Technical Specification

BMR310 series DC-DC Converters Input 40 - 60 V, Output up to 65A / 860 W	28701-BMR310 rev A April 2022

Key Features

- low profile form factor
  57.9 x 25 x 6.5 mm (2.28 x 0.984 x 0.26 in)
- Non-isolated DC-DC converter
- Ultra-high efficiency, typical 98% at 13.25 Vout, half load
- Maximum output power up to 850W
- Meets safety requirements according to IEC/EN/UL 62368-1
- Compliant with PMBus 1.3 version
- MTBF TBD Mh

General Characteristics

- Input voltage range: 40-60 V
- Output voltage: typical 13.25 V at Vin =53 V
- Flex power designer support
- Monotonic start-up
- Input over/under voltage protection
- Output over voltage protection
- Over temperature protection
- Output over current protection
- Remote control
- Highly automated manufacturing ensures quality
- ISO 9001/14001 certified supplier

Safety Approvals

Pending Pending

Design for Environment

Meets requirements in high-temperature lead-free soldering processes.

Contents

Ordering Information

Product program	Vin	Output
BMR310 4100/002	40-60 V	13.25 V, 63 A / 850 W with PG Active High

Product number and Packaging

BMR310	n_1	n_2	n_3	n_4	/	n_5	n_6	n_7	n_8
Mechanical option	x				/				
Baseplate		x			/				
Hardware option			x	x	/				
Configuration file					/	x	x	x	
Delivery package									x

Options	Description
n_1	0 = Standard pin length 5.33 mm(0.210 in.) 1 = Lead length 3.69 mm(0.145 in.) 2 = Lead length 4.57 mm(0.180 in.) 4 = SMD version
n_2 n_3	1= baseplate
n_4	00 = 40-60 Vin, 13.25 Vout
n_5 n_6 n_7	002 = standard CDA configuration with PG Active High
n_8	Tray

Example: a surface mounted, with baseplate, standard CDA configuration with power good active high and delivery in tray would be BMR3104100/002.

* Standard variant (i.e. no option selected).

General Information

Reliability

The failure rate (λ) and mean time between failures (MTBF= 1/λ) is calculated at max output power and an operating ambient temperature (T_A) of +40°C. Flex Power uses Telcordia SR-332 Issue 3 Method 1 to calculate the mean steady-state failure rate and standard deviation (σ).

Telcordia SR-332 Issue 3 also provides techniques to estimate the upper confidence levels of failure rates based on the mean and standard deviation.

Mean steady-state failure rate, λ	Std. deviation, σ
TBD nFailures/h	TBD nFailures/h

MTBF (mean value) for the BMR310 series = TBD Mh.
MTBF at 90% confidence level = TBD Mh

Compatibility with RoHS requirements

The products are compatible with the relevant clauses and requirements of the RoHS directive 2011/65/EU and 2015/863 and have a maximum concentration value of 0.1% by weight in homogeneous materials for lead, mercury, hexavalent chromium, PBB, PBDE, DEHP, BBP, DBP, DIBP and of 0.01% by weight in homogeneous materials for cadmium.

Exemptions in the RoHS directive utilized in Flex Power products are found in the Statement of Compliance document.

Flex Power Modules fulfills and will continuously fulfill all its obligations under regulation (EC) No 1907/2006 concerning the registration, evaluation, authorization and restriction of chemicals (REACH) as they enter into force and is through product materials declarations preparing for the obligations to communicate information on substances in the products.

Quality Statement

The products are designed and manufactured in an industrial environment where quality systems and methods like ISO 9000, Six Sigma, and SPC are intensively in use to boost the continuous improvements strategy. Infant mortality or early failures in the products are screened out and they are subjected to an ATE-based final test. Conservative design rules, design reviews and product qualifications, plus the high competence of an engaged work force, contribute to the high quality of the products.

Warranty

Warranty period and conditions are defined in Flex Power General Terms and Conditions of Sale.

Limitation of Liability

Flex Power does not make any other warranties, expressed or implied including any warranty of merchantability or fitness for a particular purpose (including, but not limited to, use in life support applications, where malfunctions of product can cause injury to a person's health or life).

Safety Specification

General information

Flex Power DC/DC converters and DC/DC regulators are designed in accordance with the safety standards IEC 62368-1, EN 62368-1 and UL 62368-1 *Audio/video, information and communication technology equipment - Part 1: Safety requirements*

IEC/EN/UL 62368-1 contains requirements to prevent injury or damage due to the following hazards:

- Electrical shock
- Electrically-caused fire
- Injury caused by hazardous substances
- Mechanically-caused injury
- Skin burn
- Radiation-caused injury

On-board DC/DC converters, Power interface modules and DC/DC regulators are defined as component power supplies. As components they cannot fully comply with the provisions of any safety requirements without “conditions of acceptability”. Clearance between conductors and between conductive parts of the component power supply and conductors on the board in the final product must meet the applicable safety requirements. Certain conditions of acceptability apply for component power supplies with limited stand-off (see Mechanical Information for further information). It is the responsibility of the installer to ensure that the final product housing these components complies with the requirements of all applicable safety standards and regulations for the final product.

Component power supplies for general use shall comply with the requirements in IEC/EN/UL 62368-1. Product related standards, e.g. IEEE 802.3af *Power over Ethernet*, and ETS-300132-2 *Power interface at the input to telecom equipment, operated by direct current (dc)* are based on IEC/EN/UL 60950-1 with regards to safety.

Flex Power DC/DC converters, Power interface modules and DC/DC regulators are UL 62368-1 recognized and certified in accordance with EN 62368-1. The flammability rating for all construction parts of the products meet requirements for V-0 class material according to IEC 60695-11-10, *Fire hazard testing, test flames* – 50 W horizontal and vertical flame test methods.

Isolated DC/DC converters

The product may provide basic or functional insulation between input and output according to IEC/EN/UL 62368-1 (see Safety Certificate), different conditions shall be met if the output of a basic or a functional insulated product shall be considered as ES1 energy source.

For basic insulated products (see Safety Certificate) the output is considered as ES1 energy source if one of the following conditions is met:

- The input source provides supplementary or double or reinforced insulation from the AC mains according to IEC/EN/UL 62368-1.
- The input source provides functional or basic insulation from the AC mains and the product’s output is reliably connected to protective earth according to IEC/EN/UL 62368-1.

For functional insulated products (see Safety Certificate) the output is considered as ES1 energy source if one of the following conditions is met:

- The input source provides double or reinforced insulation from the AC mains according to IEC/EN/UL 62368-1.
- The input source provides basic or supplementary insulation from the AC mains and the product’s output is reliably connected to protective earth according to IEC/EN/UL 62368-1.
- The input source is reliably connected to protective earth and provides basic or supplementary insulation according to IEC/EN/UL 62368-1 and the maximum input source voltage is 60 Vdc.

Galvanic isolation between input and output is verified in an electric strength test and the isolation voltage (V_{iso}) meets the voltage strength requirement for basic insulation according to IEC/EN/UL 62368-1.

It is recommended to use a slow blow fuse at the input of each DC/DC converter. If an input filter is used in the circuit the fuse should be placed in front of the input filter. In the rare event of a component problem that imposes a short circuit on the input source, this fuse will provide the following functions:

- Isolate the fault from the input power source so as not to affect the operation of other parts of the system
- Protect the distribution wiring from excessive current and power loss thus preventing hazardous overheating

Absolute Maximum Ratings

Characteristics			min	typ	max	Unit
T_{P1}	Operating Temperature (see Thermal Consideration section)		-40		+125	°C
T_S	Storage temperature		-55		+125	°C
V_I	Input voltage		-0.5		+64	V
C_{out}	Output capacitance		100		10000	µF
V_{iso}	Isolation voltage (baseplate to output)				60	Vdc
V_{tr}	Input voltage transient, see Note1				80	V
V_{EN}	Enable pin voltage (see Operating Information section)	Positive logic option	-0.5		5	V
		Negative logic option	-0.5		5	V

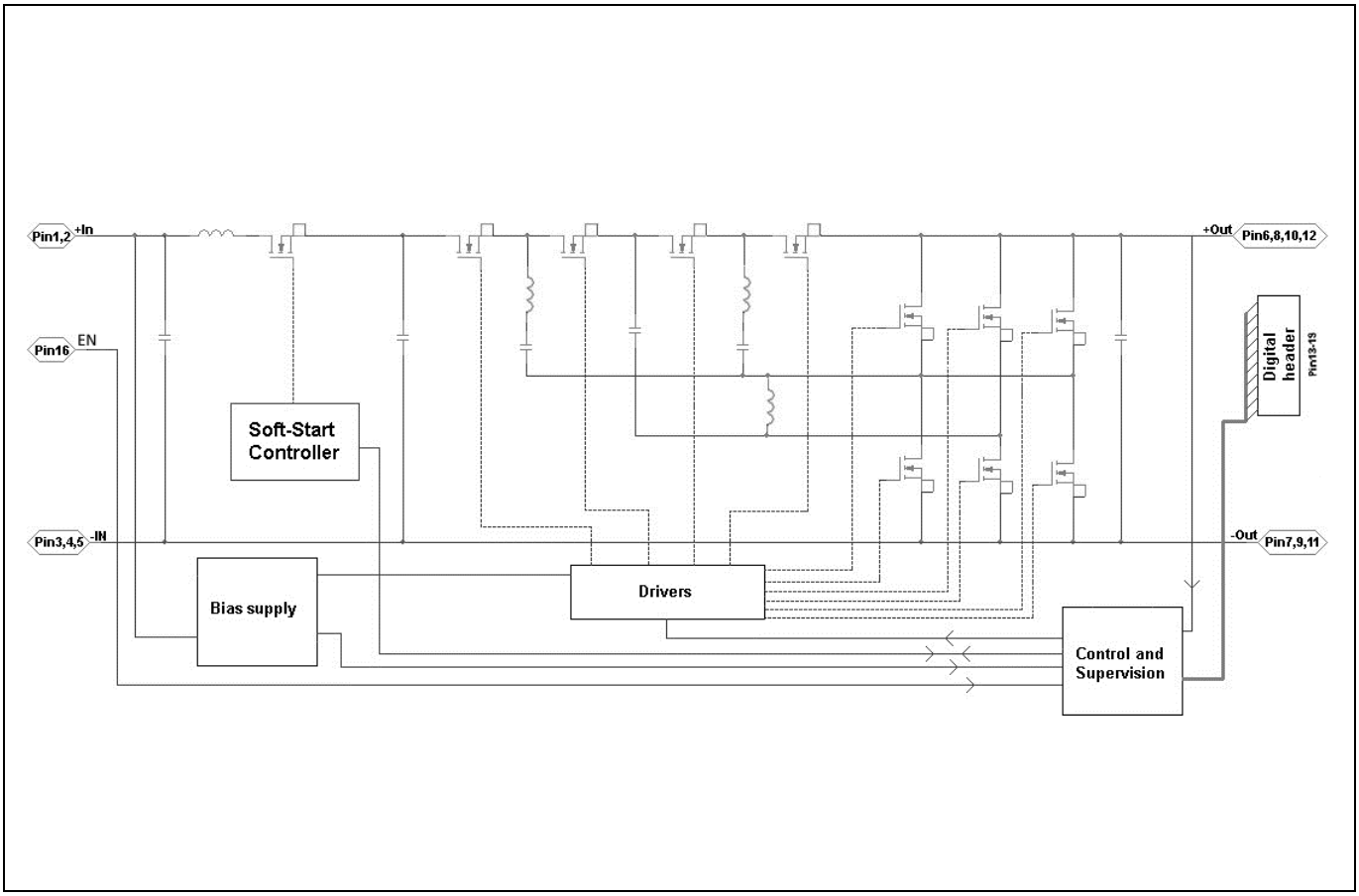
Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the Electrical Specification section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note1: Input transients applied directly to the converter input can trigger over current protection and/or output over voltage protection.

Configuration File

This product is designed with a digital control circuit. The control circuit uses a configuration file which determines the functionality and performance of the product. The Electrical Specification table shows parameter values of functionality and performance with the Standard configuration, unless otherwise specified. The Standard configuration is designed to fit most application needs. Changes in Standard configuration can be done to optimize performance in specific application.

Fundamental Circuit Diagram



Common Electrical Specification

This section includes parameter specifications common to all product versions within the product series. Typically these are parameters defined by the digital controller of the products. In the table below PMBus commands for configurable parameters are written in capital letters.

T_{P1} = -30 to +95 °C, V_I = 40 to 60 V, unless otherwise specified under Conditions.
Typical values given at: T_{P1} = +25 °C, V_I = 53 V, max I_O, unless otherwise specified under Conditions:
BMR310XXXX/002 (Stand alone)

Characteristics		Conditions	min	typ	max	Unit
f_{SW} = $1/T_{SW}$	Switching Frequency			600		kHz
	Switching Frequency Set-point Accuracy	T_{P1} = +25 °C	-1		1	%

T_{INIT}	Initialization Time	From V_I > ~27 V to ready to be enabled	30	ms
T_{ONdel_tot}	Output voltage Total On Delay Time	Enable by input voltage	T_{INIT} + T_{ONdel}	
		Enable by EN pin	T_{ONdel}	
T_{ONdel}	Output voltage On Delay Time	PMBus configurable Turn on delay duration	300	ms
		Range TON_DELAY	0 – 655	ms
		Accuracy (actual delay vs set value)	±1	%
T_{OFFdel}	Output voltage Off Delay Time	PMBus configurable Turn off delay duration, Note 1	5	ms
		Range TOFF_DELAY	0 – 655	ms
		Accuracy (actual delay vs set value), Note 2	±1	%
V_{Ioff}	Input turn off range	States the level where the output voltage is disabled, PMBus configurable	30 – 60	V
V_{Ion}	Input turn on range	States the level where the output voltage is enabled, PMBus configurable.	30 – 60	V

Characteristics		Conditions	min	typ	max	Unit
Power Good , PG	PG threshold	PMBus configurable Rising		11.5		V_O
		PMBus configurable Falling		11		V_O
	PG thresholds range	POWER_GOOD_ON VOUT_UV_FAULT_LIMIT	0		100	% V_O
	PG delay	From V_O reaching target to PG assertion		1		ms
Input Under Voltage Protection, IUVP	IUVP threshold	PMBus configurable		0		V
	IUVP threshold range	VIN_UV_FAULT_LIMIT		0-100		%V_{IN}
	IUVP hysteresis	PMBus configurable		0		V
	IUVP hysteresis range	VIN_UV_FAULT_LIMIT- VIN_UV_WARN_LIMIT		0		V
	Set point accuracy			1		%
	IUVP response delay			100		µs
	Fault response	PMBus configurable VIN_UV_FAULT_RESPONSE	Ignore fault			
Input Over Voltage Protection, IOVP	IOVP threshold	PMBus configurable		85		V
	IOVP threshold range	VIN_OV_FAULT_LIMIT		0-100		%V_{IN}
	IOVP hysteresis	PMBus configurable VIN_OV_FAULT_LIMIT- VIN_OV_WARN_LIMIT		5		V
	IOVP hysteresis range	VIN_OV_WARN_LIMIT		0-100		%V_{IN}
	Set point accuracy			±1		%
	IOVP response delay			100		µs
	Fault response	PMBus configurable VIN_OV_FAULT_RESPONSE	Disable until Fault Cleared			
Output Voltage Over/Under Voltage Protection, OVP/UVP	UVP threshold	PMBus configurable		0		V_O
	UVP threshold range	VOUT_UV_FAULT_LIMIT		0-100		%V_O
	OVP threshold	PMBus configurable		17		V_O
	OVP threshold range	VOUT_OV_FAULT_LIMIT		0-18		V_O
	UVP/OVP response time			100/50		µs
	Fault response	PMBus configurable VOUT_UV_FAULT_RESPONSE	Ignore fault			
		PMBus configurable VOUT_OV_FAULT_RESPONSE	Disable until fault cleared			
Over Current Protection, OCP Note 4	OCP threshold	PMBus configurable		80		A
	OCP threshold max	IOUT_OC_FAULT_LIMIT			90	A
	Protection delay	See Note 5		0		ms
	Fault response	PMBus configurable MFR_IOUT_OC_FAULT_RESPONSE -Stand alone, see Note 3 -DLS	Shutdown, automatic restart 2 ms delay then shut down, no retry			
Over Temperature Protection, OTP Position P5 Note 6	OTP threshold	PMBus configurable		125		°C
	OTP threshold range	OT_FAULT_LIMIT	-50		+150	°C
	OTP hysteresis	PMBus configurable OT_FAULT_LIMIT- OT_WARN_LIMIT		35		°C
	Fault response	PMBus configurable OT_FAULT_RESPONSE	Shutdown, automatic restart when no fault exist, ~90°C @ the temperature sensor			

Characteristics		Conditions	min	typ	max	Unit
Monitoring Accuracy	Input voltage READ_VIN			±125		mV
	Output voltage READ_VOUT			±10		mV
	Output current READ_IOUT	T_{P1} = 25 °C, V_O = 12.0 V		±0.25		A
		T_{P1} = -30 - 125 °C, V_O = 12.0 V		±1		A
	Duty cycle READ_DUTY_CYCLE			No tolerance, Read value is the actual value applied by PWM controller		
	Temperature READ_TEMPERATURE_1	Temperature sensor, -30 to 125 °C		±5		°C
	Temperature READ_TEMPERATURE_2	Temperature sensor, -30 to 125 °C		±5		°C

Current difference between products in a current sharing group	Steady state operation, See note 8		N/A	
Supported number of products in a current sharing group			6	

V_{OL}	Logic output low signal level	SCL, SDA, GCB, SALERT, PG Sink / source current = 4 mA			0.25	V
V_{OH}	Logic output high signal level		2.7			V
I_{OL}	Logic output low sink current				4	mA
I_{OH}	Logic output high source current				4	mA
V_{IL}	Logic input low threshold	SCL, SDA, EN			1.1	V
V_{IH}	Logic input high threshold		2.1			V
C_{I_PIN}	Logic pin input capacitance	SCL, SDA, EN		10		pF
EN_{S_PU}	Enable logic pin internal pull-up resistance	SCL, SDA, SALERT		No internal pull-up		
		EN to +3.3V Note 7		5.6		kΩ
f_{SMB}	Supported SMBus Operating frequency		100		400	kHz
T_{BUF}	SMBus Bus free time	STOP bit to START bit See section SMBus – Timing		1.3		µs
t_{set}	SMBus SDA setup time from SCL	See section SMBus – Timing		100		ns
t_{hold}	SMBus SDA hold time from SCL	See section SMBus – Timing		0		ns
	SMBus START/STOP condition setup/hold time from SCL			600		ns
T_{low}	SCL low period		1.3			µs
T_{high}	SCL high period			0.6	50	µs

Note 1. A default value of 0 ms forces the device to Immediate Off behavior with TOFF_FALL ramp-down setting being ignored.
Note 2. The specified accuracy applies for off delay times larger than 4 ms. When setting 0 ms the actual delay will be 0 ms.
Note 3. According to the combination of command MFR_RESPONSE_UNIT_CFG and delay time set in IOUT_OC_FAULT_RESPONSE, see Appendix – PMBus commands.
Note 4. Note that higher OCP threshold than specified may result in damage of the module at OC fault conditions.
Note 5. For current setting see Appendix – PMBus commands
Note 6. See section Over Temperature Protection (OTP).
Note 7. If configure the EN pin with internal Pull-up with command MFR_MULTI_PIN_CONFIG, see Appendix – PMBus commands.
Note 8. For current sharing, see Parallel Operation DLS (Droop Load Share) in the Operating Information section

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13.25 V, 65 A / 860 W

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T_{P1} = -30 to +95ºC, V_I = 40 to 60 V
Typical values given at: T_{P1} = +25°C, V_I= 53 V_I max P_{OTDP}, unless otherwise specified under Conditions.
Additional C_{in} = 220 µF, Cout = 2000 µF. See Operating Information section for selection of capacitor types.

