IRPS5401 command set

Scope and purpose

This document is used to list and describe the PMBus™ commands supported by the IRPS5401 platform.

This document describes, in a very detailed manner, the PMBus™ commands supported by the IRPS5401 platform. Each command is associated with a command code, a description and a set/range of supported/legal values. Also included is a description of the actions to be taken in the event of illegal/unsupported data values.

IRPS5401 consists of four switching regulators and one linear low dropout regulator. Most of the PMBus™ commands are common to all five regulators. However, there are differences and these are detailed in the descriptions for each command. For the remainder of this document, the four switching regulators will be referred to as SW-A, SW-B, SW-C, and SW-D, or collectively as "the switchers". The LDO will simply be referred to as the LDO.

For each PMBus™ command description there is a corresponding table, located just below the command name, which lists various parameters of the command, including resolution, range and reset value. The reset values are the contents of the register at power up. They will remain set until changed by the user. The notation for range and resolution is generally in decimal. When binary notation is used it will be in the format of 'b0_0000. An X in any location indicates a "don't care" bit. When hexadecimal notation is used it will be in the format of 0x0000.

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1 Supported PMBus™ commands

Command code	Command name	PMBus™ transaction type	# of bytes	Reset default	Switcher support	LDO support
00h	PAGE	R/W Byte	1	0x00	Yes	Yes
01h	OPERATION	R/W Byte	1	0x00	Yes	Yes
02h	ON_OFF_CONFIG	R/W Byte	1	0x17	Yes	Yes
03h	CLEAR_FAULTS	Send Byte	0	N/A	Yes	Yes
06h	PAGE_PLUS_READ	Block Read Process Call	x	N/A	Yes	Yes
10h	WRITE_PROTECT	R/W Byte	1	0x00	Yes	Yes
12h	RESTORE_DEFAULT_ALL	Send Byte	0	N/A	Yes	Yes
15h	STORE_USER_ALL	Send Byte	0	N/A	Yes	Yes
16h	RESTORE_USER_ALL	Send Byte	0	N/A	Yes	Yes
19h	CAPABILITY	Read Byte	1	0xB0	Yes	Yes
1Bh	SMBALERT_MASK	Wr Word Block Read/Write Process Call	2	0x00	Yes	Yes
20h	VOUT_MODE	R/W Byte	1	0x18	Yes	Yes
21h	VOUT_COMMAND	R/W Word	2	0x0000	Yes	No
22h	VOUT_TRIM	R/W Word	2	0x0000	Yes	No
24h	VOUT_MAX	R/W Word	2	0x8000	Yes	No
25h	VOUT_MARGIN_HIGH	R/W Word	2	0x0000	Yes	No
26h	VOUT_MARGIN_LOW	R/W Word	2	0x0000	Yes	No
27h	VOUT_TRANSITION_RATE	R/W Word	2	0xE808	Yes	No
29h	VOUT_SCALE_LOOP	R/W Word	2	0xE808	Yes	No
33h	FREQUENCY_SWITCH	R/W Word	2	0x0320	Yes	No
35h	VIN_ON	R/W Word	2	0xF001	Yes	Yes
36h	VIN_OFF	R/W Word	2	0xF000	Yes	Yes
39h	IOUT_CAL_OFFSET	R/W Word	2	0xD000	Yes	Yes
40h	VOUT_OV_FAULT_LIMIT	R/W Word	2	0x8000	Yes	Yes
41h	VOUT_OV_FAULT_RESPONSE	R/W Byte	1	0x00	Yes	Yes
42h	VOUT_OV_WARN_LIMIT	R/W Word	2	0x8000	Yes	Yes
43h	VOUT_UV_WARN_LIMIT	R/W Word	2	0x0000	Yes	Yes
44h	VOUT_UV_FAULT_LIMIT	R/W Word	2	0x0000	Yes	Yes
45h	VOUT_UV_FAULT_RESPONSE	R/W Byte	1	0x00	Yes	No
46h	IOUT_OC_FAULT_LIMIT	R/W Word	2	0xD900	Yes	Yes
47h	IOUT_OC_FAULT_RESPONSE	R/W Byte	1	0xF8	Yes	Yes
4Ah	IOUT_OC_WARN_LIMIT	R/W Word	2	0xD900	Yes	Yes
4Fh	OT_FAULT_LIMIT	R/W Word	2	0x0080	Yes	Yes
50h	OT_FAULT_RESPONSE	R/W Byte	1	0x00	Yes	Yes
51h	OT_WARN_LIMIT	R/W Word	2	0x0080	Yes	Yes
55h	VIN_OV_FAULT_LIMIT	R/W Word	2	0xE200	Yes	Yes
56h	VIN_OV_FAULT_RESPONSE	R/W Byte	1	0x00	Yes	Yes
58h	VIN_UV_WARN_LIMIT	R/W Word	2	0xE000	Yes	Yes
5Eh	POWER_GOOD_ON	R/W Word	2	0x0000	Yes	Yes
5Fh	POWER_GOOD_OFF	R/W Word	2	0x0000	Yes	Yes
60h	TON_DELAY	R/W Word	2	0xF800	Yes	Yes

Supported PMBus™ commands

Command code	Command name	PMBus™ transaction type	# of bytes	Reset default	Switcher support	LDO support
61h	TON_RISE	R/W Word	2	0xF004	Yes	No
62h	TON_MAX_FAULT_LIMIT	R/W Word	2	0xF004	Yes	Yes
63h	TON_MAX_FAULT_RESPONSE	R/W Byte	1	0x00	Yes	Yes
64h	TOFF_DELAY	R/W Word	2	0xF800	Yes	No
65h	TOFF_FALL	R/W Word	2	0xF004	Yes	No
78h	STATUS BYTE	Read Byte	1	N/A	Yes	Yes
79h	STATUS WORD	Read Word	2	N/A	Yes	Yes
7Ah	STATUS_VOUT	Read Byte	1	N/A	Yes	Yes
7Bh	STATUS_IOUT	Read Byte	1	N/A	Yes	Yes
7Ch	STATUS_INPUT	Read Byte	1	N/A	Yes	Yes
7Dh	STATUS_TEMPERATURE	Read Byte	1	N/A	Yes	Yes
7Eh	STATUS_CML	Read Byte	1	N/A	Yes	Yes
88h	READ_VIN	Read Word	2	N/A	Yes	Yes
89h	READ_IIN	Read Word	2	N/A	Yes	No
8Bh	READ_VOUT	Read Word	2	N/A	Yes	Yes
8Ch	READ_IOUT	Read Word	2	N/A	Yes	Yes
8Dh	READ_TEMPERATURE_1	Read Word	2	N/A	Yes	Yes
96h	READ_POUT	Read Word	2	N/A	Yes	Yes
97h	READ_PIN	Read Word	2	N/A	Yes	Yes
98h	PMBUS_REVISION	Read Byte	1	0x22	Yes	Yes
99h	MFR_ID	Block Read/Write	3	0x004952	Yes	Yes
9Ah	MFR_MODEL	Block Read/Write	4	0x00000052	Yes	Yes
9Bh	MFR_REVISION	Block Read/Write	4	0x00000002	Yes	Yes
ADh	IC_DEVICE_ID	Block Read	1	0x52	Yes	Yes
AEh	IC_DEVICE_REV	Block Read	1	0x02	Yes	Yes
D0h	MFR_REG_ACCESS	Block Write Process Call	W=5 R=2	N/A	Yes	Yes
D6h	MFR_I2C_ADDRESS	R/W Byte	1	0x10	Yes	Yes
D8h	MFR_TPGDLY	R/W Word	2	0x0000	Yes	Yes
D9h	MFR_FCCM	R/W Byte	1	0x01	Yes	No
DBh	MFR_VOUT_PEAK	Read Word	2	0x0000	Yes	Yes
DCh	MFR_IOUT_PEAK	Read Word	2	0x0000	Yes	Yes
DDh	MFR_TEMPERATURE_PEAK	Read Word	2	0x0000	Yes	Yes
DEh	MFR_LDO_MARGIN	R/W Byte	2	0x00	No	Yes

1.1 PAGE (00h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW Support	SW range/res	SW reset value	LDO Support	LDO range/res	LDO reset value
PAGE	Write Byte	Read Byte	1	y	0x00-0x04, 0xFF	0	y	0x00-0x04, 0xFF	0

The PAGE command allows the control, monitoring and configuration of multiple outputs on a single device through a single physical address. A different PAGE number is assigned to each individual output, and when the PAGE command is set to a particular PAGE number all subsequent PMBus™ commands will be directed to the targeted output only. To write or read settings for a different output, the PAGE command will have to be written to the corresponding PAGE number.

In IRPS5401, there are five outputs: SW-A, SW-B, SW-C, SW-D, and the LDO. For IRPS5401, setting the PAGE command to 00h will access SW-A. PAGE 01h will access SW-B, PAGE 02h will access SW-C and PAGE 03h will access SW-D. To access the LDO, set PAGE to 04h. To send a command to all the loops, set PAGE to FFh.

1.2 OPERATION (01h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW Support	SW range/res	SW reset value	LDO Support	LDO range/res	LDO reset value
OPERATION	Write Byte	Read Byte	1	y	0x00-0xFF 1	0	y	0x00-0xFF 1	0

The OPERATION command, in conjunction with the Enable pin as determined by the ON_OFF_CONFIG command, controls the operation of the device, turning it on or off, or setting the output voltage to the programmed MARGIN VOLTAGEs for the switchers.

The contents of the data byte are shown below in Table 1.

Any value not shown in the table is an invalid data. Bits [1:0] are reserved. XX is “don’t care”.

Table 1

Bits [7:6]	Bits [5:4]	Bits [3:2]	Bits [1:0]	Unit On Or Off	Margin State
00	XX	XX	XX	Immediate Off (No Sequencing)	N/A
01	XX	XX	XX	Soft Off (With Sequencing)	N/A
10	00	XX	XX	On	Off
10	01	01	XX	On	Margin Low (Ignore Fault)
10	01	10	XX	On	Margin Low (Act On Fault)
10	10	01	XX	On	Margin High (Ignore Fault)
10	10	10	XX	On	Margin High (Act On Fault)

Attempting to set the command to any setting not listed in the table above will result in an Invalid Data CML Fault Response

Settings for ON with “Act on Fault” will treat an output voltage level that is above the overvoltage warning or fault limit while the output is margined high as a fault or warning and respond as programmed by the fault or warning fault response command. Additionally, if the output voltage level is below the under voltage warning or fault limit while the output is margined low, it will be treated as a fault or warning and the response will be as determined by the setting of the under voltage fault or warning response command. Settings for ON with “Ignore Fault” will ignore under voltage conditions while margined low, and ignore overvoltage conditions while margined high.

