $\mu$ S
		3	620 $\mu$ S	2500 $\mu$ S
		2	465 $\mu$ S	1875 $\mu$ S
		1	310 $\mu$ S	1250 $\mu$ S
		0	155 $\mu$ S	625 $\mu$ S
10:9	0b10	$I_{LIM}$ Range (Current Limit Selection)		
		Value	Positive Valley Current Limit $I_{LIM-POS}$ (Typ)	Negative Valley Current Limit $I_{LIM-NEG}$ (Typ)
		3	9A	-9A
		2	9A	-7.5A
		1	7A	-6A
		0	4A	-3.5A
8:6	0b111	Internal Compensation Capacitor Value $C_{ITH}$		
		Value	$C_{ITH}$ Capacitor Value	
		7	165pF	
		6	155pF	
		5	145pF	
		4	135pF	
		3	125pF	
		2	115pF	
		1	105pF	
		0	95pF	

BITS	DEFAULT	DESCRIPTION	
5:3	0b011	Internal compensation lead resistor value $R_{ITH}$	
		<b>Value</b>	<b><math>R_{ITH}</math> Resistor Value</b>
		7	60k $\Omega$
		6	42k $\Omega$
		5	29k $\Omega$
		4	20k $\Omega$
		3	14k $\Omega$
		2	10k $\Omega$
		1	7k $\Omega$
		0	5k $\Omega$
2	0	Must be 0.	
1	0	0 = Disable High-Performance, Low- $V_{OUT}$ mode. Full $V_{OUT}$ range available. 1 = Enable High-Performance, Low- $V_{OUT}$ mode when $V_{OUT}$ programmed between 600mV and 1.375V. Maximizes transient response and DC accuracy.	
0	0	Must be 0.	

When High-Performance, Low- $V_{OUT}$  (HPLV) mode is enabled, any of  $V_{OUT\_COMMAND}$ ,  $V_{OUT\_MARGIN\_HIGH}$ ,  $V_{OUT\_MARGIN\_LOW}$ , or  $V_{OUT\_MAX}$  that is above 1.375 is set to 1.375. In this mode, attempts to write any of those commands above 1.375 will cause an invalid data CML fault.

When bit 6 of  $MFR\_CONFIG\_ALL\_LT7184S$  is 0, configuration resistors may override stored NVM values for this command at power-up.

### MFR\_PWM\_PHASE\_LT7184S

The  $MFR\_PWM\_PHASE\_LT7184S$  command sets the channel PWM phase in degrees. The value is internally rounded to the nearest 15°. Inputs that are rounded to 360° or greater will cause an invalid data CML fault.

When bit 6 of  $MFR\_CONFIG\_ALL\_LT7184S$  is 0, configuration resistors may override stored NVM values for this command at power-up.



**MFR\_SYNC\_CONFIG\_LT7184S****Table 16. Data Byte Contents for MFR\_SYNC\_CONFIG\_LT7184S**

<b>BITS</b>	<b>DEFAULT</b>	<b>DESCRIPTION</b>
7:2	000000	Must be 0.
1	0	0 = SYNC clock input is used. 1 = Ignore SYNC clock input. Note that the SYNC clock input is always ignored if 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 POR: 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_LT7184S command is set to its factory-default value of 0 in EEPROM), the LT7184S will configure internal settings as described in the Operation section of the <a href="#">LT<sup>®</sup>7184S</a> data sheet.
0	0	0 = Disable SYNC output clock. 1 = Enable SYNC output clock (will run whenever SHARE_CLK is active).

When bit 6 of MFR\_CONFIG\_ALL\_LT7184S is 0, configuration resistors may override stored NVM values for this command at power-up.

**Input Voltage and Limits****Table 17. Input Voltage and Limits Commands**

<b>COMMAND NAME</b>	<b>CODE</b>	<b>DESCRIPTION</b>	<b>TYPE</b>	<b>PAGED</b>	<b>UNITS</b>	<b>NVM</b>	<b>DEFAULT</b>
VIN_ON	0x35	Input voltage at which channel starts power conversion.	R/W Word	Y	V	Y	Ch. 0: 1.5 Ch. 1: 1.4
VIN_OFF	0x36	Input voltage at which channel stops power conversion.	R/W Word	Y	V	Y	Ch. 0: 1.45 Ch. 1: 1.35
VIN_UV_WARN_LIMIT	0x58	Input supply undervoltage warning limit.	R/W Word	Y	V	Y	-1.0

**VIN\_ON**

The VIN\_ON command sets the value of the PV<sub>INN</sub> input voltage, in Volts, above which the unit starts power conversion.

**Note:** The LT7184S regulators will not start unless the internal INTV<sub>CC</sub> and DRV<sub>CC</sub> supplies are at least 2.8V, which requires that either EXTV<sub>CC</sub> or PV<sub>INO</sub> be at least 2.9V.

This command has two data bytes encoded in either Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**Max** 16.0V  
**Min** 1.4V

**VIN\_OFF**

This command sets the value of the PV<sub>INN</sub> input voltage, in Volts, below which the unit should stop power conversion.

This command has two data bytes encoded in either Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**Max** 16.0V  
**Min** 1.35V

**Note:** The LT7184S regulators can be programmed with VIN\_ON below VIN\_OFF, this is not recommended. If the LT7184S is programmed with VIN\_ON below VIN\_OFF, the part will cycle itself on and off repeatedly until both conditions are met or the VIN\_ON and VIN\_OFF values are reprogrammed so that VIN\_ON is above VIN\_OFF.

**VIN\_UV\_WARN\_LIMIT**

The VIN\_UV\_WARN\_LIMIT command sets the value of the PV<sub>INN</sub> input voltage that causes an input voltage low warning.

This alarm is masked until the input exceeds the warning limit at least once since the LT7184S has been powered.

In response to the VIN\_UV\_WARN\_LIMIT being exceeded, the device:

- ▶ Sets the NONE\_OF\_THE\_ABOVE bit in the STATUS\_BYTE.
- ▶ Sets the INPUT bit in the STATUS\_WORD.
- ▶ Sets the V<sub>IN</sub> UV Warning bit in the STATUS\_INPUT command.
- ▶ Notifies the host by asserting  $\overline{\text{ALERT}}$  pin low, unless masked.

This command has two data bytes encoded in either Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

This condition is detected by the ADC. Typical response time is less than 6.75ms in continuous monitor mode and is less than 100ms in low-power telemetry mode. Note that this response delay may occur even when the previous ADC measurement is under the new VIN\_UV\_WARN\_LIMIT.

**Max** 18.0V  
**Min** -1.0V

## Output Voltage and Limits

**Table 18. Output Voltage and Limits Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	UNITS	NVM	DEFAULT
VOUT_MODE	0x20	Output voltage format and exponent.	R Byte	Y			0x60
VOUT_COMMAND	0x21	Nominal output voltage set point.	R/W Word	Y	V	Y	0.5
VOUT_MAX	0x24	The upper limit on the commanded output voltage.	R/W Word	Y	V	Y	0.537
VOUT_MARGIN_HIGH	0x25	Margin high output voltage set point.	R/W Word	Y	V	Y	0.525
VOUT_MARGIN_LOW	0x26	Margin low output voltage set point.	R/W Word	Y	V	Y	0.475
VOUT_OV_FAULT_LIMIT	0x40	Output overvoltage fault limit.	R/W Word	Y	V	Y	0.55
VOUT_OV_WARN_LIMIT	0x42	Output overvoltage warning limit.	R/W Word	Y	V	Y	0.537
VOUT_UV_WARN_LIMIT	0x43	Output undervoltage warning limit.	R/W Word	Y	V	Y	0.467
VOUT_UV_FAULT_LIMIT	0x44	Output undervoltage fault limit.	R/W Word	Y	V	Y	0.465
MFR_DISCHARGE_THRESHOLD	0xE4	The voltage threshold that determines output has decayed sufficiently.	R/W Word	Y	V	Y	0.2
MFR_PGOOD_DELAY	0xF2	Time output voltage must be between UV and OV before PGOODN transitions high.	R/W Word	Y	ms	Y	1.0
MFR_NOT_PGOOD_DELAY	0xF3	Time output voltage must be below UV or above OV before PGOODN transitions low.	R/W Word	Y	ms	Y	0.1

## VOUT\_MODE

The read-only VOUT\_MODE command contains a 3-bit mode and a 5-bit parameter that describe the numerical format used by output voltage commands. VOUT\_MODE will be one of two values. 0x60 indicates IEEE half-precision floating point format. 0x14 indicates unsigned linear 16 format with a fixed exponent of  $2^{-12}$ .

## VOUT\_COMMAND

This command sets the output voltage when the OPERATION command has selected VOUT\_COMMAND, and uses either ULinear16 or half-precision floating point format as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

If OPERATION is set to 0x80 (turn on the output with the target voltage of VOUT\_COMMAND) and VOUT\_COMMAND is greater than VOUT\_MAX, the target output voltage will be limited to VOUT\_MAX. When VOUT\_COMMAND is commanded to a value greater than VOUT\_MAX, a VOUT\_MAX warning will occur.

When bit 6 of MFR\_CONFIG\_ALL\_LT7184S is 0, configuration resistors may override stored NVM values for this command at power-up.

**Max** 5.5V  
**Min** 0.4V

## 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 will be limited to VOUT\_MAX. When VOUT\_MAX is lower than VOUT\_COMMAND, VOUT\_MARGIN\_HIGH, or VOUT\_MARGIN\_LOW, a VOUT\_MAX warning will occur.

