MAX15301 PMBus Command Set User's Guide

Rev 1; 10/14

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Introduction

Maxim Integrated InTune™ digital power products utilize the PMBus™ command standard for configuration, control and telemetry.

This document lists and describes the PMBus commands implemented in the MAX15301 digital DC-DC controller. Standard commands from the PMBus specification are not described in detail unless there are deviations from the PMBus specification functionality. Maxim manufacturer-specific commands are fully described in this document.

References for this document are found on the PMBus and SMBus organization websites.

http://pmbus.org/specs.html
http://smbus.org/specs/

The commands in this document are presented in the following format:

<COMMAND_NAME>

Reference:	<"Standard" or "Maxim Specific">	**Lockable:**	<yes/no>
Command Code:	<hex value>	**Format:**	<data format>
Data Bytes:	<byte count>	**Units:**	<unit of measure>
Transfer:	<SMBus transaction>	**Factory Value:**	<Maxim setting>
Description/Notes:	<Command definition if Maxim-specific, or notes on command functionality where it differs from the PMBus specification.>		

Part Number Differences

The MAX15301 controller is available under different part numbers with some functional differences as follows.

MAX15301AA01

The MAX15301AA01 has the first production firmware, version 4018.

MAX15301AA02

The MA15301AA02 has improved firmware, version 4328, with the following improvements:

- Changed to 2-point thermal measurement algorithm to improve the READ_TEMPERATURE_2 accuracy
- Added support for v6 final test/trim scheme (improves READ_TEMPERATURE_1 accuracy)
- Changed IC_DEVICE_ID length from 8 to 12 bytes
- PMBUS_REVISION changed to 0x22
- Changed EXT_TEMP_CAL defaults to improve READ_TEMPERATURE_2 accuracy
- Added SMBus timeout support
- Bug fix for interrupted PMBus read operations
- Bug fix for operation with FREQUENCY_SWITCH <400kHz and temperature sense diode connected to TEMPX

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On, Off, and Margin Testing Related Commands

OPERATION

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x01	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read/Write Byte	**Factory Value:**	0x40 (see Description table)

Description/Notes: See Section 12.1 of the PMBus Specification Part II.

If the values of VOUT_OV_FAULT_LIMIT or VOUT_UV_FAULT_LIMIT are set between the values of VOUT_MARGIN_HIGH and VOUT_MARGIN_LOW, it is possible that a fault will be detected when exiting the "Margin High/Low (Ignore Fault)" command states. This occurs when fault detection is re-enabled before the output has had time to return to the VOUT_COMMAND value. This condition can be avoided in most cases by increasing the value of VOUT_TRANSITION_RATE, thereby decreasing the amount of time required for the output to return to normal VOUT_COMMAND setpoint.

The value of the OPERATION command is maintained in volatile memory, and *cannot* be stored in the Default Store or User Store nonvolatile memory. This prevents inadvertent preservation of a margin-high or margin-low state. If it is desired to keep the output always enabled or always disabled upon power-up, this can be achieved by storing the appropriate value of the ON_OFF_CONFIG command.

Useful values for the OPERATION command:

0x00 Immediate-off, no sequencing: both DH and DL outputs low[a] (note: same as 0x01-0x3F)
0x40 Soft-off, with sequencing (factory setting)[b] (note: same as 0x41-0x7F)
0x80 Output enabled, if allowed by ON_OFF_CONFIG setting (note: same as 0x81-0x8F)
0x94 Margin low, ignore faults (note: same as 0x95-0x97)
0x98 Margin low, act on faults (note: same as 0x99-0x9B)
0xA4 Margin high, ignore faults (note: same as 0xA5-0xA7)
0xA8 Margin high, act on faults (note: same as 0xA9-0xAB)

Invalid values for the OPERATION command:

0x90-0x93
0x9C-0x9F
0xA0-0xA3
0xAC-0xFF

These invalid data bytes will trigger an "Invalid Or Unsupported Data" response per section 10.9.3 of the PMBus specification.

After writing the OPERATION command to enable the output, the PMBus master must either wait for a time equal to (TON_DELAY + TON_RISE + 50ms), or wait for PG to assert, before sending additional PMBus commands.

ON_OFF_CONFIG

[a] An "immediate-off," "hard-stop," or "tri-state" shutdown means the MAX15301 will stop switching and keep both DH and DL outputs low, allowing the output voltage to decay naturally according to load and output capacitance.

[b] In this application note (and other InTune documents) a "soft-off," "soft-stop," or "ramp-down" shutdown means the MAX15301 actively controls the output voltage along a linear ramp to zero Volts, per the TOFF_DELAY and TOFF_FALL values.

ON_OFF_CONFIG

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x02	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read/Write Byte	**Factory Value:**	0x16 (see Description table)

Description/Notes: See Section 12.2 of the PMBus Specification Part II.

Useful Values for the ON_OFF_CONFIG command:

0x00	Output always enabled (note: same as 0x01-0x0F)
0x10	Output always disabled (note: same as 0x11-0x13)
0x14	Ignore bit 7 of OPERATION, require EN low to run, soft-off on loss of EN
0x15	Ignore bit 7 of OPERATION, require EN low to run, immediate-off on loss of EN
0x16	Ignore bit 7 of OPERATION, require EN high to run, soft-off on loss of EN (factory setting)
0x17	Ignore bit 7 of OPERATION, require EN high to run, immediate-off on loss of EN
0x18	Require bit 7 of OPERATION to run, ignore EN (note: same as 0x19-0x1B)
0x1C	Require bit 7 of OPERATION *and* EN low to run, soft-off on loss of EN
0x1D	Require bit 7 of OPERATION *and* EN low to run, immediate-off on loss of EN
0x1E	Require bit 7 of OPERATION *and* EN high to run, soft-off on loss of EN
0x1F	Require bit 7 of OPERATION *and* EN high to run, immediate-off on loss of EN

In general, odd values of ON_OFF_CONFIG that require a valid EN signal will have an immediate-off shutdown when EN is not valid. Even values that require EN will have a soft-off shutdown when EN is not valid.

After writing the ON_OFF_CONFIG command to enable the output, the PMBus master must either wait for a time equal to (TON_DELAY + TON_RISE + 50ms), or wait for PG to assert, before sending additional PMBus commands.

VIN_ON

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x35	**Format:**	Linear
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0xCB00 (6.0V)

Description/Notes: See Section 14.5 of the PMBus Specification Part II.

The MAX15301 hardware has 8-bit resolution for the minimum input voltage required for regulation, to a maximum value of ≈14.75V.

The desired value of VIN_ON is retained in memory, regardless limitations imposed by the 8-bit fault limit resolution, but the read-back value is based on actual hardware register settings.

VIN_OFF

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x36	**Format:**	Linear
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0xCAC0 (5.5V)
Description/Notes:	See Section 14.6 of the PMBus Specification Part II. The MAX15301 hardware has 8-bit resolution for the minimum input voltage required for regulation, to a maximum value of ≈14.75V. The desired value of VIN_OFF is retained in memory, regardless limitations imposed by the 8-bit fault limit resolution, but the read-back value is based on actual hardware register settings.		

Output Voltage Related Commands

VOUT_MODE

Reference:	Standard Command	**Lockable:**	No
Command Code:	0x20	**Format:**	Mixed: bit-field and 2's complement
Data Bytes:	1	**Units:**	N/A
Transfer:	Read Byte	**Factory Value:**	0x14 (Linear Mode, exponent -12)

Description/Notes:

See Section 8.2 of the PMBus Specification Part II.

The MAX15301 only supports Linear Mode values for output voltage related commands. The VOUT_MODE command is read-only and the value cannot be changed.

The 5-bit exponent for output voltage data is -12, or two's-complement 10100. This means that voltage command data sent to and from the MAX15301 using either the 2-byte unsigned integer mantissa or Direct mantissa formats must be divided by 4096 to determine the actual voltage value.

VOUT_COMMAND

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x21	**Format:**	Unsigned integer mantissa
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0x0001 (see Description)

Description/Notes:

See Section 8.2 of the PMBus Specification Part II.

VOUT_COMMAND mantissa data sent to and from the MAX15301 must be divided by 4096 to determine the actual voltage value, according to the fixed value of VOUT_MODE.

The factory value of 0x0001 (0.244mV) will be overridden during initialization by the hardware (pin-strap) value determined by the resistance to ground detected at the SET pin, unless a specific value has been written to the User Store. The value of the SET pin resistance is measured only once during initialization (power-up).

In the MAX15301, there are seven possible output voltage ranges based on seven corresponding internal feedback divider taps. The value of VOUT_COMMAND is retained and read back from volatile memory, regardless of limitations imposed by the feedback divider range.

New values of VOUT_COMMAND can be written at any time, but large changes (specifically, those that require a different feedback divider selection;, see Table 7 of the MAX15301 data sheet) will require the output to be disabled for the feedback divider to change.

VOUT_TRIM

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x22	**Format:**	Linear
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0x0000 (0V)

Description/Notes:

See Section 13.3 of the PMBus Specification Part II.

In the MAX15301, the value of VOUT_TRIM is summed with the value of VOUT_COMMAND and

VOUT_TRIM

	VOUT_CAL_OFFSET, and the result is sent to the control loop as the output voltage setpoint. The value of VOUT_TRIM is not subtracted from READ_VOUT, so nonzero VOUT_TRIM values will result in a difference between VOUT_COMMAND and READ_VOUT. This command is intended to allow an end user of a PMBus device to tailor a specific supply to the performance requirements of a specific load device, while retaining use of a "nominal" voltage setpoint for all similar load devices.

VOUT_CAL_OFFSET

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x23	**Format:**	Linear
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0x0000 (0V)
Description/Notes:	See Section 13.4 of the PMBus Specification Part II. In the MAX15301, the value of VOUT_CAL_OFFSET is summed with the value of VOUT_COMMAND and VOUT_TRIM, and the result is sent to the control loop as the output voltage setpoint. The value of VOUT_CAL_OFFSET is subtracted from READ_VOUT, so VOUT_CAL_OFFSET values never result in a difference between VOUT_COMMAND and READ_VOUT. This command is intended to allow a PMBus device manufacturer or an end user to calibrate the output voltage of a module (or other power-supply assembly) to match an external reference instrument during their final-test process.		

VOUT_MAX

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x24	**Format:**	Unsigned integer mantissa
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0x0001 (see Description)
Description/Notes:	See Section 13.5 of the PMBus Specification Part II. VOUT_MAX mantissa data sent to and from the MAX15301 must be divided by 4096 to determine the actual voltage value, according to the fixed value of VOUT_MODE. The factory value of 0x0001 (0.244mV) will be overridden during initialization to VOUT_COMMAND x 1.10, unless a specific value has been written to the User Store.		