Soft off with sequencing is available only on the switchers. Any attempt to set the LDO to “Soft off” will be NACKd. Only Immediate Off and any On are legal commands for the LDO. However, since the LDO has no capability to set Margin voltages, all commands from 0x80 to 0x8F will be treated as an ON without margining for the LDO.

For ready reference, some data bytes for the OPERATION command are given below:

Table 2

Desired operation	Data byte
ON without margining (Default)	80h
ON with value loaded from VOUT_MARGIN_LOW, ignoring fault	94h
ON with value loaded from VOUT_MARGIN_LOW, acting on fault	98h
ON with value loaded from VOUT_MARGIN_HIGH, ignoring fault	A4h
ON with value loaded from VOUT_MARGIN_HIGH, acting on fault	A8h
Soft OFF	40h
OFF	00h

1.3 ON_OFF_CONFIG (02h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW Support	SW range/res	SW reset value	LDO Support	LDO range/res	LDO reset value
ON_OFF_CONFIG	Write Byte	Read Byte	1	y	0x00-0x1F	0x17	y	0x15 0x17 0x19 0x1B 0x1D 0x1F	0x17

The ON_OFF_CONFIG command determines how the combination of the OPERATION and turn on and off delay commands work with the Enable pin and input power to turn the device on and off**. ON_OFF_CONFIG should be set before initial power up of V_{in} (+12 V). It is not meant to be used to turn on and off the device, but instead determines how OPERATION and the Enable pin are used to turn the device on and off.**

Supported PMBus™ commands

Table 3

Bit number	Purpose	Bit value	Meaning
[7:5]		000	Reserved For Future Use
4	Sets the default to either operate any time power is present or for the on/off to be controlled by Enable pin and serial bus commands	0	Power conversion will start anytime PVin and Vcc are up without needing the Enable pin to be active and without being commanded to do so by the OPERATION command.
		1	Power conversion does not start until commanded by the Enable pin and OPERATION command (as programmed in bits [3:0]).
3	Controls how the unit responds to commands received via the serial bus	0	The device ignores the on/off portion (bit[7]) of the OPERATION command from serial bus
		1	To start, the device requires that that the on/off portion (bit[7]) of the OPERATION command is instructing the unit to run. Depending on bit [2], the device may also require the Enable pin to be asserted for the unit to start power conversion
2	Controls how the unit responds to the Enable pin	0	Device ignores the Enable pin (on/off controlled only the OPERATION command)
		1	Device requires the Enable pin to be asserted to start power conversion. Depending on bit [3], the OPERATION command may also be required to instruct the device to start before the output is energized.
1	Polarity of the Enable pin	0	Active low (Pull pin low to start the unit).
		1	Active high (Pull high to start the unit)
0	Enable pin action when commanding the unit to turn off	0	Use the programmed turn off delay TOFF_DELAY and fall time TOFF_FALL
		1	Turn off the output and stop transferring energy to the output as fast as possible.

Legal values for the LDO are restricted to 0x17, 0x15, 0x1B, 0x19, 0x1D and 0X1F, and therefore will always turn off as fast as possible. The legal values for SW-A through SW-D are 0x00 to 0x1F. The default for all outputs is 0x17.

Attempting to set the command to any setting not listed above will result in an Invalid Data CML Fault Response

1.4 CLEAR_FAULTS (03h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
CLEAR_FAULTS	Send Byte	N/A	0	y	n/a	n/a	y	n/a	n/a

The CLEAR_FAULTS command clears all bits in all status registers simultaneously and de-asserts the SALERT signal, if asserted. It will not automatically restart a device that has been latched off due to a fault. Restart is accomplished by cycling the Enable pin and / or the OPERATION command, or by cycling Vcc. If the fault is still present when CLEAR_FAULTS is issued, the corresponding faults bits will be immediately re-set.

This command is write only. There is no data byte for this command.

1.5 PAGE_PLUS_READ (06h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
PAGE_PLUS_READ	N/A	Block Read	Variable	y			y		

The PAGE_PLUS_READ command is used to set the page within a device, send a command, and read the data returned by the command in one packet. The PAGE_PLUS_READ command uses the BLOCK WRITE – BLOCK READ PROCESS CALL protocol. The Page will revert to its previous value unless the *regmap_common.pmb_page_plus_latch_new_page* is asserted.

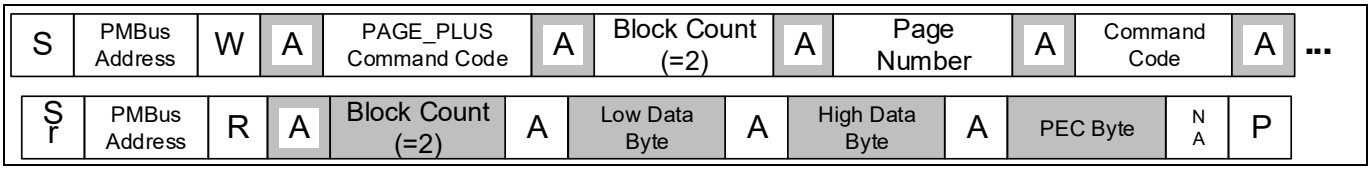


Figure 1 PAGE_PLUS_READ command example with data to read and PEC

1.6 WRITE_PROTECT (10h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
WRITE_PROTECT	Write Byte	Read Byte	1	y	0x00, 0x20 0x40, 0x80	0	y	0x00, 0x20 0x40, 0x80	0

The WRITE_PROTECT command is used to prevent accidental changes to the PMBus™ settings. Commands can still have their settings read when WRITE is disabled. WRITE_PROTECT command does not protect against writing controller registers via the I2C bus. To prevent writing controller registers through the I2C bus, the I2C bus can be disabled by setting the I2C address to 0 in REG 0x0020[14:8]. The I2C registers can also be write protected by enabling the I2C write protection in the I2C USER ssection. See UN0065 (IRPS5401 customer register map) for more details

This command has one data byte as shown in table below: The default is 00h.

Supported PMBus™ commands

Table 4

Data byte	Action
80h	Disable all writes except to the WRITE_PROTECT command
40h	Disable all writes except to the WRITE_PROTECT and OPERATION commands
20h	Disable all writes except to the WRITE_PROTECT, OPERATION, ON_OFF_CONFIG and VOUT_COMMAND commands
00h	Enable writes to all commands.

Attempting to set the command to any setting not listed above will result in an Invalid Data CML Fault Response

1.7 RESTORE_DEFAULT_ALL (12h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
RESTORE_DEFAULT_ALL	Send Byte	N/A	0	y	N/A	N/A	y	N/A	N/A

Write-only command that restores the contents of the most recent USER image from NVM into the registers. The data for this command is ignored. All USER registers (common, four switchers and the LDO) are restored, regardless of the current PMBus™ PAGE.

Note that the function of this command is identical to RESTORE_USER_ALL. The restore operation takes approximately 40 µsec

1.8 STORE_USER_ALL (15h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
STORE_USER_ALL	Send Byte	N/A	0	y	N/A	N/A	y	N/A	N/A

Write-only command that programs the contents of the NVM-backed USER registers into the next available slot of the NVM array. The data for this command is ignored. All USER registers (common, four switchers and the LDO) are stored, regardless of the current PMBus™ PAGE.

The duration of the program operation varies based on the number of 1's that need to be programmed into the registers (approx. 51 µsec per 1 bit). Maximum time for all bits to be set to 1's is 255 msec. When the programming is complete, *nvm_command[15]* will be set to 1 by the hardware.

1.9 RESTORE_USER_ALL (16h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
RESTORE_USER_ALL	Send Byte	N/A	0	y	N/A	N/A	y	N/A	N/A

Write-only command that restores the contents of the most recent USER image from NVM into the registers. The data for this command is ignored.

Note that the function of this command is identical to RESTORE_DEFAULT_ALL. The restore operation takes approximately 40 µsec.

1.10 CAPABILITY (19h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
CAPABILITY	N/A	Read Byte	1	y	0xB0	0xB0	y	0xB0	0xB0

This is a read only command that provides information to the host system concerning capabilities of a PMBus™ device. There is one data byte formatted as shown in the table below.

1.10.1 CAPABILITY COMMAND Data Byte Format

Table 5

Bits	Description	Value	Meaning
7	Packet Error Checking	0	Packet Error Checking not supported
		1	Packet Error Checking is supported
6:5	Maximum Bus Speed	00	Maximum supported bus speed is 100 kHz
		01	Maximum supported bus speed is 400 kHz
		10	Reserved
		11	Reserved
4	SMBALERT#	0	The device does not have a SMBALERT# pin and does not support the SMBus Alert Response protocol
		1	The device does have a SMBALERT# pin and does support the SMBus Alert Response protocol
3:0	Reserved	X	Reserved (returns 0000)

For the IRPS5401 platform, this command will return B0h, indicating that IRPS5401 supports:

- Packet Error Checking
- Maximum bus speed of 400 kHz
- SMBus Alert Response protocol through the SALERT pin

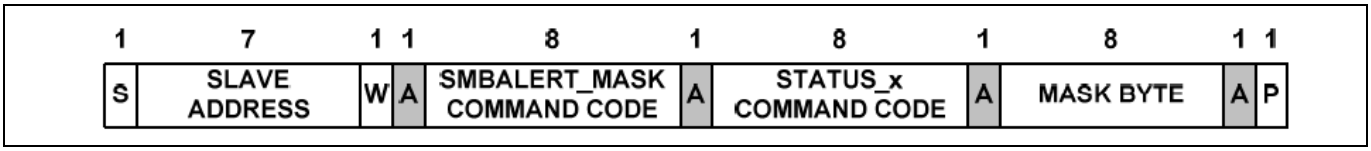
1.11 SMBALERT_MASK (1Bh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
SMBALERT_MASK	Write Word	Block Wr/Block Rd Proc. Call	2	y	0x00-0xFF per STATUS	0x00 per STATUS	y	0x00-0xFF per STATUS	0x00 per STATUS

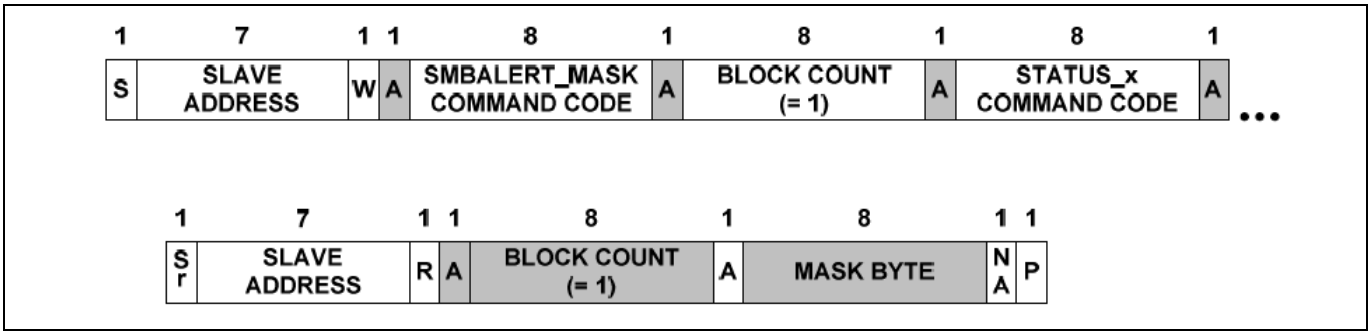
The SMBALERT_MASK command is used to mask warning or fault conditions from asserting the SALERT signal. The format used is to pass the command code for the status register which would indicate the fault intended to be masked, along with bit or bits in the status register which would be set in the case of a fault.