This command uses either ULinear16 or half-precision floating point format as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

When bit 6 of MFR\_CONFIG\_ALL\_LT7184S is 0, configuration resistors may override stored NVM values for this command at power-up.

**Max** 5.5V  
**Min** 0.4V

## VOUT\_MARGIN\_HIGH

This command loads the unit 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 will be limited to VOUT\_MAX. When VOUT\_MARGIN\_HIGH is commanded to a value greater than VOUT\_MAX, the VOUT\_MAX warning will occur.

This command uses ULinear16 or half-precision floating point format as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

When bit 6 of MFR\_CONFIG\_ALL\_LT7184S is 0, configuration resistors may override stored NVM values for this command at power-up.

**Max** 5.5V  
**Min** 0.4V

### VOUT\_MARGIN\_LOW

This command loads the unit 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 (Margin Low), and VOUT\_MARGIN\_LOW is greater than VOUT\_MAX, the output voltage will be VOUT\_MAX. When VOUT\_MARGIN\_LOW is commanded to a value greater than VOUT\_MAX, the VOUT\_MAX Warning bit in VOUT\_STATUS will be set.

This command uses ULinear16 or half-precision floating point format as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

When bit 6 of MFR\_CONFIG\_ALL\_LT7184S is 0, configuration resistors may override stored NVM values for this command at power-up.

**Max** 5.5V  
**Min** 0.4V

### VOUT\_OV\_FAULT\_LIMIT

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

This command uses ULinear16 or half-precision floating point format as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

The value must be greater than VOUT\_UV\_WARN\_LIMIT, VOUT\_UV\_FAULT\_LIMIT, and MFR\_DISCHARGE\_THRESHOLD, or an invalid data error will occur.

When bit 6 of MFR\_CHAN\_CONFIG\_LT7184S is 0, configuration resistors may override stored NVM values for this command at power-up.

**Max** 6.0V  
**Min** 0.4V

### VOUT\_OV\_WARN\_LIMIT

This 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 device:

- ▶ Sets the NONE\_OF\_THE\_ABOVE bit in the STATUS\_BYTE.
- ▶ Sets the VOUT bit in the STATUS\_WORD.
- ▶ Sets the VOUT OV Warning bit in the STATUS\_VOUT command.
- ▶ Notifies the host by asserting the ALERT pin low, unless masked.

This command uses ULinear16 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

The value must be greater than VOUT\_UV\_WARN\_LIMIT, VOUT\_UV\_FAULT\_LIMIT, and MFR\_DISCHARGE\_THRESHOLD, or an invalid data error will occur.

When bit 6 of MFR\_CHAN\_CONFIG\_LT7184S is 0, configuration resistors may override stored NVM values for this command at power-up.

**Max** 6.0V  
**Min** 0.0V

**VOUT\_UV\_WARN\_LIMIT**

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

In response to the VOUT\_UV\_WARN\_LIMIT being exceeded, the device:

- ▶ Sets the NONE\_OF\_THE\_ABOVE bit in the STATUS\_BYTE.
- ▶ Sets the VOUT bit in the STATUS\_WORD.
- ▶ Sets the VOUT UV Warning bit in the STATUS\_VOUT command.
- ▶ Notifies the host by asserting the  $\overline{\text{ALERT}}$  pin low, unless masked.

This command uses ULinear16 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

The value must be less than VOUT\_OV\_WARN\_LIMIT and VOUT\_OV\_FAULT\_LIMIT, or an invalid data error will occur.

When bit 6 of MFR\_CONFIG\_ALL\_LT7184S is 0, configuration resistors may override stored NVM values for this command at power-up.

**Max** 5.5V

**Min** 0.0V

**VOUT\_UV\_FAULT\_LIMIT**

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

This command uses ULinear16 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

The value must be less than VOUT\_OV\_WARN\_LIMIT and VOUT\_OV\_FAULT\_LIMIT, or an invalid data error will occur.

When bit 6 of MFR\_CONFIG\_ALL\_LT7184S is 0, configuration resistors may override stored NVM values for this command at power-up.

**Max** 5.5V

**Min** 0.36V

**MFR\_DISCHARGE\_THRESHOLD**

The MFR\_DISCHARGE\_THRESHOLD command specifies the output voltage threshold below which the output voltage must decay before the channel turns on. If the discharge threshold is selected in MFR\_FAULT\_PROPAGATE\_LT7184S, and the channel is commanded on while  $V_{\text{OUT}}$  is greater than the discharge threshold, the FAULTN pin is pulled low until  $V_{\text{OUT}}$  is below the discharge threshold.

If the discharge threshold is enabled, when automatically retrying after a fault, the device will also wait for  $V_{\text{OUT}}$  to be below 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 will occur.

**Max** 2.2V

**Min** 0.1V

**MFR\_PGOOD\_DELAY**

The MFR\_PGOOD\_DELAY command sets the time in milliseconds, rounded to the nearest 10 $\mu$ s, that the output voltage must be between VOUT\_OV\_FAULT\_LIMIT and VOUT\_UV\_FAULT\_LIMIT before the PGOODN pin transitions high. If the output voltage moves below the undervoltage limit or above the overvoltage limit before PGOODN transitions high, the delay timer will reset to zero. Note that the PGOODN is always held low when the channel is off and during TON\_RISE, regardless of whether V<sub>OUT</sub> is within the limits.

**Max** 64000ms

**Min** 0ms

**MFR\_NOT\_PGOOD\_DELAY**

The MFR\_NOT\_PGOOD\_DELAY command sets the time in milliseconds, rounded to the nearest 10 $\mu$ s, that the output voltage must be between VOUT\_OV\_FAULT\_LIMIT and VOUT\_UV\_FAULT\_LIMIT before the PGOODN pin is pulled low. If the output voltage is between the undervoltage and overvoltage limits before PGOODN transitions low, the delay timer will reset to zero. Note that this command only applies when the channel is enabled; if the channel is disabled by command, RUNN pin, or a fault condition set to disable the output, the PGOODN pin is pulled low immediately. If V<sub>OUT</sub> is the command to change voltage and MFR\_CHAN\_CONFIG\_LT7184S bit 9 is set to 1, then PGOODN will also pull low without delay.

**Max** 100ms

**Min** 0ms

**Input Current Limits****Table 19. Input Current Limit Command**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	UNITS	NVM	DEFAULT
IIN_OC_WARN_LIMIT	0x5D	Sets the input overcurrent warning limit	R/W Word	Y	A	Y	9.0

**IIN\_OC\_WARN\_LIMIT**

The IIN\_OC\_WARN\_LIMIT command sets the value of the input current, in amperes, which causes a warning indicating the input current is high.

In response to the IIN\_OC\_WARN\_LIMIT being exceeded, the device:

- ▶ Sets the NONE\_OF\_THE\_ABOVE bit in the STATUS\_BYTE.
- ▶ Sets the INPUT bit in the upper byte of the STATUS\_WORD.
- ▶ Sets the IIN OC Warning bit in the STATUS\_INPUT command.
- ▶ Notifies the host by asserting the  $\overline{\text{ALERT}}$  pin low, unless masked.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

This condition is detected by the ADC. Typical response time is less than 6.75ms in continuous monitor mode and is less than 100ms in low-power telemetry mode.

**Max** 30A

**Min** 0.0A

## Output Current Limits

**Table 20. Output Current Limits Command**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	UNITS	NVM	DEFAULT
IOUT_OC_WARN_LIMIT	0x4A		R/W Word	Y	A	Y	11.0

### IOUT\_OC\_WARN\_LIMIT

This command sets the value of the output current that causes an output overcurrent warning in amperes.

In response to the IOUT\_OC\_WARN\_LIMIT being exceeded, the device:

- Sets the NONE\_OF\_THE\_ABOVE bit in the STATUS\_BYTE.
- Sets the IOUT bit in the STATUS\_WORD.
- Sets the IOUT OC Warning bit in the STATUS\_IOUT command.
- Notifies the host by asserting the  $\overline{\text{ALERT}}$  pin low, unless masked.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

This condition is detected by the ADC. Typical response time is less than 6.75ms in continuous monitor mode and is less than 100ms in low-power telemetry mode.

The IOUT\_OC\_WARN\_LIMIT is ignored during TON\_RISE.

**Max** 30A

**Min** 0.0A

## Temperature

**Table 21. Temperature Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	UNITS	NVM	DEFAULT
OT_FAULT_LIMIT	0x4F	Overtemperature fault limit.	R/W Word		C	Y	160
OT_WARN_LIMIT	0x51	Overtemperature warning limit.	R/W Word		C	Y	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 Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**Max** 160°C

**Min** -60°C

In response to the OT\_FAULT\_LIMIT being exceeded, the device follows the OT\_FAULT\_RESPONSE command as described in [Table 35](#).



**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 device:

- ▶ Sets the TEMPERATURE bit in the STATUS\_BYTE.
- ▶ Sets the OT Warning bit in the STATUS\_TEMPERATURE command.
- ▶ Notifies the host by asserting the  $\overline{\text{ALERT}}$  pin low, unless masked.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

The OT\_WARN\_LIMIT and OT\_FAULT\_LIMIT conditions are detected by the ADC. Typical response time is less than 20ms, and less than 100ms in low-power telemetry mode.