VOUT_MARGIN_HIGH

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x25	**Format:**	Unsigned integer mantissa
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0x0001 (see Description)

VOUT_MARGIN_HIGH

Description/Notes:	See Section 13.6 of the PMBus Specification Part II. VOUT_MARGIN_HIGH mantissa data sent to and from the MAX15301 must be divided by 4096 to determine the actual voltage value, according to the fixed value of VOUT_MODE. The factory value of 0x0001 (0.244mV) will be overridden during initialization to VOUT_COMMAND x 1.05, unless a specific value has been written to the User Store. In the MAX15301, there are seven possible output voltage ranges based on seven corresponding internal feedback divider taps. The desired value of VOUT_MARGIN_HIGH is retained and read back from Operating Memory, regardless of hardware limitations imposed by the feedback divider range. If the MAX15301 is set for margin-high operation prior to the output being enabled, the output will rise directly to VOUT_MARGIN_HIGH at the rate determined by VOUT_COMMAND/TON_RISE. Likewise, if the output is disabled from margin-high operation, the output will fall at a rate determined by -VOUT_COMMAND/TOFF_FALL.

VOUT_MARGIN_LOW

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x26	**Format:**	Unsigned integer mantissa
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0x0001 (see Description)

Description/Notes:	See Section 13.7 of the PMBus Specification Part II. VOUT_MARGIN_LOW mantissa data sent to and from the MAX15301 must be divided by 4096 to determine the actual voltage value, according to the fixed value of VOUT_MODE. The factory value of 0x0001 (0.244V) will be overridden during initialization to VOUT_COMMAND x 0.95, unless a specific value has been written to the User Store. In the MAX15301, there are seven possible output voltage ranges based on seven corresponding internal feedback divider taps. The desired value of VOUT_MARGIN_LOW is retained and read back from Operating Memory, regardless of hardware limitations imposed by the feedback divider range. If the MAX15301 is set for margin-low operation prior to the output being enabled, the output will rise directly to VOUT_MARGIN_LOW at the rate determined by VOUT_COMMAND/TON_RISE. Likewise, if the output is disabled from margin-low operation, the output will fall at a rate determined by -VOUT_COMMAND/TOFF_FALL.

VOUT_TRANSITION_RATE

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x27	**Format:**	Linear
Data Bytes:	2	**Units:**	mV/µs (or V/ms, kV/s)
Transfer:	Read/Write Word	**Factory Value:**	0x9B33 (0.1V/ms, see Description)

Description/Notes: See Section 13.8 of the PMBus Specification Part II.

To achieve output voltage slew-rate control, the MAX15301 has an 8-bit timer with approximately 243ns resolution. When the timer expires, the 12-bit voltage setpoint is incremented or decremented until the setpoint reaches its final value. This limits the minimum and maximum possible slew-rates for each feedback divider range as follows:

Feedback Divider	VOUT_TRANSITION_RATE, kV/s	
	Min	Max
0	≈ 0.005	≈ 1.171
1	≈ 0.005	≈ 1.323
2	≈ 0.006	≈ 1.519
3	≈ 0.007	≈ 1.782
4	≈ 0.008	≈ 2.16
5	≈ 0.011	≈ 2.736
6	≈ 0.015	≈ 3.725
7	≈ 0.023	≈ 5.862

For each divider range, the minimum transition rate is also the resolution (minimum step size).

The desired value of VOUT_TRANSITION_RATE is retained in memory, regardless of hardware limitations imposed by the feedback divider range, but the read-back value is based on actual hardware register settings.

If a commanded value of VOUT_TRANSITION_RATE exceeds the maximum possible slew-rate for the feedback divider range, the MAX15301 sets the slew-rate control timer to zero, and the output voltage setpoint is updated to the new setpoint value immediately and without delay. In this case, VOUT_TRANSITION_RATE will read back as 0mV/µs to avoid a divide-by-zero operation.

VOUT_DROOP

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x28	**Format:**	Linear
Data Bytes:	2	**Units:**	mΩ (or mV/A)
Transfer:	Read/Write Word	**Factory Value:**	0x0000 (0mΩ)

Description/Notes: See Section 13.9 of the PMBus Specification Part II.

The MAX15301 uses low-pass filtered inductor DCR current-sense information (i.e. the READ_IOUT signal) to establish the load-line characteristic according to the VOUT_DROOP value. Because of this low-pass filtering of the load current information, there will be some settling time in the output voltage positioning when VOUT_DROOP is non-zero.

It is also important to calibrate READ_IOUT using IOUT_CAL_GAIN and IOUT_CAL_OFFSET to achieve

VOUT_DROOP	
	accurate adaptive voltage positioning results with the VOUT_DROOP command. Note that VOUT_DROOP can accept negative resistance values, allowing a user to compensation for resistive losses between the output voltage remote sense point and the load, if desired. (Setting VOUT_DROOP to a negative value will case output voltage to rise with increasing load.) Wait at least 500µs for execution after sending the VOUT_DROOP command before sending additional PMBus commands.

Switching Frequency and PWM Commands

FREQUENCY_SWITCH

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x33	**Format:**	Linear
Data Bytes:	2	**Units:**	kHz
Transfer:	Read/Write Word	**Factory Value:**	0x0258 (see Description)

Description/Notes:

See Section 14.4 of the PMBus Specification Part II.

The factory value of 0x0258 (600kHz) will be overridden during initialization by the hardware (pin-strap) value determined by the resistance to ground detected at the SYNC pin, unless a specific value has been written to the User Store. The value of the SYNC pin resistance is measured only once during initialization (power-up).

The MAX15301 can also synchronize to an external clock at the SYNC input. If the external clock is present at or before power-up, the SYNC resistance reading will fail and FREQUENCY_SWITCH will be set to 300kHz.

The MAX15301 has two different PWM "speed modes" to support FREQUENCY_SWITCH values at or below 475kHz, and above 475kHz. It is important to ensure that FREQUENCY_SWITCH is set, either by PMBus command or by *successful* resistor pin-strap, to a value that is within ±10% of the expected external clock frequency.

If the external clock is present at the time of output enable, the operating memory value of FREQUENCY_SWITCH will be updated to reflect the external clock frequency. If the external clock is applied after enabling the output, the PWM will synchronize to the external clock, but FREQUENCY_SWITCH will not be updated.

If the external clock crosses the 475kHz boundary while regulating, unexpected results or output voltage transients may result.

The *actual* switching frequency can be obtained using the READ_FREQUENCY command.

Wait at least 10ms for execution after sending the FREQUENCY_SWITCH command before sending additional PMBus commands.

INTERLEAVE

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x37	**Format:**	4 x 4-bit unsigned integer "nibbles"
Data Bytes:	2	**Units:**	N/A
Transfer:	Read/Write Word	**Factory Value:**	0x0000 (see Description)

Description/Notes:

See Section 14.7 of the PMBus Specification Part II.

The INTERLEAVE command determines the phase delay of the MAX15301, measured from the rising edge of an external clock applied at SYNC to the center of the PWM positive pulse.[c]

The factory value of 0x0000 (zero degrees phase shift) will be overridden during initialization by the hardware (pin-strap) value determined by the resistances to ground detected at the ADDR0 and

[c] Because the MAX15301 has dual-edge modulation, the rising and falling edges of the PWM waveform both "move" relative to the center of the high-side switch on-time.

INTERLEAVE

ADDR1 pins, unless a non-zero value of INTERLEAVE has been written to the User Store. The value of the ADDR0 and ADDR1 pin resistance is measured only once during initialization (power-up).

Because the MAX15301 uses one of two different PWM "speed modes" depending on the switching frequency selected (see FREQUENCY_SWITCH), the INTERLEAVE command will show unexpected results if switching frequency crosses the 475kHz speed-mode boundary after initialization.

The MAX15301 includes enhancements beyond the PMBus specification INTERLEAVE command functionality:

- Setting the "Number In Group" to zero will be interpreted by the MAX15301 as 16 possible phases. This allows phase-spreading in 22.5º increments.
- The low nibble of the high byte of INTERLEAVE contains the "Group ID Number" per the PMBus specification, but this is a value that has no function and no dependent parameters in either the MAX15301 device or in the PMBus specification. As a result, it is not necessary to set a "Group ID Number." Both nibbles of the high byte of INTERLEAVE can be used separately or together as "scratchpad" data, if desired.

Output Voltage Sequencing Commands

POWER_GOOD_ON

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x5E	**Format:**	Unsigned integer mantissa
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0x1135 (see Description)

Description/Notes:

See Section 15.32.1 of the PMBus Specification Part II.

POWER_GOOD_ON mantissa data sent to and from the MAX15301 must be divided by 4096 to determine the actual voltage value, according to the fixed value of VOUT_MODE.

In the MAX15301, there are seven possible output voltage ranges based on seven corresponding internal feedback divider taps. The MAX15301 hardware has 8-bit resolution for the power-good threshold within each of these seven ranges.

The desired value of POWER_GOOD_ON is retained in memory, regardless of limitations imposed by the feedback divider range and the 8-bit fault limit resolution, but the read-back value is based on actual hardware register settings.

The factory value of 0x1135 (1.080V) will be overridden during initialization to VOUT_COMMAND x 0.95, unless a specific value has been written to the User Store.

POWER_GOOD_OFF

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x5F	**Format:**	Unsigned integer mantissa
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0x0F99 (see Description)

Description/Notes:

See Section 15.32.2 of the PMBus Specification Part II.

POWER_GOOD_OFF mantissa data sent to and from the MAX15301 must be divided by 4096 to determine the actual voltage value, according to the fixed value of VOUT_MODE.

In the MAX15301, there are seven possible output voltage ranges based on seven corresponding internal feedback divider taps. The MAX15301 hardware has 8-bit resolution for the power-good threshold within each of these seven ranges.

The desired value of POWER_GOOD_OFF is retained in memory, regardless of limitations imposed by the feedback divider range and the 8-bit fault limit resolution, but the read-back value is based on actual hardware register settings.

The factory value of 0x0F99 (0.980V) will be overridden during initialization to VOUT_COMMAND x 0.93, unless a specific value has been written to the User Store.

TON_DELAY

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x60	**Format:**	Linear
Data Bytes:	2	**Units:**	ms
Transfer:	Read/Write Word	**Factory Value:**	0xCA80 (see Description)

Description/Notes:

See Section 16.1 of the PMBus Specification Part II.

The TON_DELAY command sets the delay time between a valid enable condition and the beginning of the output ramp to regulation at VOUT_COMMAND. The nominal factory value is 5ms.

An 8-bit timer with approximately 570µs resolution allows for delay times from ≈1ms to ≈145ms.

TON_RISE

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x61	**Format:**	Linear
Data Bytes:	2	**Units:**	ms
Transfer:	Read/Write Word	**Factory Value:**	0xCA80 (see Description)

Description/Notes:

See Section 16.2 of the PMBus Specification Part II.

The TON_RISE command sets the ramp-up time from 0V to regulation at VOUT_COMMAND. The nominal factory value is 5ms.