For example, a VOUT_OV_WARN_LIMIT warning would set bit 6 in the STATUS_VOUT register. If we want to mask the SALERT when this occurs we would use the SMBALERT_MASK to set the command code for STATUS_VOUT (7Ah) and the bit for OV warn (40h). In this case, an overvoltage warning condition on VOUT would not assert the SALERT. However, an OV fault would. If we wish to mask both the fault and the warning on VOUT, we would set bits 7 and 6 (C0h) in the SMBALERT_MASK of STATUS_VOUT. The bit maps for each warning or fault condition are found in the individual STATUS descriptions, commands 7Ah through 7Eh. The STATUS_X_COMMAND code is sent in the low byte and the bits to be masked is sent with the high byte.

The format for setting SMBALERT_MASK is shown below.



In order to retrieve the SMBALERT_MASK setting for a given status register, the Block Write Block Read Process call transaction is used with 1 byte and is shown below.



1.12 VOUT Related Commands

1.12.1 VOUT_MODE (20h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VOUT_MODE	Write Byte	Read Byte	1	y	0x14 0x17 0x18	0x18	y	0x14 0x17 0x18	0x18

The VOUT_MODE command sets or reads which of the three formats (LINEAR, VID, DIRECT) the device uses for output voltage related data. The data byte for the VOUT_MODE command is one byte that consists of a three bit Mode and a five bit Parameter as shown in the table below.

Table 6

Mode	Bits [7:5]	Bits [4:0] (Parameter)
Linear	000b	Five bit 2's compliment exponent for the mantissa delivered as the data bytes for an output voltage related command.

The three bit Mode sets whether the device uses the Linear, VID or Direct modes for output voltage related commands. The five bit Parameter provides more information about the selected mode, such as which manufacturer's VID codes are being used. Sending the VOUT_MODE command with the address set for writing sets the Mode and Parameter into the PMBus™ device, if it accepts changes to these values.

IRPS5401 only supports a 16 Bit Linear format VOUT_MODE command with an exponent of -8 (18h), -9 (17h) or -12 (14h). The default value upon startup is -8.

The setting of VOUT_MODE determines the mode and exponent of the following commands:

```
001     VOUT_COMMAND
002     VOUT_TRIM
003     VOUT_MAX
004     VOUT_MARGIN_HIGH
005     VOUT_MARGIN_LOW
006     VOUT_OV_FAULT_LIMIT
007     VOUT_UV_FAULT_LIMIT
008     VOUT_OV_WARN_LIMIT
009     VOUT_UV_WARN_LIMIT
010     READ_VOUT
011     POWER_GOOD_ON
012     POWER_GOOD_OFF
```

When writing a value to these commands, the exponent and mode are implied and only the mantissa needs to be set. For example, if VOUT_MODE is set to 18h (linear mode, -8 exponent), then setting VOUT_COMMAND to 00E7h will result in a Vout of 0.902 V.

See PMBus™ Specification Part II Revision 1.2 Section 8.3.1 for a more detailed explanation.

1.12.2 VOUT_COMMAND (21h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value

VOUT_COMMAND	Write Word	Read Word	2	y	0V – VOUT_MAX, VOUT_MODE	0x0000	n	n/a	n/a

This is a command that is used to set the output voltage when the OPERATION command is set to ON without margining. It has 2 data bytes in 16-bit linear format. The **exponent is determined by VOUT_MODE**. IRPS5401 only supports VOUT_MODE with an exponent of -8, -9 or -12. The resolution with -8 is 3.906 mV per LSB. With a -9 exponent the resolution is 1.953 mV per LSB. For a -12 exponent, the resolution is 0.24 mV per LSB.

During startup and shutdown the output voltage ramps to and from the voltage defined by VOUT_COMMAND in a time defined by TON_RISE and TOFF_FALL, respectively. However, if this command is issued when the output is up and in steady state, the time to transition to the newly commanded voltage is dictated by VOUT_TRANSITION_RATE.

1.12.3 VOUT_TRIM (22h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VOUT_TRIM	Write Word	Read Word	2	y	-5 V to +5 V, VOUT_MODE	0x0000	n	n/a	n/a

The VOUT_TRIM command is a 2's complement number used to trim the commanded output voltage by adding an offset. It is most often used by the end user to trim the output voltage at the time of assembly. This might be done, for example, to adjust the voltage at the pins of a critical IC to optimize its performance. VOUT_TRIM is applied to VOUT_COMMAND, VOUT_MARGIN_HIGH and VOUT_MARGIN_LOW.

VOUT_TRIM is not a valid command for the LDO. It is only supported by the switching outputs. Any attempt to set a VOUT_TRIM value for the LDO will be NACKd.

The resolution for VOUT_TRIM is determined by VOUT_MODE. With VOUT_MODE set to -8, the resolution is +/- 3.91 mV / LSB. For VOUT_MODE = -9, the resolution is +/- 1.95 mV / LSB. For a VOUT_MODE of -12 the resolution is +/- 0.24 mV / LSB.

The output voltage will slew the specified difference at the VOUT_TRANSITION_RATE rate.

1.12.4 VOUT_MAX (24h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VOUT_MAX	Write Word	Read Word	2	y	0x0000 – 0xFFFF, VOUT_MODE	0x8000	n	n/a	n/a

This command is used to limit the maximum commanded output voltage and to act as a safeguard against a user accidentally setting the output voltage to a possibly destructive level rather than to be the primary output overprotection. This limit applies to VOUT_COMMAND, VOUT_MARGIN_HIGH, VOUT_MARGIN_LOW, and VOUT_TRIM. **The exponent is set by VOUT_MODE.**

If an attempt is made to program the output voltage higher than the limit set by this command, this will flag a WARNING condition, but NOT a fault. The device will respond as follows:

- The commanded output voltage will be set to VOUT_MAX
- The NONE OF THE ABOVE bit will be set in the STATUS_BYTE
- The VOUT bit will be set in the STATUS_WORD
- The VOUT_MAX Warning bit will be set in the STATUS_VOUT register
- The device notifies the host by pulling down SALERT

1.12.5 VOUT_MARGIN_HIGH (25h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VOUT_MARGIN_HIGH	Write Word	Read Word	2	y	0V – VOUT_MAX, VOUT_MODE	0x0000	n	n/a	n/a

This command is used to set the output voltage when the Operation command is set to Margin High. **The exponent is set by VOUT_MODE**.

During startup and shutdown the output voltage ramps to and from the voltage defined by VOUT_MARGIN_HIGH in a time defined by TON_RISE and TON_FALL respectively. However, if this command is issued when the output is up and in steady state, the time to transition to the new commanded voltage (provided the OPERATION command is set to Margin High) is dictated by VOUT_TRANSITION_RATE.

VOUT_MARGIN_HIGH is not a valid command for the LDO. Any attempt to write this command to the LDO will result in an Invalid Data CML Fault Response

1.12.6 VOUT_MARGIN_LOW (26h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO Sspport	LDO range/res	LDO reset value
VOUT_MARGIN_LOW	Write Word	Read Word	2	y	0V – VOUT_MAX, VOUT_MODE	0x0000	n	n/a	n/a

This command is used to set the output voltage when the Operation command is set to Margin low. **The exponent is set by VOUT_MODE**.

During startup and shutdown the output voltage ramps up and ramps down to and from the voltage defined by VOUT_MARGIN_LOW in a time defined by TON_RISE and TOFF_FALL respectively. However, if this command is issued when the output is up and in steady state, the time to transition to the new commanded voltage (provided the OPERATION command is set to Margin Low) is dictated by VOUT_TRANSITION_RATE.

VOUT_MARGIN_LOW is not a valid command for the LDO. Any attempt to write this command to the LDO will result in an Invalid Data CML Fault Response

1.12.7 VOUT_TRANSITION_RATE (27h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VOUT_TRANSITION_RATE	Write Word	Read Word	2	y	0 to 127uS 0.125uS	0xE808	n	n/a	n/a

This command sets the rate, in mV/µs, at which the output will transition from one commanded voltage to another due to the VOUT_COMMAND, VOUT_MARGIN, or OPERATION (Margin High or Low) commands. It does not control the rate when the VR is turned on or off.

This command has two data bytes formatted in the 11 Bit Linear Data format**. Only an exponent of -3 is supported.** The resolution is 0.125 mV / µsec and the range is 0 to 127.875 mV / µsec. The default value is 1 mV / µsec.

VOUT_TRANSITION_RATE is not a valid command for the LDO. Any attempt to write this command to the LDO will be NACKd.

Any attempt to set an exponent other than -3 or to set the transition to a negative value will be rejected and result in an Invalid Data CML Fault Response

1.12.8 VOUT_SCALE_LOOP (29h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VOUT_SCALE_LOOP	Write Word	Read Word	2	y	0xE808 (1:1) 0xE804 (1:2)	0xE808	n	n/a	n/a

VOUT_SCALE_LOOP is meant to scale the reported output voltage to the control circuit of the VR when using an external resistor divider (as shown in figure 1) from Vout to Vout sense, so that the output voltage is reported accurately. This command has two data bytes formatted in the 11 Bit Linear Data format. The value is dimensionless.

The only values supported in IRPS5401 are a scale of 1 or 0.5. Only an exponent of -3 is supported.

VOUT_SCALE_LOOP is not a valid command for the LDO. Any attempt to write this command to the LDO will be NACKd.