**Max** 160°C

**Min** -60°C

**Timing****Sequencing On****Table 22. Sequencing On Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	UNITS	NVM	DEFAULT
VOUT_TRANSITION_RATE	0x27	Rate the output changes when commanded to a new value.	R/W Word	Y	V/ms	Y	0.25
TON_DELAY	0x60	Time from RUN or OPERATION on to output turn-on.	R/W Word	Y	ms	Y	0
TON_RISE	0x61	Time from output turn-on to reach the commanded value.	R/W Word	Y	ms	Y	1.0
TON_MAX_FAULT_LIMIT	0x62	The maximum time from the start of TON_RISE for $V_{OUT}$ to cross VOUT_UV_FAULT_LIMIT.	R/W Word	Y	ms	Y	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 0.05V/ms are recommended.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**Max\*** 25V/ms  
**Min** 0.01 V/ms

\*While the VOUT\_TRANSITION\_RATE may be commanded up to 25V/ms, the actual achievable output voltage transition rate may be limited by other factors, including output capacitance, current limit, and compensation.

### 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 $\mu$ s.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**Max** 64000ms  
**Min** 0s

### TON\_RISE

The TON\_RISE command sets the time, in milliseconds, from the time the output starts to rise after the RUNN pin or an OPERATION command to the time the output enters the regulation band at the end of a soft-start. The time is internally rounded to the nearest 10 $\mu$ s. The channel is set to pulse-skipping mode during TON\_RISE events. The maximum rise rate of the digital ramp controller is 25V/ms. If the commanded output voltage divided by TON\_RISE is more than 25V/ms, the digital control will ramp at this rate. The minimum output voltage rise time may be further limited by the 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 device will act on the command as soon as possible. However, the new ramp rate will be calculated for a full ramp from 0 Volts. Since the output is partially ramped and time has already passed, the actual total ramp time will differ from the new value for TON\_RISE.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**Max** 2000ms  
**Min** 0s

### TON\_MAX\_FAULT\_LIMIT

The TON\_MAX\_FAULT\_LIMIT command sets the value, in milliseconds, that determines how long the unit can attempt to power up the output without reaching the output undervoltage fault limit. The time is internally rounded down to the nearest 10 $\mu$ s. A data value of 0ms 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 $\mu$ 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.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**Max** 64000ms  
**Min (Disabled)** 0s

## Sequencing Off

Table 23. Sequencing Off Commands

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	UNITS	NVM	DEFAULT
TOFF_DELAY	0x64	Time from RUN and/or Operation off to the start of TOFF_FALL	R/W Word	Y	ms	Y	0.0
TOFF_FALL	0x65	Time from when the output starts to fall until the output reaches zero volts	R/W Word	Y	ms	Y	2.0
TOFF_MAX_WARN_LIMIT	0x66	Maximum allowed time, after TOFF_FALL is completed, for output to decay below MFR_DISCHARGE_THRESHOLD	R/W Word	Y	ms	Y	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 $\mu$ s.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**Max** 64000ms

**Min** 0ms

**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 $\mu$ s. It is the ramp time of the V<sub>OUT</sub> DAC.

During V<sub>OUT</sub> ramp-down, the LT7184S uses continuous conduction mode to discharge the output capacitor. The maximum fall rate of the digital ramp controller is -25V/ms. If the commanded output voltage divided by TOFF\_FALL is larger in amplitude than -25V/ms, the digital control will ramp down at this rate. The minimum V<sub>OUT</sub> fall time may be further limited by the analog behavior of the switcher, which is affected by several factors, including output load, output capacitance, and current limit selection. After the digital ramp-down is completed, the switching regulator is disabled. If the V<sub>OUT</sub> fall rate is limited by analog behavior, then the regulator will become disabled before the ramp-down is complete, and the output will not be forced all the way to zero. Setting TOFF\_FALL to 2ms or greater will ensure that V<sub>OUT</sub> will be ramped to zero during TOFF\_FALL.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**Max** 2000ms

**Min** 0ms

**TOFF\_MAX\_WARN\_LIMIT**

The TOFF\_MAX\_WARN\_LIMIT command sets the value, in milliseconds, that determines how long the unit can attempt to turn off the output until a warning is asserted. The time is internally rounded to the nearest 1ms. 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\_LT7184S set to 1).

In response to the TOFF\_MAX\_WARN\_LIMIT being exceeded, the device:

- ▶ Sets the NONE\_OF\_THE\_ABOVE bit in the STATUS\_BYTE.
- ▶ Sets the VOUT bit in the STATUS\_WORD.
- ▶ Sets the TOFF\_MAX\_Warning bit in the STATUS\_VOUT command.
- ▶ Notifies the host by asserting the  $\overline{ALERT}$  pin low, unless masked.

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

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

For this warning, the  $V_{OUT}$  voltage is detected by the ADC. Typical response time is less than 6.75ms in continuous monitor mode and is less than 100ms in low-power telemetry mode.

<b>Max</b>	64000ms
<b>Min</b>	10.0ms
<b>Disabled</b>	0.0ms

**Restarting****Table 24. MFR\_RESTART\_DELAY Command**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	UNITS	NVM	DEFAULT
MFR_RESTART_DELAY	0xDC	Minimum RUNN pin off time	R/W Word	Y	ms	Y	10.0

**MFR\_RESTART\_DELAY**

This command specifies the minimum off time in milliseconds. To enforce this off time, the LT7184S pulls the RUNN pin low for this length of time when a falling edge of the RUNN pin is detected. The time is internally rounded to the nearest 10 $\mu$ s. Note that the restart delay is different than the retry delay. The restart delay pulls the RUNN pin low for the specified time, after which a standard start-up sequence is initiated when the RUNN pin rises again. While the minimum value for this command is 0.04ms, the minimum pull-down time for the RUNN pin is TOFF\_DELAY + TOFF\_FALL + 0.02ms. The output rail can be off longer than the MFR\_RESTART\_DELAY after the RUNN pin is pulled high if the output takes a long time to decay below MFR\_DISCHARGE\_THRESHOLD.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

<b>Max</b>	64000ms
<b>Min</b>	0.04ms

## Fault Response

### All Faults

**Table 25. All Faults Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	UNITS	NVM	DEFAULT
MFR_RETRY_DELAY	0xDB	Retry interval during fault retry	R/W Word	Y	ms	Y	10.0

### MFR\_RETRY\_DELAY

This 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 $\mu$ s. This command value is used for all fault responses that require retry. The retry time starts once a fault has been detected by the offending channel. Note that the retry delay time is determined by the longer of the MFR\_RETRY\_DELAY command or the time required for the regulated output to decay below MFR\_DISCHARGE\_THRESHOLD. 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\_LT7184S.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**Max** 64000ms

**Min** 0.02ms

### Input Voltage

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

**Table 26. VIN\_OV\_FAULT\_RESPONSE Command**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	NVM	DEFAULT
VIN_OV_FAULT_RESPONSE	0x56	Action to be taken when an input overvoltage fault is detected.	R/W Byte	Y	Y	0xB8

### VIN\_OV\_FAULT\_RESPONSE

The VIN\_OV\_FAULT\_RESPONSE command sets the action the device will take in response to an input overvoltage fault.

The device also:

- ▶ Sets the NONE\_OF\_THE\_ABOVE bit in the STATUS\_BYTE.
- ▶ Sets the INPUT bit in the upper byte of the STATUS\_WORD.
- ▶ Sets the VIN OV Fault bit in the STATUS\_INPUT command.
- ▶ Notifies the host by asserting the  $\overline{\text{ALERT}}$  pin low, unless masked.

**Table 27. Data Byte Contents for VIN\_OV\_FAULT\_RESPONSE**

BITS	DESCRIPTION	DEFAULT	VALUE	DESCRIPTION
7:6	Response: For all values of bits [7:6], the device sets the $V_{IN}$ OV bit in the status commands and pulls the $\overline{ALERT}$ pin low, unless masked	10	00	Not supported. Writing this value will generate a CML fault.
			01	Not supported. Writing this value will generate a CML fault.
			10	The device shuts down immediately (disables the output) and responds according to the retry setting in bits [5:3].
			11	Not supported. Writing this value will generate a CML fault.
5:3	Retry Setting	111	000–110	The unit does not attempt to restart. The output remains disabled until the device is commanded off or bias power is removed by removing $PV_{IN0}$ and $EXTV_{CC}$ .
			111	The device attempts to restart continuously, without limitation, until it is 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: The retry interval is set by the MFR_RETRY_DELAY command.
2:0	Delay Time	000	000	Must be 0. Writing this to nonzero will generate a CML fault.

## Output Voltage

The output voltage faults only cause a configured fault response when the associated channel is on. Any associated  $\overline{FAULTN}$  pin will only be asserted when the channel is on. However, the  $\overline{ALERT}$  pin will be asserted low unless masked by  $SMBALERT\_MASK$ .

**Table 28. Output Voltage Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	NVM	DEFAULT
VOUT_OV_FAULT_RESPONSE	0x41	Action to be taken when an output overvoltage fault is detected.	R/W Byte	Y	Y	0xB8
VOUT_UV_FAULT_RESPONSE	0x45	Action to be taken when an output undervoltage fault is detected.	R/W Byte	Y	Y	0x00
TON_MAX_FAULT_RESPONSE	0x63	Action to be taken when a TON_MAX_FAULT event is detected.	R/W Byte	Y	Y	0x00

**VOUT\_OV\_FAULT\_RESPONSE**

The VOUT\_OV\_FAULT\_RESPONSE command sets device's action in response to an output overvoltage fault.