Characteristics		Conditions	min	typ	max	Unit
V_I	Input voltage range		40		60	V
V_{Ioff}	Turn-off input voltage,	Decreasing input voltage	31	33	35	V
V_{Ion}	Turn-on input voltage	Increasing input voltage	33	35	37	V
C_I	Internal input capacitance			15		µF
P_{OTDP}	Output power (TDP)	See Note 1	0		860	W
P_{OMAX}	Output power peak (t ≤1s)	See Note 1			1000	W
η	Efficiency	P_O = 50% of P_{OTDP}		98		%
		P_O = 100% of P_{OTDP}		97		
		P_O = 50% of P_{OTDP}, V_I = 48 V		97.9		
		P_O = 100% of P_{OTDP}, V_I = 48 V		96.8		
P_d	Power Dissipation	P_O = 100% of P_{OTDP}		26.9	35.9	W
P_{Ii}	Input idling power	I_O = 0 A, V_I = 53 V		3.3		W
P_{EN}	Input standby power	V_I = 53 V (turned off with EN)		0.56		W
f_s	Switching frequency	0-100 % of P_{OTDP} see Note 2	590	600	610	kHz

V_{Oi}	Output voltage initial setting and accuracy	T_{P1} = +25°C, V_I = 53 V, P_O = 0 W	12.78	12.9	13.02	V
V_O	Output voltage tolerance band	0-100% of P_{OTDP}	9.5		15.015	V
	Idling voltage	I_O = 0 A	10		15.015	V
	Load regulation	V_I = 53 V, 0-100% of P_{OTDP}		390	515	mV
V_{tr}	Load transient voltage deviation	V_I = 53 V, Load step 25-75-25% of P_{OTDP}, di/dt = 5 A/µs, C_{out} = 5 mF, see Note 3		± 185	± 515	mV
t_r	Ramp-up time (from 10% of V_{Oi})	See Graph Current Limit and Start-up		20		ms
t_s	Start-up time (from V_I connection to 10% of V_{Oi})			60		ms
t_{EN}	EN start-up time (from V_{EN} connection to 100% of V_{Oi})	See Graph Current Limit and Start-up		21		ms
EN	Sink current	See operating information	0.5			mA
	Trigger level			1.2		V
	Response time		0.4		1.1	ms
I_O	Output current		0		65	A
I_{lim}	Current limit threshold	25°C < T_{P1} < max T_{P1}	76	80	86	A
		min T_{P1} < T_{P1} < max T_{P1}			100	A
I_{sc}	Short circuit current	T_{P1} = 25ºC, see Note 4		1.1		A
C_{out}	Required Capacitive Load		100	2000	10000	µF
V_{Oac}	Output ripple & noise	See ripple & noise section, V_{Oi} ,see Note 5, Tref ≤ Tmax		300	500	mVp-p
		V_{Oi} ,see Note 5, Tmin ≤ Tmax			800	mVp-p
OVP	Over voltage protection	T_{P1} = +25°C, V_I = 53 V, 0-100% of P_{OTDP}		16		V

Note 1: The maximum output current is rated to 75A. The maximum power is ≤1000W (t ≤ 1s) and the continuous power (TDP, Thermal Design Power) is ≤860W, depending on thermal conditions.
Note 2: For higher values, contact FAE.
Note 3: Not regulated, controlled by load regulation (droop) and the combination of input and output filters
Note 4: Typical RMS current when BMR310 OCP is operating in hiccup mode.
Note 5: BW = 20 MHz

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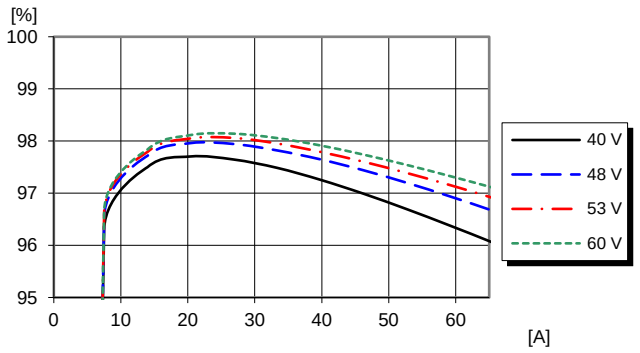
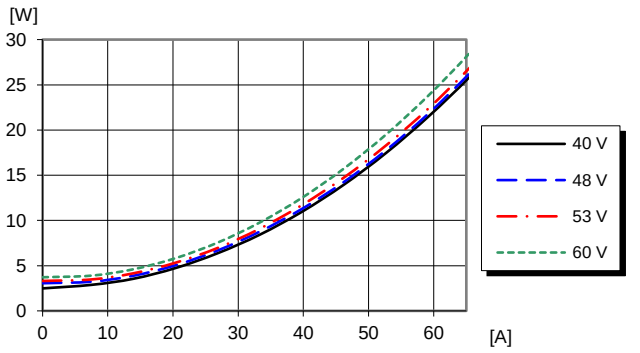
Efficiency



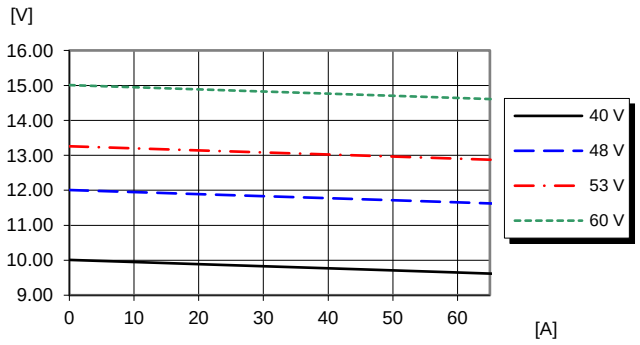
Efficiency vs. load current and input voltage at T_{P1} = +25°C.

Power Dissipation



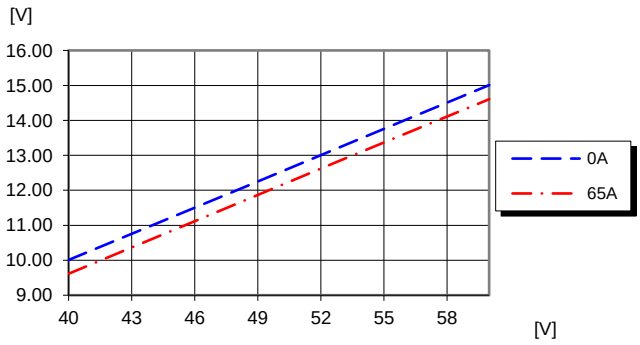
Dissipated power vs. load current and input voltage at T_{P1} = +25°C.

Output Characteristics



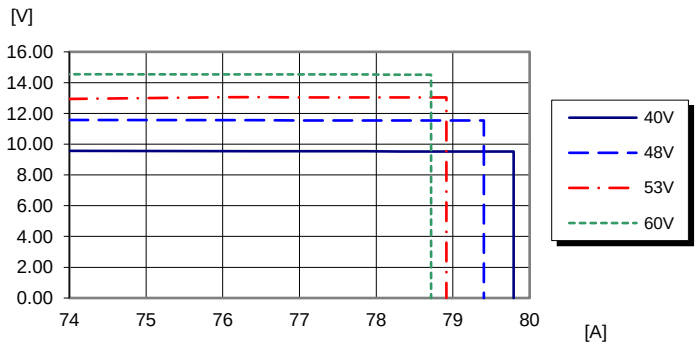
Output voltage vs. load current at T_{P1} = +25°C.

Output Characteristics



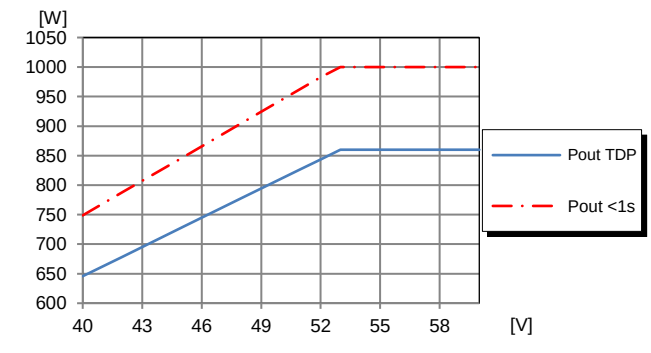
Output voltage vs. input voltage and load current at T_{P1} = +25°C.

Current Limit Characteristics



Output voltage vs. load current at I_O > max I_O, T_{P1} = +25°C.

Available Power



Output power vs. input voltage at T_{P1} = +25°C.

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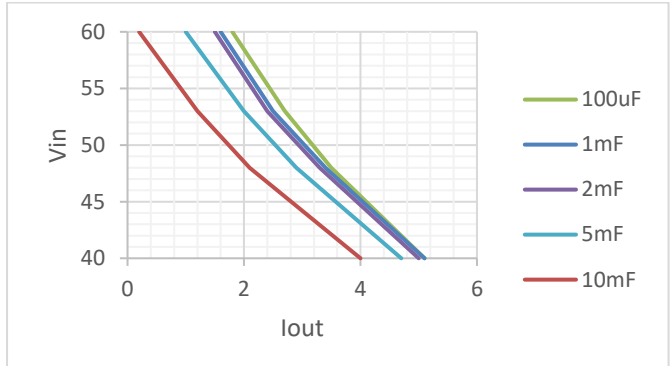
Max Load Current at Start-up



Output capacitance vs. load current and input voltage at T_{P1} = +25°C.

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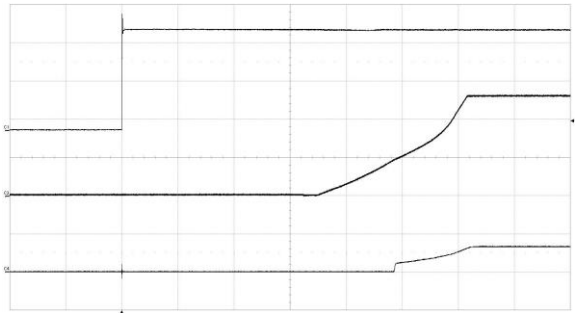
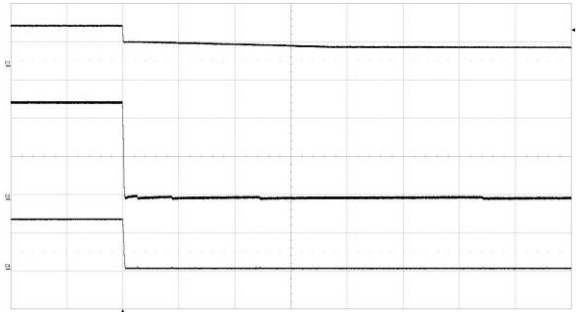
Start-up



Start-up enabled by connecting V_I at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 6.5 A resistive load.

Top trace: input voltage (20 V/div.).
Mid trace: output voltage (5 V/div.).
Bottom trace: load current (10 A/div.).
Time scale: (10 ms/div.).

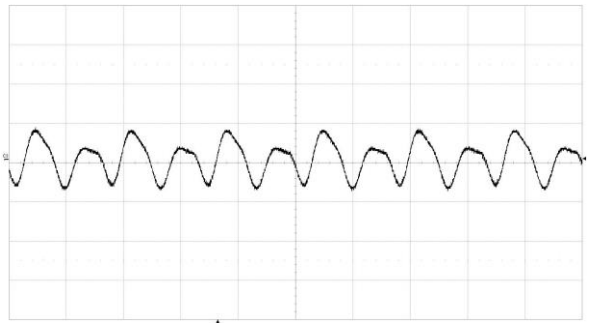
Shut-down



Shut-down enabled by disconnecting V_I at:
T_{P1} = +25°C, V_I = 53 V,
I_O = 65 A resistive load.

Top trace: input voltage (50 V/div.).
Mid trace: output voltage (5 V/div.).
Bottom trace: load current (50 A/div.).
Time scale: (50 ms/div.).

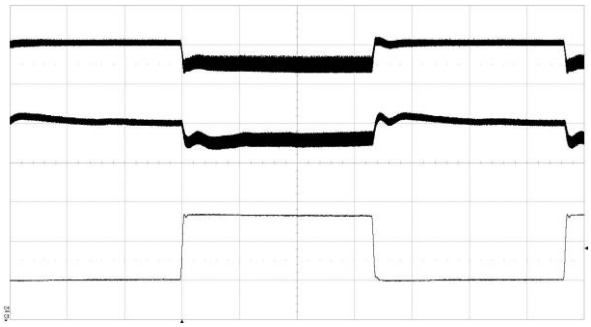
Output Ripple & Noise



Output voltage ripple at:
T_{P1} = +25°C, V_I = 53V,
I_O = 65 A resistive load.

Trace: output voltage (200 mV/div.).
Time scale: (1 µs/div.).

Output Load Transient Response



Output voltage response to load current step-change (16.25-48.75-16.25 A) at:
T_{P1} =+25°C, V_I = 53 V, C_{out}=10mF.

Top trace: input voltage (500 mV/div.).
Mid trace: output voltage (500 mV/div.).
Bottom trace: load current (20 A/div.).
Time scale: (0.5 ms/div.).

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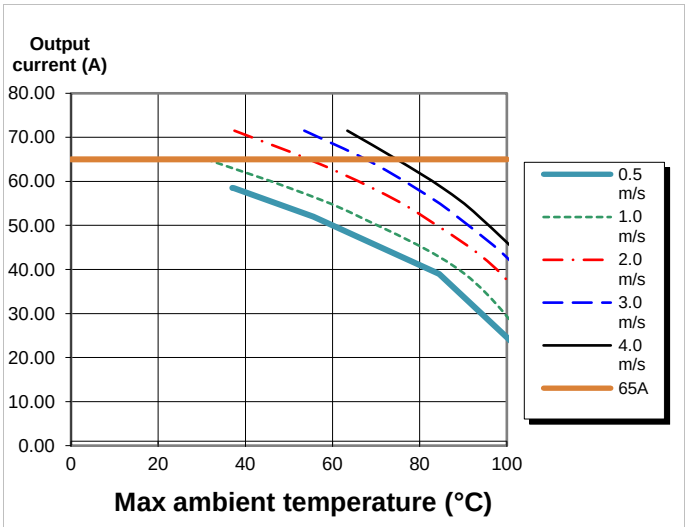
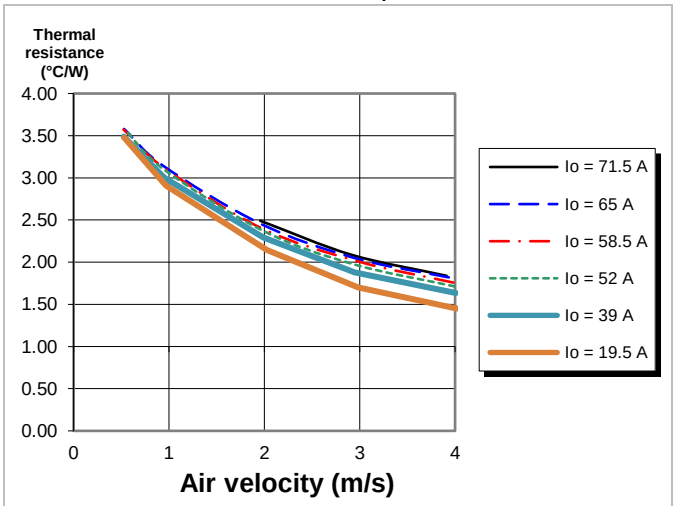
BMR 310 0000/002

Output Current Derating – Base plate



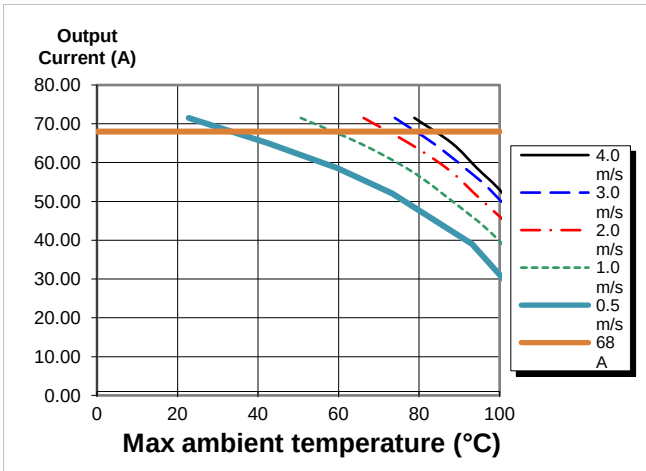
Available load current vs. ambient air temperature and airflow at V_I = 53 V. See Thermal Consideration section.

Thermal Resistance – Base plate



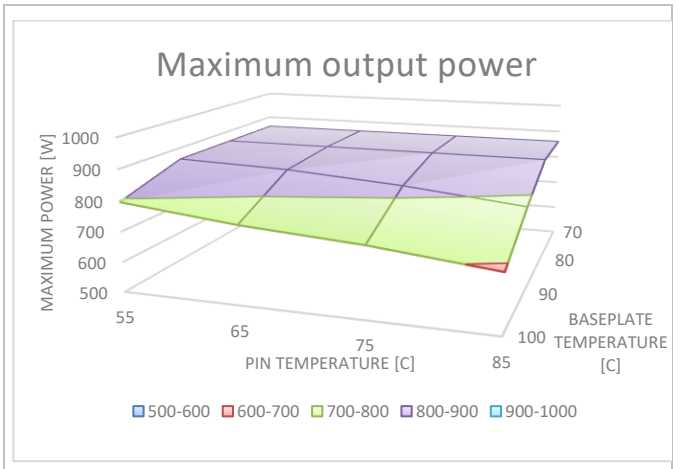
Thermal resistance vs. airspeed measured at the converter. Tested in wind tunnel with airflow and test conditions as per the Thermal consideration section. V_I = 53 V.

Output Current Derating – Base plate and ½" Heat sink



Available load current vs. ambient air temperature and airflow at V_I = 53 V. See Thermal Consideration section.

Output Current Derating

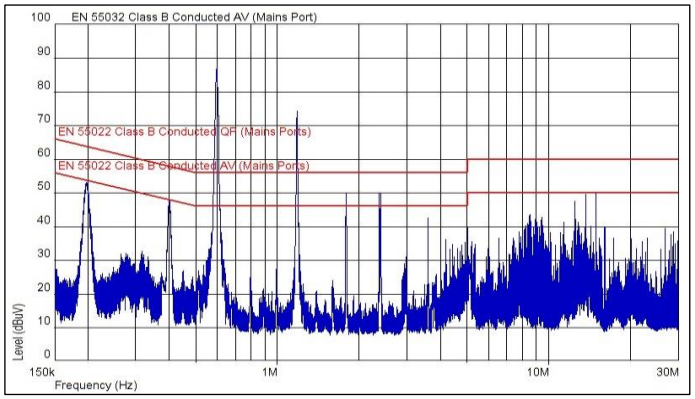


Available load current vs. base plate and pin temperature. V_I = 53 V. See Thermal Consideration section.

EMC Specification

Conducted EMI measured according to EN55032, CISPR 32 and FCC part 15J (see test set-up). The fundamental switching frequency is 600 kHz. The EMI characteristics below is measured at VI = 53 V and max IO.

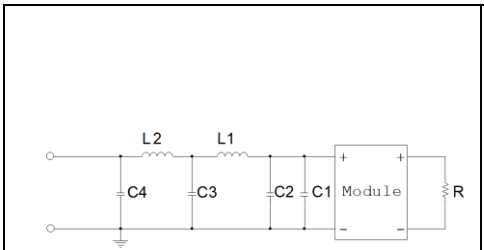
Conducted EMI Input terminal value (typ)



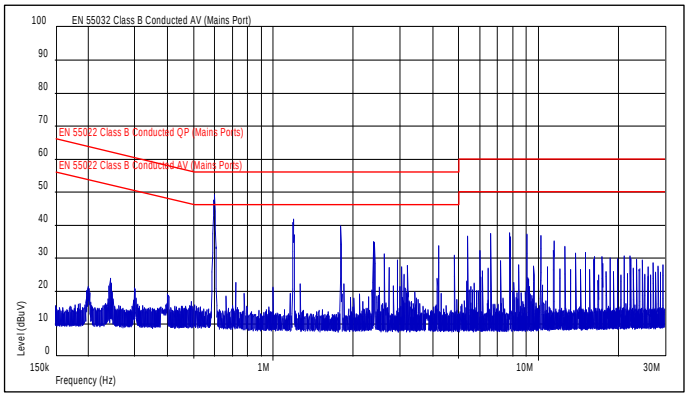
EMI without filter

Optional external filter for class B

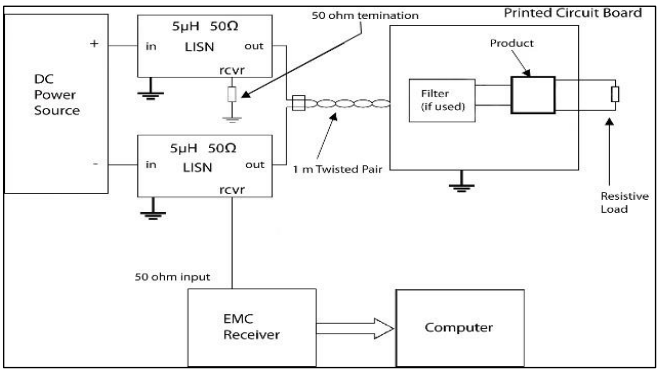
Suggested external input filter in order to meet class B in EN 55032, CISPR 32 and FCC part 15J.