1.13 FREQUENCY_SWITCH (33h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
FREQUENCY_SWITCH	Write Word	Read Word	2	Y For SW-C	200 kHz to 2 MHz 1 or 0.5 kHz	0x0320	n	n/a	n/a

The FREQUENCY_SWITCH command sets the switching frequency (in kHz). This command has two data bytes formatted in the 11 Bit Linear Data format **with only exponents of 0 or 1 supported for frequencies up to 1024 kHz and only an exponent of 0 for frequencies above 1024 kHz.**

FREQUENCY_SWITCH is not a valid command for the LDO. Any attempt to write this command to the LDO will be NACKd.

While the command will accept any positive value with an exponent of 0 or 1, the frequency range is only from 200 kHz to 2 MHz. If FREQUENCY_SWITCH is set lower than 200 kHz, the effective switching frequency will be 200 kHz; likewise, if FREQUENCY_SWITCH is set higher than 2 MHz, the effective switching frequency will be 2 MHz.

The frequency set for SW-C will determine the switching frequency for all other switchers. SW-B and SW-D will have the same frequency as SW-C. If the setting for SW-A is less than the setting for SW-C, SW-A will switch at ½ the frequency of SW-C. If the setting for SW-A is greater than or equal to the setting for SW-C, it will switch at the same frequency as SW-C.

OUTPUT	FREQUENCY_SWITCH < SW-C	FREQUENCY_SWITCH >/= SW-C
SW-A	½ SW-C Frequency[1]	SW-C Frequency
SW-B	SW-C Frequency	SW-C Frequency
SW-D	SW-C Frequency	SW-C Frequency

Note:

1. *If SW-C is 400 kHz of lower, the switching frequency for SW-A will be 200 kHz*

For switchers A, B and D this is still a R/W command. If written to a different value than the setting of SW-C, the value will be ACKd and ignored. A subsequent READ will return the value last written, but the actual switching frequency will be the value for SW-C (or ½ SW-C)

Negative frequency settings are not allowed. Any attempt to set an exponent that is not 0 or 1, or to set a negative frequency will result in an Invalid Data CML Fault Response

1.14 VIN_ON (35h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VIN_ON	Write Word	Read Word	2	y	0 to 31V 0.25V	0xF001	y	0 to 8 V 31 mV	0xD801

The VIN_ON command sets the value of the input voltage Vin, in volts, at which the device is enabled to start power conversion. This command has two data bytes formatted in the 11 Bit Linear Data format.

For the switchers, thresholds from 0V to 31.75 V are supported with 0.25 V resolution (a -2 exponent). Any values higher than 31.75 V will be rejected and result in an Invalid Data CML fault.

For the LDO, thresholds of 0 V to 7.96875 V are supported with a 31.25 mV resolution (a -5 exponent). Any values higher than 7.96875 V will be rejected and result in an Invalid Data CML fault.

Any attempt to set an exponent other than -2 for the switchers or -5 for the LDO, or to set a negative threshold will be rejected and result in an Invalid Data CML Fault Response

1.15 VIN_OFF (36h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VIN_OFF	Write Word	Read Word	2	y	0 to 31 V 0.25 V	0xF000	y	0 to 8 V 31 mV	0xD800

The VIN_OFF command sets the value of the input voltage Vin, in volts, at which the device is disabled to stop power conversion. This command has two data bytes formatted in the 11 Bit Linear Data format.

For the switchers, thresholds from 0V to 31.75 V are supported with 0.25 V resolution (a -2 exponent). Any values higher than 31.75 V will be rejected and result in an Invalid Data CML fault.

For the LDO, thresholds of 0V to 7.96875 V are supported with a 31 mV resolution (a -5 exponent). Any values higher than 7.96875 V will be rejected and result in an Invalid Data CML fault.

Any attempt to set an exponent other than -2 for the switchers or -5 for the LDO, or to set a negative threshold will be rejected and result in an Invalid Data CML Fault Response

1.16 IOUT_CAL_OFFSET (39h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
IOUT_CAL_OFFSET	Write Word	Read Word	2	y	-32 A to 31 A / 0.016 A or -256 A to 255 A / 0.125 A	0xD000	y	-1 A to 1 A 976 µA	0xB000

The IOUT_CAL_OFFSET command can be used to add a positive or negative value to the output of the output current sensing circuit to calibrate and null out any offsets. The units of the IOUT_CAL_OFFSET are amperes. This command has two data bytes formatted in the 11 Bit Linear Data format.

For the switchers with an internal driver only an exponent of -6 is supported. The range is -32 A to 31.984375 A and the resolution is 0.016 A.For the switchers with an external driver only an exponent of -3 is supported. The range is -256 A to 255.875 A and the resolution is 0.125 A.

For the LDO only an exponent of -10 is supported. The range is -1 A to 0.999 A and the resolution is 976 µA.

1.17 VOUT_OV_FAULT_LIMIT (40h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VOUT_OV_FAULT_LIMIT	Write Word	Read Word	2	y	VOUT_MODE	0x8000	y	read-only	0xF08D

The VOUT_OV_FAULT_LIMIT command sets the value of the over voltage threshold of the output voltage. **The format of the returned value is determined by VOUT_MODE.**

For the switchers there are 8 settings above VOUT that the fault limit can be set, ranging from 50 mV to 400 mV in 50 mV increments. The fault threshold will be the value set in the register rounded down to the nearest lower setting. For example, if VOUT_COMMAND is set to 1 V and VOUT_OV_FAULT_LIMIT is set to 1.23 V, then the actual fault limit will be 1.2 V and a relative threshold of 200 mV. The relative threshold will change if a new VOUT_COMMAND is sent. To continue the example above, if VOUT_COMMAND is increased from 1 V to 1.2 V with VOUT_OV_FAULT_LIMIT set to 1.23 V, the relative threshold will decrease from 200 mV to 50 mV

Any setting greater than 400 mV above VOUT_COMMAND will result in a fault limit of VOUT_COMMAND + 400 mV. With 2:1 scaling, the relative threshold range is 100 mV to 800 mV in 100 mV increments

For the LDO the fault limit is read only and set to 25% above the value shown in register *regmap_ldo.ldo_target_vout* if in non-tracking mode or VIN/2 if in tracking mode.

1.18 VOUT_OV_FAULT_RESPONSE (41h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VOUT_OV_FAULT_RESPONSE	Write Byte	Read Byte	1	y	0x00, 0x80	0x00	y	0x00, 0x80	0x00

The VOUT_OV_FAULT_RESPONSE command determines the action taken in response to an output overvoltage fault. The data byte is in the format given in Section 10.5.1 of the PMBus™ Spec.

IRPS5401 **only supports two responses**, ignore and shutdown, as shown in the table below:

Table 7

VOUT_OV_FAULT_RESPONSE	Response
00	Ignore
80	Shutdown

In response to VOUT_OV_FAULT the device also:

- Sets the VOUT_OV_FAULT bit in the STATUS_BYTE,
- Sets the VOUT bit in the STATUS_WORD,
- Sets the VOUT_OV_FAULT bit in the STATUS_VOUT register, and
- Notifies the host as described in Section 10.2.2 of the PMBus™ spec.

1.19 VOUT_OV_WARN_LIMIT (42h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VOUT_OV_WARN_LIMIT	Write Word	Read Word	2	y	VOUT_MODE	0x8000	mode only	read-only	0xF089

The VOUT_OV_WARN_LIMIT command sets the threshold for the output voltage high warning.

For the LDO the fault limit is read only and set to 12.5% above the value shown in *regmap_ldo.ldo_target_vout* if in non-tracking mode or VIN/2 if in tracking mode

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 register, and
- Notifies the host as described in Section 10.2.1 of the PMBus™ spec.

1.20 VOUT_UV_WARN_LIMIT (43h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VOUT_UV_WARN_LIMIT	Write Word	Read Word	2	y	VOUT_MODE	0x0000	y	read-only	0xF077

The VOUT_UV_WARN_LIMIT command sets threshold for the output voltage low warning. This warning is masked until the unit reaches the programmed output voltage. The data bytes are two bytes **formatted according to the setting of the VOUT_MODE** command.

For the LDO, the fault limit is read only and set to 12.5% below the value shown in *regmap_ldo.ldo_target_vout* if in non-tracking mode or VIN/2 if in tracking mode

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 register, and
- Notifies the host as described in Section 10.2.1 of the PMBus™ spec.

1.21 VOUT_UV_FAULT_LIMIT (44h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VOUT_UV_FAULT_LIMIT	Write Word	Read Word	2	y	VOUT_MODE	0x0000	y	read-only	0xF073

For the switchers, the VOUT_UV_FAULT_LIMIT command sets threshold for the output voltage low fault. This fault is masked until the unit reaches the programmed output voltage. The data bytes are two bytes **formatted according to the setting of the VOUT_MODE** command.

For the switchers there are 8 settings below VOUT_COMMAND that the fault limit can be set, ranging from 50 mV to 400 mV in 50 mV increments. The fault threshold will be the value set in the register rounded up to the nearest lower setting. For example, if VOUT_COMMAND is set to 1V and VOUT_UV_FAULT_LIMIT is set to 0.93 V, then the actual fault limit will be 0.95 V. This will result in a relative threshold of VOUT_COMMAND-50 mV. Any setting greater than 400 mV below VOUT_COMMAND will result in a fault limit of VOUT_COMMAND-400 mV. With 2:1 scaling, the relative threshold range is 100 mV to 800 mV in 100 mV increments

For the LDO, the fault limit is read only and set to 25% below the value shown in *regmap_ldo.ldo_target_vout* if in non-tracking mode or VIN/2 if in tracking mode

1.22 VOUT_UV_FAULT_RESPONSE (45h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VOUT_UV_FAULT_RESPONSE	Write Byte	Read Byte	1	y	0x00, 0x80	0x00	n	n/a	n/a

The VOUT_UV_FAULT_RESPONSE command determines the action taken in response to an output undervoltage fault. The data byte is in the format given in Section 10.5.1 of the PMBus™ spec.

IRPS5401**only supports two responses**, ignore and shutdown, as shown in the table below:

Table 8

VOUT_UV_FAULT_RESPONSE	Response
00	Ignore
80	Shutdown

In response to the VOUT_UV_FAULT_LIMIT being exceeded, the device also:

- 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 register, and
- Notifies the host as described in Section 10.2.2 of the PMBus™ spec.

The VOUT_UV_FAULT_RESPONSE command is not supported for the LDO. **Any attempt to write this command to the LDO will be NACKd.**

1.23 IOUT_OC_FAULT_LIMIT (46h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
IOUT_OC_FAULT_LIMIT	Write Word	Read Word	2	y	0 to 32A / 31mA or 0 to 256A / 0.25A	0xD900	y	read-only 0xC0B8 (0.72 A)	0xC0B8

The IOUT_OC_FAULT_LIMIT command sets the threshold, in amperes, for the overcurrent fault condition. The range for switchers with an internal driver is 0 to 31.96875 A with a resolution of 0.031 A. The exponent is -5. The range for switchers with an external driver is 0 to 255.75 A with a resolution of 0.25 A. The exponent is -2.