The device also:

- ▶ Sets the VOUT\_OV bit in the STATUS\_BYTE.
- ▶ Sets the VOUT bit in the STATUS\_WORD.
- ▶ Sets the VOUT OV Fault bit in the STATUS\_VOUT command.
- ▶ Sets the VOUT OV Warning bit in the STATUS\_VOUT command.
- ▶ Notifies the host by asserting the  $\overline{\text{ALERT}}$  pin low, unless masked.

**Table 29. Data Byte Contents for VOUT\_OV\_FAULT\_RESPONSE**

BITS	DESCRIPTION	DEFAULT	VALUE	DESCRIPTION
7:6	Response Default: 10 For all values of bits [7:6], the device: Sets the V <sub>OUT</sub> OV bit in the status commands Pulls the $\overline{\text{ALERT}}$ pin low, unless masked	10	00	The device operates in continuous mode while the fault is active, attempting to regulate the programmed voltage.
			01	The device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that fault. If the fault condition is still present at the end of the delay time, the device responds as programmed in the Retry Setting (bits [5:3]).
			10	The device shuts down immediately (disables the output) and responds according to the retry setting in bits [5:3].
			11	Not supported. Writing this value will generate a CML fault.
5:3	Retry Setting	111	000–110	The unit does not attempt to restart. The output remains disabled until the device is commanded off or bias power is removed by removing PV <sub>INO</sub> and EXT <sub>VCC</sub> .
			111	The device attempts to restart continuously, without limitation, until it is 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: The retry interval is set by the MFR_RETRY_DELAY command.
2:0	Delay Time	000		The delay time is in 10 $\mu$ s increments. This delay time determines how long the channel continues operating after a fault is detected.

**VOUT\_UV\_FAULT\_RESPONSE**

The VOUT\_UV\_FAULT\_RESPONSE command sets the action the device will take in response to an output undervoltage fault.

- ▶ Sets the NONE\_OF\_THE\_ABOVE bit in the STATUS\_BYTE.
- ▶ Sets the VOUT bit in the STATUS\_WORD.
- ▶ Sets the VOUT UV Fault bit in the STATUS\_VOUT command.
- ▶ Sets the VOUT UV Warning bit in the STATUS\_VOUT command.
- ▶ Notifies the host by asserting the  $\overline{\text{ALERT}}$  pin low, unless masked.

The UV fault and warning status bits are masked until all of the following criteria are achieved:

- ▶ The TON\_MAX\_FAULT\_LIMIT has been reached.
- ▶ The TON\_DELAY sequence has completed.
- ▶ The TON\_RISE sequence has completed.
- ▶ The VOUT\_UV\_FAULT\_LIMIT threshold has been 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 30. Data Byte Contents for VOUT\_UV\_FAULT\_RESPONSE**

BITS	DESCRIPTION	DEFAULT	VALUE	DESCRIPTION
7:6	Response For all values of bits [7:6], the device: Sets the $V_{\text{OUT}}$ UV bit in the status commands Pulls the $\overline{\text{ALERT}}$ pin low, unless masked.	00	00	The device continues operation without interruption
			01	The device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that fault. If the fault condition is still present at the end of the delay time, the device responds as programmed in the Retry Setting (bits [5:3]).
			10	The device shuts down immediately (disables the output) and responds according to the retry setting in bits [5:3].
			11	Not supported. Writing this value will generate a CML fault.
5:3	Retry Setting	000	000–110	The unit does not attempt to restart. The output remains disabled until the device is commanded off or bias power is removed by removing $PV_{\text{IN0}}$ and $\text{EXTV}_{\text{CC}}$ .
			111	The device attempts to restart continuously, without limitation, until it is commanded off (by the RUNN pin or OPERATION command or both), bias power is removed, or another fault condition causes the unit to shut down without retry. Note: The retry interval is set by the MFR_RETRY_DELAY command.
2:0	Delay Time	000	XXX*	The delay time is in 10 $\mu\text{s}$ increments. This delay time determines how long the channel continues operating after a fault is detected.

\*X means don't care.



**TON\_MAX\_FAULT\_RESPONSE**

The TON\_MAX\_FAULT\_RESPONSE command sets the action the device will take in response to a TON\_MAX fault.

The device also:

- ▶ Sets the NONE\_OF\_THE\_ABOVE bit in the STATUS\_BYTE.
- ▶ Sets the VOUT bit in the STATUS\_WORD.
- ▶ Sets the TON\_MAX Fault bit in the STATUS\_VOUT command.
- ▶ Notifies the host by asserting the  $\overline{\text{ALERT}}$  pin low, unless masked.
- ▶ A value of 0 disables the TON\_MAX\_FAULT\_RESPONSE. It is not recommended to use 0.

**Table 31. Data Byte Contents for TON\_MAX\_FAULT\_RESPONSE**

BITS	DESCRIPTION	DEFAULT	VALUE	DESCRIPTION
7:6	Response For all values of bits [7:6], the device sets the TON_MAX bit in the status commands and pulls the $\overline{\text{ALERT}}$ pin low, unless masked.	00	00	The device continues operation without interruption.
			01	Not supported. Writing this value will generate a CML fault.
			10	The device shuts down immediately (disables the output) and responds according to the retry setting in bits [5:3].
			11	Not supported. Writing this value will generate a CML fault.
5:3	Retry Setting	000	000–110	The unit does not attempt to restart. The output remains disabled until the device is commanded off or bias power is removed by removing $\text{PV}_{\text{IN0}}$ and $\text{EXTV}_{\text{CC}}$ .
			111	The device attempts to restart continuously, without limitation, until it is 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: The retry interval is set by the MFR_RETRY_DELAY command.
2:0	Delay Time	000	000	Must be 0. Writing this to nonzero will generate a CML fault.

## Output Current

Table 32. Output Current Fault Command

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	NVM	DEFAULT
IOUT_OC_FAULT_RESPONSE	0x47	Action to be taken when an output overcurrent fault is detected	R/W Byte	Y	Y	0x00

Table 33. Data Byte Contents for IOUT\_OC\_FAULT\_RESPONSE

BITS	DESCRIPTION	DEFAULT	VALUE	DESCRIPTION
7:6	Response: For all values of bits [7:6], the device sets the IOUT OC bit in the status commands and pulls the $\overline{\text{ALERT}}$ pin low, unless masked.	00	00	The device continues operation indefinitely while maintaining the output current set by MFR_PWM_MODE_LT7184S without regard to the output voltage (known as constant-current or brick wall limiting).
			01	Not supported. Writing this value will generate a CML fault.
			10	The device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that fault. If the fault condition is still present at the end of the delay time, the device responds as programmed in the Retry Setting (bits [5:3]).
			11	The device shuts down immediately (disables the output) and responds according to the retry setting in bits [5:3].
5:3	Retry Setting	000	000–110	The unit does not attempt to restart. The output remains disabled until the device is commanded off or bias power is removed by removing $PV_{\text{IN0}}$ and $\text{EXTV}_{\text{CC}}$ .
			111	The device attempts to restart continuously, without limitation, until it is 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: The retry interval is set by the MFR_RETRY_DELAY command.
2:0	Delay Time	000	XXX*	The delay time is in 10 $\mu$ s increments. This delay time determines how long the channel continues operating after a fault is detected.

\*X means don't care

## Temperature

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

**Table 34. Over Temperature Fault Command**

COMMAND NAME	CODE	DESCRIPTION	TYPE	NVM	DEFAULT
OT_FAULT_RESPONSE	0x50	Action to be taken when an internal overtemperature fault is detected	R/W Byte	Y	0xC0

## OT\_FAULT\_RESPONSE

The OT\_FAULT\_RESPONSE command sets the device's action in response to an internal overtemperature fault.

The device also:

- Sets the MFR bit in the STATUS\_WORD.
- Sets the OT Fault bit in the STATUS\_TEMPERATURE command.
- Notifies the host by asserting the  $\overline{\text{ALERT}}$  pin low, unless masked.

**Table 35. Data Byte Contents for OT\_FAULT\_RESPONSE**

BITS	DESCRIPTION	DEFAULT	VALUE	DESCRIPTION
7:6	Response: For all values of bits [7:6], the device sets the OT bit in the status commands, and pulls the $\overline{\text{ALERT}}$ pin low, unless masked.	11	00	Not supported. Writing this value will generate a CML fault.
			01	Not supported. Writing this value will generate a CML fault.
			10	The device shuts down immediately (disables the output) and responds according to the retry setting in bits [5:3].
			11	The device's output is disabled while the fault is present. Operation resumes, and the output is enabled when the fault condition no longer exists.
5:3	Retry Setting	000	000–110	The unit does not attempt to restart. The output remains disabled until the device is commanded off or bias power is removed by removing $\text{PV}_{\text{INO}}$ and $\text{EXTV}_{\text{CC}}$ .
			111	Not supported. Writing this value will generate a CML fault.
2:0	Ignored	000	XXX*	Ignored

\*X means don't care

## Fault Sharing Commands

**Table 36. Fault Sharing Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	NVM	DEFAULT
MFR_FAULT_PROPAGATE_LT7184S	0xD2	Determines which faults are propagated to the $\overline{\text{FAULTN}}$ pin.	R/W Word	Y	Y	0xE0D7
MFR_FAULT_RESPONSE	0xD5	Action to be taken when the $\overline{\text{FAULTN}}$ pin is asserted low.	R/W Byte	Y	Y	0xC0

### MFR\_FAULT\_PROPAGATE\_LT7184S

The MFR\_FAULT\_PROPAGATE\_LT7184S command selects the conditions that can cause the  $\overline{\text{FAULTN}}$  pin to be asserted low. When the  $\overline{\text{FAULTN}}$  pin is asserted low due to a fault condition, it will remain asserted until:

- ▶ The channel is disabled and then enabled (by RUN or OPERATION, depending on ON\_OFF\_CONFIG), clearing the fault condition;
- ▶ MFR\_RETRY\_DELAY expires when the fault condition is no longer present for faults that are configured with a retry response.