Filter components:
C1 =4 x 1 µF
C2 = 220 µF (e-lyt) + 15uF (e-lyt Oscon) + 2 x 4.7 µF
L1 = 6.8 uH
C3 =4.7 nF +
2 x 10 uF + 4.7 uF
L2 = 6.8 uH
C4 = 2 x 10 µF + 4.7 uF



EMI with filter



Test set-up

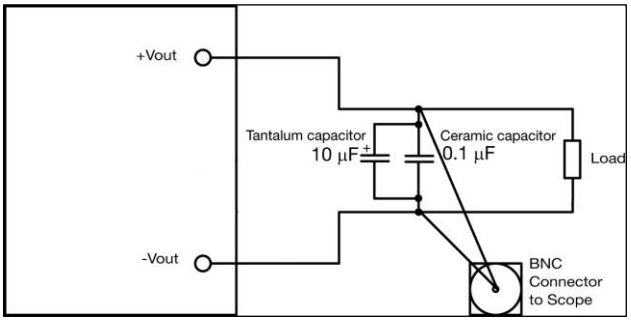
Layout recommendations

The radiated EMI performance of the product will depend on the PWB layout and ground layer design. It is also important to consider the stand-off of the product. If a ground layer is used, it should be connected to the output of the product and the equipment ground or chassis.

A ground layer will increase the stray capacitance in the PWB and improve the high frequency EMC performance.

Output ripple and noise

Output ripple and noise measured according to figure below. See Design Note 022 for detailed information.



Output ripple and noise test setup

Power Management Overview

This product is equipped with a PMBus interface. The product incorporates a wide range of readable and configurable power management features that are simple to implement with a minimum of external components.

Additionally, the product includes protection features that continuously safeguard the load from damage due to unexpected system faults. A fault is also shown as an alert on the SALERT pin. The following product parameters can continuously be monitored by a host: Input voltage, output voltage/current, and internal temperature.

The product is delivered with a default configuration suitable for a wide range operation in terms of input voltage, and load. The configuration is stored in an internal Non-Volatile Memory (NVM). All power management functions can be reconfigured using the PMBus interface

Throughout this document, different PMBus commands are referenced. A detailed description of each command is provided in the appendix at the end of this specification.

The Flex Power Designer software suite can be used to configure and monitor this product via the PMBus interface. For more information, please contact your local Flex sales representative.

SMBus Interface

This product provides a PMBus digital interface that enables the user to configure many aspects of the device operation as well as to monitor the input and output voltages, output current and device temperature. The product can be used with any standard two-wire I2C or SMBus host device. In addition, the product is compatible with PMBus version 1.3 and includes an SALERT line to help mitigate bandwidth limitations related to continuous fault monitoring. The product supports 100 kHz and 400 kHz bus clock frequency only. The PMBus signals, SCL, SDA and SALERT require passive pull-up resistors as stated in the SMBus Specification. Pull-up resistors are required to guarantee the rise time as follows:

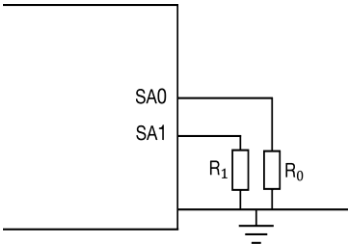
Eq. 7 $\tau = R_P C_p \leq 1us$

where Rp is the pull-up resistor value and Cp is the bus load. The maximum allowed bus load is 400 pF. The pull-up resistor should be tied to an external supply between 2.7 to 5.5 V, which should be present prior to or during power-up. If the proper power supply is not available, voltage dividers may be applied but one must still stay within the range. Note that in this case, the resistance in the equation above corresponds to parallel connection of the resistors forming the voltage divider.

It is recommended to always use PEC (Packet Error Check) when communicating via PMBus.

PMBus Addressing

The following figure and table show recommended resistor values with min and max voltage range for hard-wiring PMBus addresses (series E12, 1% tolerance resistors suggested):



Schematic of connection of address resistors

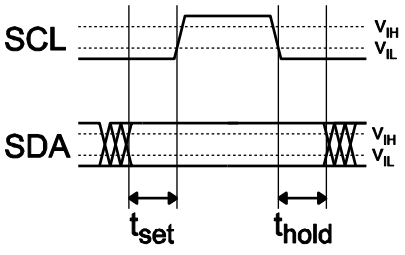
SA0/SA1 Index	R_{SA0}/R_{SA1} [kΩ]
0	10
1	22
2	33
3	47
4	68
5	100
6	150
7	220

The SA0 and SA1 pins can be configured with a resistor to DGND according to the following equation.

PMBus Address (decimal) = 8 x (SA0 index) + (SA1 index)

If the calculated PMBus address is 0, 11 or 12, PMBus address 127 is assigned instead. From a system point of view, the user shall also be aware of further limitations of the addresses as stated in the PMBus Specification. It is not recommended to keep the SA0 and SA1 pins left open. There is an option to only use SA0 as address pin, see section MFR_OFFSET_ADDRESS how to set the command to utilize single address pin option.

I2C/SMBus – Timing



Setup and hold times timing diagram

The setup time, t_{set}, is the time data, SDA, must be stable before the rising edge of the clock signal, SCL. The hold time t_{hold}, is the time data, SDA, must be stable after the rising edge of the clock signal, SCL. If these times are violated incorrect data may be captured or meta-stability may occur, and the bus communication may fail. All standard SMBus protocols must be followed, including clock stretching. This product supports the BUSY flag in the status commands to indicate product being too busy for SMBus response. A bus-free time delay between every SMBus transmission (between every stop & start condition) must occur. Refer to the SMBus specification, for SMBus electrical and timing requirements. Note that an additional delay of 5 ms has to be inserted in case of storing the RAM content into the internal non-volatile memory.

Monitoring via PMBus

It is possible to continuously monitor a wide variety of parameters through the PMBus interface. These include, but are not limited to, the parameters listed in the table below.

Parameter	PMBus Command
Input voltage	READ_VIN
Output voltage	READ_VOUT
Output current	READ_IOUT
Temperature *	READ_TEMPERATURE_1
Temperature *	READ_TEMPERATURE_2
Switching Frequency	READ_FREQUENCY

*Reports the temperature from temperature sensor set in command 0xDC, internal (controller IC)/external (temp sensor).

Monitoring Faults

Fault conditions can be detected using the SALERT pin, which will be asserted low when any number of pre-configured fault or warning conditions occurs. The SALERT pin will be held low until faults and/or warnings are cleared by the CLEAR_FAULTS command, or until the output voltage has been re-enabled. It is possible to mask which fault conditions should not assert the SALERT pin by the command SMBALERT_MASK. In response to the SALERT signal, the user may read a number of status commands to find out what fault or warning condition occurred, see table below.

Fault & Warning Status	PMBus Command
Overview, Power Good	STATUS_BYTE STAUS_WORD
Output voltage level	STATUS_VOUT
Output current level	STATUS _IOUT
Input voltage level	STATUS_INPUT
Temperature level	STATUS_TEMPERATURE
PMBus communication	STATUS_CML
Miscellaneous	STATUS_MFR_SPECIFIC

Black Box/ Event Recorder

Overview

A black box, or history event recorder, is provided to capture brick data at the time of fault occurrence. The intent is to assist in fault diagnosis.

48 life cycle & fault & events

- status flags according to PMBus spec part II rev 1.3
- life cycle events such as
  - boot
  - fault event recorder erased
  - VinOff/VinOn
  - Vin drop out

24 event slots are dedicated for fault events

- Fault events are defined by setting SMBALERT_MASK
- The default configuration defines following faults:
  - VOUT UV Fault
  - VOUT OV Fault
  - VIN UV Fault
  - VIN OV Fault
  - IOUT UC Fault
  - IOUT OC Fault
  - UT Fault
  - OT Fault
- First in - first out (in case the event recorder was not erased the oldest event gets discarded as new events are recorded)
- When either life cycle event memory or the fault event memory becomes full, the oldest 4 events in that bank are erased. A “full” event recorder therefore contains a minimum of 20 fault events and 20 life cycle events.
- Reading the event recorder involves setting the index (PMBus write byte) and reading the indexed event (PMBus read block)
- Ability to clear the section of the event recorder that are dedicated for faults

An event contains following information:

- EventID# < 2^16
- Time stamp 100 ms resolution < 13.6 years
- Status Word, non sticky bits
- Status bytes for all PMBus status registers, non-sticky bits
- Telemetry for Vin, Vout, Iout and temperature (resolution below)

Black Box/ Event Recorder resolution for telemetry

Following resolutions are valid

- Vin: 0.5 V
- Vout: 2^(VoutMode+8) V
  - e.g. if VoutMode = -11, Vout resolution is 2^(-11+8) = 2^-3 = 125 mV
- Iout: Resolution depends on IOUT_OC_FAULT_LIMIT
  - e.g. if IOUT_OC_FAULT_LIMIT < 85 A, Iout resolution is 0.5 A)
- Temperature: 1 °C

Unit off status codes

Applies only to the life cycle section of the event recorder

When the Status Word in an event is 0x0040 (Unit off) the StatusMfr byte indicates if the unit was turned on or off and with what source.

- Bit 0: Source is internal configuration
- Bit 1: Source is Primary RC
- Bit 2: Source is Secondary RC
- Bit 3: Source is PMBus
- Bit 4: 0: unit was turned off, 1: unit was turned on

Power Good status codes

Applies only to the life cycle section of the event recorder
When the Status Word in an event is 0x0800 (Power Good) the StatusMfr byte indicates if PG was asserted or de-asserted. 1 means power is not good, 2 means power is good

Manufacturer status codes (StatusMfr)

When status word is 0x0001 a system event is reported in the StatusMfr byte:

- 0x01 BOOT_EVENT
- 0x02 INPUT_LOW_ EVENT
- 0x04 CANCEL_EVENT
- 0x08 ERASE_EVENT
- 0x10 CLR_EVENT
- 0x20 ERASE_OVFL_EVENT

All codes apply to the life cycle section of the event recorder. Only INPUT_LOW_DETECT, CANCEL_EVENT and ERASE_OVFL_EVENT apply to the fault section of the event recorder.

- The BOOT_EVENT records time data when needed
- An INPUT_LOW_ EVENT might be recorded at shut down. The purpose of this event is to store time data at shutdown unless it has already been stored
- The maximum time between two events is 2.1 years. A time out will be recorded as a CANCEL_EVENT
- An ERASE_EVENT is recorded in the life cycle section when the fault section is cleared
- A CLR_EVENT is recorded in the life cycle section when a CLEAR_FAULTS command is sent to the unit
- An ERASE_OVFL_EVENT indicates that the event recorder was overloaded while erasing old records but did recover

Reading the event recorder

EVENT_INDEX
Writing to this command sets current index to read by the READ_EVENT command. It also provides means to clear the fault section of the event recorder and finding the newest event (equal to number of events stored in the event recorder)

Write byte	Read after write
0 – 47	same value as written.
254	Index of newest record in the life cycle section of the event recorder.
255	Index of newest record in the fault section of the event recorder.
0xAA	0xAA. The fault section of the event recorder is cleared.

For all the above; READ_EVENT is prepared for reading the index that was written.
Index 0-23 refers to the fault section of the event recorder
Index 24-47 refers to the life cycle section of the event recorder

READ_EVENT
One event, prepared by writing to EVENT_INDEX, read as a 23 byte block.

Notes

- When clearing the fault section of the event recorder, the event id number is reset but time stamp data is kept
- Clearing the fault section of the event recorder takes typically 121 ms. During this time fault handling is disabled and a PMBus host must not access the unit.
- Reading an empty event will return 0xFF in all bytes.
- Setting up the event record (after indexing with the EVENT_INDEX command) takes typically 30 us. Reading within this time frame will return unpredictable result.

PMBus command details

EVENT_INDEX (read/write byte 0xDB)
Offset value 0-47. 0 is always the oldest event in the fault section of the event recorder. 24 is the oldest event in the life cycle section. For other options see above.

Start	Device Address & R/*W*	Command byte 0xDB	*Index value (byte)*	PEC	Stop

READ_EVENT (read block 0xD7)

Start	Device Address & W	Command Code 0xD7	Repeated start	Device Address & R	Block count = 23
EventID# (high byte)		EventID# (low byte)	TimeStamp (byte3)	TimeStamp (byte2)	
TimeStamp (byte1)		TimeStamp (byte0)	StatusWord (high byte)	StatusWord (low byte)	
StatusVout		StatusIout	StatusInput	StatusTemperature	
StatusCML		StatusOther	StatusMfr	VinValue (high byte)	
VinValue (low byte)		VoutValue (high byte)	VoutValue (low byte)	IoutValue (high byte)	
IoutValue (low byte)		TemperatureValue (high byte)	TemperatureValue (low byte)	PEC	Stop

Non-Volatile Memory (NVM)

The product incorporates two Non-Volatile Memory areas for storage of the PMBus command values; the Default NVM and the User NVM. The Default NVM is pre-loaded with Flex factory default values. The Default NVM is write-protected and can be used to restore the Flex factory default values through the command RESTORE_DEFAULT_ALL.
The User NVM is pre-loaded with Flex factory default values. The User NVM is writable and open for customization. The values in NVM are loaded during initialization according to section Initialization Procedure, where after commands can be changed through the PMBus Interface. The STORE_USER_ALL command will store the changed parameters to the User NVM.

Operating Information

Input Voltage

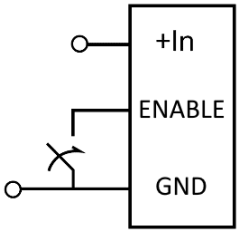
The input voltage range 40 to 60 Vdc meets the requirements for normal input voltage range in 48/53 Vdc systems.

Short duration transient disturbances can occur on the DC distribution and input of the product when a short circuit fault occurs on the equipment side of a protective device (fuse or circuit breaker). The voltage level, duration and energy of the disturbance are dependent on the particular DC distribution network characteristics and can be sufficient to damage the product unless measures are taken to suppress or absorb this energy. The transient voltage can be limited by capacitors and other energy absorbing connected across the positive and negative input conductors at a number of strategic points in the distribution network. The end-user must secure that the transient voltage will not exceed the value stated in the Absolute maximum ratings.

Turn-on and -off Input Voltage

The products monitor the input voltage and will turn on and turn off at configured thresholds (see Electrical Specification). The turn-on input voltage threshold is set higher than the corresponding turn-off threshold. Hence, there is a hysteresis between turn-on and turn-off input voltage levels.
The minimum hysteresis between turn on and turn off input voltage is 1V.

Remote Control - Enable



The products are fitted with an enable pin referenced to the negative connection (GND), with negative and positive logic options available. Enable pin allows the product to be turned on/off by an external device like a semiconductor or mechanical switch.

To turn off the product the ENABLE pin should be left open for a minimum of time 150 µs, the same time requirement applies when the product shall turn on
The external device must provide a minimum required sink current >0.5 mA to guarantee a voltage not higher than maximum voltage on the ENABLE pin (see Electrical characteristics table). When the ENABLE pin is left open, the voltage generated on the ENABLE pin is max 3.6 V, via an internal pull up resistor. The logic option for the primary remote control is easily configured via ON_OFF_CONFIG (0x02) command using Flex Power Designer. The standard product is provided with “negative logic” RC and will be off until the RC pin is connected to the GND. To turn off the product the ENABLE pin should be left open. In situations where it is desired to have the product to power up automatically without the need for control signals or a switch, the ENABLE pin can be wired directly to GND.

Peak Power Considerations

The DC/DC converter have a peak capability t≤1sec in order to handle higher power than the thermal design power (TDP) for the converter. In the peak power area, the power loss increases. Extended use of peak power capability will cause increase heating of the converter. A guideline is that the average power-loss of the converter during a 10sec period not exceeding the maximum TDP power-loss. The overload protections do not monitor the average power and will not actively limit the power over time. For further assistance, contact your local Flex Power representative.

Input and Output Impedance

The impedance of both the input source and the load will interact with the impedance of the product. It is important that the input source has low characteristic impedance. Minimum recommended external input capacitance is 100 µF. The electrolytic capacitors will be degraded in low temperature. The needed input capacitance in low temperature should be equivalent to 100 µF at 20°C. The performance in some applications can be enhanced by addition of external capacitance as described under External Decoupling Capacitors. If the input voltage source contains significant inductance, the addition of a 22 – 100 µF capacitor across the input of the product will ensure stable operation. The minimum required capacitance value depends on the output power and the input voltage. The higher output power the higher input capacitance is needed.

External Decoupling Capacitors

When powering loads with significant dynamic current requirements, the voltage stability at the point of load can be improved by addition of decoupling capacitors at the load. The most effective technique is to locate low ESR ceramic and electrolytic capacitors as close to the load as possible, using several parallel capacitors to lower the effective ESR. The ceramic capacitors will handle high-frequency dynamic load changes while the electrolytic capacitors are used to handle low frequency dynamic load changes. It is equally important to use low resistance and low inductance PWB layouts and cabling.

.
The ESR of the capacitors is a very important parameter. Stable operation is guaranteed with a verified ESR value of >1 mΩ across the output connections.
For further information please contact your local Flex Power Modules representative.

PMBus configuration and support

The product provides a PMBus digital interface that enables the user to configure many aspects of the device operation as well as monitor the input and output parameters.

The Flex Power Designer software suite can be used to configure and monitor this product via the PMBus interface.

Soft-start Power Up

Rise time is the function of the output capacitance. Min and max time are specified in Electrical specification.

Soft start is achieved by a MOSFET operation in a linear region, this is managed by a dedicated analog controller. Recommended max load and capacitance conditions must therefore be carefully observed.

It is strongly recommended not to apply load until PG is asserted.

If the application requires a current load during start-up, conditions in the table below must be followed before PG is asserted.

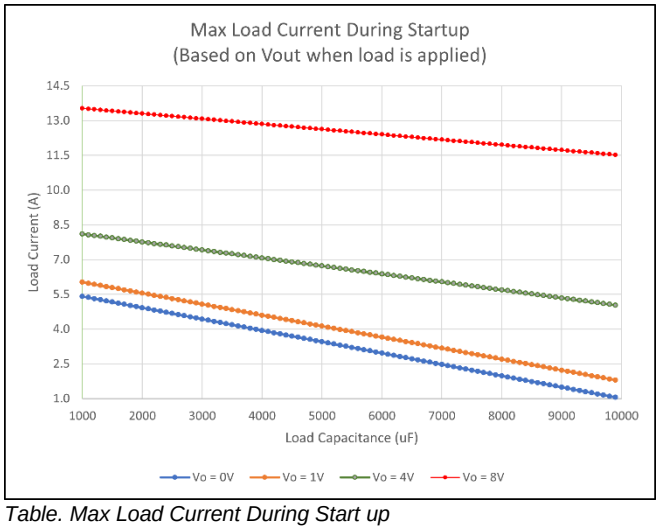


Table. Max Load Current During Start up

The “Max Load Current During Start up” graph is intended to ensure the application can successfully ramp from 0V to full output voltage by appropriately limiting the load current during start up. Heavy load during start up can lead to the module self-protection engaging and that would lead to a no-start result. Full output current is available after the output voltage reaches its final value or the PG signal is asserted.

The available load current during start up is a function of applied output capacitance and the voltage level when the load turns on. For example, a typical load might be a group of point of load (POL) regulators drawing essentially 0A until the input voltage reaches a minimum threshold such as 8V which is common input voltage threshold for 12V POLs. The graph above shows that an application with 5000uF connected to the output could support up to 12.5A of load current when the demand for that current turns on at 8V. With that same output capacitance and the load turning on at 4V, the load current could be up to 6.9A.