For the LDO this is a READ ONLY command and will return the value of 0.72 A.

1.24 IOUT_OC_FAULT_RESPONSE (47h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
IOUT_OC_FAULT_RESPONSE	Write Byte	Read Byte	1	y	0xC0 0xF8 0xF0	0xF8	y	0x00 0xC0	0xC0

The IOUT_OC_FAULT_RESPONSE command determines the action taken in response to an output overcurrent fault. **Only the following settings are supported by** IRPS5401:

Table 9

IOUT_OC_FAULT_RESPONSE SETTING	Response
C0h	Shutdown
F8h	Hiccup Forever
F0h	Hiccup 6 times, then shutdown

In response to an IOUT_OC_FAULT the device also:

- Sets the IOUT_OC_FAULT bit in the STATUS_BYTE,
- Sets the IOUT bit in the STATUS_WORD,
- Sets the IOUT_OC_FAULT bit in the STATUS_IOUT register, and
- Notifies the host as described in Section 10.2.2 of the PMBus™ spec.

1.25 IOUT_OC_WARN_LIMIT (4Ah)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO Sspport	LDO range/res	LDO reset value
IOUT_OC_WARN_LIMIT	Write Word	Read Word	2	y	0 to 32 A / 31 mA or 0 to 256 A / 0.25 A	0xD900	y	read-only 0xC0B8 (0.72 A)	C0B8

For the switchers the IOUT_OC_WARN_LIMIT command sets the threshold, in amperes, for the output overcurrent warning. The range for switchers with an internal driver is 0 to 31.96875 A with a resolution of 0.031 A. The exponent is -5. The range for switchers with an external driver is 0 to 255.75 A with a resolution of 0.25 A. The exponent is -2. The range for the LDO is 0 to 0.72 A with a resolution of 3.9 mA. The exponent is -8.

Any attempt to set an exponent other than -2 for the internal drivers or -5 for the external drivers, or to set a negative threshold will be rejected and result in an Invalid Data CML fault as follows:

- NACK the unsupported/invalid data bytes received before the next STOP condition,
- Flush or ignore the received command code and any received data,
- Set the CML bit in the STATUS_BYTE,
- Set the Invalid Or Unsupported Data Received bit in the STATUS_CML register
- Notify the host by pulling down SALERT

1.26 OT_FAULT_LIMIT (4Fh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
OT_FAULT_LIMIT	Write Word	Read Word	2	y	0 to 255°C 1°C	0x80	y	0 to 255°C 1°C	0x80

The OT_FAULT_LIMIT command sets the threshold, in degrees Celsius, for the over temperature fault. The two data bytes are formatted in the 11 Bit Linear Data format, with **only a fixed exponent of 0 supported**.

The range is 0 to 255°C, with a resolution of 1°C. Any attempt to set an exponent other than 0 or to set a fault threshold above 255°C will be rejected and result in an Invalid Data CML fault as follows:

- NACK the unsupported/invalid data bytes received before the next STOP condition,
- Flush or ignore the received command code and any received data,
- Set the CML bit in the STATUS_BYTE,
- Set the Invalid Or Unsupported Data Received bit in the STATUS_CML register
- Notify the host by pulling down SALERT

1.27 OT_FAULT_RESPONSE (50h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
OT_FAULT_RESPONSE	Write Byte	Read Byte	1	y	0x00, 0x80, 0xC0	0x00	y	0x00, 0x80, 0xC0	0x00

The OT_FAULT_RESPONSE command determines the action taken in response to an overtemperature fault.

IRPS5401**only supports three responses**: ignore, shutdown, and restart when fault is cleared.

Table 10

OT_FAULT_RESPONSE	Response
00	Ignore
80	Shutdown
C0	Shutdown, restart when fault is cleared.

In response to an OT_FAULT the device also:

- Sets the TEMPERATURE bit in the STATUS_BYTE,
- Sets the OT_FAULT bit in the STATUS_TEMPERATURE register, and
- Notifies the host as described in Section 10.2.2 of the PMBus™ spec.

1.28 OT_WARN_LIMIT (51h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
OT_WARN_LIMIT	Write Word	Read Word	2	y	0 to 255°C 1°C	0x80	y	0 to 255°C 1°C	0x80

The OT_WARN_LIMIT command sets the threshold, in degrees Celsius, for the Overtemperature Warning alarm. The two data bytes are formatted in the 11 Bit Linear Data format, with **only a fixed exponent of 0 supported**.

The range is 0 to 255°C, with a resolution of 1°C.

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 register, and
- Notifies the host as described in Section 10.2.1 of the PMBus™ spec.

1.29 VIN_OV_FAULT_LIMIT (55h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VIN_OV_FAULT_LIMIT	Write Word	Read Word	2	y	0 to 64 V 0.0625 V	0xE200	y	0 to 8 V 7.81 mV	0xCAC0

The VIN_OV_FAULT_LIMIT command sets the threshold for the input overvoltage fault. The two data bytes are formatted in the 11 Bit Linear Data format with **only an exponent of -4 supported for the switchers**. The range is 0 to 63.9375 V and the resolution is 0.0625 V per bit. The range for the LDO is 0 to 8 V with a resolution of 7.81 mV. The exponent is -7

1.30 VIN_OV_FAULT_RESPONSE (56h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VIN_OV_FAULT_RESPONSE	Write Byte	Read Byte	1	y	0x00, 0x80	0x00	y	0x00, 0x80	0x00

The VIN_OV_FAULT_RESPONSE command determines the action taken in response to an input overvoltage fault. This command has a single data byte.

IRPS5401**supports only 2 types of responses** to an overvoltage fault on the input voltage.

Table 11

VIN_OV_FAULT_RESPONSE	Response
00	Ignore
80	Shutdown

The default response is to shutdown (80h)

Irrespective of the response type, the device also:

- Sets the NONE OF THE ABOVE bit in the STATUS_BYTE,
- Set the INPUT bit in the upper byte of the STATUS_WORD,
- Sets the VIN_OV_FAULT bit in the STATUS_INPUT register, and
- Notify the host by pulling down SAlert

Any attempt to command a response type other than those defined in the table above will be rejected and will result in an Invalid Data CML Fault Response

1.31 VIN_UV_WARN_LIMIT (58h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
VIN_UV_WARN_LIMIT	Write Word	Read Word	2	y	0 to 64 V 0.0625 V	0xE000	y	0 to 7.992 V 7.8125 mV	0xC800

The VIN_UV_WARN_LIMIT command sets the threshold for the input voltage low warning.

This alarm is masked until the input exceeds the value set by the VIN_ON command

and the unit has been enabled. This command has two data bytes formatted in the 11 Bit Linear Data format. IRPS5401**supports only an exponent of -4**.

The range is 0 to 63.9375 V and the resolution is 0.0625 V.

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 is the upper byte of the STATUS_WORD,
- Sets the VIN_UV_WARNING bit in the STATUS_INPUT register, and
- Notify the host by pulling down SAlert

1.32 POWER_GOOD_ON (5Eh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
POWER_GOOD_ON	Write Word	Read Word	2	y	VOUT_MODE	0x0000	y	VOUT_MODE	0x8000

1.33 POWER_GOOD_OFF (5Fh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
POWER_GOOD_OFF	Write Word	Read Word	2	y	VOUT_MODE	0x0000	y	VOUT_MODE	0x8000

The POWER_GOOD_ON and OFF commands sets the output voltage at which the POWER_GOOD signal is asserted and de-asserted. It has 2 data bytes in 16-bit linear format. The **exponent is determined by VOUT_MODE**. IRPS5401only supports VOUT_MODE with an exponent of -8, -9 or -12. The resolution with -8 is 3.906 mV per LSB. With a -9 exponent the resolution is 1.953 mV per LSB. For a -12 exponent, the resolution is 0.24 mV per LSB. The difference between the POWER_GOOD_ON and POWER_GOOD_OFF setting is the hysteresis.

1.34 TON_DELAY (60h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
TON_DELAY	Write Word	Read Word	2	y	0 to 64 ms 0.5 ms	0xF800	y	0 to 64 ms 0.5 ms	0xF800

The TON_DELAY sets the delay, in milliseconds, from when a startup condition is received until the output voltage starts to rise. It has 2 data bytes in Linear Format with **only an exponent of -1 supported**. The range is 0 to 63.5 ms, and the resolution is 0.5 ms.

Any attempt to set an exponent other than -1 or to set the delay more than 63.5 ms or to a negative value will be rejected and result in an Invalid Data CML Fault Response

1.35 TON_RISE (61h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
TON_RISE	Write Word	Read Word	2	y	0 to 31 ms 0.25 ms	0xF004	n	n/a	n/a

The TON_RISE sets the rise time, in milliseconds, for the output voltage to enter the regulation band. It has 2 data bytes in 11 Bit Linear Format with **only an exponent of -2 supported**. The range is 0 to 31.75 ms, and the resolution is 0.25 ms.

The TON_RISE command is not supported for the LDO. Any attempt to write this command to the LDO will be NACKd.

Any attempt to set an exponent other than -2 or to set the rise time to more than 31.75 ms or to a negative value will be rejected and result in an Invalid Data CML Fault Response

1.36 TON_MAX_FAULT_LIMIT (62h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
TON_MAX_FAULT_LIMIT	Write Word	Read Word	2	y	0 to 31 ms 0.25 ms	0xF004	y	0 to 31 ms 0.25 ms	0xF000

The TON_MAX_FAULT_LIMIT command sets a maximum time, in milliseconds, for the output to cross the undervoltage fault limit threshold upon startup. It has 2 data bytes in 11 Bit Linear Format with **only an exponent of -2 supported**. The range is 0 to 31.75 ms, and the resolution is 0.25 ms.

Any attempt to set an exponent other than -2 or to set the rise time to more than 31.75 ms or to a negative value will be rejected and result in an Invalid Data CML Fault Response

1.37 TON_MAX_FAULT_RESPONSE (63h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
TON_MAX_FAULT_RESPONSE	Write Byte	Read Byte	1	y	0x00, 0x80	0x00	y	0x00, 0x80	0x00

This command controls how the device responds to a Ton_Max fault. IRPS5401**only supports two types of responses to a Ton_Max fault.**

Table 12

TON_MAX_FAULT_RESPONSE	Response
00	Ignore
80	Shutdown

The TON_MAX_FAULT_RESPONSE command has one data byte.