The MAX15301 achieves startup dV_{OUT}/dt control by incrementing the loop setpoint by one 12-bit step every time a certain number of ramp-controller clock cycles have elapsed in an 8-bit counter. This results in a setpoint that increases at a controlled rate, in turn creating a constant dV_{OUT}/dt during startup.

Because the MAX15301 must calculate the ramp control timer setting based upon the value of VOUT_COMMAND, the possible range and resolution of TON_RISE will vary significantly.

The desired value of TON_RISE is retained in memory, regardless of ramp-timer limitations, but the read-back value is based on actual hardware register settings.

TOFF_DELAY

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x64	**Format:**	Linear
Data Bytes:	2	**Units:**	ms
Transfer:	Read/Write Word	**Factory Value:**	0xBA00 (see Description)

Description/Notes:

See Section 16.5 of the PMBus Specification Part II.

The TOFF_DELAY command sets the delay time between loss of enable condition and the beginning of the output ramp-down. The nominal factory value is 1ms.

An 8-bit timer with approximately 570µs resolution allows for delay times from 0ms to ≈145ms.

TOFF_FALL

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x65	**Format:**	Linear
Data Bytes:	2	**Units:**	ms
Transfer:	Read/Write Word	**Factory Value:**	0xCA80 (see Description)

Description/Notes:

See Section 16.6 of the PMBus Specification Part II.

The TOFF_FALL command sets the ramp-down time from regulation at VOUT_COMMAND to 0V. The nominal factory value is 5ms.

The MAX15301 achieves shutdown dV_{OUT}/dt control by decrementing the loop setpoint by one 12-bit step every time a certain number of ramp-controller clock cycles have elapsed in an 8-bit counter. This results in a setpoint that decreases at a controlled rate, in turn creating a constant dV_{OUT}/dt during shutdown.

Because the MAX15301 must calculate the ramp control timer setting based upon the value of VOUT_COMMAND, the possible range and resolution of TOFF_FALL will vary significantly.

The desired value of TOFF_FALL is retained in memory, regardless of ramp-timer limitations, but the read-back value is based on actual hardware register settings.

Fault Related Commands

CLEAR_FAULTS

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x03	**Format:**	N/A
Data Bytes:	0	**Units:**	N/A
Transfer:	Send Byte	**Factory Value:**	N/A
Description/Notes:	See Section 15.1 of the PMBus Specification Part II. If the MAX15301 has latched off for a fault condition, sending the CLEAR_FAULTS command will cause a restart.		

VOUT_OV_FAULT_LIMIT

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x40	**Format:**	Unsigned integer mantissa
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0x0025 (see Description)
Description/Notes:	See Section 15.2 of the PMBus Specification Part II. VOUT_OV_FAULT_LIMIT mantissa data sent to and from the MAX15301 must be divided by 4096 to determine the actual voltage value, according to the fixed value of VOUT_MODE. In the MAX15301, there are seven possible output voltage ranges based on seven corresponding internal feedback divider taps. The MAX15301 hardware has 8-bit resolution for the overvoltage fault limit within each of these seven ranges. The desired value of VOUT_OV_FAULT_LIMIT is retained in memory, regardless of limitations imposed by the feedback divider range and the 8-bit fault limit resolution, but the read-back value is based on actual hardware register settings. The factory value of 0x0025 (9mV) will be overridden during initialization to VOUT_COMMAND x 1.15, unless a specific value has been written to the User Store.		

VOUT_OV_FAULT_RESPONSE

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x41	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read/Write Byte	**Factory Value:**	0x80 (Stop regulating and remain off)

Description/Notes:

See Sections 10.5.1 and 15.3 of the PMBus Specification Part II.

Note that the MAX15301 does not support finite, non-zero restart-attempt counts. (Continuous restart attempts are supported.)

The VOUT_OV_FAULT_RESPONSE command data comprises three bit-fields:

Bits [7:6] determine the basic fault-response mode. The MAX15301 supports the following modes:

- 00 Ignore the fault condition.
- 01 Continue operating and wait for the fault to abate for time specified in bits [2:0]. If the fault does not abate, shutdown and attempt to restart according to bits [5:3].
- 10 Stop regulating immediately, delay for the time specified in bits [2:0], then attempt to restart according to bits [5:3]. *(Default setting)*
- 11 Stop regulating immediately, and then restart as soon as possible after the fault condition abates.

Bits [5:3] determine the number of retry attempts. The MAX15301 supports only a subset of the full PMBus functionality for this portion of the command:

- 000-110 No attempt is made to restart after a fault shutdown. *(Default setting)*
- 111 Attempt to restart continuously until commanded off, or until another fault condition causes the unit to shut down.

Bits [2:0] determine the fault-tolerance or retry-delay timing. Each binary value in bits [2:0] corresponds to a multiple of 100ms, up to a possible maximum of 111_{bin} = 700ms. A value of 000_{bin} will cause the MAX15301 to use the minimum possible timing value, typically about 30-40ms. *(The default timing for overvoltage faults is* 000_{bin}*.)*

VOUT_UV_FAULT_LIMIT

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x44	**Format:**	Unsigned integer mantissa
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0x019A (see Description)

Description/Notes:

See Section 15.6 of the PMBus Specification Part II.

VOUT_UV_FAULT_LIMIT mantissa data sent to and from the MAX15301 must be divided by 4096 to determine the actual voltage value, according to the fixed value of VOUT_MODE.

In the MAX15301, there are seven possible output voltage ranges based on seven corresponding internal feedback divider taps. The MAX15301 hardware has 8-bit resolution for the undervoltage fault limit within each of these seven ranges.

The desired value of VOUT_UV_FAULT_LIMIT is retained in memory, regardless of limitations imposed by the feedback divider range and the 8-bit fault limit resolution, but the read-back value is based on actual hardware register settings.

The factory value of 0x019A (0.100V) will be overridden during initialization to

VOUT_UV_FAULT_LIMIT

	VOUT_COMMAND x 0.85, unless a specific value has been written to the User Store.

VOUT_UV_FAULT_RESPONSE

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x45	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read/Write Byte	**Factory Value:**	0x00 (Ignore undervoltage faults)

Description/Notes: See Sections 10.5.1 and 15.7 of the PMBus Specification Part II.

Note that the MAX15301 does not support finite, non-zero restart-attempt counts. (Continuous restart attempts are supported.)

The VOUT_UV_FAULT_RESPONSE command data comprises three bit-fields:

Bits [7:6] determine the basic fault-response mode. The MAX15301 supports the following modes:

- 00 Ignore the fault condition. *(Default setting)*
- 01 Continue operating and wait for the fault to abate for time specified in bits [2:0]. If the fault does not abate, shutdown and attempt to restart according to bits [5:3].
- 10 Stop regulating immediately, delay for the time specified in bits [2:0], then attempt to restart according to bits [5:3].
- 11 Stop regulating immediately, and then restart as soon as possible after the fault condition abates.

Bits [5:3] determine the number of retry attempts. The MAX15301 supports only a subset of the full PMBus functionality for this portion of the command:

- 000-110 No attempt is made to restart after a fault shutdown. *(Default setting)*
- 111 Attempt to restart continuously until commanded off, or until another fault condition causes the unit to shut down.

Bits [2:0] determine the fault-tolerance or retry-delay timing. Each binary value in bits [2:0] corresponds to a multiple of 100ms, up to a possible maximum of 111_{bin} = 700ms. A value of 000_{bin} will cause the MAX15301 to use the minimum possible timing value, typically about 30-40ms. *(The default timing for undervoltage faults is* 000_{bin}*.)*

IOUT_OC_FAULT_LIMIT

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x46	**Format:**	Linear
Data Bytes:	2	**Units:**	A
Transfer:	Read/Write Word	**Factory Value:**	0xDB20 (25A)

Description/Notes: See Section 15.8 of the PMBus Specification Part II.

The MAX15301 hardware has 8-bit resolution for the overcurrent fault limit within a 30A full-scale load current range.

The desired value of IOUT_OC_FAULT_LIMIT is retained in memory, regardless limitations imposed by the 8-bit fault limit resolution, but the read-back value is based on actual hardware register settings.

IOUT_OC_FAULT_RESPONSE

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x47	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read/Write Byte	**Factory Value:**	0xBF (Shut down, retry every 700ms)

Description/Notes:

See Sections 10.5.1 and 15.9 of the PMBus Specification Part II.

For overcurrent faults, the MAX15301 implements the fault responses of PMBus Specification section 10.5.1, rather than the responses of section 10.5.2.

Note that…

- MAX15301 does not support finite, non-zero restart-attempt counts. (Continuous restart attempts *are* supported.)
- MAX15301 also does not support the "delay before shutdown" (sometimes referred to as "wait for abate") option for overcurrent faults.

The IOUT_OC_FAULT_RESPONSE command data comprises three bit-fields:

Bits [7:6] determine the basic fault-response mode. The MAX15301 supports the following modes:

00 Ignore the fault condition.
01 Same as setting 10.
10 Stop regulating immediately, delay for the time specified in bits [2:0], then attempt to restart according to bits [5:3]. *(Default setting)*
11 Same as setting 10.

Bits [5:3] determine the number of retry attempts. The MAX15301 supports only a subset of the full PMBus functionality for this portion of the command:

000-110 No attempt is made to restart after a fault shutdown.
111 Attempt to restart continuously until commanded off, or until another fault condition causes the unit to shut down. *(Default setting)*

Bits [2:0] determine the retry-delay timing. Each binary value in bits [2:0] corresponds to a multiple of 100ms, up to a possible maximum of 111_{bin} = 700ms. A value of 000_{bin} will cause the MAX15301 to use the minimum possible timing value, typically about 30-40ms. *(The default timing for overcurrent faults is 700ms.)*

OT_FAULT_LIMIT

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x4F	**Format:**	Linear
Data Bytes:	2	**Units:**	°C
Transfer:	Read/Write Word	**Factory Value:**	0xEB98 (115°C)

Description/Notes:

See Section 15.17 of the PMBus Specification Part II.

The MAX15301 has an internal temperature signal and can also measure temperature at an external location, using a diode junction.

The OT_FAULT_LIMIT applies to the external temperature signal, if a valid sensor is detected during initialization. If no external sensor is detected, the OT_FAULT_LIMIT applies to the internal

OT_FAULT_LIMIT

temperature signal instead.

In addition to the PMBus-programmable OT_FAULT_LIMIT value, there is also a hard-coded limit of 130°C that applies solely to the internal temperature signal to protect the flash memory of the MAX15301.

Overtemperature fault hysteresis is achieved in the MAX15301 by using the OT_WARN_LIMIT as the "fault cleared" threshold for OT_FAULT_LIMIT. For this reason, it is important to always set OT_WARN_LIMIT below OT_FAULT_LIMIT.

OT_FAULT_RESPONSE

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x50	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read/Write Byte	**Factory Value:**	0xC0 (Shut down, restart when fault abates)

Description/Notes: See Sections 10.5.1 and 15.18 of the PMBus Specification Part II.