A fault is only propagated to the  $\overline{\text{FAULTN}}$  pin if the corresponding fault response command is configured to disable the channel, and the corresponding bit is set to 1 in MFR\_FAULT\_PROPAGATE\_LT7184S.

**Table 37. Data Byte Contents for MFR\_FAULT\_PROPAGATE\_LT7184S**

BITS	DEFAULT	CONDITION	DESCRIPTION
15	1	V <sub>OUT</sub> turned on while discharging	Enables propagation of the V <sub>OUT</sub> discharge condition. If a channel is turned on while V <sub>SENSE</sub> is above MFR_DISCHARGE_THRESHOLD, V <sub>OUT</sub> is disabled until V <sub>SENSE</sub> decays below that threshold.
14	1	Short Shutdown Cycle	Enables propagation of the Short Shutdown Cycle condition if bit 3 of MFR_CHAN_CONFIG_LT7184S is set.
13	1	T <sub>ON</sub> Max Fault	
12	0	Reserved	
11:8	0	Reserved	
7	1	Overtemperature fault	
6	1	Internal voltage reference fault	
5	0	Reserved	
4	1	Input OV fault	
3	0	Reserved	
2	1	I <sub>OUT</sub> OC fault	
1	1	V <sub>OUT</sub> UV fault	
0	1	V <sub>OUT</sub> OV fault	

## MFR\_FAULT\_RESPONSE

This command determines the device's response to the  $\overline{\text{FAULTN}}$  pin being pulled low.

**Table 38. MFR\_FAULT\_RESPONSE Command**

VALUE	DESCRIPTION
0xC0	The device will stop delivering power as fast as possible in response to the $\overline{\text{FAULTN}}$ pin being pulled low.
0x00	The device continues operation without interruption.

The device also:

- Sets the NONE\_OF\_THE\_ABOVE bit in the STATUS\_BYTE.
- Sets the MFR bit in the STATUS\_WORD.
- Sets bit 0 in the STATUS\_MFR\_SPECIFIC command if bit 1 of MFR\_CHAN\_CONFIG\_LT7184S is not set.
- Notifies the host by asserting the  $\overline{\text{ALERT}}$  pin low, unless masked. The  $\overline{\text{ALERT}}$  pin pulled low can be disabled by setting bit 0 of MFR\_CHAN\_CONFIG\_LT7184S.

## Identification

**Table 39. Identification Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	DEFAULT
CAPABILITY	0x19	PMBus optional communication protocols supported.	R Byte	N	0xD8
PMBUS_REVISION	0x98	PMBus revision supported. Currently 1.3.	R Byte	N	0x33
MFR_ID	0x99	Returns “ADI”.	R String	N	Analog Devices
MFR_MODEL	0x9A	Returns “LT7184S”.	R String	N	LT7184S
MFR_REVISION	0x9B	Manufacturer revision number.	R Block	N	
MFR_SERIAL	0x9E	Unit-specific unique serial number.	R Block	N	
IC_DEVICE_ID	0xAD	Returns “LT7184S”.	R Block	N	LT7184S
IC_DEVICE_REV	0xAE	Manufacturer revision number.	R Block	N	
MFR_SPECIAL_ID	0xE7	Manufacturer code.	R Word	N	0x1C1D

## Status

[Figure 1](#) summarizes the internal LT7184S status registers accessible by the PMBus command. These contain indications of various faults, warnings, and other important operating conditions. As shown, the STATUS\_BYTE and STATUS\_WORD commands summarize the 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 register (including any fault or warning) also pulls the  $\overline{\text{ALERT}}$  pin low.

With some exceptions, the SMBALERT\_MASK command can be used to prevent the LT7184S from pulling the  $\overline{\text{ALERT}}$  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  $\overline{\text{ALERT}}$  is masked for all bits in channel 0 STATUS\_VOUT, then  $\overline{\text{ALERT}}$  is effectively masked for the  $V_{\text{OUT}}$  bit in STATUS\_WORD for PAGE 0.

Status information contained in MFR\_COMMON and MFR\_PADS can be used to debug further or clarify the contents of STATUS\_BYTE or STATUS\_WORD as shown, but the contents of MFR\_COMMON and MFR\_PADS do not directly affect the state of the  $\overline{\text{ALERT}}$  pin.

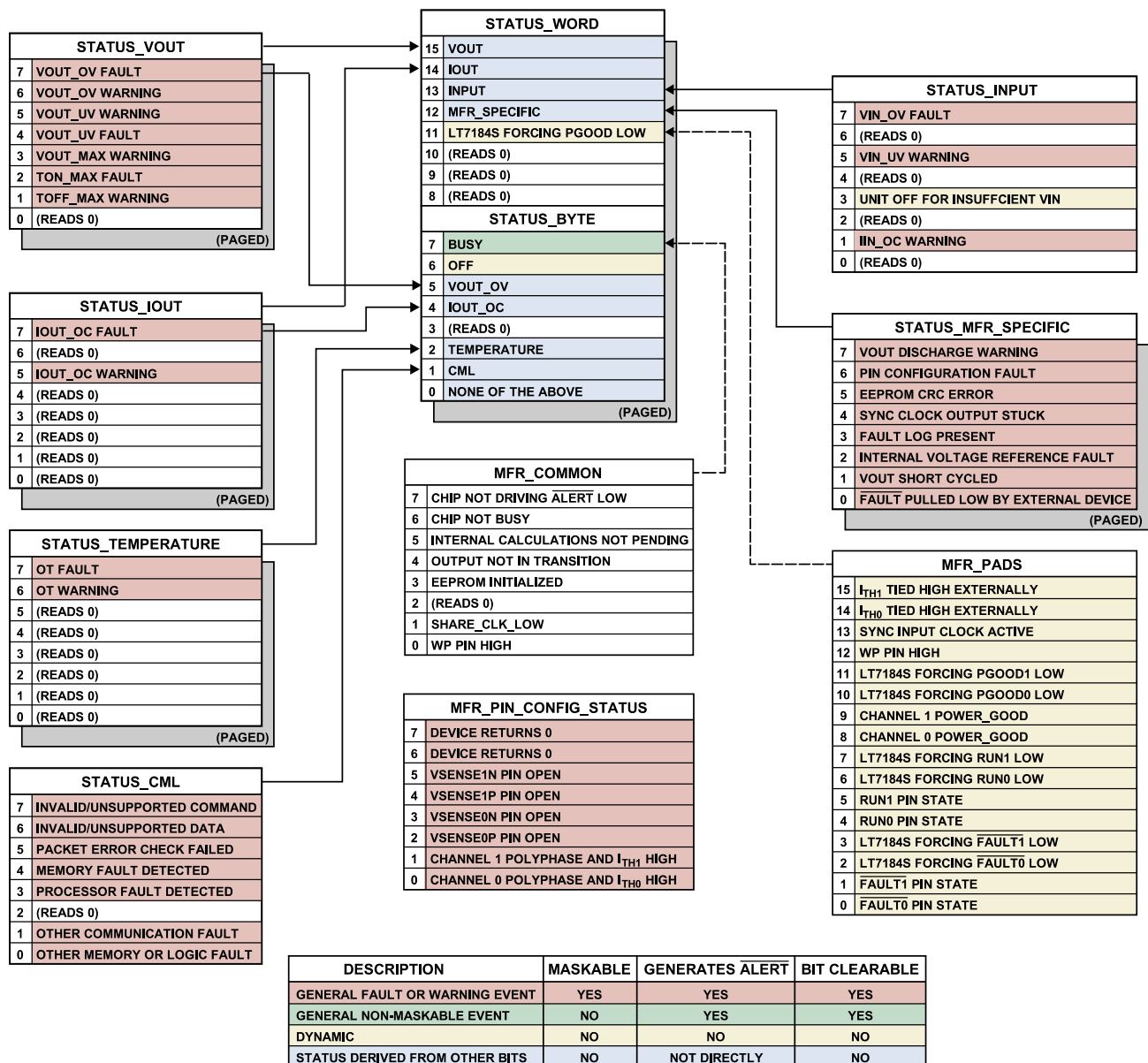


Figure 1. LTC7184S Status Register Summary

**Table 40. Status Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	NVM	DEFAULT
CLEAR_FAULTS	0x03	Clear all fault bits.	Send Byte	N		
SMBALERT_MASK	0x1B	Mask $\overline{\text{ALERT}}$ pin.	Block R/W	Y	Y	
STATUS_BYTE	0x78	One-byte summary of the unit's faults and warnings.	R/W Byte	Y		
STATUS_WORD	0x79	One-word summary of the unit's faults and warnings.	R/W Word	Y		
STATUS_VOUT	0x7A	Output voltage faults and warnings.	R/W Byte	Y		
STATUS_IOUT	0x7B	Output current faults and warnings.	R/W Byte	Y		
STATUS_INPUT	0x7C	Input supply faults and warnings.	R/W Byte	Y		
STATUS_TEMPERATURE	0x7D	Internal temperature faults and warnings.	R/W Byte	N		
STATUS_CML	0x7E	Communications, memory, and logic faults and warnings.	R/W Byte	N		
STATUS_MFR_SPECIFIC	0x80	Manufacturer-specific faults and warnings.	R/W Byte	Y		
MFR_PADS_LT7184S	0xE5	Digital status of I/O pads.	R Word	N		
MFR_COMMON	0xEF	Manufacturer status bits are common across multiple Analog Devices parts.	R/W Byte	N		
MFR_CHANNEL_STATE	0xF1	Returns the state of the channel.	R Byte	Y		
MFR_PIN_CONFIG_STATUS	0xF7	Indicates the source of pin config fault.	R Byte	N		

## 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. This command also deasserts the  $\overline{\text{ALERT}}$  pin. If the fault is still present when the bit is cleared, the fault bit will remain set, and the host will be notified by asserting the  $\overline{\text{ALERT}}$  pin low.