Irrespective of the response mode, if a TON_MAX_FAULT occurs the device:

- Sets the NONE OF THE ABOVE bit in the STATUS_BYTE,
- Sets the VOUT bit in the STATUS_WORD register
- Sets the Ton Max Fault bit in the STATUS_VOUT register.
- Notifies the host by issuing SALERT #
- Pulls PGood low

Any attempt to command a response type other than those defined in the table above will be rejected and will result in an Invalid Data CML Fault Response

1.38 TOFF_DELAY (64h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
TOFF_DELAY	Write Word	Read Word	2	y	0 to 63 ms 0.5 ms	0xF800	n	n/a	n/a

The TOFF_DELAY sets the delay time, in milliseconds, for the VR to stop transferring energy to the output when commanded to stop with the ON_OFF_CONFIG programmed to soft off. It has 2 data bytes in Linear Format with **only an exponent of -1 supported**. The range is 0 to 63.5 ms, and the resolution is 0.5 ms.

The TOFF_DELAY command is not supported for the LDO. Any attempt to write this command to the LDO will be NACKd.

Any attempt to set an exponent other than -1 or to set the delay more than 63.5 ms or to a negative value will be rejected and result in an Invalid Data CML Fault Response

1.39 TOFF_FALL (65h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
TOFF_FALL	Write Word	Read Word	2	y	0 to 31 ms 0.25 ms	0xF004	n	n/a	n/a

The TOFF_FALL sets the fall time, in milliseconds, for the reference voltage to reach zero when a stop command is issued with the ON_OFF_CONFIG programmed for soft off. This time starts from the end of the turn-off delay time. It has 2 data bytes in 11 Bit Linear Format with **only an exponent of -2 supported**. The range is 0 to 31.75 ms, and the resolution is 0.25 ms.

The TOFF_FALL command is not supported for the LDO. Any attempt to write this command to the LDO will be NACKd.

Any attempt to set an exponent other than -2 or to set the delay more than 31.75 ms or to a negative value will be rejected and result in an Invalid Data CML Fault Response

1.40 STATUS_BYTE (78h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
STATUS_BYTE	Write Byte	Read Byte	1	y	n/a	0	y	n/a	0

STATUS_BYTE is a read only command that returns one byte of information with a summary of the most critical faults. The format is indicated in the table below:

Table 13

Bit	Status Bit Name	Description
7	BUSY	*Reserved. Always returns a 0.*
6	OFF	This bit is asserted if the device is OFF because power conversion is disabled
5	VOUT_OV_FAULT	An output overvoltage fault has occurred
4	IOUT_OC_FAULT	An output overcurrent fault has occurred
3	VIN_UV_FAULT	An input under voltage fault has occurred
2	TEMPERATURE	A temperature fault or warning has occurred
1	CML	A communications, memory or logic fault has occurred
0	NONE OF THE ABOVE	A fault or warning not listed in bits [7:1] has occurred

1.41 STATUS_WORD (79h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
STATUS_WORD	Write Word	Read Word	2	y	n/a	0	y	n/a	0

STATUS_WORD is a read only command that returns two bytes summarizing the device's fault information in broad categories such as VOUT or INPUT. More detailed information can be found in the fault specific status registers.

The low byte of the STATUS_WORD is the same register as the STATUS_BYTE command.

The format for the high byte is indicated in the table below:

Table 14

Bit	Status bit name	Description
7	VOUT	An output voltage fault or warning has occurred
6	IOUT/POUT	An output current or output power fault or warning has occurred.
5	INPUT	An input voltage, input current, or input power fault or warning has occurred
4	MFR_SPECIFIC	*Reserved. Always returns a 0.*
3	POWER_GOOD#	When this is 1, it indicates that the output power is not good.
2	FANS	*Reserved. Always returns a 0.*
1	OTHER	*Reserved. Always returns a 0.*
0	UNKNOWN	*Reserved. Always returns a 0.*

1.42 STATUS_VOUT (7Ah)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
STATUS_VOUT	Write Byte	Read Byte	1	y	n/a	0	y	n/a	0

The STATUS_VOUT command returns one data byte with contents as follows:

Table 15

Bit	Description
7	VOUT_OV_FAULT (Output Over voltage Fault)
6	VOUT_OV_WARNING (Output Over voltage Warning)
5	VOUT_UV_WARNING (Output Under voltage Warning)
4	VOUT_UV_FAULT (Output Under voltage Fault)
3	VOUT_MAX Warning (An attempt has been made to set the output voltage to value higher than allowed by the VOUT_MAX command)
2	TON_MAX_FAULT
1	*Reserved. Always returns a 0.*
0	*Reserved. Always returns a 0.*

Assuming that the fault or warning condition that causes a STATUS_VOUT bit to be set disappears, the individual bit clearing mechanism can be used to clear that bit. For instance, if STATUS_VOUT is 30h, indicating that bits 5 and 4 (VOUT_UV_WARNING as well as VOUT_UV_FAULT) are set, writing 30h to STATUS_VOUT will clear bits [5:4] if the fault and warning conditions no longer exist.

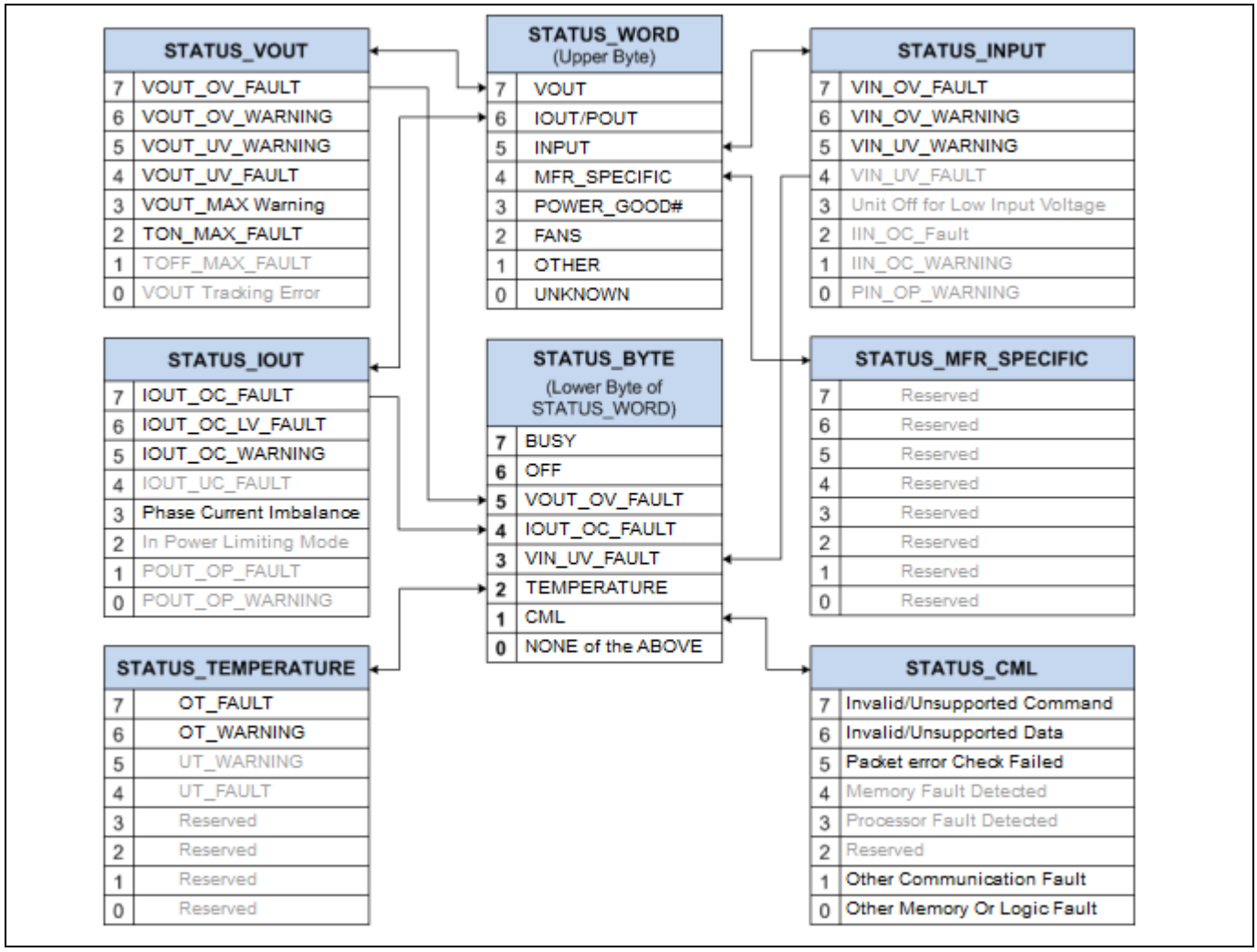


Figure 2 Active status registers for the IRPS5401

1.43 STATUS_IOUT (7Bh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
STATUS_IOUT	Write Byte	Read Byte	1	y	n/a	0	y	n/a	0

The STATUS_IOUT command returns one data byte with contents as follows:

Table 16

Bit	Description
7	IOUT_OC_FAULT (Output Overcurrent Fault)
6	*Reserved. Always returns a 0.*
5	IOUT_OC_WARNING (Output Overcurrent Warning)
4	*Reserved. Always returns a 0.*
3	*Reserved. Always returns a 0.*
2	*Reserved. Always returns a 0.*
1	*Reserved. Always returns a 0.*
0	*Reserved. Always returns a 0.*

Assuming that the fault or warning condition that causes a STATUS_IOUT bit to be set disappears, the individual bit clearing mechanism can be used to clear that bit. For instance, if STATUS_IOUT is A0h, indicating that bits 7 and 5 (IOUT_OC_FAULT as well as IOUT_OC_WARNING) are set, writing A0h to STATUS_IOUT will clear bits 7 and 5 if the fault and warning conditions no longer exist.

1.44 STATUS_INPUT (7Ch)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
STATUS_INPUT	Write Byte	Read Byte	1	y	n/a	0	y	n/a	0

The STATUS_INPUT command returns one data byte with contents as follows:

Table 17

Bit	Description
7	VIN_OV_FAULT (Input Overvoltage Fault)
6	*Reserved. Always returns a 0.*
5	VIN_UV_WARNING (Input Under voltage Warning)
4	VIN_UV_FAULT (Input Under voltage Fault)
3	*Reserved. Always returns a 0.*
2	*Reserved. Always returns a 0.*
1	*Reserved. Always returns a 0.*
0	*Reserved. Always returns a 0.*

Assuming that the fault or warning condition that causes a STATUS_INPUT bit to be set disappears, the individual bit clearing mechanism can be used to clear that bit. For instance, if STATUS_INPUT is 28h, indicating that bits 5 and 3 (VIN_UV_WARNING as well as Unit off for Insufficient Input Voltage) are set, writing 28h to STATUS_INPUT will clear bits 7 and 5 if the fault and warning conditions no longer exist.