Note that the MAX15301 does not support finite, non-zero restart-attempt counts. (Continuous restart attempts are supported.)

The OT_FAULT_RESPONSE command data comprises three bit-fields:

Bits [7:6] determine the basic fault-response mode. The MAX15301 supports the following modes:

- 00 Ignore the fault condition.
- 01 Continue operating and wait for the fault to abate for time specified in bits [2:0]. If the fault does not abate, shutdown and attempt to restart according to bits [5:3].
- 10 Stop regulating immediately, delay for the time specified in bits [2:0], then attempt to restart according to bits [5:3].
- 11 Stop regulating immediately, and then restart as soon as possible after the fault condition abates.[d] *(Default setting)*

Bits [5:3] determine the number of retry attempts. The MAX15301 supports only a subset of the full PMBus functionality for this portion of the command:

- 000-110 No attempt is made to restart after a fault shutdown. *(Default setting)*
- 111 Attempt to restart continuously until commanded off, or until another fault condition causes the unit to shut down.

Bits [2:0] determine the fault-tolerance or retry-delay timing. Each binary value in bits [2:0] corresponds to a multiple of 100ms, up to a possible maximum of 111_{bin} = 700ms. A value of 000_{bin} will cause the MAX15301 to use the minimum possible timing value, typically about 30-40ms. *(The default timing for overtemperature faults is* 000_{bin}*.)*

[d] An overtemperature fault (i.e. relevant temperature signal above OT_FAULT_LIMIT) is not considered to have abated until the temperature has fallen below the OT_WARN_LIMIT value.

OT_WARN_LIMIT

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x51	**Format:**	Linear
Data Bytes:	2	**Units:**	°C
Transfer:	Read/Write Word	**Factory Value:**	0xEAF8 (95°C)

Description/Notes:

See Section 15.19 of the PMBus Specification Part II.

The MAX15301 has an internal temperature signal and can also measure temperature at an external location, using a diode junction.

The OT_WARN_LIMIT applies to the external temperature signal, if a valid sensor is detected during initialization. If no external sensor is detected, the OT_WARN_LIMIT applies to the internal temperature signal instead.

Overtemperature fault hysteresis is achieved in the MAX15301 by using the OT_WARN_LIMIT as the "fault cleared" threshold for OT_FAULT_LIMIT. For this reason, it is important to always set OT_WARN_LIMIT below OT_FAULT_LIMIT.

VIN_OV_FAULT_LIMIT

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x55	**Format:**	Linear
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0xD380 (14V)

Description/Notes:

See Section 15.23 of the PMBus Specification Part II.

The MAX15301 hardware has 8-bit resolution for the input overvoltage fault limit, to a maximum value of ≈14.75V.

The desired value of VIN_OV_FAULT_LIMIT is retained in memory, regardless limitations imposed by the 8-bit fault limit resolution, but the read-back value is based on actual hardware register settings.

VIN_OV_FAULT_RESPONSE

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x56	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read/Write Byte	**Factory Value:**	0xC0 (Shut down, restart when fault abates)

Description/Notes:

See Sections 10.5.1 and 15.24 of the PMBus Specification Part II.

Note that the MAX15301 does not support finite, non-zero restart-attempt counts. (Continuous restart attempts are supported.)

The VIN_OV_FAULT_RESPONSE command data comprises three bit-fields:

Bits [7:6] determine the basic fault-response mode. The MAX15301 supports the following modes:

- 00 Ignore the fault condition.
- 01 Continue operating and wait for the fault to abate for time specified in bits [2:0]. If the fault does not abate, shutdown and attempt to restart according to bits [5:3].

VIN_OV_FAULT_RESPONSE

	10 Stop regulating immediately, delay for the time specified in bits [2:0], then attempt to restart according to bits [5:3]. 11 Stop regulating immediately, and then restart as soon as possible after the fault condition abates. *(Default setting)* Bits [5:3] determine the number of retry attempts. The MAX15301 supports only a subset of the full PMBus functionality for this portion of the command: 000-110 No attempt is made to restart after a fault shutdown. *(Default setting)* 111 Attempt to restart continuously until commanded off, or until another fault condition causes the unit to shut down. Bits [2:0] determine the fault-tolerance or retry-delay timing. Each binary value in bits [2:0] corresponds to a multiple of 100ms, up to a possible maximum of 111_{bin} = 700ms. A value of 000_{bin} will cause the MAX15301 to use the minimum possible timing value, typically about 30-40ms. *(The default timing for input overvoltage faults is* 000_{bin}*.)*

VIN_UV_FAULT_LIMIT

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x59	**Format:**	Linear
Data Bytes:	2	**Units:**	V
Transfer:	Read/Write Word	**Factory Value:**	0xCA1A (4.2V)
Description/Notes:	See Section 15.27 of the PMBus Specification Part II. The MAX15301 hardware has 8-bit resolution for the input undervoltage fault limit, to a maximum value of ≈14.75V. The desired value of VIN_UV_FAULT_LIMIT is retained in memory, regardless limitations imposed by the 8-bit fault limit resolution, but the read-back value is based on actual hardware register settings.		

VIN_UV_FAULT_RESPONSE

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x5A	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read/Write Byte	**Factory Value:**	0xC0 (Shut down, restart when fault abates)
Description/Notes:	See Sections 10.5.1 and 15.28 of the PMBus Specification Part II. Note that the MAX15301 does not support finite, non-zero restart-attempt counts. (Continuous restart attempts are supported.) The VIN_UV_FAULT_RESPONSE command data comprises three bit-fields: Bits [7:6] determine the basic fault-response mode. The MAX15301 supports the following modes: 00 Ignore the fault condition. 01 Continue operating and wait for the fault to abate for time specified in bits [2:0]. If the fault does not abate, shutdown and attempt to restart according to bits [5:3]. 10 Stop regulating immediately, delay for the time specified in bits [2:0], then attempt to		

VIN_UV_FAULT_RESPONSE

restart according to bits [5:3].

11 Stop regulating immediately, and then restart as soon as possible after the fault condition abates. *(Default setting)*

Bits [5:3] determine the number of retry attempts. The MAX15301 supports only a subset of the full PMBus functionality for this portion of the command:

000-110 No attempt is made to restart after a fault shutdown. *(Default setting)*

111 Attempt to restart continuously until commanded off, or until another fault condition causes the unit to shut down.

Bits [2:0] determine the fault-tolerance or retry-delay timing. Each binary value in bits [2:0] corresponds to a multiple of 100ms, up to a possible maximum of 111_{bin} = 700ms. A value of 000_{bin} will cause the MAX15301 to use the minimum possible timing value, typically about 30-40ms. *(The default timing for input undervoltage faults is* 000_{bin}*.)*

Unit Status Commands

STATUS_BYTE

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x78	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read Byte	**Factory Value:**	N/A
Description/Notes:	See Section 17.1 of the PMBus Specification Part II.		

STATUS_WORD

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x79	**Format:**	Bit field
Data Bytes:	2	**Units:**	N/A
Transfer:	Read Word	**Factory Value:**	N/A
Description/Notes:	See Section 17.2 of the PMBus Specification Part II. Bit #2 of the STATUS_WORD low byte is not implemented in the MAX15301 because there are no relevant fan-related commands.		

STATUS_VOUT

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x7A	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read Byte	**Factory Value:**	N/A
Description/Notes:	See Section 17.3 of the PMBus Specification Part II. Bits #5 and #6 of STATUS_VOUT are not implemented in the MAX15301 because the VOUT_UV_WARNING and VOUT_OV_WARNING commands are not supported. Bit #1 is not implemented in the MAX15301 because the TOFF_MAX_WARNING is not supported.		

STATUS_IOUT

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x7B	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read Byte	**Factory Value:**	N/A
Description/Notes:	See Section 17.4 of the PMBus Specification Part II. Bits #6, #4, #2, #1, and #0 are not implemented in the MAX15301 because the corresponding fault commands are not supported.		

STATUS_INPUT

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x7C	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read Byte	**Factory Value:**	N/A
Description/Notes:	See Section 17.5 of the PMBus Specification Part II. Bits #6, #5, #2, #1, and #0 are not implemented in the MAX15301 because the corresponding fault commands are not supported.		

STATUS_TEMPERATURE

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x7D	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read Byte	**Factory Value:**	N/A
Description/Notes:	See Section 17.6 of the PMBus Specification Part II. Bits #5 and #4 are not implemented in the MAX15301 because the corresponding fault commands are not supported.		

STATUS_CML

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x7E	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read Byte	**Factory Value:**	N/A
Description/Notes:	See Section 17.7 of the PMBus Specification Part II.		

Telemetry Commands

READ_VIN

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x88	**Format:**	Linear
Data Bytes:	2	**Units:**	V
Transfer:	Read Word	**Factory Value:**	N/A
Description/Notes:	See Section 18.1 of the PMBus Specification Part II. The MAX15301 has 12-bit measurement resolution for input voltage to a maximum value of about 14.75V.		

READ_VOUT

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x8B	**Format:**	Unsigned integer mantissa
Data Bytes:	2	**Units:**	V
Transfer:	Read Word	**Factory Value:**	N/A
Description/Notes:	See Section 18.4 of the PMBus Specification Part II. The value of VOUT_TRIM *is not* subtracted from READ_VOUT, so non-zero VOUT_TRIM values *will* result in a difference between VOUT_COMMAND and READ_VOUT. The value of VOUT_CAL_OFFSET *is* subtracted from READ_VOUT, so VOUT_CAL_OFFSET values *never* result in a difference between VOUT_COMMAND and READ_VOUT.		

READ_IOUT

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x8C	**Format:**	Linear
Data Bytes:	2	**Units:**	A
Transfer:	Read Word	**Factory Value:**	N/A
Description/Notes:	See Section 18.5 of the PMBus Specification Part II. The MAX15301 has 8-bit measurement resolution for load current over a variable, symmetric bipolar range of inductor DCR voltage. READ_IOUT data is filtered and decimated, so reported load current may display greater than 8-bit resolution. READ_IOUT must be calibrated by means of IOUT_CAL_GAIN and IOUT_CAL_OFFSET to achieve accurate results. The value of READ_IOUT is temperature compensated for sense-element resistance change according to READ_TEMPERATURE_2 and the resistive temperature coefficient value in the third data byte of EXT_TEMP_CAL.		

READ_TEMPERATURE_1

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x8D	**Format:**	Linear
Data Bytes:	2	**Units:**	°C
Transfer:	Read Word	**Factory Value:**	N/A
Description/Notes:	See Section 18.6 of the PMBus Specification Part II. The MAX15301 uses READ_TEMPERATURE_1 to report its internal (i.e. die) temperature.		