When starting by applying input voltage the control circuit boot-up time adds an additional 25 ms delay. The soft-start and soft-stop control functionality allows the output voltage to ramp-up and ramp-down with defined timing with respect to the control of the output. This can be used to control inrush current and manage supply sequencing of multiple controllers.
The rise time is the time taken for the output to ramp to its target voltage, while the fall time is the time taken for the output to ramp down from its output voltage to 0 V. The TON_DELAY (0x60) time sets a delay from when the output is enabled until the output voltage starts to ramp up. The TOFF_DELAY (0x64) delay time sets a delay from when the output is disabled until the output voltage starts to ramp down.

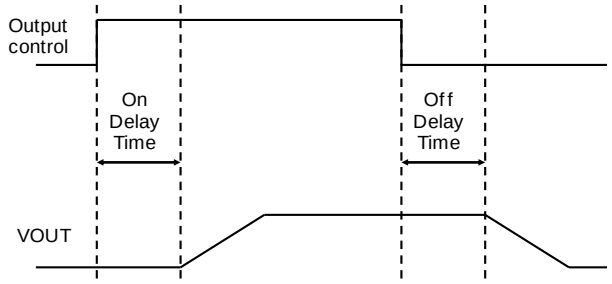


Illustration of TON_DELAY and TOFF_DELAY.

Over/Under Temperature Protection (OTP, UTP)

The products are protected from thermal overload by an internal over temperature sensor.
When TP1 as defined in thermal consideration section exceeds 125°C the product will shut down. The temperature sensor is located close to TP1. The OTP limit is set to 125 °C and triggers when the temperature reaches 125 °C on the temperature sensor. The product will make continuous attempts to start up (non-latching mode) and resume normal operation automatically when the temperature has dropped below the temperature threshold set in command 0x51 OT_WARN_LIMIT.

The OTP and hysteresis of the product can be re-configured using the PMBus interface. The product has also an under-temperature protection. The OTP and UTP fault limit and fault response can be configured via the PMBus.
Note 1: using the fault response “continue without interruption” may cause permanent damage to the product.
Note 2: After OTP event product re-starts when temperature is below OTP warning level. Setting OTP warning limit over 100 °C may cause permanent damage to the product.

Pre-bias Start-up

The product has a Pre-bias start up functionality and will not sink current during start up if a pre-bias source is present at the output terminals. If the Pre-bias voltage is lower than Vin/4, the product will ramp up to the target value. If the Pre-bias voltage is higher Vin/4, the product will not start until the Pre-bias voltage is below Vin/4.

Parallel Operation DLS (Droop Load Share)

With the same input voltage and an output contact/trace resistance, the converters may be paralleled for redundancy if the total current is equal to or less than n × 0.90 × IO max. For best result, trace resistance and module cooling must be symmetrical. At this condition, the modules current share within 10% at the maximum load.
No external components are required for parallel operation or load sharing.
Impedance between load sharing unit´s inputs should be low since the output voltage is proportional to the input voltage and therefore will impact the load sharing capability.

Input Over/Under Voltage Protection

The input of the product can be protected from high input voltage and low input voltage by a pre-configured value with a response time of 100us. The over/under-voltage fault level and fault response is easily configured using Flex Power Designer software, see also Appendix – PMBus commands.

Output Over Voltage Protection (OVP)
The product includes over voltage limiting circuitry for protection of the load. If the output voltage exceeds the OVP limit, the product can respond in different ways.
The default response from an over voltage fault is to immediately shut down. The device will continuously check for the presence of the fault condition, and when the fault condition no longer exists the device will be re-enabled.
The OVP fault level and fault response can be configured via the PMBus interface, see Appendix – PMBus commands.

Over Current Protection (OCP)

The products include current limiting circuitry for protection at continuous overload. For default configuration, the output voltage will shut down and automatic restart for output currents in excess of max output current at start up (See table in Soft-start Power Up). The product will resume normal operation after removal of the overload. The load distribution should be designed for the maximum output short circuit current specified.
The over current protection of the product can be configured via the PMBus interface, see Appendix – PMBus commands.

Power Good

The power good pin 13(PG) indicates when the product is ready to provide output voltage to the load. During ramp-up and during a fault condition, PG is held low. By default, PG is asserted high when the soft start is fully saturated AND the output voltage exceeds the voltage set in the POWER_GOOD_ON register, and de-asserted (pulled low) during fault conditions OR if the output voltage drops below the POWER_GOOD_OFF threshold. These thresholds may be changed using the PMBus commands POWER_GOOD_ON and POWER_GOOD_OFF.
By default, the PG pin is configured as Push/pull output but it is also possible to set the output in open drain mode by the command MFR_MULTI_PIN_CONFIG (0xF9), see Appendix – PMBus commands.
The polarity is by default configured to active high, the polarity of PG can be set to active low in the command MFR_PGOOD_POLARITY (0xD0):
0xD0 = 00 (active low)
0xD0 = 01 (active high)
The product provides Power Good flag in the Status Word register that indicates the output voltage is within a specified tolerance of its target level and no-fault condition exists.
It is not recommended to use Push-pull when paralleling PG-pins.

Multi pin configuration

The MFR_MULTI_PIN_CONFIG (0xF9) command can be re-configured using the PMBus interface to enable or disable different functions and set the pin configuration of the digital header (pin 13-19), see Appendix – PMBus commands.

Address Offset

The command MFR_OFFSET_ADDRESS 0xEE enables to use only 1 external address pin, SA0. This option can be utilized via MFR_MULTI_PIN_CONFIG 0xF9. The PMBus-address offset increments with the value stated in 0xEE and referenced to resistor value set to SA0 pin, see PMBus addressing. The address offset is set in command 0xEE, see Appendix – PMBus commands.

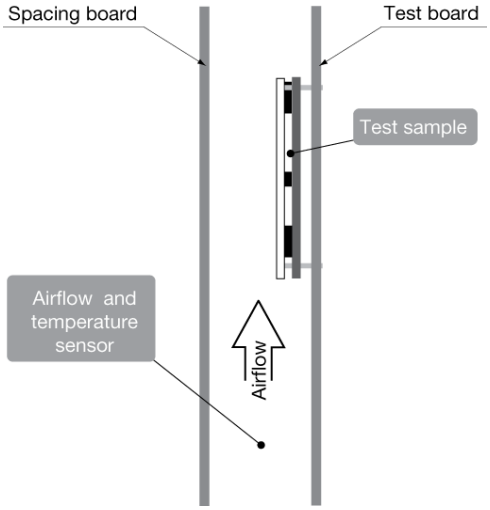
Thermal Consideration

General

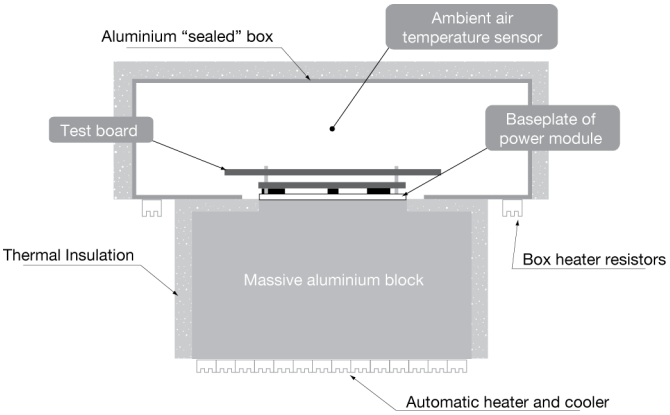
The products are designed to operate in different thermal environments and sufficient cooling must be provided to ensure reliable operation.

For products mounted on a PWB without a heat sink attached, cooling is achieved mainly by conduction, from the pins to the host board, and convection, which is dependent on the airflow across the product. Increased airflow enhances the cooling of the product. The Output Current Derating graph found in the Output section for each model provides the available output current vs. ambient air temperature and air velocity at
VI = 53 V.

The product is tested on a 254 x 254 mm, 35 µm (1 oz), 16-layer test board mounted vertically in a wind tunnel with a cross-section of 608 x 203 mm.



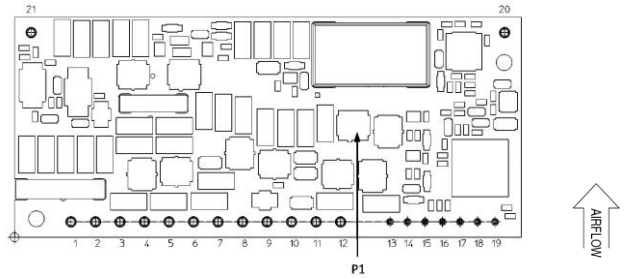
For products with base plate used in a sealed box/cold wall application, cooling is achieved mainly by conduction through the cold wall. The Output Current Derating graphs are found in the Output section for each model. The product is tested in a sealed box test set up with ambient temperatures 85°C. See Design Note 028 for further details.



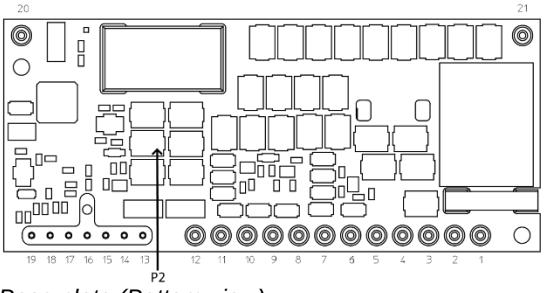
Definition of product operating temperature

The product operating temperatures is used to monitor the temperature of the product, and proper thermal conditions can be verified by measuring the temperature at positions P1The temperature at these positions (TP1) should not exceed the maximum temperatures in the table below. The number of measurement points may vary with different thermal design and topology. Temperatures above maximum TP1, measured at the reference point P1 are not allowed and may cause permanent damage.

Position	Description	Max Temp.
P1	MOSFET case (reference point, open frame)	T_{P1}=125º C
P2	Capacitor (reference point, baseplate)	T_{P2}=120º C



Open frame (Top view)



Base plate (Bottom view)

Ambient Temperature Calculation

For products with base plate the maximum allowed ambient temperature can be calculated by using the thermal resistance.

1. The power loss is calculated by using the formula ((1/η) - 1) × output power = power losses (Pd).
η = efficiency of product. E.g. 98% = 0.98

2. Find the thermal resistance (Rth) in the Thermal Resistance graph found in the Output section for each model. Note that the thermal resistance can be reduced if a heat sink is mounted on the top of the base plate.

Calculate the temperature increase (□T).
ΔT = Rth x Pd

3. Max allowed ambient temperature is:
Max TP1 - ΔT .

E.g. BMR 310 0000 at 1.5m/s:

1. $((\frac{1}{0.94}) - 1) \times 520\ W = 12.8\ W$

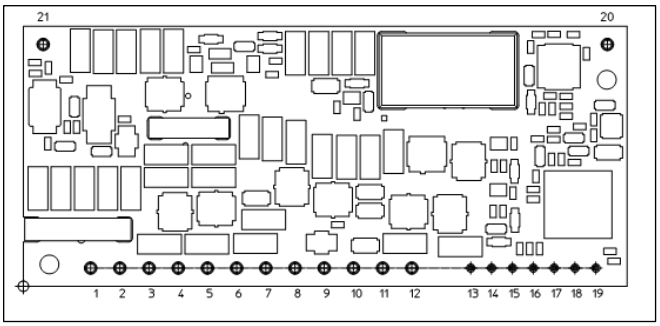
2. 12.8 W × 3.0°C/W = 38.4°C

3. 125 °C – 38.4°C = max ambient temperature is 86.6°C

4. The thermal performance can be improved by mounting a heat sink on top of the base plate.

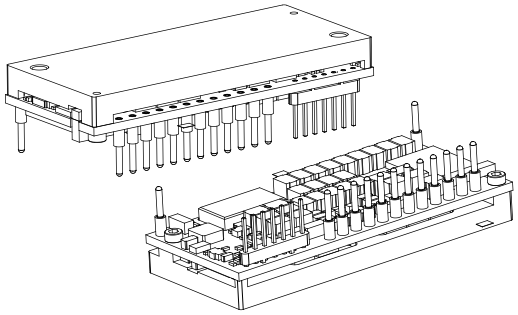
The actual temperature will be dependent on several factors such as the PWB size, number of layers and direction of airflow.

Connections (Top view)

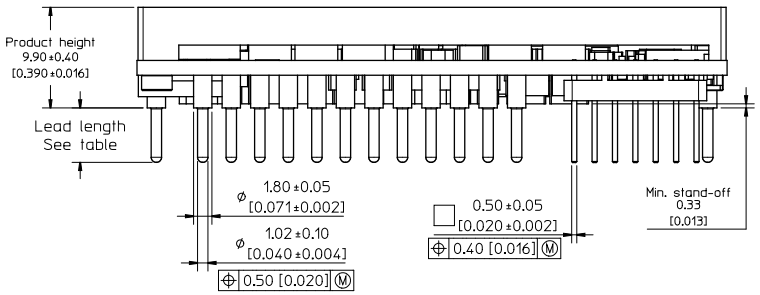


Pin	Designation	Function
1	+IN	Positive Input
2	+IN	Positive Input
3	GND	Power Ground
4	GND	Power Ground
5	GND	Power Ground
6	VOUT	Positive Output
7	GND	Power Ground
8	VOUT	Positive Output
9	GND	Power Ground
10	VOUT	Positive Output
11	GND	Power Ground
12	VOUT	Positive Output
13	PG	Power Good
14	DGND	Digital Ground
15	SDA	PMBus Data
16	ENABLE	Remote Control
17	SCL	PMBus Clock
18	SA1	PMBus Address 1
19	SA0	PMBus Address 0
20	Mechanical Pin	Support Pin
21	Mechanical Pin	Support Pin

Mechanical Information – Thru hole with baseplate version



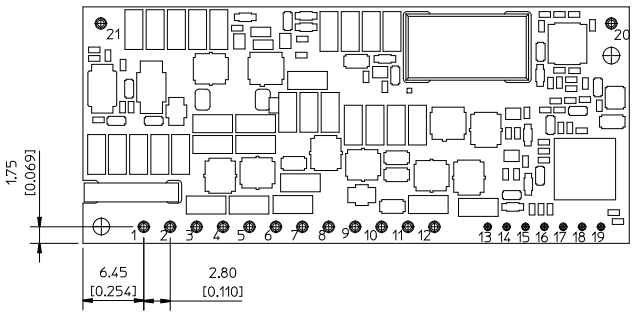
SIDE VIEW – WITH HEATSINK



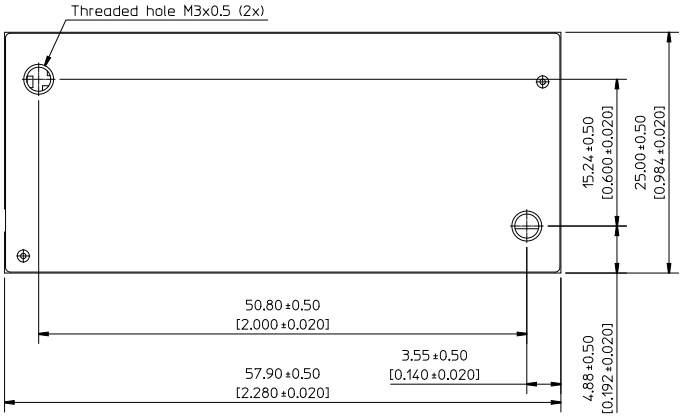
Pin option	Lead length
Standard	5.33 [0.210]
LA	3.69 [0.145]
LB	4.57 [0.180]
LC	2.79 [0.110]

Lead length table

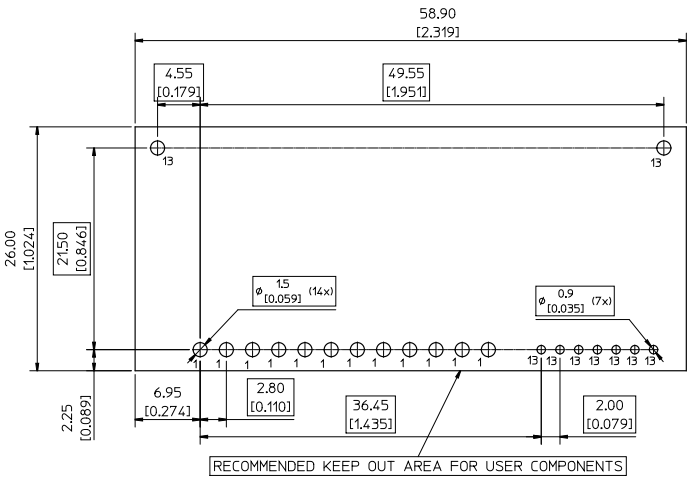
TOP VIEW – WITHOUT HEATSINK
PIN position according to recommended footprint



TOP VIEW – WITH HEATSINK



RECOMMENDED FOOTPRINT - TOP VIEW



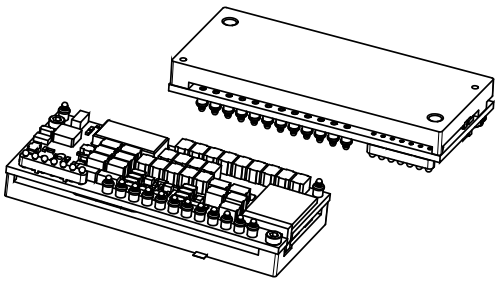
BASEPLATE INTERFACE
Material: Aluminum
For Screw attachment apply
mounting torque
of max 0.44Nm [3.9lbf in.] M3
Screw must not
protrude more than 2.7mm [0.106]
into the
base plate

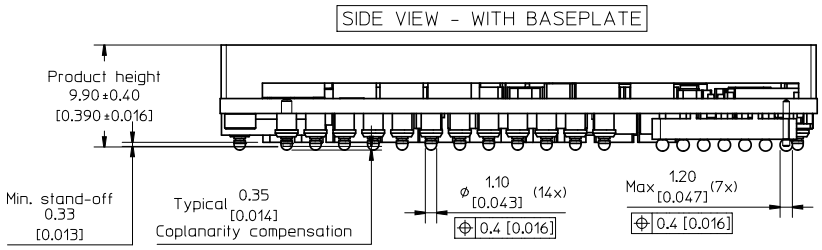
PIN SPECIFICATION
Pin 1-12, 20 & 21, Pin 13-19
Material: Copper alloy
Solder sphere: SAC305
Plating: Min 0,1µm Au over 2µm Ni

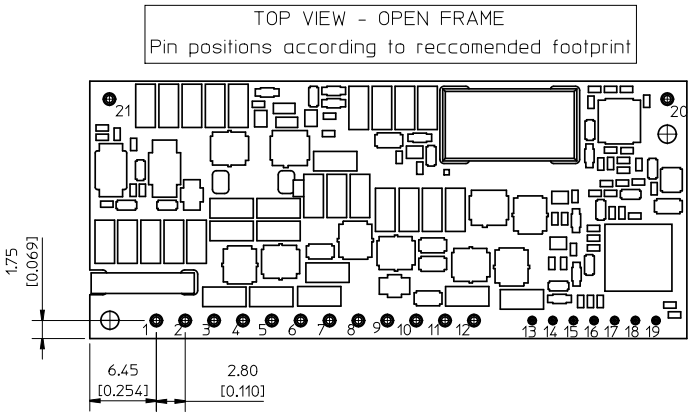
Weight: Typical 33 g
All dimensions in mm [inch].
Tolerances unless specified
x.x mm ±0.5 mm [0.02 in]
x.xx mm ±0.25 mm [0.01 in]
(not applied on footprint or
typical values)

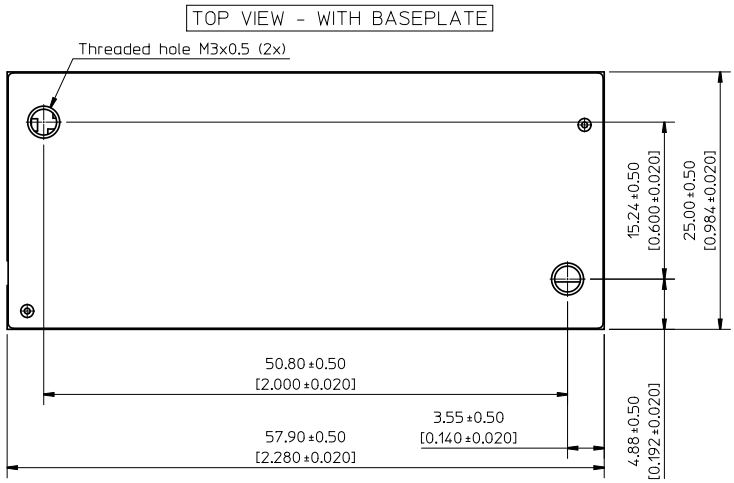
BMR310 series DC-DC Converters Input 40 - 60 V, Output up to 65A / 860 W	28701-BMR310 rev A April 2022 © Flex