The CLEAR\_FAULTS command does not clear the  $\overline{\text{FAULTN}}$  pin, nor does CLEAR\_FAULTS cause a unit that has latched off for a fault condition to restart. Units that have shut down for a fault condition are restarted only when:

- ▶ The output is commanded to turn off and then to turn back on via the RUN pin and/or OPERATION command, or,
- ▶ MFR\_RESET command is issued, or,
- ▶  $\text{PV}_{\text{IN0}}$  and  $\text{EXTV}_{\text{CC}}$  bias power are removed and reapplied to the device.

The overtemperature and internal reference faults are shared between both channels. Disabling and then reenabling either channel will clear the latched condition for overtemperature and internal reference faults for both channels.

CLEAR\_FAULTS can take up to 10 $\mu\text{s}$  to process. If a fault occurs within that time frame, it may be cleared before the status register is set.

## 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, then a subsequent Overtemperature Warning would still set bit 6 of STATUS\_TEMPERATURE but not assert  $\overline{\text{ALERT}}$  low. All other supported STATUS\_TEMPERATURE bits would 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 may be masked. STATUS\_WORD is not supported for SMBALERT\_MASK.

Providing an unsupported command code to SMBALERT\_MASK will generate a CML for Invalid/Unsupported Data.

**Table 41. Factory Default SMBALERT\_MASK Settings**

STATUS REGISTER	MASK VALUE	MASKED BITS
STATUS_VOUT	0x00	None
STATUS_IOUT	0x80	IOUT_OC Fault
STATUS_TEMPERATURE	0x00	None
STATUS_CML	0x00	None
STATUS_INPUT	0x02	IIN_OC Warning
STATUS_MFR_SPECIFIC	0x01	Fault pulled low by external device.



**STATUS\_BYTE**

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

**Table 42. Data Byte Contents for STATUS\_BYTE**

BIT	NAME	DESCRIPTION
7	BUSY	A fault was declared because the device was could not 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 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.

**STATUS\_WORD**

The STATUS\_WORD command returns a two-byte summary of the channel's fault condition. The low byte of the STATUS\_WORD is the same as the STATUS\_BYTE command. Bit 7 may be cleared by writing a 1 to its position.

**Table 43. Data Byte Contents for STATUS\_WORD**

BIT	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 LT7184S has occurred.
11	POWER NOT GOOD	This bit is set when the PGOOD pin is 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 may be cleared by writing a 1 to its position.

**Table 44. STATUS\_VOUT Bit Contents**

BIT	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 part was 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 may be cleared by writing a 1 to its position.

**Table 45. Data Byte Contents for STATUS\_IOUT**

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 may be cleared by writing a 1 to its position.

**Table 46. Data Byte Contents for STATUS\_INPUT**

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 LOW INPUT VOLTAGE	Unit is off due to insufficient input voltage.
2	UNSUPPORTED	Not supported (device returns 0).
1	IIN OC WARNING	Input overcurrent warning.
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 may be cleared by writing a 1 to its position.

**Table 47. Data Byte Contents for STATUS\_TEMPERATURE**

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 may be cleared by writing a 1 to its position.

**Table 48. Data Byte Contents for STATUS\_CML**

BIT	DESCRIPTION
7	Invalid or unsupported command received.
6	Invalid or unsupported data received.
5	Packet error check failed.
4	Memory fault detected.
3	Contact factory.
2	Not supported (device returns 0).
1	Other communication fault.
0	Other memory or logic fault.

**STATUS\_MFR\_SPECIFIC**

The STATUS\_MFR\_SPECIFIC commands return one byte with the manufacturer-specific status information. Bit 2 through Bit 5 are not page-specific. An individual bit may be cleared by writing a 1 to its position, with the exception of the fault log present bit. That bit can only be cleared by the MFR\_FAULT\_LOG\_CLEAR command.

**Table 49. Data Byte Contents for STATUS\_MFR\_SPECIFIC**

BIT	DESCRIPTION
7	$V_{OUT}$ is turned on when the output voltage is above the discharge threshold.
6	Pin configuration fault. (See <a href="#">MFR_PIN_CONFIG_STATUS</a> for more information).
5	NVM fault.
4	Sync stuck low while the SYNC pin is configured as a clock output (MFR_SYNC_CONFIG_LT7184S bit 0 is set to 1).
3	Fault log present.
2	Internal voltage reference fault.
1	A short shutdown cycle event occurred.
0	FAULTN pin pulled low by an external device.

**MFR\_PIN\_CONFIG\_STATUS**

During initialization, the LT7184S checks for various illegal pin configurations. If a pin configuration fault is detected, the LT7184S pulls down the FAULT and PGOOD pins, sets STATUS\_MFR\_SPECIFIC bit 6, and the regulator outputs are locked off until the part is reset. The MFR\_PIN\_CONFIG\_STATUS commands returns one read-only byte indicating what type of pin configuration fault has been detected.

**Table 50. Data Byte Contents for MFR\_PIN\_CONFIG\_STATUS**

BIT	DESCRIPTION
7	Device returns 0.
6	Device returns 0.
5	VSENSE1N pin was detected open-circuit during initialization.
4	VSENSE1P pin was detected open-circuit during initialization.
3	VSENSE0N pin was detected open-circuit during initialization.
2	VSENSE0P pin was detected open-circuit during initialization.
1	Channel 1 is set for polyphase follower (MFR_CHAN_CONFIG_LT7184S bit 8 set high) while internal compensation is selected ( $I_{TH1}$ pin tied high).
0	Channel 0 is set for polyphase follower (MFR_CHAN_CONFIG_LT7184S bit 8 set high) while internal compensation is selected ( $I_{TH0}$ pin tied high).

**MFR\_PADS\_LT7184S**

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

**Table 51. Data Byte Contents for MFR\_PADS\_LT7184S**

BIT	DESCRIPTION
15	$I_{TH1}$ tied high externally (internal compensation selected).
14	$I_{TH0}$ tied high externally (internal compensation selected).
13	Sync input clock active.
12	WP
11	Device driving PGOOD1 low.
10	Device driving PGOOD0 low.
9	PGOOD1
8	PGOOD0
7	Device driving RUN1 low.
6	Device driving RUN0 low.
5	RUN1
4	RUN0
3	Device driving $\overline{\text{FAULT1}}$ low.
2	Device driving $\overline{\text{FAULT0}}$ low.
1	$\overline{\text{FAULT1}}$
0	$\overline{\text{FAULT0}}$

**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  $\overline{\text{ALERT}}$  pin to be asserted.

**Table 52. Data Byte Contents for MFR\_COMMON**

BITS	DESCRIPTION
7	Chip not driving $\overline{\text{ALERT}}$ low.
6	Chip not busy.
5	Calculations not pending.
4	Output not in transition.
3	NVM initialized.
2	Reserved (device returns 0).
1	SHARE_CLK timeout.
0	WP pin status.

**MFR\_CHANNEL\_STATE**

The MFR\_CHANNEL\_STATE command returns to the state of the channel.

**Table 53. Data Byte Contents for MFR\_CHANNEL\_STATE**

BITS	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).

## Telemetry

**Table 54. Telemetry Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	UNITS	NVM	DEFAULT
READ_VIN	0x88	Measured input supply voltage.	R Word	Y	V		
READ_VOUT	0x8B	Measured output voltage.	R Word	Y	V		
READ_IIN	0x89	Calculated input supply current.	R Word	Y	A		
READ_IOUT	0x8C	Measured output current.	R Word	Y	A		
READ_TEMPERATURE_1	0x8D	Measured internal temperature.	R Word	N	C		
READ_FREQUENCY	0x95	Frequency of top gate.	R Word	Y	kHz		
READ_POUT	0x96	Calculated output power.	R Word	Y	W		
MFR_READ_EXTVCC	0xCD	Measured EXTV <sub>CC</sub> pin voltage.	R Word	N	V		
MFR_READ_ITH	0xCE	Measured I <sub>THN</sub> pin voltage.	R Word	Y	V		
MFR_IOUT_PEAK	0xD7	Maximum READ_IOUT.	R Word	Y	A		
MFR_ADC_CONTROL_LT7184S	0xD8	ADC configuration.	R/W Byte	N		Y	0x00
MFR_VOUT_PEAK	0xDD	Maximum READ_VOUT.	R Word	Y	V		
MFR_VIN_PEAK	0xDE	Maximum READ_VIN.	R Word	Y	V		
MFR_TEMPERATURE_1_PEAK	0xDF	Maximum READ_TEMPERATURE_1	R Word	Y	C		
MFR_CLEAR_PEAKE	0xE3	Clears all recorded peak values	Send Byte	Y			

### READ\_VIN

The READ\_VIN command returns the measured input voltage.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

### READ\_VOUT

The READ\_VOUT command returns the measured output voltage.