READ_TEMPERATURE_2

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x8E	**Format:**	Linear
Data Bytes:	2	**Units:**	°C
Transfer:	Read Word	**Factory Value:**	N/A
Description/Notes:	See Section 18.6 of the PMBus Specification Part II. The MAX15301 uses READ_TEMPERATURE_2 to report external temperature as measured by an external diode junction, typically placed near the power inductor to facilitate READ_IOUT temperature compensation. If no external diode junction is detected, READ_TEMPERATURE_2 returns a value of -273°C and is not used for temperature faults or READ_IOUT temperature compensation. The Maxim-specific command EXT_TEMP_CAL can be used to adjust the diode ideality factor to match that of the actual diode junction used for external temperature sensing and to add or remove a fixed temperature offset for calibration purposes.		

READ_DUTY_CYCLE

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x94	**Format:**	Linear
Data Bytes:	2	**Units:**	%
Transfer:	Read Word	**Factory Value:**	N/A
Description/Notes:	See Section 18.9 of the PMBus Specification Part II. The READ_DUTY_CYCLE command returns an averaged measure of the pulse-width modulator output value in percent. The duty-cycle value is averaged over 256 PWM cycles.		

READ_FREQUENCY

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x95	**Format:**	Linear
Data Bytes:	2	**Units:**	kHz
Transfer:	Read Word	**Factory Value:**	N/A

Description/Notes:

See Section 18.10 of the PMBus Specification Part II.

The READ_FREQUENCY command returns the *actual* switching frequency in kilohertz.

The desired switching frequency is set using the FREQUENCY_SWITCH command.

PMB_VALUES

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xF5	**Format:**	See Description
Data Bytes:	215	**Units:**	See Description
Transfer:	Read/Write Block	**Factory Value:**	See Description

Description/Notes:

This command returns most PMBus command values from the device for ease of recording the device configuration. The command data returned is as follows:

<ON_OFF_CONFIG position="0" Type="U8" NumElem="1"/>
<WRITE_PROTECT position="1" Type="U8" NumElem="1"/>
<VOUT_COMMAND position="2" Type="Float" NumElem="1"/>
<VOUT_TRIM position="3" Type="Float" NumElem="1"/>
<VOUT_CAL_OFFSET position="4" Type="Float" NumElem="1"/>
<VOUT_MAX position="5" Type="Float" NumElem="1"/>
<VOUT_MARGIN_HIGH position="6" Type="Float" NumElem="1"/>
<VOUT_MARGIN_LOW position="7" Type="Float" NumElem="1"/>
<VOUT_TRANSITION_RATE position="8" Type="Float" NumElem="1"/>
<VOUT_DROOP position="9" Type="Float" NumElem="1"/>
<FREQUENCY_SWITCH position="10" Type="Float" NumElem="1"/>
<VIN_ON position="11" Type="Float" NumElem="1"/>
<VIN_OFF position="12" Type="Float" NumElem="1"/>
<INTERLEAVE position="13" Type="U8" NumElem="2"/>
<IOUT_CAL_GAIN position="14" Type="Float" NumElem="1"/>
<IOUT_CAL_OFFSET position="15" Type="Float" NumElem="1"/>
<VOUT_OV_FAULT_LIMIT position="16" Type="Float" NumElem="1"/>
<VOUT_OV_FAULT_RESPONSE position="17" Type="U8" NumElem="1"/>
<VOUT_UV_FAULT_LIMIT position="18" Type="Float" NumElem="1"/>
<VOUT_UV_FAULT_RESPONSE position="19" Type="U8" NumElem="1"/>
<IOUT_OC_FAULT_LIMIT position="20" Type="Float" NumElem="1"/>
<IOUT_OC_FAULT_RESPONSE position="21" Type="U8" NumElem="1"/>
<OT_FAULT_LIMIT position="22" Type="Float" NumElem="1"/>
<OT_FAULT_RESPONSE position="23" Type="U8" NumElem="1"/>
<OT_WARN_LIMIT position="24" Type="Float" NumElem="1"/>
<VIN_OV_FAULT_LIMIT position="25" Type="Float" NumElem="1"/>
<VIN_OV_FAULT_RESPONSE position="26" Type="U8" NumElem="1"/>
<VIN_UV_FAULT_LIMIT position="27" Type="Float" NumElem="1"/>
<VIN_UV_FAULT_RESPONSE position="28" Type="U8" NumElem="1"/>
<POWER_GOOD_ON position="29" Type="Float" NumElem="1"/>

PMB_VALUES	
	<POWER_GOOD_OFF position="30" Type="Float" NumElem="1"/> <TON_DELAY position="31" Type="Float" NumElem="1"/> <TON_RISE position="32" Type="Float" NumElem="1"/> <TON_MAX_FAULT_LIMIT position="33" Type="U8" NumElem="2"/> <TON_MAX_FAULT_RESPONSE position="34" Type="U8" NumElem="1"/> <TOFF_DELAY position="35" Type="Float" NumElem="1"/> <TOFF_FALL position="36" Type="Float" NumElem="1"/> <MFR_ID position="37" Type="U8" NumElem="8"/> <MFR_MODEL position="38" Type="U8" NumElem="13"/> <MFR_REVISION position="39" Type="U8" NumElem="7"/> <MFR_LOCATION position="40" Type="U8" NumElem="8"/> <MFR_DATE position="41" Type="U8" NumElem="6"/> <MFR_SERIAL position="42" Type="U8" NumElem="13"/> <ADAPTIVE_MODE position="43" Type="U8" NumElem="2"/> <ADAPTIVE_MODE_FAULT_RESPONSE position="44" Type="U8" NumElem="1"/> <FEEDBACK_EFFORT position="45" Type="Float" NumElem="1"/> <LOOP_CONFIG position="46" Type="U8" NumElem="2"/> <ILOAD_CAL_GAIN position="47" Type="Float" NumElem="1"/> <COMP_MODEL position="48" Type="Float" NumElem="3"/> <STRAP_DISABLE position="49" Type="U8" NumElem="2"/> <MANUF_LOCK position="50" Type="U8" NumElem="2"/> <USER_LOCK position="51" Type="U8" NumElem="2"/> <ZETAP position="52" Type="Float" NumElem="1"/> <EXT_TEMP_CAL position="53" Type="Float" NumElem="2"/>

Calibration Commands

IOUT_CAL_GAIN

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x38	**Format:**	Linear
Data Bytes:	2	**Units:**	mΩ
Transfer:	Read/Write Word	**Factory Value:**	0xB200 (see Description)

Description/Notes:

See Section 14.8 of the PMBus Specification Part II.

The differential voltage measured between the DCRP and DCRN pins is divided by the value of IOUT_CAL_GAIN and the value of IOUT_CAL_OFFSET is subtracted to provide a load current signal, accessible through the READ_IOUT command.

The factory value of 0xB200 (0.5mΩ) will be overridden during initialization by the hardware (pin-strap) value determined by the resistances to ground detected at the ADDR1 pin, unless a specific value of IOUT_CAL_GAIN has been written to the User Store. The value of the ADDR1 pin resistance is measured only once during initialization (power-up).

The value of IOUT_CAL_GAIN is internally temperature compensated according to READ_TEMPERATURE_2 and EXT_TEMP_CAL.

Wait at least 500µs for execution after sending the IOUT_CAL_GAIN command before sending additional PMBus commands.

IOUT_CAL_OFFSET

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x39	**Format:**	Linear
Data Bytes:	2	**Units:**	A
Transfer:	Read/Write Word	**Factory Value:**	0x0000 (0A)

Description/Notes:

See Section 14.9 of the PMBus Specification Part II.

The differential voltage measured between the DCRP and DCRN pins is divided by the value of IOUT_CAL_GAIN and the value of IOUT_CAL_OFFSET is subtracted to provide a load current signal, accessible through the READ_IOUT command.

Note that the MAX15301 implementation of IOUT_CAL_OFFSET differs from the PMBus specification because the sign of IOUT_CAL_OFFSET is inverted (i.e., IOUT_CAL_OFFSET is subtracted rather than added.)

EXT_TEMP_CAL (MAX15301AA01)

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xF8	**Format:**	Linear
Data Bytes:	4	**Units:**	Scalar, °K
Transfer:	Read/Write Block	**Factory Value:**	0xBA02 (1.004363), 0x0000 (0°K)

Description/Notes:

The EXT_TEMP_CAL command allows the user to calibrate the READ_TEMPERATURE_2 data and to adjust for different temperature-sense diode junction ideality factors.

EXT_TEMP_CAL (MAX15301AA01)

Byte #	Data Byte Name	Units	Description
0	Ideality Factor and Gain Correction	None	Combined diode ideality factor and external temperature gain correction scalar
1	Offset correction	°K	External temperature measurement offset correction

The corrections are applied internal to the MAX15301 as follows:

READ_TEMPERATURE_2 = (Measured external temperature) / EXT_TEMP_CAL[0] + EXT_TEMP_CAL[1] - 273.15°K

EXT_TEMP_CAL (MAX15301AA02)

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xF8	**Format:**	Linear
Data Bytes:	4	**Units:**	Scalar, °K
Transfer:	Read/Write Block	**Factory Value:**	1.00391, -8°K

Description/Notes: The EXT_TEMP_CAL command allows calibration of the external temperature sense signal. The two arguments of the EXT_TEMP_CAL signal are as follows:

Data Byte Number	Data Byte Name	Units	Description
0	m	None	Combined temperature gain correction and diode ideality factor
1	b	°K	Temperature offset correction

Temperature Calibration

The default gain term is nominally set for use with a Fairchild MMBT3904 transistor diode junction. To correct the gain term for a different temperature sense transistor, do the following:

1. Read the existing value of EXT_TEMP_CAL from the device
2. Multiply the existing value of the gain correction term by the new transistor ideality factor
3. Divide the result by 1.0046
   Send the final result back to the device

Device Identification Commands

CAPABILITY

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x19	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read Byte	**Factory Value:**	0xA0
Description/Notes:	See Section 11.12 of the PMBus Specification Part II.		

PMBUS_REVISION

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0x98	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read Byte	**Factory Value:**	0x42 (see Description)

Description/Notes:

See Section 22.1 of the PMBus Specification Part II.

Note that the Maxim interpretation of the specification is to omit bit #4, placing the Part I Revision level in bits [7:5] and the Part II Revision level in bits [3:0].

Bits [7:5] describe the PMBus specification Part I revision level as follows:

000 Revision 1.0
001 Revision 1.1
010 Revision 1.2

Bit [4] is unused and is set to zero.

Bits [3:0] describe the PMBus specification Part II revision level as follows:

0000 Revision 1.0
0001 Revision 1.1
0010 Revision 1.2

MFR_ID

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x99	**Format:**	ASCII string
Data Bytes:	8	**Units:**	N/A
Transfer:	Read/Write Block	**Factory Value:**	Null string

Description/Notes:

See Section 22.2.1 of the PMBus Specification Part II.

Note that the MAX15301 implements MFR_ID as a fixed-width string, not as part of a shared memory space.