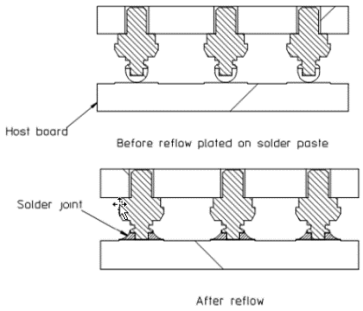
Mechanical Information – Surface mount with baseplate version

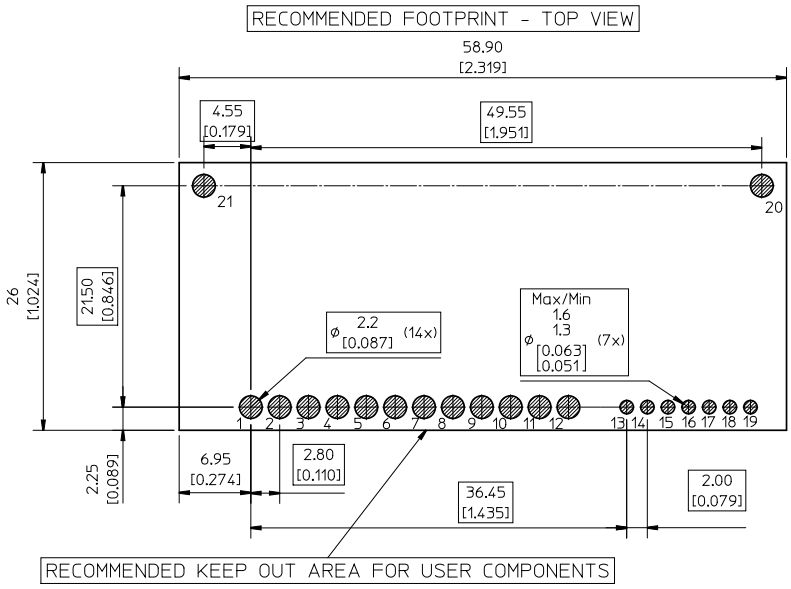












BASEPLATE INTERFACE
Material: Aluminium
For Screw attachemnt apply mounting torque of max 0.44Nm [3.9lbf in.] M3 Screw must not protrude more than 2.7mm [0.106] into the base plate

PIN SPECIFICATION
Pin 1-12, 20 & 21, Pin 13-19
Material: Copper alloy
Solder sphere: SAC305
Plating: Min 0,1µ Au over 2µ Ni

Weight: Typical 33 g
All dimensions in mm [inch].
Tolerances unless specified
x.x mm ±0.5 mm [0.02 in]
x.xx mm ±0.25 mm [0.01 in]
(not applied on footprint or typical values)

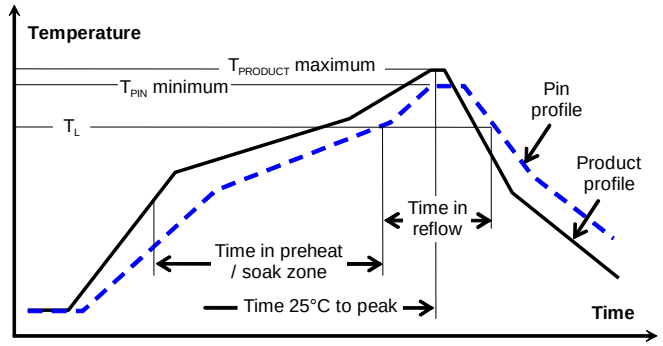
Soldering Information – Surface Mounting and Hole Mount through Pin in Paste Assembly

The surface mount product is intended for forced convection or vapor phase reflow soldering in Pb-free processes.

The reflow profile should be optimised to avoid excessive heating of the product. It is recommended to have a sufficiently extended preheat time to ensure an even temperature across the host PWB and it is also recommended to minimize the time in reflow.

A no-clean flux is recommended to avoid entrapment of cleaning fluids in cavities inside the product or between the product and the host board, since cleaning residues may affect long time reliability and isolation voltage.

General reflow process specifications		Pb-free
Average ramp-up ($T_{PRODUCT}$)		3°C/s max
Typical solder melting (liquidus) temperature	T_L	221°C
Minimum reflow time above T_L		60 s
Minimum pin temperature	T_{PIN}	235°C
Peak product temperature	$T_{PRODUCT}$	245°C
Average ramp-down ($T_{PRODUCT}$)		6°C/s max
Maximum time 25°C to peak		8 minutes



Thermocoupler Attachment

$T_{PRODUCT}$ is measured on the base plate top side, since this will likely be the warmest part of the product during the reflow process.
T_{PIN} temperature is measured on the power module pins solder joints at customer board

Product reflow classification

The product has been tested for the following:

Pb-free solder classification

For Pb-free solder processes, the product is qualified for MSL 3 according to IPC/JEDEC standard J-STD-020C

Product reflow processes

Lead-free (Pb-free) solder processes

For Pb-free solder processes, a pin temperature (T_{PIN}) in excess of the solder melting temperature (T_L, 217 to 221°C for SnAgCu solder alloys) for more than 30 seconds and a peak temperature of 235°C on all solder joints is recommended to ensure a reliable solder joint.

During reflow $T_{PRODUCT}$ must not exceed 245 °C at any time

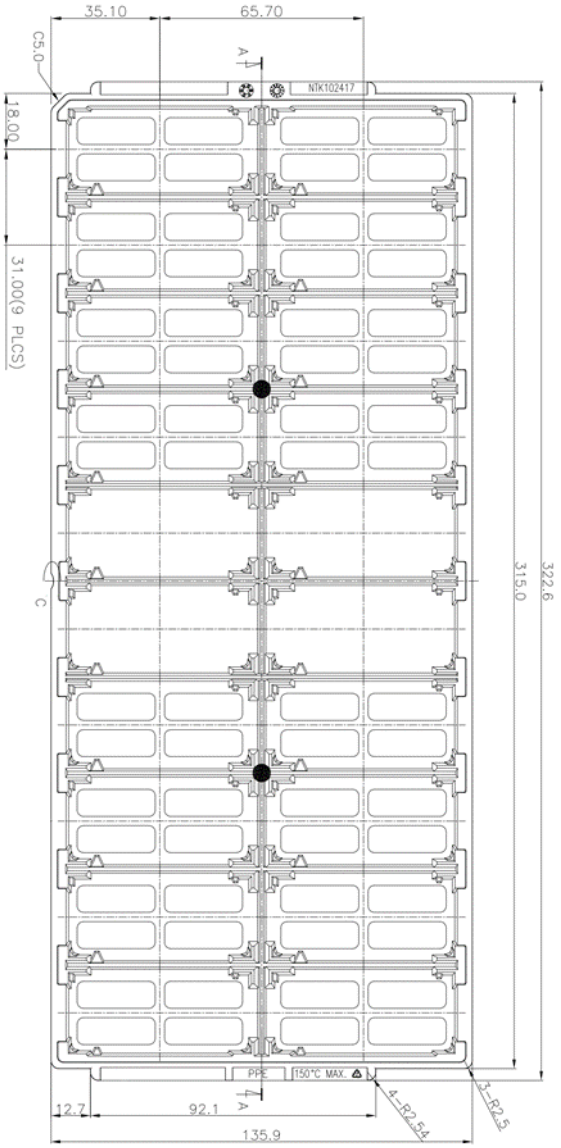
Dry Pack Information

Products intended for Pb-free reflow soldering processes are delivered in standard moisture barrier bags according to IPC/JEDEC standard J-STD-033 (Handling, packing, shipping and use of moisture/reflow sensitivity surface mount devices).

Using products in high temperature Pb-free soldering processes requires dry pack storage and handling. In case the products have been stored in an uncontrolled environment and no longer can be considered dry, the modules must be baked according to J-STD-033.

Delivery Package Information

Tray Specifications – SMD pins (dry pack)	
Material	Antistatic PPE
Surface resistance	10^5 < Ohm/square < 10^{10}
Bakeability	The trays can be baked at maximum 125°C for 48 hours
Tray capacity	20 products /tray
Box capacity	100 products (5 full trays + 1 empty tray /box)
Weight	206 g empty [4536 g full box]



Product Qualification Specification

Characteristics			
External visual inspection	IPC-A-610		
Change of temperature (Temperature cycling)	IEC 60068-2-14 Na	Temperature range Number of cycles Dwell/transfer time	-40 to 100°C 1000 15 min/0-1 min
Cold (in operation)	IEC 60068-2-1 Ad	Temperature T_A Duration	-45°C 72 h
Damp heat	IEC 60068-2-67 Cy	Temperature Humidity Duration	85°C 85 % RH 1000 hours
Dry heat	IEC 60068-2-2 Bd	Temperature Duration	125°C 1000 h
Electrostatic discharge susceptibility	IEC 61340-3-1, JESD 22-A114 IEC 61340-3-2, JESD 22-A115	Human body model (HBM) Machine Model (MM)	Class 2, 2000 V Class 3, 200 V
Immersion in cleaning solvents	IEC 60068-2-45 XA, method 2	Water Glycol ether Isopropyl alcohol	55°C 35°C 35°C
Mechanical shock	IEC 60068-2-27 Ea	Peak acceleration Duration	100 g 6 ms
Moisture reflow sensitivity	J-STD-020C	Level 3 (Pb Free)	260°C
Operational life test	MIL-STD-202G, method 108A	Duration	800 h
Robustness of terminations	IEC 60068-2-21 Test Ua1 IEC 60068-2-21 Test Ue1	Through hole mount products Surface mount products	All leads All leads
Solderability	IEC 60068-2-58 test Td	Preconditioning Temperature, SnPb Eutectic Temperature, Pb-free	150°C dry bake 16 h 215°C 235°C
Vibration, broad band random	IEC 60068-2-64 Fh, method 1	Frequency Spectral density Duration	10 to 500 Hz 0.07 g^2/Hz 10 min in each direction

Template for PMBus Command Appendix

This appendix contains a detailed reference of the PMBus commands supported by the product.

Data Formats
The products make use of a few standardized numerical formats, along with custom data formats. A detailed walkthrough of the above formats is provided in AN304, as well as in sections 7 and 8 of the PMBus Specification Part II. The custom data formats vary depending on the command, and are detailed in the command description.

Standard Commands
The functionality of commands with code 0x00 to 0xCF is usually based on the corresponding command specification provided in the PMBus Standard Specification Part II (see Power System Management Bus Protocol Documents below). However there might be different interpretations of the PMBus Standard Specification or only parts of the Standard Specification applied, thus the detailed command description below should always be consulted.

Forum Websites
The System Management Interface Forum (SMIF)
http://www.powersig.org/
The System Management Interface Forum (SMIF) supports the rapid advancement of an efficient and compatible technology base that promotes power management and systems technology implementations. The SMIF provides a membership path for any company or individual to be active participants in any or all of the various working groups established by the implementer forums.

Power Management Bus Implementers Forum
(PMBUS-IF)
http://pmbus.org/
The PMBus-IF supports the advancement and early adoption of the PMBus protocol for power management. This website offers recent PMBus specification documents, PMBus articles, as well as upcoming PMBus presentations and seminars, PMBus Document Review Board (DRB) meeting notes, and other PMBus related news.

PMBus – Power System Management Bus Protocol Documents
These specification documents may be obtained from the PMBus-IF website described above. These are required reading for complete understanding of the PMBus implementation. This appendix will not re-address all of the details contained within the two PMBus Specification documents.

Specification Part I – General Requirements Transport And Electrical Interface
Includes the general requirements, defines the transport and electrical interface and timing requirements of hard wired signals.

Specification Part II – Command Language
Describes the operation of commands, data formats, fault management and defines the command language used with the PMBus.

SMBus – System Management Bus Documents
System Management Bus Specification, Version 2.0, August 3, 2000
This specification specifies the version of the SMBus on which Revision 1.2 of the PMBus Specification is based. This specification is freely available from the System Management Interface Forum Web site at:
http://www.smbus.org/specs/

PMBus Command Summary and Factory Default Values of Standard Configuration

The factory default values provided in the table below are valid for the Standard configuration. Factory default values for other configurations can be found using the Flex Power Designer tool.

Code	Name	Data Format	Factory Default Value Standard Configuration BMR 310 4100 / 001	
0x01	OPERATION	R/W Byte	0x80	
0x02	ON_OFF_CONFIG	R/W Byte	0x1D	
0x03	CLEAR_FAULTS	Send Byte		
0x10	WRITE_PROTECT	R/W Byte	0x00	
0x11	STORE_DEFAULT_ALL	Send Byte		
0x12	RESTORE_DEFAULT_ALL	Send Byte		
0x15	STORE_USER_ALL	Send Byte		
0x16	RESTORE_USER_ALL	Send Byte		
0x19	CAPABILITY	Read Byte		
0x1B	SMBALERT_MASK (STATUS_VOUT)	SMBAlert Mask	0x6F	
0x1B	SMBALERT_MASK (STATUS_IOUT)	SMBAlert Mask	0x6F	
0x1B	SMBALERT_MASK (STATUS_INPUT)	SMBAlert Mask	0x6F	
0x1B	SMBALERT_MASK (STATUS_TEMPERATURE)	SMBAlert Mask	0x6F	
0x1B	SMBALERT_MASK (STATUS_CML)	SMBAlert Mask	0xFF	
0x20	VOUT_MODE	Read Byte	0x15	
0x2A	VOUT_SCALE_MONITOR	R/W Word	Unit Specific	
0x32	MAX_DUTY	Read Word	0xEAD3	90.4 %
0x33	FREQUENCY_SWITCH	Read Word	0x0258	600.0 kHz
0x35	VIN_ON	R/W Word	0x0022	34.0 V
0x36	VIN_OFF	R/W Word	0x0020	32.0 V
0x37	INTERLEAVE	R/W Word	0x0021	
0x39	IOUT_CAL_OFFSET	Read Word	Unit Specific	
0x40	VOUT_OV_FAULT_LIMIT	R/W Word	0x7CCC	15.6 V
0x41	VOUT_OV_FAULT_RESPONSE	R/W Byte	0xC0	
0x42	VOUT_OV_WARN_LIMIT	R/W Word	0x7800	15.0 V
0x43	VOUT_UV_WARN_LIMIT	R/W Word	0x3000	6.0 V
0x44	VOUT_UV_FAULT_LIMIT	R/W Word	0x2000	4.0 V
0x45	VOUT_UV_FAULT_RESPONSE	R/W Byte	0x00	
0x46	IOUT_OC_FAULT_LIMIT	R/W Word	0xEA80	80.0 A
0x47	IOUT_OC_FAULT_RESPONSE	R/W Byte	0x7B	
0x48	IOUT_OC_LV_FAULT_LIMIT	R/W Word	0x0400	0.5 V
0x4A	IOUT_OC_WARN_LIMIT	R/W Word	0x003C	60.0 A
0x4F	OT_FAULT_LIMIT	R/W Word	0x007D	125.0 °C
0x50	OT_FAULT_RESPONSE	R/W Byte	0xC0	
0x51	OT_WARN_LIMIT	R/W Word	0x0073	115.0 °C
0x52	UT_WARN_LIMIT	R/W Word	0xF418	-250.0 °C
0x53	UT_FAULT_LIMIT	R/W Word	0xF410	-252.0 °C
0x54	UT_FAULT_RESPONSE	R/W Byte	0x00	
0x55	VIN_OV_FAULT_LIMIT	R/W Word	0x0055	85.0 V
0x56	VIN_OV_FAULT_RESPONSE	R/W Byte	0xC0	
0x57	VIN_OV_WARN_LIMIT	R/W Word	0x0050	80.0 V
0x58	VIN_UV_WARN_LIMIT	R/W Word	0xE290	41.0 V
0x59	VIN_UV_FAULT_LIMIT	R/W Word	0xE250	37.0 V
0x5A	VIN_UV_FAULT_RESPONSE	R/W Byte	0xC0	
0x5E	POWER_GOOD_ON	R/W Word	0x4000	8.0 V
0x5F	POWER_GOOD_OFF	R/W Word	0x2800	5.0 V
0x60	TON_DELAY	R/W Word	0x0000	0.0 ms
0x61	TON_RISE	Read Word	0x000A	10.0 ms
0x62	TON_MAX_FAULT_LIMIT	R/W Word	0x001E	30.0 ms
0x63	TON_MAX_FAULT_RESPONSE	R/W Byte	0xC0	
0x64	TOFF_DELAY	R/W Word	0x0000	0.0 ms
0x65	TOFF_FALL	Read Word	0x0000	0.0 ms

Code	Name	Data Format	Factory Default Value Standard Configuration BMR 310 4100 / 001	
0x66	TOFF_MAX_WARN_LIMIT	R/W Word	0x000F	15.0 ms
0x78	STATUS_BYTE	Read Byte		
0x79	STATUS_WORD	Read Word		
0x7A	STATUS_VOUT	Read Byte		
0x7B	STATUS_IOUT	Read Byte		
0x7C	STATUS_INPUT	Read Byte		
0x7D	STATUS_TEMPERATURE	Read Byte		
0x7E	STATUS_CML	Read Byte		
0x7F	STATUS_OTHER	Read Byte		
0x80	STATUS_MFR_SPECIFIC	Read Byte		
0x88	READ_VIN	Read Word		
0x8B	READ_VOUT	Read Word		
0x8C	READ_IOUT	Read Word		
0x8D	READ_TEMPERATURE_1	Read Word		
0x8E	READ_TEMPERATURE_2	Read Word		
0x94	READ_DUTY_CYCLE	Read Word		
0x95	READ_FREQUENCY	Read Word		
0x98	PMBUS_REVISION	Read Byte		
0x99	MFR_ID	R/W Block12	Unit Specific	
0x9A	MFR_MODEL	R/W Block20	Unit Specific	
0x9B	MFR_REVISION	R/W Block12	Unit Specific	
0x9C	MFR_LOCATION	R/W Block12	Unit Specific	
0x9D	MFR_DATE	R/W Block12	Unit Specific	
0x9E	MFR_SERIAL	R/W Block20	Unit Specific	
0xAD	IC_DEVICE_ID	Read Block8		
0xAE	IC_DEVICE_REV	Read Block8		
0xB0	USER_DATA_00	R/W Block16	Unit Specific	
0xC4	MFR_VIN_OV_WARN_RESPONSE	R/W Byte	0x00	
0xC5	MFR_CONFIG_UNUSED_PINS	Read Word	0x0000	
0xC6	MFR_RC_LEVEL	Read Word		
0xC7	MFR_KS_PRETRIG	Read Word		
0xC8	MFR_FAST_VIN_OFF_OFFSET	R/W Byte	0x40	
0xC9	MFR_ADDRESS_TABLE	Read Block26	0xFF0FFF0FFF0FFF0FFF0FFF0F170C2 7087D05C2039E02CB010301	
0xD0	MFR_PGOOD_POLARITY	R/W Byte	0x00	
0xD1	MFR_FAST_OCP_CFG	R/W Word	0x04D0	80 level, 4 samples
0xD2	MFR_RESPONSE_UNIT_CFG	R/W Byte	0x55	
0xD3	MFR_VIN_SCALE_MONITOR	Read Block4	Unit Specific	
0xD4	MFR_PREBIAS_DVDT_CFG	R/W Block8	0x1E001E00F0040401	
0xD7	MFR_READ_EVENT	Read Block23		
0xD8	MFR_TEMP_COMPENSATION	Read Block8	0x009590008580007F	
0xD9	MFR_SET_ROM_MODE	Write Block4		
0xDA	MFR_ISHARE_THRESHOLD	R/W Block8	0x0000000000000000	
0xDB	MFR_EVENT_INDEX	R/W Byte		
0xDC	MFR_SELECT_TEMPERATURE_SENSOR	R/W Byte	0x01	
0xDD	MFR_VIN_OFFSET	Read Block4	Unit Specific	
0xDE	MFR_VOUT_OFFSET_MONITOR	Read Word	Unit Specific	
0xE0	MFR_SPECIAL_OPTIONS	R/W Byte	0x00	
0xE1	MFR_TEMP_OFFSET_INT	Read Word	Unit Specific	
0xE2	MFR_REMOTE_TEMP_CAL	Read Block4	Unit Specific	
0xE3	MFR_REMOTE_CTRL	R/W Byte	0x00	
0xE7	MFR_TEMP_COEFF	Read Block6	0x000000000000	
0xEA	MFR_IOUT_CAL_GAIN	Read Word	Unit Specific	
0xEC	MFR_ACTIVE_CLAMP	Read Word	0x4570	112 x4 ns, 69 x4 ns
0xED	MFR_ANALOG_DELAY_COMPENSATION	R/W Byte	0x00	0 ns
0xEE	MFR_OFFSET_ADDRESS	R/W Byte	0x00	0 n + SA0
0xF0	MFR_DEBUG_BUFF	R/W Block8		
0xF1	MFR_SETUP_PASSWORD	R/W Block12		

Code	Name	Data Format	Factory Default Value Standard Configuration BMR 310 4100 / 001	
0xF2	MFR_DISABLE_SECURITY_ONCE	R/W Block6		
0xF4	MFR_SECURITY_BIT_MASK	Read Block32		
0xF5	MFR_TRANSFORMER_TURN	Read Byte	0x41	
0xF6	MFR_OSC_TRIM	Read Byte	0x3F	
0xF8	MFR_ILIM_SOFTSTART	R/W Byte	0x14	20 %
0xF9	MFR_MULTI_PIN_CONFIG	R/W Word	0x0005	
0xFD	MFR_FIRMWARE_DATA	Read Block20		
0xFE	MFR_RESTART	Write Block4		

PMBus Command Details

OPERATION (0x01)
Description: Sets the desired PMBus enable and margin operations.