This command uses ULinear16 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**READ\_IIN**

The READ\_IIN command returns an approximation of the input current.

The input current for a channel,  $I_{IN}$ , is calculated internally using the following equation:

$$I_{IN} = \left( \frac{V_{OUT}}{V_{IN}} \times I_{OUT} \right) + (V_{IN} \times \text{Switching Frequency} \times V_{IN} \text{ Gain Trim SW})$$

For  $I_{IN}[0]$ , if  $EXTV_{CC}$  is not present,  $I_{VCC}$  current is calculated using the equation below and added to  $I_{IN}$ .

$$I_{VCC} = ((\text{Switching Frequency}[ch0]) + (\text{Switching Frequency}[ch1])) \times KI_{VCC} + I_{VCCSTBY}$$

Where the constants in the equations above are based on characterization. This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**READ\_IOUT**

The READ\_IOUT command returns the measured output current.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**READ\_TEMPERATURE\_1**

The READ\_TEMPERATURE\_1 command returns the internal device temperature.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**READ\_FREQUENCY**

The READ\_FREQUENCY command returns the top switching frequency in kHz.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**READ\_POUT**

The READ\_POUT command returns the average output power. The output power is calculated based on the most recent correlated output voltage and output current readings.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**MFR\_READ\_EXTVCC**

The MFR\_READ\_EXTVCC command returns the measured voltage on the EXTVCC pin.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**MFR\_READ\_ITH**

The MFR\_READ\_ITH command returns the measured voltage on the  $I_{TH0}$  pin or the  $I_{TH1}$  pin, depending on the selected page.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**MFR\_IOUT\_PEAK**

The MFR\_IOUT\_PEAK command reports the highest output current measured.

This command is cleared using the MFR\_CLEAR\_PEAKS command.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**MFR\_ADC\_CONTROL\_LT7184S**

The MFR\_ADC\_CONTROL\_LT7184S command controls adjustable features of the telemetry loop.

Bit 1 enables low-power telemetry mode measurements to reduce input supply current. When this bit is set, the telemetry runs with a typical period of 100ms (compared to a typical period of 6.5ms when this bit is zero).

Bit 0 enables the debug telemetry measurements:  $EXTV_{CC}$ ,  $I_{TH0}$ ,  $I_{TH1}$ . When those are enabled, the sampling rate of the other measurements decreases.

**Table 55. Data Byte Contents for MFR\_ADC\_CONTROL\_LT7184S**

BIT	DEFAULT	DESCRIPTION
1	0	Enable low-power telemetry mode (100ms typical period, 2mA typical supply current reduction)
0	0	Debug telemetry measurements: standard + $EXTV_{CC}$ , $I_{TH0}$ , $I_{TH1}$ .

**MFR\_VOUT\_PEAK**

The MFR\_VOUT\_PEAK command reports the highest output voltage measured.

This command is cleared using the MFR\_CLEAR\_PEAKS command.

This command uses ULinear16 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**MFR\_VIN\_PEAK**

The MFR\_VIN\_PEAK command reports the highest input voltage measured.

This command is cleared using the MFR\_CLEAR\_PEAKS command.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**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.

This command uses Linear11 or half-precision floating point format, as selected by MFR\_CONFIG\_ALL\_LT7184S bit 8.

**MFR\_CLEAR\_PEAKS**

The MFR\_CLEAR\_PEAKS command clears the MFR\_\*\_PEAK data values. These values are also cleared at reset or power-up.



## NVM Commands

All EEPROM commands are disabled if the internal die temperature exceeds 170°C. They are re-enabled when the die temperature falls below 150°C.

Most EEPROM access commands will take milliseconds to complete.

**Table 56. Store/Restore COMMANDS**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	NVM	DEFAULT
STORE_USER_ALL	0x15	Store user operating memory to NVM.	Send Byte			
RESTORE_USER_ALL	0x16	Restore user operating memory from NVM.	Send Byte			
MFR_COMPARE_USER_ALL	0xF0	Compares current command contents with NVM.	Send Byte			
MFR_USER_DATA_00	0xC9	EEPROM word available for the user.	R/W Word		Y	0x0000
MFR_USER_DATA_01	0xCA	EEPROM word available for the user.	R/W Word		Y	0x0000
MFR_USER_DATA_02	0xCB	EEPROM word available for the user.	R/W Word		Y	0x0000
MFR_USER_DATA_03	0xCC	EEPROM word available for the user.	R/W Word		Y	0x0000
MFR_DISABLE_OUTPUT	0xFB	Disables regulator outputs until reset.	R/W Byte			0x00
MFR_EE_USER_WP	0xFC	Disables commands that write user NVM.	R/W Byte	N	Y	0x00

### STORE\_USER\_ALL

The STORE\_USER\_ALL command instructs the device to copy the contents of the Operating Memory to nonvolatile EEPROM memory (NVM). All commands designated as NVM-backed commands will be stored in NVM by this command.

Executing this command if the die temperature exceeds 150°C is not recommended, and the data retention of 10 years cannot be guaranteed. If the die temperature exceeds 170°C, the STORE\_USER\_ALL command is disabled. The command is re-enabled when the IC temperature drops below 150°C.

### RESTORE\_USER\_ALL

The RESTORE\_USER\_ALL command provides a means by which the user can reset the device.

### MFR\_COMPARE\_USER\_ALL

The MFR\_COMPARE\_USER\_ALL command instructs the PMBus device to compare current command contents with what is stored in nonvolatile memory. If the compare operation detects differences, a CML bit 0 fault will be generated.

MFR\_COMPARE\_USER\_ALL commands are disabled if the LT7184S exceeds 170°C and are not re-enabled until the device temperature drops below 150°C.

**MFR\_USER\_DATA\_00, MFR\_USER\_DATA\_01, MFR\_USER\_DATA\_02, and MFR\_USER\_DATA\_03**

The MFR\_USER\_DATA\_XX commands may be used by the user to store any data. Each of these commands stores one 16-bit word. This data is written to the EEPROM when the STORE\_USER\_ALL command is written.

**MFR\_DISABLE\_OUTPUT**

When written to 0xFF, this command disables the regulator outputs until reset. This allows anything to be programmed into ON\_OFF\_CONFIG, OPERATION, etc., without powering up the output. This is intended to enable all NVM-stored commands to be configured, and written to EEPROM with STORE\_USER\_ALL without powering up the output. This command can be read to determine the state of the output disable function.

**MFR\_EE\_USER\_WP**

When written to 0xFF, this command disables the commands that can be used to write the user NVM space: STORE\_USER\_ALL, MFR\_EE\_ERASE, MFR\_EE\_DATA writes. This command can only be written to 0xFF. Once written to NVM with STORE\_USER\_ALL, these commands will remain disabled, including when power is removed and reapplied.

**FAULT Logging**

If a fault condition occurs that is configured to turn off the regulator output, an event is written in the fault log in EEPROM. Any preceding warning or fault not configured to turn off the output is written as a subevent when an event is written. A timestamp is written with each event and subevent. The fault log stores up to three fault-off events. The fault log may be read by the MFR\_FAULT\_LOG command. The fault log is cleared from EEPROM by writing the MFR\_FAULT\_LOG\_CLEAR command. The fault log function is enabled by default and may be disabled by clearing bit 7 of MFR\_CONFIG\_ALL.

If INTV<sub>CC</sub> UV is detected while writing the fault log, the PMBus port and ADC loop will be immediately disabled to save power.

Automatic fault logging is never disabled due to overtemperature.

**Table 57. Fault Logging Commands**

COMMAND NAME	CODE	DESCRIPTION	TYPE	PAGED	NVM	DEFAULT
MFR_FAULT_LOG_TIMESTAMP_MSBS	0xE8	Sets the fault log timestamp upper 13 bits, clears lower 32 (read and write first).	R/W 32	N		
MFR_FAULT_LOG_TIMESTAMP_LSBS	0xE9	Sets the fault log timestamp lower 32 bits.	R/W 32	N		
MFR_FAULT_LOG_STORE	0xEA	Force a fault log entry to be written.	Send Byte	N		
MFR_FAULT_LOG_CLEAR	0xEC	Erases all fault log entries, if any.	Send Byte	N		
MFR_FAULT_LOG	0xEE	Read the contents of the fault log, if any.	R Block	N	Y	

**MFR\_FAULT\_LOG\_TIMESTAMP\_MSBS, and MFR\_FAULT\_LOG\_TIMESTAMP\_LSBS**

The MFR\_FAULT\_LOG\_TIMESTAMP\_MSBS command sets the most significant 13 bits of the fault log timestamp, and the MFR\_FAULT\_LOG\_TIMESTAMP\_LSBS command sets the least significant 32 bits of the fault log timestamp. The timestamp has units of SHARE\_CLK pulses (typically approximately 10µs).

The most significant 13 bits (MSBS) must be written before the least significant 32 bits (LSBS) are written. Writing the MSBS causes the LSBS to be cleared to 0. This guarantees that the 45-bit timestamp counter can be written atomically.

The MSBS must also be read before the LSBS are read. Reading the MSBS causes the LSBS to be captured and prepared to be read. This guarantees that the 45-bit timestamp counter can be read automatically.

**MFR\_FAULT\_LOG\_STORE**

The MFR\_FAULT\_LOG\_STORE command forces a fault log to be written to EEPROM as if a fault event occurred.

**MFR\_FAULT\_LOG\_CLEAR**

The MFR\_FAULT\_LOG\_CLEAR command will erase the stored fault log, if any. It will also clear bit 3 in the STATUS\_MFR\_SPECIFIC command.