MFR_MODEL

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x9A	**Format:**	ASCII string
Data Bytes:	13	**Units:**	N/A
Transfer:	Read/Write Block	**Factory Value:**	Null string
Description/Notes:	See Section 22.2.2 of the PMBus Specification Part II. Note that the MAX15301 implements MFR_MODEL as a fixed-width string, not as part of a shared memory space.		

MFR_REVISION

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x9B	**Format:**	ASCII string
Data Bytes:	7	**Units:**	N/A
Transfer:	Read/Write Block	**Factory Value:**	Null string
Description/Notes:	See Section 22.2.3 of the PMBus Specification Part II. Note that the MAX15301 implements MFR_REVISION as a fixed-width string, not as part of a shared memory space.		

MFR_LOCATION

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x9C	**Format:**	ASCII string
Data Bytes:	8	**Units:**	N/A
Transfer:	Read/Write Block	**Factory Value:**	Null string
Description/Notes:	See Section 22.2.4 of the PMBus Specification Part II. Note that the MAX15301 implements MFR_LOCATION as a fixed-width string, not as part of a shared memory space.		

MFR_DATE

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x9D	**Format:**	ASCII string
Data Bytes:	6	**Units:**	N/A
Transfer:	Read/Write Block	**Factory Value:**	Null string
Description/Notes:	See Section 22.2.5 of the PMBus Specification Part II. Note that the MAX15301 implements MFR_DATE as a fixed-width string, not as part of a shared memory space. The recommended format is YYMMDD where Y, M, and D are integer values from 0 to 9, inclusive.		

MFR_SERIAL

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x9E	**Format:**	ASCII string
Data Bytes:	13	**Units:**	N/A
Transfer:	Read/Write Block	**Factory Value:**	Null string
Description/Notes:	See Section 22.2.6 of the PMBus Specification Part II. Note that the MAX15301 implements MFR_SERIAL as a fixed-width string, not as part of a shared memory space.		

IC_DEVICE_ID (MAX15301AA01)

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0xAD	**Format:**	ASCII string
Data Bytes:	8	**Units:**	N/A
Transfer:	Read Block	**Factory Value:**	MAX15301
Description/Notes:	See Section 22.2.7 of the PMBus Specification Part II. Note that the MAX15301 implements IC_DEVICE_ID as a fixed-width string, not as part of a shared memory space.		

IC_DEVICE_ID (MAX15301AA02)

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0xAD	**Format:**	ASCII string
Data Bytes:	12	**Units:**	N/A
Transfer:	Read Block	**Factory Value:**	MAX15301AA02
Description/Notes:	See Section 22.2.7 of the PMBus Specification Part II. Note that the MAX15301 implements IC_DEVICE_ID as a fixed-width string, not as part of a shared memory space.		

IC_DEVICE_REV

Reference:	Standard Command	**Lockable:**	N/A
Command Code:	0xAE	**Format:**	ASCII string
Data Bytes:	8	**Units:**	N/A
Transfer:	Read Block	**Factory Value:**	Firmware revision (see Description)
Description/Notes:	See Section 22.2.8 of the PMBus Specification Part II. Note that the MAX15301 implements IC_DEVICE_REV as a fixed-width string, not as part of a shared memory space. The default value is the firmware revision number stored as an ASCII string, typically a 4-digit number. The Maxim PowerTool GUI uses this information to identify the supported command set for a particular slave device.		

Security Commands

WRITE_PROTECT

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x10	**Format:**	Bit field
Data Bytes:	1	**Units:**	N/A
Transfer:	Read/Write Byte	**Factory Value:**	0x00
Description/Notes:	See Section 11.1 of the PMBus Specification Part II.		

MANUF_CONF

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xE0	**Format:**	Bit field
Data Bytes:	32	**Units:**	N/A
Transfer:	Read/Write Block	**Factory Value:**	0

Description/Notes:

To allow password-based write-protection on a per-command basis, the MANUF_CONF command has 32 data bytes, with one bit per possible PMBus command; the byte order is low to high. Each bit position within the 32 bytes correlates to a PMBus command number from 0x00 to 0xFF. For example:

Byte 0, bit 0: PAGE command
Byte 0, bit 1: OPERATION command
Byte 0, bit 2: ON_OFF_CONFIG command
…
Byte 6, bit 3: FREQUENCY_SWITCH command
etc…

If the bit for a particular command is set in MANUF_CONF, and the read-only SECURITY_LEVEL command is *not* set to level 2 by successfully sending a value of MANUF_PASSWD that matches the working memory value of MANUF_LOCK, then the MAX15301 will ignore attempts to write data to that command.

Note that setting a bit for a read-only PMBus command or send-byte PMBus command has no effect, regardless of SECURITY_LEVEL. Likewise, read operations for any PMBus command are never blocked on the basis of MANUF_CONF and SECURITY_LEVEL.

The 32 data bytes for MANUF_CONF are saved in flash memory as a unique, single instance (i.e. not as part of the USER, DEFAULT, or MAXIM PMBus command stores.) The data is written to flash every time the MANUF_CONF command data is written to the MAX15301.

Wait at least 350ms for execution after sending the MANUF_CONF command before sending additional PMBus commands.

MANUF_LOCK

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xE1	**Format:**	Direct
Data Bytes:	2	**Units:**	N/A
Transfer:	Write Word	**Factory Value:**	0x0000

Description/Notes:

The MANUF_LOCK command contains the password value for the "manufacturer" PMBus command security level. If the working-memory value of MANUF_PASSWD matches the working-memory value of MANUF_LOCK, the SECURITY_LEVEL value is set to 2, and any PMBus commands flagged in MANUF_CONF or USER_CONF are unlocked for write operations.

Note that SECURITY_LEVEL must be set to 2 before a new value can be written to MANUF_LOCK.

The value of MANUF_LOCK can be stored in both the USER and DEFAULT nonvolatile PMBus memory with separate and distinct values – this should be taken into account when setting up command security.

MANUF_PASSWD

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xE2	**Format:**	Direct
Data Bytes:	2	**Units:**	N/A
Transfer:	Read/Write Word	**Factory Value:**	N/A

Description/Notes:

The MANUF_PASSWD command is the "key" or password-attempt command used to unlock the "manufacturer" security level. If the working-memory value of MANUF_PASSWD matches the working-memory value of MANUF_LOCK, the SECURITY_LEVEL value is set to 2, and any PMBus commands flagged in MANUF_CONF or USER_CONF are unlocked for write operations.

The value of MANUF_PASSWD is only retained in working memory and cannot be stored.

USER_CONF

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xE3	**Format:**	Bit field
Data Bytes:	32	**Units:**	N/A
Transfer:	Read/Write Block	**Factory Value:**	0

Description/Notes:

To allow password-based write-protection on a per-command basis, the USER_CONF command has 32 data bytes, with one bit per possible PMBus command; the byte order is low to high. Each bit position within the 32 bytes correlates to a PMBus command number from 0x00 to 0xFF. For example:

Byte 0, bit 0: PAGE command
Byte 0, bit 1: OPERATION command
Byte 0, bit 2: ON_OFF_CONFIG command
…
Byte 6, bit 3: FREQUENCY_SWITCH command
etc…

If the bit for a particular command is set in USER_CONF, and the read-only SECURITY_LEVEL command is *not* set to level 1 by successfully sending a value of USER_PASSWD that matches the working

USER_CONF

	memory value of USER_LOCK, then the MAX15301 will ignore attempts to write data to that command. Note that setting a bit for a read-only PMBus command or send-byte PMBus command has no effect, regardless of SECURITY_LEVEL. Likewise, read operations for any PMBus command are never blocked on the basis of USER_CONF and SECURITY_LEVEL. The 32 data bytes for USER_CONF are saved in flash memory as a unique, single instance (i.e. not as part of the USER, DEFAULT, or MAXIM PMBus command stores.) The data is written to flash every time the USER_CONF command data is written to the MAX15301. Wait at least 350ms for execution after sending the USER_CONF command before sending additional PMBus commands.

USER_LOCK

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xE4	**Format:**	Direct
Data Bytes:	2	**Units:**	N/A
Transfer:	Read Word	**Factory Value:**	0x0000
Description/Notes:	The USER_LOCK command contains the password value for the "user" PMBus command security level. If the working-memory value of USER_PASSWD matches the working-memory value of USER_LOCK, the SECURITY_LEVEL value is set to 1, and any PMBus commands flagged in USER_CONF are unlocked for write operations. Note that SECURITY_LEVEL must be set to 1 before a new value can be written to USER_LOCK. The value of USER_LOCK can be stored in both the USER and DEFAULT nonvolatile PMBus memory with separate and distinct values – this should be taken into account when setting up command security.		

USER_PASSWD

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xE5	**Format:**	Direct
Data Bytes:	2	**Units:**	N/A
Transfer:	Read/Write Word	**Factory Value:**	N/A
Description/Notes:	The USER_PASSWD command is the "key" or password-attempt command used to unlock the "user" security level. If the working-memory value of USER_PASSWD matches the working-memory value of USER_LOCK, the SECURITY_LEVEL value is set to 1, and any PMBus commands flagged in USER_CONF are unlocked for write operations. The value of USER_PASSWD is only retained in working memory and cannot be stored.		

SECURITY_LEVEL

Reference:	Maxim Specific	**Lockable:**	N/A
Command Code:	0xE6	**Format:**	Direct
Data Bytes:	1	**Units:**	N/A
Transfer:	Read Byte	**Factory Value:**	0x00

Description/Notes:

The MAX15301 provides two levels of password protection for all writeable PMBus commands, on a per-command basis. The SECURITY_LEVEL command value shows the present security level as follows:

SECURITY_LEVEL	Description
0x00	No write access to commands locked by USER_CONF or MANUF_CONF
0x01	Write access granted to commands locked by USER_CONF
0x02	Write access granted to commands locked by MANUF_CONF and USER_CONF

Note that SECURITY_LEVEL is 0 until a value is written to USER_PASSWD or MANUF_PASSWD that matches the working-memory value of USER_LOCK or MANUF_LOCK respectively.

When the working-memory value of USER_LOCK is written to USER_PASSWD, SECURITY_LEVEL is set to 1.

When the working-memory value of MANUF_LOCK is written to MANUF_PASSWD, SECURITY_LEVEL is set to 2.

Writing a "mismatched" (or wrong) value of USER_PASSWD or MANUF_PASSWD causes SECURITY_LEVEL to reset to 0.

The values of USER_LOCK and USER_CONF can only be changed when SECURITY_LEVEL is 1 or 2.

The values of MANUF_LOCK and MANUF_CONF can only be changed when SECURITY_LEVEL is 2.

Memory and Storage Commands

STORE_DEFAULT_ALL

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x11	**Format:**	N/A
Data Bytes:	0	**Units:**	N/A
Transfer:	Send Byte	**Factory Value:**	N/A

Description/Notes: See Section 11.2 of the PMBus Specification Part II.