Bit	Function	Description	Value	Function	Description
7:6	Enable	Make the device enable or disable.	00	Immediate Off	Disable Immediately without sequencing.
			01	Soft Off	Disable "Softly" with sequencing.
			10	Enable	Enable device to the desired margin state.
5:4	Margin	Select between margin high/low states or nominal output.	00	Nominal	Operate at nominal output voltage.
			01	Margin Low	Operate at margin low voltage set in VOUT_MARGIN_LOW.
			10	Margin High	Operate at margin high voltage set in VOUT_MARGIN_HIGH.
3:2	Act on Fault	Set 10b to act on fault or set to 01b to ignore fault.	01	Ignore Faults	Ignore Faults when in a margined state. The device will ignore appropriate overvoltage/undervoltage warnings and faults and respond as programmed by the warning limit or fault response command.
			10	Act on Faults	Act on Faults when in a margined state. The device will handle appropriate overvoltage/undervoltage warnings and faults and respond as programmed by the warning limit or fault response command.

ON_OFF_CONFIG (0x02)
Description: Configures how the device is controlled by the CONTROL pin and the PMBus.

Bit	Function	Description	Value	Function	Description
4	Powerup Operation	Sets the default to either operate any time power is present or for the on/off to be controlled by CONTROL pin and serial bus commands.	0	Enable Always	Unit powers up any time power is present regardless of state of the CONTROL pin, taking the RC configuration into account, see command 0xE3.
			1	Enable pin or PMBus	Unit does not power up until commanded by the CONTROL pin and OPERATION command.
3	PMBus Enable Mode	Controls how the unit responds to commands received via the serial bus.	0	Ignore PMBus	Unit ignores the on/off portion of the OPERATION command from serial bus.
			1	Use PMBus	To start, the unit requires that the on/off portion of the OPERATION command is instructing the unit to run.
2	Enable Pin Mode	Controls how the unit responds to the CONTROL pin.	0	Ignore pin	Unit ignores the CONTROL/Enable pin.
			1	Use pin	Unit requires the CONTROL pin to be asserted to start the unit.
1	Enable Pin Polarity	Polarity of the CONTROL pin.	0	Active Low	Enable pin will cause device to enable when driven low.
			1	Active High	Enable pin will cause device to enable when driven high.

Bit	Function	Description	Value	Function	Description
0	Disable Action	CONTROL pin action when commanding the unit to turn off.	0	Soft Off	Use the programmed turn off delay and fall time.
			1	Imm. Off	Turn off the output and stop transferring energy to the output as fast as possible. The device's product literature shall specify whether or not the device sinks current to decrease the output voltage fall time.

CLEAR_FAULTS (0x03)
Description: Clears all fault status bits

WRITE_PROTECT (0x10)
Description: The WRITE_PROTECT command is used to control writing to the PMBus device. The intent of this command is to provide protection against accidental changes. This command is not intended to provide protection against deliberate or malicious changes to a device's configuration or operation.

Bit	Description	Value	Function	Description
7:0	All supported commands may have their parameters read, regardless of the WRITE_PROTECT settings.	0x80	Disable all writes	Disable all writes except to the WRITE_PROTECT command.
		0x40	Enable operation	Disable all writes except to the WRITE_PROTECT, OPERATION and PAGE commands.
		0x20	Enable control and Vout commands	Disable all writes except to the WRITE_PROTECT, OPERATION, PAGE, ON_OFF_CONFIG and VOUT_COMMAND commands.
		0x00	Enable all commands	Enable writes to all commands.

STORE_DEFAULT_ALL (0x11)
Description: Commands the device to store its configuration into the Default Store.

RESTORE_DEFAULT_ALL (0x12)
Description: Commands the device to restore its configuration from the Default Store.

STORE_USER_ALL (0x15)
Description: Stores, at the USER level, all PMBus values that were changed since the last restore command.

RESTORE_USER_ALL (0x16)
Description: Restores PMBus settings that were stored using STORE_USER_ALL. This command is automatically performed at power up.

CAPABILITY (0x19)
Description: This command provides a way for a host system to determine some key capabilities of a PMBus device.

Bit	Function	Description	Value	Function	Description
7	Packet Error Checking	Packet error checking.	00	Not Supported	Packet Error Checking not supported.
			01	Supported	Packet Error Checking is supported.
6:5	Maximum Bus Speed	Maximum bus speed.	00	100kHz	Maximum supported bus speed is 100 kHz.
			01	400kHz	Maximum supported bus speed is 400 kHz.
			11	1MHz	Maximum supported bus speed is 1 MHz.

Bit	Function	Description	Value	Function	Description
4	Smbalert	SMBALERT	00	No Smbalert	The device does not have a SMBALERT# pin and does not support the SMBus Alert Response protocol.
			01	Have Smbalert	The device does have a SMBALERT# pin and does support the SMBus Alert Response protocol.
3	Numeric Format	Numeric format.	0	LINEAR or DIRECT Format	Numeric data is in LINEAR or DIRECT format.
			1	IEEE Half Precision Floating Point Format	Numeric data is in IEEE half precision floating point format.
2	AVSBus Support	AVSBus support.	0	AVSBus Not Supported	AVSBus not supported.
			1	AVSBus Supported	AVSBus supported.

SMBALERT_MASK (0x1B)
Status Registers: STATUS_VOUT (0x7A), STATUS_IOUT (0x7B), STATUS_INPUT (0x7C), STATUS_TEMPERATURE (0x7D), STATUS_CML (0x7E)
Description: The SMBALERT_MASK command may be used to prevent a warning or fault condition from asserting the SALERT output signal.

Bit	Function	Description	Value	Function	Description
7	Mask Bit 7		0	Pull SALERT	
			1	Ignore	
6	Mask Bit 6		0	Pull SALERT	
			1	Ignore	
5	Mask Bit 5		0	Pull SALERT	
			1	Ignore	
4	Mask Bit 4		0	Pull SALERT	
			1	Ignore	
3	Mask Bit 3		0	Pull SALERT	
			1	Ignore	
2	Mask Bit 2		0	Pull SALERT	
			1	Ignore	
1	Mask Bit 1		0	Pull SALERT	
			1	Ignore	
0	Mask Bit 0		0	Pull SALERT	
			1	Ignore	

VOUT_MODE (0x20)
Description: Controls how future VOUT-related commands parameters will be interpreted.

Bit	Function	Description	Format
4:0		Five bit two's complement EXPONENT for the MANTISSA delivered as the data bytes for VOUT_COMMAND in VOUT_LINEAR Mode, five bit VID code identifier per in VID Mode or always set to 00000b in Direct Mode.	Integer Signed

Bit	Function	Description	Value	Function	Description
7:5		Set to 000b to select VOUT_LINEAR Mode (Five bit	000	Linear	Linear Mode Format.
			001	VID	VID Mode.

Bit	Function	Description	Value	Function	Description
		two's complement exponent for the MANTISSA delivered as the data bytes for an output voltage related command), set to 001b to select VID Mode (Five bit VID code identifier per) or set to 010b to select Direct Mode (Always set to 00000b).	010	Direct	Direct Mode.

VOUT_SCALE_MONITOR (0x2A)
Description: Normally there is a voltage divider in the voltage sense circuit. The scale factor is represented by VOUT_SCALE_MONITOR.

Bit	Description	Format
15:0	Normally there is a voltage divider in the voltage sense circuit. The scale factor is represented by VOUT_SCALE_MONITOR.	Direct

MAX_DUTY (0x32)
Description: Configures the maximum allowed duty-cycle.

Bit	Description	Format	Unit
15:0	Sets the maximum allowable duty cycle of the switching frequency.	Linear	%

FREQUENCY_SWITCH (0x33)
Description: Controls the switching frequency in 1kHz steps.

Bit	Description	Format	Unit
15:0	Sets the switching frequency.	Linear	kHz

VIN_ON (0x35)
Description: The VIN_ON command sets the value of the input voltage, in volts, at which the unit should start power conversion.

Bit	Description	Format	Unit
15:0	Sets the VIN ON threshold.	Linear	V

VIN_OFF (0x36)
Description: The VIN_OFF command sets the value of the input voltage, in volts, at which the unit, once operation has started, should stop power conversion.

Bit	Description	Format	Unit
15:0	Sets the VIN OFF threshold.	Linear	V

INTERLEAVE (0x37)
Description: Configures the phase offset with respect to a common SYNC clock. When multiple products share a common DC input supply, spreading of the switching phases between the products can be utilized. This reduces the input capacitance requirements and efficiency losses, since the peak current drawn from the input supply is effectively spread out over the whole switch period. If two or more units have their outputs connected in parallel, interleaving will reduce ripple currents. This requires that the products are synchronized using the SYNC pin.

Bit	Function	Description	Format
11:8	Group ID Number	Value 0-15. Sets an ID number to a group of interleaved rails.	Integer Unsigned
7:4	Number of Rails	Value 0-15. Sets the number of units in the group, including the SYNC OUT product.	Integer Unsigned
3:0	Rail Position	Value 0-15. Sets the interleave order for this unit. The product configured to SYNC OUT shall be assigned to number 0	Integer Unsigned

IOUT_CAL_OFFSET (0x39)
Description: Sets the current-sense offset.

Bit	Description	Format	Unit
15:0	Sets an offset to IOUT readings. Use to compensate for delayed measurements of current ramp.	Linear	A

VOUT_OV_FAULT_LIMIT (0x40)
Description: Output over voltage fault limit.

Bit	Description	Format	Unit
15:0	Output over voltage fault limit.	Vout Mode Unsigned	V

VOUT_OV_FAULT_RESPONSE (0x41)
Description: Output over voltage fault response.

Bit	Function	Description	Value	Function	Description
7:6	Response	Describes the device interruption operation. 00b - The PMBus device continues operation without interruption. 01b - The PMBus device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit responds as programmed in the Retry Setting (bits [5:3]). 10b - The device shuts down (disables the output) and responds according to the Retry Setting in bits [5:3]. 11b - The device's output is disabled while the fault is present. Operation resumes and the output is enabled when the fault condition no longer exists.	00	Ignore Fault	The PMBus device continues operation without interruption.
			01	Perform Retries while Operating	The PMBus device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit responds as programmed in the Retry Setting (bits [5:3]).
			10	Disable and retry	The device shuts down (disables the output) and responds according to the retry setting in bits [5:3].
			11	Disable until Fault Cleared	A fault can cleared in several ways: The bit is individually cleared, The device receives a CLEAR_FAULTS command, a RESET signal (if one exists) is asserted, the output is commanded through the CTRL pin, the OPERATION command, or the combined action of the CTRL pin and OPERATION command, to turn off and then to turn back on, or Bias power is removed from the PMBus device.
5:3	Retries	The device attempts to restart the number of times set by these bits. 000b means the device does not attempt a restart. 111b means the device attempts restarting continuously.	000	Do Not Retry	A zero value for the Retry Setting means that the unit does not attempt to restart. The output remains disabled until the fault is cleared (Section 10.7).
			001	Retry Once	The PMBus device attempts to restart 1 time. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.

Bit	Function	Description	Value	Function	Description
			010	Retry Twice	The PMBus device attempts to restart 2 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			011	Retry 3 times	The PMBus device attempts to restart 3 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			100	Retry 4 times	The PMBus device attempts to restart 4 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			101	Retry 5 times	The PMBus device attempts to restart 5 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			110	Retry 6 times	The PMBus device attempts to restart 6 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			111	Retry Continuously	The PMBus device attempts to restart continuously, without limitation, until it is commanded OFF (by the CONTROL pin or OPERATION command or both), bias power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	Number of delay time units. Used for either the amount of time the device is to continue operating after a fault is detected or for the	0	1	
			1	2	
			2	4	
			3	8	

Bit	Function	Description	Value	Function	Description
		amount of time between attempts to restart. The time unit is set in register 0xD2.	4	16	
			5	32	
			6	64	
			7	128	

VOUT_OV_WARN_LIMIT (0x42)
Description: Output over voltage warning limit.

Bit	Description	Format	Unit
15:0	Output over voltage warning limit.	Vout Mode Unsigned	V

VOUT_UV_WARN_LIMIT (0x43)
Description: Output under voltage warning limit.

Bit	Description	Format	Unit
15:0	Output under voltage warning limit.	Vout Mode Unsigned	V

VOUT_UV_FAULT_LIMIT (0x44)
Description: Output under voltage fault limit.

Bit	Description	Format	Unit
15:0	Output under voltage fault limit.	Vout Mode Unsigned	V

VOUT_UV_FAULT_RESPONSE (0x45)
Description: Output under voltage fault response.

Bit	Function	Description	Value	Function	Description
7:6	Response	Describes the device interruption operation. 00b - The PMBus device continues operation without interruption. 01b - The PMBus device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit responds as programmed in the Retry Setting (bits [5:3]). 10b - The device shuts down (disables the output) and responds according to the Retry Setting in bits [5:3]. 11b - The device's output is disabled while the fault is present. Operation resumes and the output is enabled when the fault condition no longer exists.	00	Ignore Fault	The PMBus device continues operation without interruption.
			01	Perform Retries while Operating	The PMBus device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit responds as programmed in the Retry Setting (bits [5:3]).
			10	Disable and retry	The device shuts down (disables the output) and responds according to the retry setting in bits [5:3].
			11	Disable until Fault Cleared	A fault can cleared in several ways: The bit is individually cleared, The device receives a CLEAR_FAULTS command, a RESET signal (if one exists) is asserted, the output is commanded through the CTRL pin, the OPERATION command, or the combined action of the CTRL pin and OPERATION command, to turn off and then to turn back on, or Bias power is removed from the PMBus device.

Bit	Function	Description	Value	Function	Description
5:3	Retries	The device attempts to restart the number of times set by these bits. 000b means the device does not attempt a restart. 111b means the device attempts restarting continuously.	000	Do Not Retry	A zero value for the Retry Setting means that the unit does not attempt to restart. The output remains disabled until the fault is cleared (Section 10.7).
			001	Retry Once	The PMBus device attempts to restart 1 time. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			010	Retry Twice	The PMBus device attempts to restart 2 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			011	Retry 3 times	The PMBus device attempts to restart 3 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			100	Retry 4 times	The PMBus device attempts to restart 4 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			101	Retry 5 times	The PMBus device attempts to restart 5 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.

Bit	Function	Description	Value	Function	Description
			110	Retry 6 times	The PMBus device attempts to restart 6 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			111	Retry Continuously	The PMBus device attempts to restart continuously, without limitation, until it is commanded OFF (by the CONTROL pin or OPERATION command or both), bias power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	Number of delay time units. Used for either the amount of time the device is to continue operating after a fault is detected or for the amount of time between attempts to restart. The time unit is set in register 0xD2.	0	1	
			1	2	
			2	4	
			3	8	
			4	16	
			5	32	
			6	64	
			7	128	

IOUT_OC_FAULT_LIMIT (0x46)
Description: Output over current limit.

Bit	Description	Format	Unit
15:0	Output over current fault limit.	Linear	A

IOUT_OC_FAULT_RESPONSE (0x47)
Description: Output over current fault response.

Bit	Function	Description	Value	Function	Description
7:6	Response	For all values of bits [7:6],the device: Sets the corresponding fault bit in the status registers and If the device supports notifying the host, it does so.	00	Ignore Fault	The PMBus device continues to operate indefinitely while maintaining the output current at the value set by IOUT_OC_FAULT_LIMIT without regard to the output voltage (known as constant-current or brickwall limiting).
			01	Conditioned constant current	The PMBus device continues to operate indefinitely while maintaining the output current at the value set by IOUT_OC_FAULT_LIMIT as long as the output voltage remains above the minimum value specified by IOUT_OC_LV_FAULT_LIMIT. If the output voltage is pulled down to less than that value, then the PMBus device shuts down and responds according to the Retry setting in bits [5:3].

Bit	Function	Description	Value	Function	Description
			10	Delay w/ Const. Current & Retry	The PMBus device continues to operate, maintaining the output current at the value set by IOUT_OC_FAULT_LIMIT without regard to the output voltage, for the delay time set by bits [2:0] and the delay time units for specified in the IOUT_OC_FAULT_RESPONSE. If the device is still operating in current limiting at the end of the delay time, the device responds as programmed by the Retry Setting in bits [5:3].
			11	Disable and Retry	The PMBus device shuts down and responds as programmed by the Retry Setting in bits [5:3].
5:3	Retries	The device attempts to restart the number of times set by these bits. 000b means the device does not attempt a restart. 111b means the device attempts restarting continuously.	000	Do Not Retry	A zero value for the Retry Setting means that the unit does not attempt to restart. The output remains disabled until the fault is cleared (Section 10.7).
			001	Retry Once	The PMBus device attempts to restart 1 time. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			010	Retry Twice	The PMBus device attempts to restart 2 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			011	Retry 3 times	The PMBus device attempts to restart 3 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			100	Retry 4 times	The PMBus device attempts to restart 4 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.

Bit	Function	Description	Value	Function	Description
			101	Retry 5 times	The PMBus device attempts to restart 5 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			110	Retry 6 times	The PMBus device attempts to restart 6 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			111	Retry Continuously	The PMBus device attempts to restart continuously, without limitation, until it is commanded OFF (by the CONTROL pin or OPERATION command or both), bias power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	Number of delay time units. Used for either the amount of time the device is to continue operating after a fault is detected or for the amount of time between attempts to restart. The time unit is set in register 0xD2.	0	1	
			1	2	
			2	4	
			3	8	
			4	16	
			5	32	
			6	64	
			7	128	

IOUT_OC_LV_FAULT_LIMIT (0x48)
Description: Set the output over-current low-voltage fault threshold.

Bit	Description	Format	Unit
15:0	Set the output over-current low-voltage fault threshold.	Vout Mode Unsigned	V

IOUT_OC_WARN_LIMIT (0x4A)
Description: Output over current warning limit.

Bit	Description	Format	Unit
15:0	Output over current warning limit.	Linear	A

OT_FAULT_LIMIT (0x4F)
Description: Over temperature fault limit.

Bit	Description	Format	Unit
15:0	Over temperature fault limit.	Linear	°C

OT_FAULT_RESPONSE (0x50)
Description: Over temperature fault response.

Bit	Function	Description	Value	Function	Description

Bit	Function	Description	Value	Function	Description
7:6	Response		00	Ignore Fault	The PMBus device continues operation without interruption.
			01	Perform Retries while Operating	The PMBus device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit responds as programmed in the Retry Setting (bits [5:3]).
			10	Disable and retry	The device shuts down (disables the output) and responds according to the retry setting in bits [5:3].
			11	Disable until Fault Cleared	A fault can cleared in several ways: The bit is individually cleared, The device receives a CLEAR_FAULTS command, a RESET signal (if one exists) is asserted, the output is commanded through the CTRL pin, the OPERATION command, or the combined action of the CTRL pin and OPERATION command, to turn off and then to turn back on, or Bias power is removed from the PMBus device.
5:3	Retries		000	Do Not Retry	A zero value for the Retry Setting means that the unit does not attempt to restart. The output remains disabled until the fault is cleared (Section 10.7).
			001	Retry Once	The PMBus device attempts to restart 1 time. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			010	Retry Twice	The PMBus device attempts to restart 2 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.