1.45 STATUS_TEMPERATURE (7Dh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
STATUS_TEMPERATURE	Write Byte	Read Byte	1	y	n/a	0	y	n/a	0

The STATUS_TEMPERATURE command returns one data byte with contents as follows:

Table 18

Bit	Description
7	OT_FAULT (Over temperature Fault)
6	OT_WARNING (Over temperature Warning)
5	*Reserved. Always returns a 0.*
4	*Reserved. Always returns a 0.*
3	*Reserved. Always returns a 0.*
2	*Reserved. Always returns a 0.*
1	*Reserved. Always returns a 0.*
0	*Reserved. Always returns a 0.*

Assuming that the fault or warning condition that causes a STATUS_TEMPERATURE bit to be set disappears, the individual bit clearing mechanism can be used to clear that bit. For instance, if STATUS_TEMPERATURE is C0h, indicating that bits 7 and 6 (OT_FAULT as well as OT_WARNING) are set, writing C0h to STATUS_TEMPERATURE will clear bits 7 and 6 if the fault and warning conditions no longer exist.

1.46 STATUS_CML (7Eh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
STATUS_CML	Write Byte	Read Byte	1	y	n/a	0	y	n/a	0

The STATUS_CML command returns one data byte with contents as follows:

Table 19

Bit	Description
7	Invalid Or Unsupported Command Received; set to 1 if PMBus™ command is invalid or unsupported
6	Invalid Or Unsupported Data Received; set to 1 if invalid data is received or if any attempt is made to send too many bytes to the IRPS5401device. An example of the latter is when the host tries to write a PEC byte to the IRPS5401device when it is operating in PEC unsupported mode.
5	Packet Error Check Failed; set to 1 by a PEC error
4	*Reserved. Always returns a 0.*
3	*Reserved. Always returns a 0.*
2	*Reserved. Always returns a 0.*
1	A communication fault other than the ones listed in this table has occurred; set to 1 if any of the conditions listed are true: a) Improperly set read bit in the address. b) Host sends too many bits c) Host reads too few bits d) Host reads too many bytes e) Command too short
0	Other Memory Or Logic Fault has occurred. ; Always returns a 0.

Assuming that the fault or warning condition that causes a STATUS_CML bit to be set disappears, the individual bit clearing mechanism can be used to clear that bit. For instance, if STATUS_CML is 40h, indicating that bit 6 (Invalid or Unsupported Data received) are set, writing 40h to STATUS_CML will clear bit 6.

1.47 READ_VIN (88h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
READ_VIN	N/A	Read Word	2	y	0 to 31V 31mV	n/a	y	0 to 8V 7.8mV	n/a

The READ_VIN command returns the input voltage in volts, with a resolution of 1/32 V for the switchers and 1/128 V for the LDO. The two data bytes are formatted in the 11 Bit Linear Data format.

1.48 READ_IIN (89h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
READ_IIN	N/A	Read Word	2	y	-16 A to +16 A / 7.8 mA or -127 A to +127 A 62.5 mA	n/a	n	n/a	n/a

The READ_IIN command returns the input current in amperes.

For switchers with an internal driver the range is -16 to +15.992 A and the resolution is 0.0078 A, with an exponent of -7.

For switchers with an external driver the range is -127 to +127.9375 A and the resolution is 0.0625 A, with an exponent of -4.

1.49 READ_VOUT (8Bh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
READ_VOUT	N/A	Read Word	2	y	VOUT_MODE	n/a	y	VOUT_MODE	n/a

The READ_VOUT command returns the output voltage in volts. The two data bytes are formatted in the Linear Data format, with **the exponent determined by VOUT_MODE**. READ_VOUT reports the actual sensed VOUT for LDO only. For all the Switcher loops, READ_VOUT reports the DAC (reference voltage) with the correct scaling

1.50 READ_IOUT (8Ch)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
READ_IOUT	N/A	Read Word	2	y	-31 A to +31 A/ 15 mA or -256 A to +255 A / 0.125 A	n/a	y	-1 A to +1 A 0.976 mA	n/a

The READ_IOUT command returns the output current in amps.

For switchers with an internal driver the range is -31 to +31.984375 A and the resolution is 0.015 A, with and exponent of -6. For switchers with an external driver the range is -256 to +255.875 A and the resolution is 0.125 A, with and exponent of -3. For the LDO the range is -1 to +1A and the resolution is 0.976 mA, with an exponent of -10. The LDO will NACK this command if *regmap_ldo.ldo_ireport_disable* is set.

1.51 READ_TEMPERATURE_1 (8Dh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
READ_TEMPERATURE_1	N/A	Read Word	2	y	0 to 255°C 1°C	n/a	y	0 to 255° 1°C	n/a

The READ_TEMPERATURE_1 command returns the measured temperature, in degrees C, with a resolution of 1° C. The two data bytes are formatted in the 11 Bit Linear Data format.

There are two temperature sensors on IRPS5401. Temp_0 is connected to SW A and SW B (PMBus™ pages 0 and 1). Temp_1 is connected to SW C, SW D and the LDO (PMBus™ pages 2, 3 and 4).

1.52 READ_POUT (96h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
READ_POUT	N/A	Read Word	2	y	0 to 32 W / 31 mW or 0 to 255 W / 0.25 W	n/a	y	0 to 16 W 15.6 mW	n/a

The READ_POUT is a read only command that returns the output power, in watts, of the device. For switchers with an internal driver, the range is 0 to 31.96875 W, the resolution is 0.03125 W with an exponent of -5. For SW-A configured for use with an external driver, the range is 0 to 255.75 W; the resolution is 0.25 W with an exponent of -2. For the LDO the range is 0 to 15.984375 W, the resolution is 0.015625 W with an exponent of -6.

1.53 READ_PIN (97h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
READ_PIN	N/A	Read Word	2	y	0 to 32 W / 31 mW or 0 to 255 W / 0.25 W	n/a	y	0 to 16 W 15.6 mW	n/a

The READ_PIN is a read only command that returns the input power, in watts, of the device. For switchers with an internal driver, the range is 0 to 31.96875 W, the resolution is 0.03125 W with an exponent of -5. For SW-A configured for use with an external driver, the range is 0 to 255.75 W, the resolution is 0.25 W with an exponent of -2. For the LDO the range is 0 to 15.984375 W, the resolution is 0.015625 W with an exponent of -6.

1.54 PMBUS_REVISION (98h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
PMBUS_REVISION	N/A	Read Byte	1	y	n/a	0x22	y	n/a	0x22

PMBUS_REVISION command stores or reads the revision of the PMBus™ to which the device is compliant. The command has one data byte. Bits [7:4] indicate the revision of PMBus™ specification Part I to which the device is compliant. Bits [3:0] indicate the revision of PMBus specification Part II to which the device is compliant. IRPS5401implements this command as a read only command and will return 22h, indicating that is compliant to Rev 1.2 of PMBus™ specification Part I and compliant to Rev 1.2 of PMBus™ specification Part 2.

1.55 MFR_ID (99h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
MFR_ID	Block Write	Block Read	3	y	n/a	0x004952	y	n/a	0x004952

The MFR_ID command is used to either set or read the manufacturer's ID (name, abbreviation or symbol that identifies the unit's manufacturer). MFR_ID is typically only set once, at the time of manufacture, and the value is stored in OTP.

IRPS5401will return 3 bytes in response to this command as 0x005249. The 3 bytes are the ASCII equivalent of "IR", however the user may over-write the value with any 3 bytes of data. IRPS5401also stores the MFR_ID in the OTP register under the name pmbus_mfr_id_0 and _1.

1.56 MFR_MODEL (9Ah)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
MFR_MODEL	Block Write	Block Read	4	y	n/a	0x00000052	y	n/a	0x00000052

The MFR_MODEL command is used to either set or read the manufacturer's model number. MFR_MODEL is typically only set once, at the time of manufacture, and the value is stored in OTP. The 4 bytes are specified by the user. IRPS5401will return 4 bytes in response to this command as 0x00000052 if the user does not a write value to this command. IRPS5401also stores the MFR_MODEL in the OTP register under the name pmbus_mfr_model_0 and _1.

1.57 MFR_REVISION (9Bh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
MFR_REVISION	Block Write	Block Read	4	y	n/a	0x00000002	y	n/a	0x00000002

The MFR_REVISION command is used to either set or read the manufacturer's revision number. MFR_REVISION is typically only set once, at the time of manufacture, and the value is stored in OTP. The 4 bytes are specified by the user. IRPS5401will return 4 bytes in response to this command as 0x00000002 if the user does not write a value to this command. IRPS5401also stores the MFR_REVISION in the OTP register under the name pmbus_mfr_revision_0 and _1.

1.58 IC_DEVICE_ID (ADh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
IC_DEVICE_ID	N/A	Block Read	1	y	n/a	0x52	y	n/a	0x52

The IC_DEVICE_ID command is used to read the part number of the device controller IC. IC_DEVICE_ID is set once, at the time of manufacture, and is read only. In IRPS5401, this command will return two bytes. The 1st byte is 01h indicating that one more byte will follow. The 2nd byte is the value in product_id_otp [7:0], 0x52.

1.59 IC_DEVICE_REV (AEh)

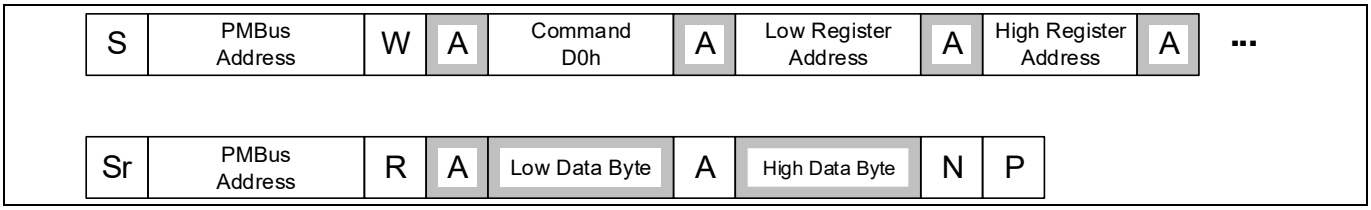
Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
IC_DEVICE_REV	n/a	Block Read	Variable	y	n/a	0x02	y	n/a	0x02

The IC_DEVICE_REV command is used to read the revision of the IC. IC_DEVICE_REV is set once, at the time of manufacture. Any new revision in the IC will be accompanied by rewiring the metal to indicate the new revision number and this number gets passed to IC_DEVICE_REV.