The MAX15301 includes three banks of nonvolatile (flash memory) storage for most "writeable" PMBus command values, referred to as the USER, DEFAULT, and MAXIM stores. These stores are fully independent, but identical in structure.

The DEFAULT store is intended to function as a backup of an original equipment manufacturer (OEM) preferred device configuration. OEMs should save identical configurations to the USER store and the DEFAULT store, such that the USER store can be refreshed from the DEFAULT store if needed.

The contents of the DEFAULT store are never loaded into working memory unless the RESTORE_DEFAULT_ALL command is sent.

In general, when the STORE_DEFAULT_ALL command is sent, the existing contents of the DEFAULT store are erased, and the contents of the working PMBus memory (volatile RAM) are written into the DEFAULT store. There are exceptions to this behavior, as follows:

OPERATION	The OPERATION command is not stored to prevent unintentional enabling/disabling of the output.
TEST_MODE	TEST_MODE is not stored to prevent unintentional operation in special test modes.
COMP_MODEL	The working memory COMP_MODEL data is only stored if the command has been edited (as recorded by STRAP_DISABLE).
MANUF_CONF	The manufacturer flags for password command locking are stored independently in nonvolatile memory for security.
MANUF_PASSWD	The manufacturer security password is always volatile for obvious reasons.
USER_CONF	The user flags for password command locking are stored independently in nonvolatile memory for security.
USER_PASSWD	The user security password is always volatile for obvious reasons.
DEADTIME_GCTRL	This command is used to initiate a partial internal edit of the nonvolatile "Config Page" special-purpose memory bank.
START_MEASUREMENT	The Parameter Analyzer setup data is only stored in volatile memory.
CONFIG_PAGE	This command is used to edit the nonvolatile "Config Page" special-purpose memory bank.
CONFIG_STORE_NLSS	This command is used to initiate a partial internal edit of the nonvolatile "Config Page" special-purpose memory bank.
INFO_PAGE	This command is used to access the nonvolatile die trim information.
NLSS_ADDR	This command is stored in volatile memory only.

STORE_DEFAULT_ALL

	NLSS_DATA This command is stored in volatile memory only. Wait at least 450ms for execution after sending the STORE_DEFAULT_ALL command before sending additional PMBus commands.

RESTORE_DEFAULT_ALL

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x12	**Format:**	N/A
Data Bytes:	0	**Units:**	N/A
Transfer:	Send Byte	**Factory Value:**	N/A

Description/Notes:	See Section 11.3 of the PMBus Specification Part II. The MAX15301 includes three banks of nonvolatile (flash memory) storage for most "writeable" PMBus command values, referred to as the USER, DEFAULT, and MAXIM stores. These stores are fully independent, but identical in structure. The DEFAULT store is intended to function as a backup of an original equipment manufacturer (OEM) preferred device configuration. The contents of the DEFAULT store are only loaded into working memory when the RESTORE_DEFAULT_ALL command is sent; there are no other conditions or actions that result in loading of the DEFAULT store to working memory. Be aware that several commands in the DEFAULT store are set to zero (or other safe values) by default to prevent unintended operational consequences following a RESTORE_DEFAULT_ALL command. Wait at least 10ms for execution after sending the RESTORE_DEFAULT_ALL command before sending additional PMBus commands. Please see STORE_DEFAULT_ALL for exceptions to PMBus nonvolatile command storage.

STORE_USER_ALL

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x15	**Format:**	N/A
Data Bytes:	0	**Units:**	N/A
Transfer:	Send Byte	**Factory Value:**	N/A

Description/Notes:	See Section 11.6 of the PMBus Specification Part II. The MAX15301 includes three banks of nonvolatile (flash memory) storage for most "writeable" PMBus command values, referred to as the USER, DEFAULT, and MAXIM stores. These stores are fully independent, but identical in structure. The USER store functions as the primary nonvolatile storage of all PMBus command values. Original equipment manufacturers (OEMs) should save identical configurations to the USER store and the DEFAULT store, such that the USER store can be refreshed from the DEFAULT store if needed. The contents of the USER store are loaded into working memory every time input power is applied to the MAX15301 device. The USER store can also be loaded to working memory at any time by sending

STORE_USER_ALL

the RESTORE_USER_ALL command.

In general, when the STORE_USER_ALL command is sent, the existing contents of the USER store are erased, and the contents of the working PMBus memory (volatile RAM) are written into the USER store. There are exceptions to this behavior, as follows:

OPERATION	The OPERATION command is not stored to prevent unintentional enabling/disabling of the output.
TEST_MODE	TEST_MODE is not stored to prevent unintentional operation in special test modes.
COMP_MODEL	The working memory COMP_MODEL data is only stored if the command has been edited (as recorded by STRAP_DISABLE).
MANUF_CONF	The manufacturer flags for password command locking are stored independently in nonvolatile memory for security.
MANUF_PASSWD	The manufacturer security password is always volatile for obvious reasons.
USER_CONF	The user flags for password command locking are stored independently in nonvolatile memory for security.
USER_PASSWD	The user security password is always volatile for obvious reasons.
DEADTIME_GCTRL	This command is used to initiate a partial internal edit of the nonvolatile "Config Page" special-purpose memory bank.
START_MEASUREMENT	The Parameter Analyzer setup data is only stored in volatile memory.
CONFIG_PAGE	This command is used to edit the nonvolatile "Config Page" special-purpose memory bank.
CONFIG_STORE_NLSS	This command is used to initiate a partial internal edit of the nonvolatile "Config Page" special-purpose memory bank.
INFO_PAGE	This command is used to access the nonvolatile die trim information.
NLSS_ADDR	This command is stored in volatile memory only.
NLSS_DATA	This command is stored in volatile memory only.

Wait at least 450ms for execution after sending the STORE_USER_ALL command before sending additional PMBus commands.

RESTORE_USER_ALL

Reference:	Standard Command	**Lockable:**	Yes
Command Code:	0x16	**Format:**	N/A
Data Bytes:	0	**Units:**	N/A
Transfer:	Send Byte	**Factory Value:**	N/A

Description/Notes:

See Section 11.7 of the PMBus Specification Part II.

The MAX15301 includes three banks of nonvolatile (flash memory) storage for most "writeable" PMBus command values, referred to as the USER, DEFAULT, and MAXIM stores. These stores are fully independent, but identical in structure.

The USER store functions as the primary nonvolatile storage of all PMBus command values. Original equipment manufacturers (OEMs) should save identical configurations to the USER store and the DEFAULT store, such that the USER store can be refreshed from the DEFAULT store if needed.

The contents of the USER store are loaded into working memory every time input power is applied to the MAX15301 device. The USER store can also be loaded to working memory at any time by sending the RESTORE_USER_ALL command.

Be aware that several commands in the USER store are set to zero (or other safe values) by default to prevent unintended operational consequences following a RESTORE_DEFAULT_ALL command.

Wait at least 10ms for execution after sending the RESTORE_USER_ALL command before sending additional PMBus commands.

Please see STORE_USER_ALL for exceptions to PMBus nonvolatile command storage.

RESTORE_MAXIM_ALL

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xEA	**Format:**	N/A
Data Bytes:	0	**Units:**	N/A
Transfer:	Send Byte	**Factory Value:**	N/A

Description/Notes:

The MAX15301 includes three banks of nonvolatile (flash memory) storage for most "writeable" PMBus command values, referred to as the USER, DEFAULT, and MAXIM stores. These stores are fully independent, but identical in structure.

The MAXIM store functions as a backup of the firmware default configuration, and it cannot be edited.

The contents of the MAXIM store are only loaded into working memory when the RESTORE_MAXIM_ALL command is sent; there are no other conditions or actions that result in loading of the MAXIM store to working memory.

Be aware that several commands in the MAXIM store are set to zero (or other safe values) by default to prevent unintended operational consequences following a RESTORE_MAXIM_ALL command.

Wait at least 10ms for execution after sending the RESTORE_MAXIM_ALL command before sending additional PMBus commands.

STRAP_DISABLE

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xDC	**Format:**	Bit field
Data Bytes:	2	**Units:**	N/A
Transfer:	Read/Write Word	**Factory Value:**	0x0000

Description/Notes:

Several commands in the MAX15301 can be set directly by resistor value connected to a device pin, or are set indirectly according to the value of other pin-configurable commands. Of these "pin-configurable" commands, the STRAP_DISABLE command keeps track of those that have been directly altered by a user through the SMBus serial interface.

When one of the commands in the table below is edited, the corresponding bit-flag in STRAP_DISABLE is set, and this flag prevents the device from automatically setting the value of that command in the future, preserving the user-set value instead.

Note that the STRAP_DISABLE command can be saved in the USER and DEFAULT nonvolatile stores. In order to disable pin-configuration of a command, the flag for that command must be 1, and a STORE_USER_ALL operation must have been performed, to ensure that the device powers up with the flag set in the working-memory version of STRAP_DISABLE. (This process is handled automatically without need for special user interaction in most situations.)

To restore pin-configuration capability for a command, clear the corresponding bit in STRAP_DISABLE and send the STORE_USER_ALL command.

Bit	Command	Comments
15	INTERLEAVE	Command set indirectly by the SMBus slave address, from R_{ADDR0} and R_{ADDR1} resistor values. (Note that this STRAP_DISABLE bit is not actually used in the INTERLEAVE pin-strapping decision; any non-zero value of INTERLEAVE cancels the determination of phase relationship based on the PMBus address.)
14	COMP_MODEL	The F_{LC} data is set automatically by the parametric extraction process
13	VOUT_MAX	Command set indirectly according to VOUT_COMMAND x 110%
12	IOUT_CAL_GAIN	Command set by R_{ADDR1} resistor value
11	FREQUENCY_SWITCH	Command set by R_{SYNC} resistor value
10	<RESERVED>	
9	IOUT_OC_FAULT_LIMIT	Command not set automatically; flag is for future sue
8	VOUT_MARGIN_LOW	Command set indirectly according to VOUT_COMMAND x 95%
7	VOUT_MARGIN_HIGH	Command set indirectly according to VOUT_COMMAND x 105%
6	POWER_GOOD_OFF	Command set indirectly according to VOUT_COMMAND x 85%
5	POWER_GOOD_ON	Command set indirectly according to VOUT_COMMAND x 90%
4	VOUT_UV_WARN_LIMIT	Undervoltage warning is not implemented
3	VOUT_UV_FAULT_LIMIT	Command set indirectly according to VOUT_COMMAND x 85%
2	VOUT_OV_WARN_LIMIT	Overvoltage warning is not implemented
1	VOUT_OV_FAULT_LIMIT	Command set indirectly according to VOUT_COMMAND x 115%
0	VOUT_COMMAND	Command set by R_{SET} resistor value

Control Loop Commands

ADAPTIVE_MODE

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xD0	**Format:**	Bit field
Data Bytes:	2	**Units:**	N/A
Transfer:	Read/Write Word	**Factory Value:**	0x024B

Description/Notes: The ADAPTIVE_MODE command configures the automatic tuning features of the MAX15301. Each bit in the two data bytes enables a particular function as follows:

Bit	Name	Effect When True
15	<RESERVED>	
14	<RESERVED>	
13	<RESERVED>	
12	FIRST_ENABLE_ONLY	Perform parametric extraction on first enable only
11	<RESERVED>	
10	<RESERVED>	
9	ADAPT_POST_RAMP	Perform parametric extraction after the startup ramp **(set by default)**
8	ADAPT_CONTINUOUS	Perform parametric extraction periodically while regulating
7	<RESERVED>	
6	UPDATE_FLC	Update working memory LC double-pole frequency (F_{LC}) after parametric extraction **(set by default)**
5	UPDATE_FZ	Update working memory output capacitor ESR zero frequency (F_Z) after parametric extraction
4	UPDATE_ZLC	Update working memory LC damping factor (Z_{LC}) after parametric extraction
3	RESET_GAINS	Reset gain registers based on USER store values when output is disabled **(set by default)**
2	WRITEFLASH	Execute STORE_USER_ALL after adaptive measurement (note that this bit is cleared from the working memory copy of ADAPTIVE_MODE after execution)
1	GAIN_CALC	Calculate new NLSS "fast gain" register values based on COMP_MODEL parameters **(set by default)**
0	FAST_GAINS	The control loop will switch to using the NLSS "fast gains" registers after ramp-up is complete **(set by default)**

Wait at least 500µs for execution after sending the ADAPTIVE_MODE command before sending additional PMBus commands.