Bit	Function	Description	Value	Function	Description
			011	Retry 3 times	The PMBus device attempts to restart 3 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			100	Retry 4 times	The PMBus device attempts to restart 4 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			101	Retry 5 times	The PMBus device attempts to restart 5 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			110	Retry 6 times	The PMBus device attempts to restart 6 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			111	Retry Continuously	The PMBus device attempts to restart continuously, without limitation, until it is commanded OFF (by the CONTROL pin or OPERATION command or both), bias power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	Number of delay time units. Used for either the amount of time the device is to continue operating after a fault is detected or for the amount of time between attempts to restart. The time unit is set in register 0xD2.	0	1	
			1	2	
			2	4	
			3	8	
			4	16	
			5	32	
			6	64	
			7	128	

OT_WARN_LIMIT (0x51)
Description: Over temperature warning limit.

Bit	Description	Format	Unit
15:0	Over temperature warning limit.	Linear	°C

UT_WARN_LIMIT (0x52)
Description: Under temperature warning limit.

Bit	Description	Format	Unit
15:0	Under temperature warning limit.	Linear	°C

UT_FAULT_LIMIT (0x53)
Description: Under temperature fault limit.

Bit	Description	Format	Unit
15:0	Under temperature fault limit.	Linear	°C

UT_FAULT_RESPONSE (0x54)
Description: Under temperature fault response.

Bit	Function	Description	Value	Function	Description
7:6	Response		00	Ignore Fault	The PMBus device continues operation without interruption.
			01	Perform Retries while Operating	The PMBus device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit responds as programmed in the Retry Setting (bits [5:3]).
			10	Disable and retry	The device shuts down (disables the output) and responds according to the retry setting in bits [5:3].
			11	Disable until Fault Cleared	A fault can cleared in several ways: The bit is individually cleared, The device receives a CLEAR_FAULTS command, a RESET signal (if one exists) is asserted, the output is commanded through the CTRL pin, the OPERATION command, or the combined action of the CTRL pin and OPERATION command, to turn off and then to turn back on, or Bias power is removed from the PMBus device.
5:3	Retries		000	Do Not Retry	A zero value for the Retry Setting means that the unit does not attempt to restart. The output remains disabled until the fault is cleared (Section 10.7).
			001	Retry Once	The PMBus device attempts to restart 1 time. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.

Bit	Function	Description	Value	Function	Description
			010	Retry Twice	The PMBus device attempts to restart 2 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			011	Retry 3 times	The PMBus device attempts to restart 3 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			100	Retry 4 times	The PMBus device attempts to restart 4 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			101	Retry 5 times	The PMBus device attempts to restart 5 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			110	Retry 6 times	The PMBus device attempts to restart 6 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			111	Retry Continuously	The PMBus device attempts to restart continuously, without limitation, until it is commanded OFF (by the CONTROL pin or OPERATION command or both), bias power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	Number of delay time units. Used for either the amount of time the device is to continue operating after a fault is detected or for the	0	1	
			1	2	
			2	4	
			3	8	

Bit	Function	Description	Value	Function	Description
		amount of time between attempts to restart. The time unit is set in register 0xD2.	4	16	
			5	32	
			6	64	
			7	128	

VIN_OV_FAULT_LIMIT (0x55)
Description: Input over voltage fault limit.

Bit	Description	Format	Unit
15:0	Input over voltage fault limit.	Linear	V

VIN_OV_FAULT_RESPONSE (0x56)
Description: Input over voltage fault response.

Bit	Function	Description	Value	Function	Description
7:6	Response		00	Ignore Fault	The PMBus device continues operation without interruption.
			01	Perform Retries while Operating	The PMBus device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit responds as programmed in the Retry Setting (bits [5:3]).
			10	Disable and retry	The device shuts down (disables the output) and responds according to the retry setting in bits [5:3].
			11	Disable until Fault Cleared	A fault can cleared in several ways: The bit is individually cleared, The device receives a CLEAR_FAULTS command, a RESET signal (if one exists) is asserted, the output is commanded through the CTRL pin, the OPERATION command, or the combined action of the CTRL pin and OPERATION command, to turn off and then to turn back on, or Bias power is removed from the PMBus device.
5:3	Retries		000	Do Not Retry	A zero value for the Retry Setting means that the unit does not attempt to restart. The output remains disabled until the fault is cleared (Section 10.7).
			001	Retry Once	The PMBus device attempts to restart 1 time. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.

Bit	Function	Description	Value	Function	Description
			010	Retry Twice	The PMBus device attempts to restart 2 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			011	Retry 3 times	The PMBus device attempts to restart 3 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			100	Retry 4 times	The PMBus device attempts to restart 4 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			101	Retry 5 times	The PMBus device attempts to restart 5 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			110	Retry 6 times	The PMBus device attempts to restart 6 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			111	Retry Continuously	The PMBus device attempts to restart continuously, without limitation, until it is commanded OFF (by the CONTROL pin or OPERATION command or both), bias power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	Number of delay time units. Used for either the amount of time the device is to continue operating after a fault is detected or for the	0	1	
			1	2	
			2	4	
			3	8	

Bit	Function	Description	Value	Function	Description
		amount of time between attempts to restart. The time unit is set in register 0xD2.	4	16	
			5	32	
			6	64	
			7	128	

VIN_OV_WARN_LIMIT (0x57)
Description: Input over voltage warning limit.

Bit	Description	Format	Unit
15:0	Input over voltage warning limit.	Linear	V

VIN_UV_WARN_LIMIT (0x58)
Description: Input under voltage warning limit. This command set also the input voltage threshold for the HRR function (Hybrid Ratio Regulation). The HRR function is enabled with command MFR_SPECIAL_OPTIONS (0xE0).

Bit	Description	Format	Unit
15:0	Input under voltage warning limit and/or HRR threshold.	Linear	V

VIN_UV_FAULT_LIMIT (0x59)
Description: Input under voltage fault limit.

Bit	Description	Format	Unit
15:0	Input under voltage fault limit.	Linear	V

VIN_UV_FAULT_RESPONSE (0x5A)
Description: Input under voltage fault response.

Bit	Function	Description	Value	Function	Description
7:6	Response		00	Ignore Fault	The PMBus device continues operation without interruption.
			01	Perform Retries while Operating	The PMBus device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit responds as programmed in the Retry Setting (bits [5:3]).
			10	Disable and retry	The device shuts down (disables the output) and responds according to the retry setting in bits [5:3].
			11	Disable until Fault Cleared	A fault can cleared in several ways: The bit is individually cleared, The device receives a CLEAR_FAULTS command, a RESET signal (if one exists) is asserted, the output is commanded through the CTRL pin, the OPERATION command, or the combined action of the CTRL pin and OPERATION command, to turn off and then to turn back on, or Bias power is removed from the PMBus device.

Bit	Function	Description	Value	Function	Description
5:3	Retries		000	Do Not Retry	A zero value for the Retry Setting means that the unit does not attempt to restart. The output remains disabled until the fault is cleared (Section 10.7).
			001	Retry Once	The PMBus device attempts to restart 1 time. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			010	Retry Twice	The PMBus device attempts to restart 2 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			011	Retry 3 times	The PMBus device attempts to restart 3 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			100	Retry 4 times	The PMBus device attempts to restart 4 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			101	Retry 5 times	The PMBus device attempts to restart 5 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.

Bit	Function	Description	Value	Function	Description
			110	Retry 6 times	The PMBus device attempts to restart 6 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			111	Retry Continuously	The PMBus device attempts to restart continuously, without limitation, until it is commanded OFF (by the CONTROL pin or OPERATION command or both), bias power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	Number of delay time units. Used for either the amount of time the device is to continue operating after a fault is detected or for the amount of time between attempts to restart. The time unit is set in register 0xD2.	0	1	
			1	2	
			2	4	
			3	8	
			4	16	
			5	32	
			6	64	
			7	128	

POWER_GOOD_ON (0x5E)
Description: Sets the output voltage threshold for asserting PG (Power Good).

Bit	Description	Format	Unit
15:0	The POWER_GOOD_ON command sets the output voltage at which an optional POWER_GOOD signal should be asserted.	Vout Mode Unsigned	V

POWER_GOOD_OFF (0x5F)
Description: If the output voltage is lower than this one, negate power good if power good is enabled through MFR_MULTI_PIN_CONFIG and set the power good bit to 1 in PMBUS status.

Bit	Description	Format	Unit
15:0	If the output voltage is lower than this one, negate power good if power good is enabled through MFR_MULTI_PIN_CONFIG and set the power good bit to 1 in PMBUS status.	Vout Mode Unsigned	V

TON_DELAY (0x60)
Description: Sets the turn-on delay time

Bit	Description	Format	Unit
15:0	Sets the delay time from ENABLE to start of VOUT rise.	Linear	ms

TON_RISE (0x61)
Description: Sets the turn-on transition time.

Bit	Description	Format	Unit
15:0	Sets the rise time of VOUT after ENABLE and TON_DELAY.	Linear	ms

TON_MAX_FAULT_LIMIT (0x62)
Description: Sets an upper limit, in milliseconds, on how long the unit can attempt to power up the output without reaching the output undervoltage fault limit.

Bit	Description	Format	Unit

Bit	Description	Format	Unit
15:0	A value of 0 milliseconds means that there is no limit and that the unit can attempt to bring up the output voltage indefinitely.	Linear	ms

TON_MAX_FAULT_RESPONSE (0x63)
Description: Only some of the response types are supported.

Bit	Function	Description	Value	Function	Description
7:6	Response		00	Ignore Fault	The PMBus device continues operation without interruption.
			01	Perform Retries while Operating	The PMBus device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit responds as programmed in the Retry Setting (bits [5:3]).
			10	Disable and retry	The device shuts down (disables the output) and responds according to the retry setting in bits [5:3].
			11	Disable until Fault Cleared	A fault can cleared in several ways: The bit is individually cleared, The device receives a CLEAR_FAULTS command, a RESET signal (if one exists) is asserted, the output is commanded through the CTRL pin, the OPERATION command, or the combined action of the CTRL pin and OPERATION command, to turn off and then to turn back on, or Bias power is removed from the PMBus device.
5:3	Retries		000	Do Not Retry	A zero value for the Retry Setting means that the unit does not attempt to restart. The output remains disabled until the fault is cleared (Section 10.7).
			001	Retry Once	The PMBus device attempts to restart 1 time. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			010	Retry Twice	The PMBus device attempts to restart 2 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.

Bit	Function	Description	Value	Function	Description
			011	Retry 3 times	The PMBus device attempts to restart 3 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			100	Retry 4 times	The PMBus device attempts to restart 4 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			101	Retry 5 times	The PMBus device attempts to restart 5 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			110	Retry 6 times	The PMBus device attempts to restart 6 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			111	Retry Continuously	The PMBus device attempts to restart continuously, without limitation, until it is commanded OFF (by the CONTROL pin or OPERATION command or both), bias power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	Number of delay time units. Used for either the amount of time the device is to continue operating after a fault is detected or for the amount of time between attempts to restart. The time unit is set in register 0xD2. TON_MAX_FAULT_RESPONSE time unit is referenced to VOUT FAULT time unit.	0	1	
			1	2	
			2	4	
			3	8	
			4	16	
			5	32	
			6	64	
			7	128	

TOFF_DELAY (0x64)
Description: Sets the turn-off delay.

Bit	Description	Format	Unit
15:0	Sets the delay time from DISABLE to start of VOUT fall.	Linear	ms

TOFF_FALL (0x65)
Description: Sets the turn-off transition time.

Bit	Description	Format	Unit
15:0	Sets the fall time for VOUT after DISABLE and TOFF_DELAY.	Linear	ms

TOFF_MAX_WARN_LIMIT (0x66)
Description: Sets an upper limit, in milliseconds, on how long the unit can attempt to power down the output without reaching 12.5% of the output voltage programmed at the time the unit is turned off.

Bit	Description	Format	Unit
15:0		Linear	ms

STATUS_BYTE (0x78)
Description: Returns a brief fault/warning status byte.

Bit	Function	Description	Value	Description
6	Off	This bit is asserted if the unit is not providing power to the output, regardless of the reason, including simply not being enabled.	0	No fault
			1	Fault
5	Vout Overvoltage Fault	An output overvoltage fault has occurred.	0	No fault
			1	Fault
4	Iout Overcurrent Fault	An output overcurrent fault has occurred.	0	No fault
			1	Fault
3	Vin Undervoltage Fault	An input undervoltage fault has occurred.	0	No fault
			1	Fault
2	Temperature	A temperature fault or warning has occurred.	0	No fault
			1	Fault
1	Communication/Logic	A communications, memory or logic fault has occurred.	0	No fault
			1	Fault
0	None of the Above	A fault or warning not listed in bits [7:1] has occurred.	0	No fault
			1	Fault

STATUS_WORD (0x79)
Description: Returns an extended fault/warning status byte.

Bit	Function	Description	Value	Description
15	Vout	An output voltage fault or warning has occurred.	0	No fault
			1	Fault
14	Iout/Pout	An output current or output power fault or warning has occurred.	0	No Fault.
			1	Fault.
13	Input	An input voltage, input current, or input power fault or warning has occurred.	0	No Fault.
			1	Fault.
12	Mfr Specific	A manufacturer specific fault or warning has occurred.	0	No Fault.
			1	Fault.
11	Power-Good	The Power-Good signal, if present, is negated.	0	No Fault.
			1	Fault.
9	Other	A bit in Status-Other is set.	0	No Fault.
			1	Fault.
6	Off	This bit is asserted if the unit is not providing power to the output, regardless of the reason, including simply not being enabled.	0	No fault
			1	Fault
5	Vout Overvoltage Fault	An output overvoltage fault has occurred.	0	No Fault.
			1	Fault.
4	Iout Overcurrent Fault	An output overcurrent fault has occurred.	0	No Fault.
			1	Fault.
3	Vin Undervoltage	An input undervoltage fault has occurred.	0	No Fault.

Bit	Function	Description	Value	Description
	Fault		1	Fault.
2	Temperature	A temperature fault or warning has occurred.	0	No Fault.
			1	Fault.
1	Communication/Logic	A communications, memory or logic fault has occurred.	0	No fault.
			1	Fault.
0	None of the Above	A fault or warning not listed in bits [7:1] has occurred.	0	No fault.
			1	Fault.

STATUS_VOUT (0x7A)
Description: Returns Vout-related fault/warning status bits.

Bit	Function	Description	Value	Description
7	Vout Overvoltage Fault	Vout Overvoltage Fault.	0	No Fault.
			1	Fault.
6	Vout Overvoltage Warning	Vout Overvoltage Warning.	0	No Warning.
			1	Warning.
5	Vout Undervoltage Warning	Vout Undervoltage Warning.	0	No Warning.
			1	Warning.
4	Vout Undervoltage Fault	Vout Undervoltage Fault.	0	No Fault.
			1	Fault.
3	Vout Max Warning	Vout Max Warning (An attempt has been made to set the output voltage to value higher than allowed by the Vout Max command (Section 13.5).	0	No Warning.
			1	Warning.
2	Ton Max Fault	Ton-Max Fault.	0	No Fault
			1	Fault.
1	Toff Max Warning	Toff Max Warning.	0	No Warning.
			1	Warning.

STATUS_IOUT (0x7B)
Description: Returns Iout-related fault/warning status bits.

Bit	Function	Description	Value	Description
7	Iout Overcurrent Fault	Iout Overcurrent Fault.	0	No Fault.
			1	Fault.
6	Iout Overcurrent And Low Voltage Fault	Iout Overcurrent and low voltage fault.	0	No Fault.
			1	Fault.
5	Iout Over Current Warning	Iout Overcurrent Warning.	0	No Warning.
			1	Warning.
4	Iout Undercurrent Fault	Iout Undercurrent Fault.	0	No Fault.
			1	Fault.

STATUS_INPUT (0x7C)
Description: Returns VIN/IIN-related fault/warning status bits.

Bit	Function	Description	Value	Description
7	Vin Overvoltage Fault	Vin Overvoltage Fault.	0	No Fault.
			1	Fault.
6	Vin Overvoltage Warning	VIN Overvoltage Warning.	0	No Warning.
			1	Warning.
5	Vin Undervoltage Warning	Vin Undervoltage Warning.	0	No Warning.
			1	Warning.
4	Vin Undervoltage Fault	Vin Undervoltage Fault.	0	No Fault.
			1	Fault.
3	Insufficient Vin	Asserted when either the input voltage has never exceeded the input turn-on threshold Vin-On, or if the unit did start, the input voltage decreased below the turn-off threshold.	0	No Insufficient VIN encountered yet.
			1	Insufficient Unit is off.

STATUS_TEMPERATURE (0x7D)
Description: Returns the temperature-related fault/warning status bits

Bit	Function	Description	Value	Description
7	Overtemperature Fault	Overtemperature Fault.	0	No Fault.
			1	Fault.
6	Overtemperature Warning	Overtemperature Warning.	0	No Warning.
			1	Warning.
5	Undertemperature Warning	Undertemperature Warning.	0	No Warning.
			1	Warning.
4	Undertemperature Fault	Undertemperature Fault.	0	No Fault.
			1	Fault.

STATUS_CML (0x7E)
Description: Returns Communication/Logic/Memory-related fault/warning status bits.

Bit	Function	Description	Value	Description
7	Invalid Or Unsupported Command Received	Invalid Or Unsupported Command Received.	0	No Invalid Command Received.
			1	Invalid Command Received.
6	Invalid Or Unsupported Data Received	Invalid Or Unsupported Data Received.	0	No Invalid Data Received.
			1	Invalid Data Received.
5	Packet Error Check Failed	Packet Error Check Failed.	0	No Failure.
			1	Failure.
4	Memory Fault Detected	Memory Fault Detected.	0	No Fault.
			1	Fault.
1	Other Communication Fault	A communication fault other than the ones listed in this table has occurred.	0	No Fault.
			1	Fault.
0	Memory Or Logic Fault	Other Memory Or Logic Fault has occurred.	0	No Fault.
			1	Fault.

STATUS_OTHER (0x7F)
Description: Returns a brief other fault/warning status bits.

Bit	Description	Format
7:0	Sync in counter	Integer Unsigned

STATUS_MFR_SPECIFIC (0x80)
Description: Returns manufacturer specific status information.

Bit	Function	Description	Format
5:0	Power Cycle Fault Counter	Power cycle fault counter.	Integer Unsigned

Bit	Function	Description	Value	Description
7	Brown Out Detected	Brown out detected.	0	No Fault.
			1	Fault.

READ_VIN (0x88)
Description: Returns the measured input voltage.

Bit	Description	Format	Unit
15:0	Returns the input voltage reading.	Linear	V

READ_VOUT (0x8B)
Description: Returns the measured output voltage.

Bit	Description	Format	Unit
15:0	Returns the measured output voltage.	Vout Mode Unsigned	V

READ_IOUT (0x8C)
Description: Returns the measured output current.

Bit	Description	Format	Unit
15:0	The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.	Linear	A

READ_TEMPERATURE_1 (0x8D)
Description: Returns the measured temperature (internal).

Bit	Description	Format	Unit
15:0		Linear	°C

READ_TEMPERATURE_2 (0x8E)
Description: Returns the measured temperature (internal).

Bit	Description	Format	Unit
15:0		Linear	°C

READ_DUTY_CYCLE (0x94)
Description: Returns the measured duty cycle in percent.

Bit	Description	Format	Unit
15:0	Returns the target duty cycle during the ENABLE state. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.	Linear	%

READ_FREQUENCY (0x95)
Description: Returns the measured SYNC frequency.

Bit	Description	Format	Unit
15:0	Returns the measured operating switch frequency. The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.	Direct	kHz

PMBUS_REVISION (0x98)
Description: Returns the PMBus revision number for this device.

Bit	Function	Description	Value	Function	Description
7:4	Part I Revision	Part I Revision.	0x0	1.0	Part I Revision 1.0.
			0x1	1.1	Part I Revision 1.1.
			0x2	1.2	Part I Revision 1.2.
			0x3	1.3	Part I Revision 1.3.
3:0	Part II Revision	Part II Revision.	0x0	1.0	Part II Revision 1.0.
			0x1	1.1	Part II Revision 1.1.
			0x2	1.2	Part II Revision 1.2.
			0x3	1.3	Part II Revision 1.3.