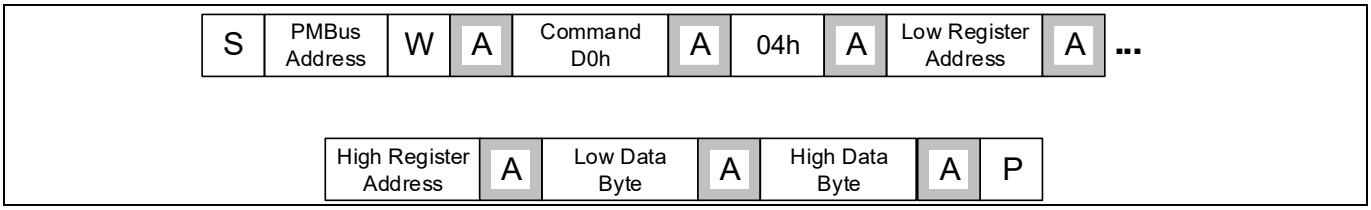
1.60 MFR_REG_ACCESS (D0h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
MFR_REG_ACCESS	Block write	Process Call	Wr = 5 Read = 2	y	n/a	n/a	y	n/a	n/a

The MFR_REG_ACCESS command is a manufacturer specific command (D0h) that is used to read from or write to the I2C register map. For reads, it uses the process call format as shown below:



For writes, it uses the Block Write format as shown below:



1.61 MFR_I2C_ADDRESS (D6h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
MFR_I2C_ADDRESS	Write Byte	Read Byte	1	y	n/a	0x10	y	n/a	0x10

This is a manufacturer specific command, the 7 LSBs of which allow the user to set the 7-bit I2C base address for the device. The device will then respond to I2C commands sent to this address, modified by the offset setting resistor on the ADDR pin. If the part is programmed after setting the address through this PMBus™ command, the value will be saved in OTP. For example, if MFR_I2C_ADDRESS=10h, and the resistor on the address pin sets an offset of +05h, the device will respond to commands sent to address 15h. If the I2C address is set to 00h, then the I2C bus will be disabled.

1.62 MFR_TPGDLY (D8h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
MFR_TPGDLY	Write Word	Read Word	2	y	0 to 15 ms 1 ms	0	y	0 to 15 ms 1 ms	0

This is a manufacturer specific command that allows a delay between when the VOUT exceeds the POWER_GOOD threshold and when the POWER GOOD signal is asserted. The resolution is 1 ms and the range is 0 to 15 ms.

1.63 MFR_FCCM (D9h)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
MFR_FCCM	Write Word	Read Word	2	y	00h 01h	01h	n	n/a	n/a

This is a manufacturer specific command that selects Adaptive On Time operation or Forced Continuious Conduction Mode. 0x00 sets Adaptive On-Time; 0x01 sets Forced Continuous Conduction Mode.

1.64 MFR_VOUT_PEAK (DBh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
MFR_VOUT_PEAK	n/a	Read Word	2	y	VOUT_MODE	n/a	y	VOUT_MODE	n/a

The MFR_VOUT_PEAK command returns the value of the highest value of VOUT seen by the device since the last read of this command. A second read of MFR_VOUT_PEAK clears the value and returns the current condition. The resolution is defined by the value of VOUT_MODE.

1.65 MFR_IOUT_PEAK (DCh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
MFR_IOUT_PEAK	n/a	Read Word	2	y	0 to 16 A / 62.5 mA or 0 to 127 A / 0.125 A	n/a	y	0 to 1 A 1 mA	n/a

The MFR_IOUT_PEAK command returns the value of the highest value of IOUT seen by the device since the last read of this command. A second read of MFR_IOUT_PEAK clears the value and returns the current condition. For switchers with an internal driver the resolution is 15.625 mA and the range is 0 to 15.984375 A. For SW-A configured for use with an external driver the resolution is 0.125 A and the range is 0 to 127.875 A. For the LDO the resolution is 0.976 mA and the range is 0 to 0.999 A.

1.66 MFR_TEMPERATURE_PEAK (DDh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
MFR_TEMPERATURE_PEAK	n/a	Read Word	2	y	0 to 255°C 1°C	n/a	y	0 to 255°C 1°C	n/a

The MFR_TEMPERATURE_PEAK command returns the value of the highest value of TEMPERATURE seen by the device since the last read of this command. A second read of MFR_TEMPERATURE_PEAK clears the value and returns the current condition. The resolution is 1°C and the range is 0 to 255.75 °C.

1.67 MFR_LDO_MARGIN (DEh)

Command	Wr. Tx	Rd. Tx	#Bytes	SW support	SW range/res	SW reset value	LDO support	LDO range/res	LDO reset value
MFR_LDO_MARGIN	Write Word	Read Word	2	n/a	n/a	n/a	y	-15% to +15% 3%	0

This command allows margining of the LDO voltage from -15% to +15% in increments of 3%. This value is a linear 2s complement number with exponent=0. The ldo_standard_source_amp_offset register (in REGMAP_LDO) allows trimming of the standard LDO to a 500 mV reference target. The Q-level of the offset trim is ~0.86 mV. For margining, a 3% step equates to (0.03*500 mV =) 15 mV, which is equivalent to a (15 mV/0.86 mV) ~17.5 decimal code change from the nominal source_amp_offset trim code. The margin code is added to or subtracted from the nominal trim code to perform the margining.

+/-3% : +/-17 codes
+/-6% : +/-35 codes
+/-9% : +/-52 codes
+/-12% : +/-70 codes
+/-15% : +/-87 codes

The nominal trim is roughly centered around the middle code in the 8-bit trim range. Margining +/-15% changes the nominal trim code by approximately +/- 88 decimal codes, so we have adequate range to support offset trim and margining with manipulation of the same trim register bits.

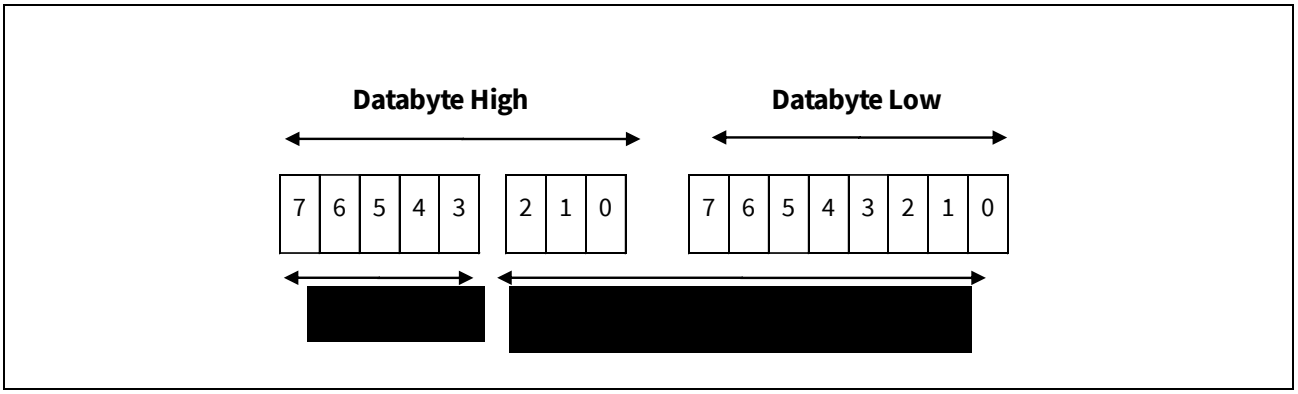
Example: To margin the LDO by +6%, the nominal trim code would need to be changed by +35 codes binary, which is 23h. The setting for MFR_LDO_MARGIN would then be set to the 2's complement value of 0023h. For a margin of -6% the nominal trim code would need to change by -35d, or -23h. Therefore the MFR_LDO_MARGIN would be set to 07E9h.

1.68 11-bit Linear Data Format

Monitored parameters use the Linear Data Format encoding into 1 Word (2 bytes), where:

$$Value = Y \times 2^{N}$$

Note N and Y are “signed” values. If VOUT is set to linear format (by VOUT_MODE), then N is set by the VOUT_MODE command and only Y is returned in the data-field as a 16-bit unsigned number.

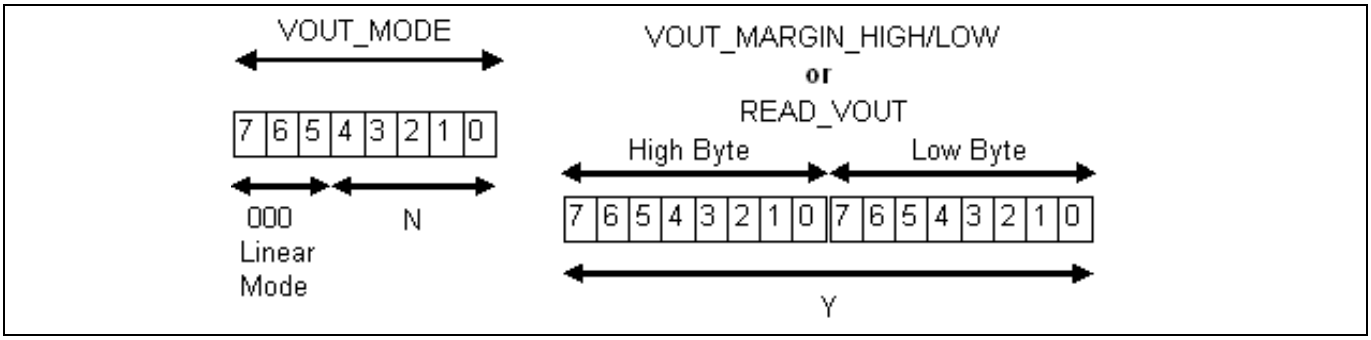


1.69 16-bit Linear Data Format

This format is only used for VOUT related commands.

$$Value = Y \times 2^{N}$$

Note N and Y are “unsigned” values. The only exception is the VOUT_TRIM (0x22) command, which is the only signed VOUT related command. If VOUT is set to linear format (by VOUT_MODE), then N is set by the VOUT_MODE command and only Y is returned in the data-field as a 16-bit unsigned number.



Revision history

Document version	Date of release	Description of changes
1.1	1/31/19	Change resolution of READ_TEMPERATURE_1 and MFR_TEMPERATURE_PEAK to 1°C
1.2	9/13/2019	Page 3; update #bytes for command 99h Page 3; update #bytes and reset value for commands 9Ah and 9Bh Page 25; Update SW reset value for command 58h Page 26; update SW reset value for command 5Eh and 5Fh Page 27; update SW reset value for command 62h Page 36; update reset value for command 99h

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