**MFR\_FAULT\_LOG**

The MFR\_FAULT\_LOG command will return the current fault log contents. The fault log comprises events, each containing event fields and two preceding subevents. Subevents are events that do not cause a fault-off condition (for example, warning or  $PV_{IN} < VIN_{OFF}$ , etc). Subevents are logged to volatile memory until a fault occurs when the fault event and associated subevents are logged to nonvolatile memory.

As with all PMBus block read commands, the least significant byte will be seen on the bus first.

The external assertion of the  $\overline{FAULTN}$  pin will be captured as an event if bit 5 of MFR\_CHAN\_CONFIG\_LT7184S is set. Otherwise, it will be captured as a subevent.

The timestamp field has units of SHARE\_CLK pulses (typically approximately 10µs).

In the event structure, the paged faults, paged warnings, unpagged faults, and unpagged warnings reflect the underlying fault and warning conditions that were present when the event was recorded. Status registers, such as status\_vout, may have bits set from prior fault or warning conditions that are no longer present.

**Table 58. Fault Log Structure**

ENTRY	ITEM	PMBus BYTE NUMBER
3	Subevent	147–140
	Subevent	139–132
	Event	131–111
2	Subevent	110–103
	Subevent	102–95
	Event	94–74
1	Subevent	73–66
	Subevent	65–58
	Event	57–37
0	Subevent	36–29
	Subevent	28–21
	Event	20–0

Table 59. Event Structure

PMBus BYTE	FIELD	STRUCTURE BIT
20–14	Reserved (some of this is parity)	167:112
13	Reserved	111:106
	Event CRC check: 0 if match	105
	Subevents CRC check: 0 if match	104
12	Temperature (unsigned, offset +70°C above die temperature)	103:96
11	Channel 1 State	95:92
	Channel 0 State	91:88
10–8	Paged Warnings	87:74
	Unpaged Warnings	73
7	Paged Faults	72:55
6	Unpaged Faults	54:53
5-1	Timestamp	52:8
0	Ordinal (see <a href="#">Table 62</a> and <a href="#">Table 63</a> )	7:3
	Page (unpaged will be 2)	2:1
	Valid Bit: 1 if valid	0

Table 60. Subevent Structure

PMBus BYTE	FIELD	STRUCTURE BIT
7	Reserved	63:61
	Channel 1 State	60:57
6	Channel 0 State	56:53
5–1	Timestamp	52:8
0	Ordinal (see <a href="#">Table 62</a> and <a href="#">Table 63</a> )	7:3
	Page (unpaged will be 2)	2:1
	Valid Bit	0

Table 61. Ordinal Table for Unpaged Events and Subevents

ORDINAL	EVENT	TYPE
5	Overtemperature Warning	Warnings
2	Thermal Shutdown	Faults that caused a fault off
1	Reference Fault	
0	No fault event. Fault event recorded by the MFR_FAULT_LOG_STORE.	

**Table 62. Ordinal Table for Paged Events and Subevents**

ORDINAL	EVENT	TYPE
25	V <sub>OUT</sub> overvoltage warning.	Warning
24	V <sub>OUT</sub> undervoltage warning.	
23	I <sub>OUT</sub> overcurrent warning.	
21	V <sub>IN</sub> undervoltage warning.	
20	I <sub>IN</sub> overcurrent warning.	
19	TOFF_MAX_WARN_LIMIT exceeded when turning off an output.	N/A
17	PV <sub>INN</sub> fell below VIN_OFF.	Faults
16	The V <sub>OUT</sub> overvoltage fault, response set to continue operation.	
15	The V <sub>OUT</sub> undervoltage fault, response set to continue operation.	
14	I <sub>OUT</sub> overcurrent fault, response set to continue operation.	
13	TON_MAX_FAULT_LIMIT exceeded when turning on an output, and the response is set to continue operation.	
12	FAULTN pin externally pulled low.	Faults that caused a fault off
9	PV <sub>INN</sub> overvoltage fault.	
7	V <sub>OUT</sub> overvoltage fault, response set to disable the output.	
6	V <sub>OUT</sub> undervoltage fault, response set to disable the output.	
5	I <sub>OUT</sub> overcurrent fault, response set to disable the output.	
4	TON_MAX_FAULT_LIMIT exceeded when turning on an output, and the response is set to disable output.	
2	Short shutdown cycle fault.	
0	No fault event. Fault event recorded by MFR_FAULT_LOG_STORE.	N/A

**Table 63. Channel State Ordinal Table**

ORDINAL	STATE
8	Sequencing off and ramping down output.
7	RESET
6	Sequencing off and waiting for TOFF_DELAY.
5	On
4	Waiting for TON_MAX_FAULT or output to rise above the VOUT_UV_FAULT_LIMIT.
3	Sequencing on and ramping up output.
2	Sequencing on and waiting for ON_DELAY.
1	Faulted off and waiting for retry delay.
0	Off

**Table 64. Data Byte Contents for Unpaged Fault**

BIT	DESCRIPTION
1	Thermal Shutdown
0	Reference Fault

**Table 65. Paged Faults Event Field**

ITEM	BITS
Paged Fault Bits Page 1	17:9
Paged Fault Bits Page 0	8:0

**Table 66. Data Byte Contents for Paged Fault**

BIT	DESCRIPTION
8	$V_{IN}$ Overvoltage Fault
7	$V_{IN}$ Off (Not a fault condition)
6	$V_{OUT}$ Overvoltage Fault
5	$V_{OUT}$ Undervoltage Fault
4	$I_{OUT}$ Overcurrent Fault
3	Reserved
2	$\overline{FAULT}$ pin Asserted
1	Short-Shutdown Cycle Fault
0	Pin Config Fault

**Table 67. Data Byte Contents for Unpaged Warning**

BIT	DESCRIPTION
0	Overtemperature Warning

**Table 68. Paged Warnings Event Field**

ITEM	BITS
Paged Warning Bits Page 1	13:7
Paged Warning Bits Page 0	6:0

**Table 69. Data Byte Content for Paged Warning**

BIT	DESCRIPTION
6	V <sub>OUT</sub> Overvoltage Warning
5	V <sub>OUT</sub> Undervoltage Warning
4	I <sub>OUT</sub> Overcurrent Warning
3	Reserved
2	V <sub>IN</sub> Undervoltage Warning
1	I <sub>IN</sub> Overcurrent Warning
0	Reserved

### Example Event

This is an example of a fault event caused by a V<sub>OUT</sub> overvoltage fault. If MFR\_FAULT\_LOG were read after this event was recorded, an example stream of bytes on the bus would be: 0x39, 0x70, 0x11, 0x01, 0x00, 0x00, 0x00, 0x20, 0x00, 0x00, 0x01, 0x05, 0xAA, 0x03, ... and 7 more bytes that should be ignored.

[Table 70](#) breaks this byte stream into bit fields in the event structure.

**Table 70. Example Event Structure Byte Stream**

PMBus BYTE NUMBER	FIELD	STRUCTURE BIT NUMBER (LSB FIRST)	DATA	MEANING
20–14	Reserved	167:112		These bits should be ignored.
13	Reserved	111:106		These bits should be ignored.
	Event CRC check	105	1	Event CRC is valid.
	Subevents CRC check	104	1	Subevent CRC is valid.
12	Temperature	103:96	0xAA	Die temperature was 100°C when the fault occurred.
11	Channel 1 State	95:92	0	Channel 1 was off when the fault occurred.
	Channel 0 State	91:88	5	Channel 0 was on when the fault occurred.
10–8	Paged Warnings	87:74	0x40, 0x00	V <sub>OUT</sub> overvoltage warning on channel 0.
	Unpaged Warnings	73	0	No unpaged warnings.

PMBus BYTE NUMBER	FIELD	STRUCTURE BIT NUMBER (LSB FIRST)	DATA	MEANING
7	Paged Faults	72:55	0x40, 0x00, 0x00	V <sub>OUT</sub> overvoltage fault on channel 0.
6	Unpaged Faults	54:53	0	No unpaged faults.
5-1	Timestamp	52:8	0x70, 0x11, 0x01, 0x00, 0x00, 0x00	70,000μs
0	Ordinal	7:3	7	Indicates a V <sub>OUT</sub> overvoltage fault.
	Page	2:1	0	Indicates the event was caused by some fault on channel 0.
	Valid Bit	0	1	Entry is valid



ALL INFORMATION CONTAINED HEREIN IS PROVIDED “AS IS” WITHOUT REPRESENTATION OR WARRANTY. NO RESPONSIBILITY IS ASSUMED BY ANALOG DEVICES FOR ITS USE, NOR FOR ANY INFRINGEMENTS OF PATENTS OR OTHER RIGHTS OF THIRD PARTIES THAT MAY RESULT FROM ITS USE. SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE. NO LICENCE, EITHER EXPRESSED OR IMPLIED, IS GRANTED UNDER ANY ADI PATENT RIGHT, COPYRIGHT, MASK WORK RIGHT, OR ANY OTHER ADI INTELLECTUAL PROPERTY RIGHT RELATING TO ANY COMBINATION, MACHINE, OR PROCESS, IN WHICH ADI PRODUCTS OR SERVICES ARE USED. TRADEMARKS AND REGISTERED TRADEMARKS ARE THE PROPERTY OF THEIR RESPECTIVE OWNERS. ALL ANALOG DEVICES PRODUCTS CONTAINED HEREIN ARE SUBJECT TO RELEASE AND AVAILABILITY.