FEEDBACK_EFFORT

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xD3	**Format:**	Linear
Data Bytes:	2	**Units:**	Scalar
Transfer:	Read Byte	**Factory Value:**	0xB200 (0.5)

Description/Notes:

This command allows some user adjustment of the tradeoff between transient response, load regulation, and output noise. The default value is 0.5, which provides a good balance of transient response performance and output noise characteristics.

Lower values of FEEDBACK_EFFORT (as low as 0.0) will tend to provide lower output noise, at the expense of transient performance and slightly reduced load regulation accuracy.

Higher values of FEEDBACK_EFFORT (up to 1.0) will provide improved transient response and load regulation, at the expense of increased output noise and PWM waveform rising/falling edge "jitter."

As a generalization, increasing FEEDBACK_EFFORT tends to increase effective control loop bandwidth, while decreasing FEDBACK_EFFORT reduces bandwidth.

Wait at least 500µs for execution after sending the FEEDBACK_EFFORT command before sending additional PMBus commands.

LOOP_CONFIG

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xD5	**Format:**	Bit field
Data Bytes:	2	**Units:**	N/A
Transfer:	Read/Write Word	**Factory Value:**	0x0100

Description/Notes:

The LOOP_CONFIG command configures miscellaneous control-loop features of the MAX15301. Each bit in the two data bytes enables a particular function as follows:

Bit	Name	Effect When True
15	<RESERVED>	
14	<RESERVED>	
13	<RESERVED>	
12	<RESERVED>	
11	<RESERVED>	
10	<RESERVED>	
9	NOGAINCALC	The control loop will only use hard-coded NLSS gain values
8	PIDMODE	Enable integral term in the control loop **(set by default)**
7	<RESERVED>	
6	GCTRLTABLEEN	Enable load-variable gate drive voltage lookup table
5	<RESERVED>	
4	AGDEN	Enable adaptive gate-drive timing system (not supported)
3	NEGDUTYEN	Enable low-side body diode "braking" on load-release transient
2	<RESERVED>	
1	<RESERVED>	
0	<RESERVED>	

Wait at least 500µs for execution after sending the LOOP_CONFIG command before sending additional PMBus commands.

COMP_MODEL

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xDB	**Format:**	Linear
Data Bytes:	6 (see Description)	**Units:**	Scalar
Transfer:	Read/Write Block	**Factory Value:**	0.03167, 0.5, 0.5

Description/Notes: The COMP_MODEL command provides access to key control loop tuning parameters. The three arguments are as follows:

Data Byte Number	Data Byte Name	Units	Description
0	F_{LC}/F_{SW}	None	Power stage LC double-pole frequency, as a fraction of the PWM fundamental frequency. In typical operation, this parameter is determined by parametric extraction.
1	F_Z/F_{SW}	None	Output capacitor ESR zero frequency, as a fraction of the PWM fundamental frequency.
2	Z_{LC}	None	Power stage damping factor. Higher values indicate a more damped LC filter; lower values represent a less damped filter.

The values of COMP_MODEL can be altered by the parametric extraction function of the MAX15301. They will reset to the USER store values whenever the output is disabled, unless bit 3 of ADAPTIVE_MODE is cleared.

Note that the values in COMP_MODEL are not saved during a STORE_USER_ALL or STORE_DEFAULT_ALL operation, unless the values have previously been set by a PMBus write to COMP_MODEL, as indicated by bit 14 of STRAP_DISABLE. This safety feature prevents inadvertent storage of parametric extraction results that could adversely affect the initial ramp control loop tuning.

Wait at least 500µs for execution after sending the COMP_MODEL command before sending additional PMBus commands.

DEADTIME_GCTRL

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xE7	**Format:**	See Description
Data Bytes:	19	**Units:**	N/A
Transfer:	Read/Write Block	**Factory Value:**	See Description

Description/Notes: The DEADTIME_GCTRL command allows configuration of the Adaptive Gate-Drive timing system (AGD), adjustment of static gate-drive timing, and adjustment of the variable gate-drive voltage system. The arguments for this command are as follows:

Byte #	Data Name	Data Type	Description	Default Value
0	fixedDTR (LSB)	Signed Integer	Static rising-edge deadtime adjustment	20
1	fixedDTR (MSB)			
2	fixedDTF (LSB)	Signed Integer	Static falling-edge deadtime adjustment	20
3	fixedDTF (MSB)			
4	TDR (LSB)	Signed Integer	AGD system rising edge deadtime target value	3
5	TDR (MSB)			

DEADTIME_GCTRL

6	TDF (LSB)	Signed Integer	AGD system falling edge deadtime target value	8
7	TDF (MSB)			
8	LXDAC	Unsigned Byte	AGD system body-diode conduction comparator threshold DAC setting	15
9	GCTRL[0]	Unsigned Byte	Variable gate drive voltage DAC lookup table value, bin 0	0
10	GCTRL[1]	Unsigned Byte	Variable gate drive voltage DAC lookup table value, bin 1	0
11	GCTRL[2]	Unsigned Byte	Variable gate drive voltage DAC lookup table value, bin 2	5
12	GCTRL[3]	Unsigned Byte	Variable gate drive voltage DAC lookup table value, bin 3	5
13	GCTRL[4]	Unsigned Byte	Variable gate drive voltage DAC lookup table value, bin 4	8
14	GCTRL[5]	Unsigned Byte	Variable gate drive voltage DAC lookup table value, bin 5	10
15	GCTRL[6]	Unsigned Byte	Variable gate drive voltage DAC lookup table value, bin 6	12
16	GCTRL[7]	Unsigned Byte	Variable gate drive voltage DAC lookup table value, bin 7	15
17	GCTRLDAC (LSB)	Unsigned Integer	Constant gate drive voltage DAC value	0
18	GCTRLDAC (MSB)			

Nonoverlap/Deadtime Adjustment

There are two sets of deadtime adjustment values: the fixedDTR and fixedDTF terms adjust the nonoverlap timing when the AGD system is disabled, whereas the TDR and TDF values provide corresponding target values that are used when the AGD system is enabled.

Note that the AGD system is disabled by default (bit 4 of the LOOP_CONFIG command) and operation of the AGD system is not recommended or supported by Maxim.

The deadtime adjustment values are given in "vernier tick" units, such that each step results in a deadtime adjustment as follows:

FREQUENCY_SWITCH ≤ 475kHz: 1 vernier tick = 1 / (FREQUENCY_SWITCH * 2048)
FREQUENCY_SWITCH > 475kHz: 1 vernier tick = 1 / (FREQUENCY_SWITCH * 1024)

Caution must be exercised when trimming the gate-drive nonoverlap timing; it is possible to set negative values and cause the high-side driver to enable before the low-side driver has disabled, and vice-versa.

Body-Diode Conduction Comparator

The LXDAC term is used to adjust the low-side MOSFET body-diode conduction detection comparator reference threshold as follows:

LXDAC Setting	Comparator Threshold (mV)
1	-150
3	-300
7	-450
15	**-600**
31	-750
61	-900
127	-1000

DEADTIME_GCTRL

255	-1200

Note: the default setting is LXDAC = 15 and this value should not be changed.

Variable Gate-Drive Voltage

The MAX15301 allows adjustment of the gate drive voltage from approximately 5.2V to 8.7V, as controlled by a 4-bit DAC. The DAC value to gate-drive voltage relationship is as follows:

GCTRLDAC Setting	Typical Gate Drive (V)
0	5.2
1	5.4
2	5.7
3	5.9
4	6.1
5	6.4
6	6.6
7	6.8
8	7.1
9	7.3
10	7.5
11	7.8
12	8
13	8.2
14	8.5
15	8.7

The variable gate drive system has two modes of operation, controlled by bit 6 of the LOOP_CONFIG command. When bit 6 is set to 1, the value of READ_IOUT is compared to determine which of "eighth" of the full load current range the device is operating in; e.g. 0 to IMAX/8, IMAX/8 to IMAX/4, etc. For each "bin" of the full load current range, there is a corresponding DAC setting in a lookup table. This table is populated by values sent in the GCTRL[0] to GCTRL[7] arguments of DEADTIME_GCTRL.

When bit 6 of LOOP_CONFIG is set to 0, the MAX15301 uses one setting for the gate-drive voltage, regardless of load current. This "fixed" setting is given by the GCTRLDAC argument of DEADTIME_GCTRL.

Wait at least 500ms for execution after sending the DEADTIME_GCTRL command before sending additional PMBus commands.

ZETA_P

Reference:	Maxim Specific	**Lockable:**	Yes
Command Code:	0xE8	**Format:**	Linear
Data Bytes:	2	**Units:**	Scalar
Transfer:	Read/Write Byte	**Factory Value:**	0xBB00 (1.5)
Description/Notes:	The ZETA_P command sets the damping ratio for the closed-loop response. The value can be changed to improve performance when using nonceramic output capacitors with higher equivalent series resistance.		

ZETA_P	
	Wait at least 500µs for execution after sending the ZETA_P command before sending additional PMBus commands.

Trademarks

InTune is a trademark of Maxim Integrated Products, Inc.

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Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	11/13	Initial release	—
1	10/14	Added information for new MAX15301AA02 part number Default value of VOUT_MAX corrected: VOUT_COMMAND x 1.10 Default values of EXT_TEMP_CAL changed in MAX15301AA02 firmware Data byte count for IC_DEVICE_ID increased to 12 in MAX15301AA02 firmware	2 11 35 38