MFR_ID (0x99)
Description: Sets the Manufacturers ID

Bit	Description	Format
95:0	Maximum of 12 characters.	ASCII

MFR_MODEL (0x9A)
Description: Sets the MFR MODEL string.

Bit	Description	Format
159:0	Maximum of 20 characters.	ASCII

MFR_REVISION (0x9B)
Description: Sets the MFR revision string.

Bit	Description	Format
95:0	Maximum of 12 characters.	ASCII

MFR_LOCATION (0x9C)
Description: Sets the MFR location string.

Bit	Description	Format
95:0	Maximum of 12 characters.	ASCII

MFR_DATE (0x9D)
Description: This command returns the date the regulator was manufactured.

Bit	Description	Format
95:0	Maximum of 12 characters.	ASCII

MFR_SERIAL (0x9E)
Description: This command returns a string of 13 characters and numbers that provides a unique identification of the regulator.

Bit	Description	Format
159:0	Maximum of 20 characters.	ASCII

IC_DEVICE_ID (0xAD)
Description:

Bit	Description	Format
63:0		ASCII fixed length

IC_DEVICE_REV (0xAE)
Description:

Bit	Description	Format
63:0		ASCII fixed length

USER_DATA_00 (0xB0)
Description: User data

Bit	Description	Format
127:0	16 bytes of user data.	ASCII

MFR_VIN_OV_WARN_RESPONSE (0xC4)
Description: Input over voltage Warn response.

Bit	Function	Description	Value	Function	Description
7:6	Response		00	Ignore Fault	The PMBus device continues operation without interruption.

Bit	Function	Description	Value	Function	Description
			01	Perform Retries while Operating	The PMBus device continues operation for the delay time specified by bits [2:0] and the delay time unit specified for that particular fault. If the fault condition is still present at the end of the delay time, the unit responds as programmed in the Retry Setting (bits [5:3]).
			10	Disable and retry	The device shuts down (disables the output) and responds according to the retry setting in bits [5:3].
			11	Disable until Fault Cleared	A fault can cleared in several ways: The bit is individually cleared, The device receives a CLEAR_FAULTS command, a RESET signal (if one exists) is asserted, the output is commanded through the CTRL pin, the OPERATION command, or the combined action of the CTRL pin and OPERATION command, to turn off and then to turn back on, or Bias power is removed from the PMBus device.
5:3	Retries		000	Do Not Retry	A zero value for the Retry Setting means that the unit does not attempt to restart. The output remains disabled until the fault is cleared (Section 10.7).
			001	Retry Once	The PMBus device attempts to restart 1 time. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			010	Retry Twice	The PMBus device attempts to restart 2 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			011	Retry 3 times	The PMBus device attempts to restart 3 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.

Bit	Function	Description	Value	Function	Description
			100	Retry 4 times	The PMBus device attempts to restart 4 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			101	Retry 5 times	The PMBus device attempts to restart 5 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			110	Retry 6 times	The PMBus device attempts to restart 6 times. If the device fails to restart, it disables the output and remains off until the fault is cleared as described in Section 10.7. The time between the start of each attempt to restart is set by the value in bits [2:] along with the delay time unit specified for that particular fault.
			111	Retry Continuously	The PMBus device attempts to restart continuously, without limitation, until it is commanded OFF (by the CONTROL pin or OPERATION command or both), bias power is removed, or another fault condition causes the unit to shut down.
2:0	Retry Time and Delay Time	Number of delay time units. Used for either the amount of time the device is to continue operating after a fault is detected or for the amount of time between attempts to restart. The time unit is set in register 0xD2.	0	1	
			1	2	
			2	4	
			3	8	
			4	16	
			5	32	
			6	64	
			7	128	

MFR_CONFIG_UNUSED_PINS (0xC5)
Description: Define if pins are used (0) or unused (1). MSB defines if unused pins should be configured as input (0) or output low(1). If an unused pin is defined as input the pin must be grounded. If an unused pin is not grounded it should be defined as output low (mainly for backward compatibility).

Bit	Function	Description	Value	Function	Description
15	Mfr. FAULT2_CONFIG	If an unused pin is defined as input the pin must be grounded, If an unused pin is not grounded it should be defined as output low.	0	INPUT	
			1	OUTPUT LOW	
14	Mfr. TMS_CONFIG	If an unused pin is defined as input the pin must be grounded, If an unused pin is not grounded it should be defined as output low.	0	INPUT	
			1	OUTPUT LOW	

Bit	Function	Description	Value	Function	Description
13	Mfr. TDI_CONFIG	If an unused pin is defined as input the pin must be grounded, If an unused pin is not grounded it should be defined as output low.	0	INPUT	
			1	OUTPUT LOW	
12	Mfr. TDO_CONFIG	If an unused pin is defined as input the pin must be grounded, If an unused pin is not grounded it should be defined as output low.	0	INPUT	
			1	OUTPUT LOW	
11	Mfr. DPWM3B_CONFIG	If an unused pin is defined as input the pin must be grounded, If an unused pin is not grounded it should be defined as output low.	0	INPUT	
			1	OUTPUT LOW	
10	Mfr. DPWM3A_CONFIG	If an unused pin is defined as input the pin must be grounded, If an unused pin is not grounded it should be defined as output low.	0	INPUT	
			1	OUTPUT LOW	
9	Mfr. DPWM2B_CONFIG	If an unused pin is defined as input the pin must be grounded, If an unused pin is not grounded it should be defined as output low.	0	INPUT	
			1	OUTPUT LOW	
8	Mfr. ADC_EXT_TRIG_CONFIG	If an unused pin is defined as input the pin must be grounded, if an unused pin is not grounded it should be defined as output low.	0	INPUT	
			1	OUTPUT LOW	
7	Mfr. Mfr. FAULT2_UTILIZATION	Define if pin is used or unused. Setting a pin to unused with this command overrides other configurations.	0	USED	
			1	UNUSED	
6	Mfr. Mfr. TMS_UTILIZATION	Define if pin is used or unused. Setting a pin to unused with this command overrides other configurations.	0	USED	
			1	UNUSED	
5	Mfr. Mfr. TDI_UTILIZATION	Define if pin is used or unused. Setting a pin to unused with this command overrides other configurations.	0	USED	
			1	UNUSED	
4	Mfr. Mfr. TDO_UTILIZATION	Define if pin is used or unused. Setting a pin to unused with this command overrides other configurations.	0	USED	
			1	UNUSED	
3	Mfr. Mfr. DPWM3B_UTILIZATION	Define if pin is used or unused. Setting a pin to unused with this command overrides other configurations.	0	USED	
			1	UNUSED	
2	Mfr. Mfr. DPWM3A_UTILIZATION	Define if pin is used or unused. Setting a pin to unused with this command overrides other configurations.	0	USED	
			1	UNUSED	
1	Mfr. Mfr. DPWM2B_UTILIZATION	Define if pin is used or unused. Setting a pin to unused with this command overrides other configurations.	0	USED	
			1	UNUSED	
0	Mfr. ADC_EXT_TRIG_UTILIZATION	Define if pin is used or unused. Setting a pin to unused with this command overrides other configurations.	0	USED	
			1	UNUSED	

MFR_RC_LEVEL (0xC6)
Description: Set the Remote control threshold when connected to AD03

Bit	Description	Format	Unit

Bit	Description	Format	Unit
7:0	Sets the level for triggering the Remote control.	Fixed Point Unsigned	V

MFR_KS_PRETRIG (0xC7)
Description: Value sets the time for pre-trigger a kickstart pulse. Value=0 equals approximately 20us, each unit adds 450ns to this value

Bit	Description	Format	Unit
7:0	Sets the time for pre-trigger a kickstart pulse. Value=0 equals approximately 20us, each unit adds 450ns to this value	Fixed Point Unsigned	us

MFR_FAST_VIN_OFF_OFFSET (0xC8)
Description: Adds an offset to the fast VinOff criteria. The offset value is referenced to VinOff value. This is to shut down the unit in a controlled fashion when Vin is falling fast.

Bit	Description	Format	Unit
7:0	Adds an offset to the fast VinOff criteria.	Fixed Point Unsigned	V

MFR_ADDRESS_TABLE (0xC9)
Description: Organized internally as 13 words, each word representing the ADC12 level threshold between address n and address n+1.

Bit	Description	Format
207:0	Use of 13 words permits 14 addresses; 0 to 13. In this case only pin SA0 is used. When the 8'th word (Data byte 15 & 16) is set to 0FFFh, only 8 levels per pin are used.	Byte Array

MFR_PGOOD_POLARITY (0xD0)
Description: Power good polarity (1:active high; 0: active low).

Bit	Description	Value	Function	Description
7:0	Power good polarity (1:active high; 0: active low).	0x00	Active Low	
		0x01	Active High	

MFR_FAST_OCP_CFG (0xD1)
Description: Set the fast OCP threshold

Bit	Function	Description	Format	Unit
12:8	OCP samples	Sets the Number of over current samples before trigger the OCP.	Integer Unsigned	samples
6:0	OCP level	Sets the level for triggering the fast OCP, resolution is in 128 divisions of 2.5V referenced to the maximum readout current.	Integer Unsigned	level

Bit	Function	Description	Value	Function	Description
7	Enable/Disable	Enable or disable Fast OCP	0	Disable	Disables Fast OCP
			1	Enable	Enables Fast OCP

MFR_RESPONSE_UNIT_CFG (0xD2)
Description: Defines the basic units 1ms, 10ms, 100ms or 1 sec for each of the four basic responses Vout, Vin, Iout and Temperature. The Configured time is calculated as: Configured time = (Retry Time and Delay Time value in specific Fault response) x (unit in 0xD2)

Bit	Function	Description	Value	Function	Description
7:6	VOUT response delay unit	Set the fault response delay unit according to configured delay time for	0	1 ms/unit	
			1	10 ms/unit	
			2	100 ms/unit	

Bit	Function	Description	Value	Function	Description
		VOUT_OV_FAULT_RESPONSE and VOUT_UV_FAULT_RESPONSE.	3	1 s/unit	
5:4	Vin response delay unit	Set the fault response delay unit according to configured delay time for VIN_OV_FAULT_RESPONSE and VIN_UV_FAULT_RESPONSE.	0	1 ms/unit	
			1	10 ms/unit	
			2	100 ms/unit	
			3	1 s/unit	
3:2	IOUT response delay unit	Set the fault response delay unit according to configured delay time for IOUT_OC_FAULT_RESPONSE and IOUT_OC_FAULT_RESPONSE.	0	1 ms/unit	
			1	10 ms/unit	
			2	100 ms/unit	
			3	1 s/unit	
1:0	Temperature response delay unit	Set the fault response delay unit according to configured delay time for OT_FAULT_RESPONSE and UT_FAULT_RESPONSE.	0	1 ms/unit	
			1	10 ms/unit	
			2	100 ms/unit	
			3	1 s/unit	

MFR_VIN_SCALE_MONITOR (0xD3)
Description: Vin Scale Monitor at ON and OFF.

Bit	Function	Description	Format
31:16	Mfr. Vin Scale Monitor on	Trimmed offset at ON	Byte Array
15:0	Mfr. Vin Scale Monitor Off	Trimmed Vin Scale at OFF	Byte Array

MFR_PREBIAS_DVDT_CFG (0xD4)
Description: Mfr. prebias dV/dt configuration

Bit	Function	Description	Format	Unit
63:48	Mfr. Maximum allowable positive dVin/dt	This value state the max positive Vin change limit to execute a pre-bias start.	Fixed Point Signed	V/ms
47:32	Mfr. Maximum allowable negative dVin/dt	This value state the max negative Vin change limit to execute a pre-bias start.	Fixed Point Signed	V/ms
31:16	Mfr. Maximum allowable positive dVout/dt	This value state the max positive Vout change limit to execute a pre-bias start.	Fixed Point Signed	V/ms
15:0	Mfr. Maximum allowable negative dVout/dt	This value state the max negative Vout change limit to execute a pre-bias start.	Fixed Point Signed	V/ms

MFR_READ_EVENT (0xD7)
Description: The command is prepared for reading the index that was written to MFR_EVENT_INDEX, is read as a 23-byte block. See MFR_EVENT_INDEX command for more details.

Bit	Function	Description	Format	Unit
183:168	Read Temperature		Linear	°C
167:152	Read Iout	The device will NACK this command when not enabled and not in the USER_CONFIG monitor mode.	Linear	A
151:136	Read Vout	Returns the measured output voltage.	Vout Mode Unsigned	V

Bit	Function	Description	Format	Unit
135:120	Read Vin	Returns the input voltage reading.	Linear	V
116:112	Power Cycle Fault Counter	Power cycle fault counter.	Integer Unsigned	
111:104	Sync In Counter	Sync in counter	Integer Unsigned	
47:16	EVENT Timestamp	Timestamp 100 ms resolution < 13.6 years.	Integer Unsigned	
15:0	Event ID	Event id < 2^16.	Integer Unsigned	

Bit	Function	Description	Value	Description
119	Brown Out Detected	Brown out detected.	0	No Fault.
			1	Fault.
103	Invalid Or Unsupported Command Received	Invalid Or Unsupported Command Received.	0	No Invalid Command Received.
			1	Invalid Command Received.
102	Invalid Or Unsupported Data Received	Invalid Or Unsupported Data Received.	0	No Invalid Data Received.
			1	Invalid Data Received.
101	Packet Error Check Failed	Packet Error Check Failed.	0	No Failure.
			1	Failure.
100	Memory Fault Detected	Memory Fault Detected.	0	No Fault.
			1	Fault.
97	Other Communication Fault	A communication fault other than the ones listed in this table has occurred.	0	No Fault.
			1	Fault.
96	Memory Or Logic Fault	Other Memory Or Logic Fault has occurred.	0	No Fault.
			1	Fault.
95	Overtemperature Fault	Overtemperature Fault.	0	No Fault.
			1	Fault.
94	Overtemperature Warning	Overtemperature Warning.	0	No Warning.
			1	Warning.
93	Undertemperature Warning	Undertemperature Warning.	0	No Warning.
			1	Warning.
92	Undertemperature Fault	Undertemperature Fault.	0	No Fault.
			1	Fault.
87	Vin Overvoltage Fault	Vin Overvoltage Fault.	0	No Fault.
			1	Fault.
86	Vin Overvoltage Warning	VIN Overvoltage Warning.	0	No Warning.
			1	Warning.
85	Vin Undervoltage Warning	Vin Undervoltage Warning.	0	No Warning.
			1	Warning.
84	Vin Undervoltage Fault	Vin Undervoltage Fault.	0	No Fault.
			1	Fault.
83	Insufficient Vin	Asserted when either the input voltage has never exceeded the input turn-on threshold Vin-On, or if the unit did start, the input voltage decreased below the turn-off threshold.	0	No Insufficient VIN encountered yet.
			1	Insufficient Unit is off.
79	Iout Overcurrent Fault	Iout Overcurrent Fault.	0	No Fault.
			1	Fault.
78	Iout Overcurrent And Low Voltage Fault	Iout Overcurrent and low voltage fault.	0	No Fault.
			1	Fault.
77	Iout Over Current Warning	Iout Overcurrent Warning.	0	No Warning.
			1	Warning.
76	Iout Undercurrent Fault	Iout Undercurrent Fault.	0	No Fault.
			1	Fault.
71	Vout Overvoltage Fault	Vout Overvoltage Fault.	0	No Fault.
			1	Fault.
70	Vout Overvoltage	Vout Overvoltage Warning.	0	No Warning.

Bit	Function	Description	Value	Description
	Warning		1	Warning.
69	Vout Undervoltage Warning	Vout Undervoltage Warning.	0	No Warning.
			1	Warning.
68	Vout Undervoltage Fault	Vout Undervoltage Fault.	0	No Fault.
			1	Fault.
67	Vout Max Warning	Vout Max Warning (An attempt has been made to set the output voltage to value higher than allowed by the Vout Max command (Section 13.5).	0	No Warning.
			1	Warning.
66	Ton Max Fault	Ton-Max Fault.	0	No Fault
			1	Fault.
65	Toff Max Warning	Toff Max Warning.	0	No Warning.
			1	Warning.
63	Vout	An output voltage fault or warning has occurred.	0	No fault
			1	Fault
62	Iout/Pout	An output current or output power fault or warning has occurred.	0	No Fault.
			1	Fault.
61	Input	An input voltage, input current, or input power fault or warning has occurred.	0	No Fault.
			1	Fault.
60	Mfr Specific	A manufacturer specific fault or warning has occurred.	0	No Fault.
			1	Fault.
59	Power-Good	The Power-Good signal, if present, is negated.	0	No Fault.
			1	Fault.
57	Other	A bit in Status-Other is set.	0	No Fault.
			1	Fault.
54	Off	This bit is asserted if the unit is not providing power to the output, regardless of the reason, including simply not being enabled.	0	No fault
			1	Fault
53	Vout Overvoltage Fault	An output overvoltage fault has occurred.	0	No Fault.
			1	Fault.
52	Iout Overcurrent Fault	An output overcurrent fault has occurred.	0	No Fault.
			1	Fault.
51	Vin Undervoltage Fault	An input undervoltage fault has occurred.	0	No Fault.
			1	Fault.
50	Temperature	A temperature fault or warning has occurred.	0	No Fault.
			1	Fault.
49	Communication/Logic	A communications, memory or logic fault has occurred.	0	No fault.
			1	Fault.
48	None of the Above	A fault or warning not listed in bits [7:1] has occurred.	0	No fault.
			1	Fault.

MFR_TEMP_COMPENSATION (0xD8)
Description: Mfr. temperature compensation parameter

Bit	Function	Description	Format
63:56	Mfr. Temperature compensation deadtime added 2	MFR_TEMP_COMPENSATION_DT_ADD_2 defines the additional dead time used at temperature levels below temperature threshold 2. Unit is nano seconds. It's an unsigned byte, meaning the value can be 0-255.	Byte Array
55:48	Mfr. Temperature compensation deadtime hysteresis 2	MFR_TEMP_COMPENSATION_DT_HYS_2 defines a level for hysteresis i.e. temperature must rise over this level again before dead times are changed.	Byte Array
47:40	Mfr. Temperature compensation deadtime threshold 2	It is a signed byte with the temperature as an integer (°C). This defines a second temperature level for temperature compensation of dead times.	Byte Array

Bit	Function	Description	Format
39:32	Mfr. Temperature compensation deadtime added 1	MFR_TEMP_COMPENSATION_DT_ADD_1 defines the additional dead time used at temperature levels below temperature threshold 1. Unit is nano seconds. It's an unsigned byte, meaning the value can be 0-255.	Byte Array
31:24	Mfr. Temperature compensation deadtime hysteresis 1	MFR_TEMP_COMPENSATION_DT_HYS_1 defines a level for hysteresis i.e. temperature must rise over this level again before dead times are changed.	Byte Array
23:16	Mfr. Temperature compensation deadtime threshold 1	It is a signed byte with the temperature as an integer (°C). This defines the first temperature level for temperature compensation of dead times.	Byte Array
15:8	Mfr. Temperature compensation EDAC slope	The second byte, TEMPERATURE_COMPENSATION_EDAC_SLOPE, sets the slope of the temperature compensation taking place above the EDAC_TEMP_COMP_TRESHOLD level. This is a signed byte in Q8 format. The unit is LSB/°C/256. Example: First byte represent 40°C so EDAC_TEMP_COMP_TRESHOLD = 40. Compensate EDAC with 25mV from 40°C to 120°C. The resolution is 1.6V/1024 = 1.56mV / LSB. To compensate for the 25mV droop over 80°C we need to add 25/80 = 0.3125mV/°C = 0.3125/1.56 LSB/°C = 0.2 LSB/°C to the reference DAC. 0.2*256 = 51 so EDAC_TEMP_COMP_SLOPE = 51	Byte Array
7:0	Mfr. Temperature compensation EDAC threshold	The first byte in the block is EDAC_TEMP_COMP_TRESHOLD. This defines the level where the temperature compensation shall begin. It is a signed byte with the temperature as an integer (°C). Example: First byte represents 40°C so EDAC_TEMP_COMP_TRESHOLD = 40. Compensate EDAC with 25mV from 40°C to 120°C. The resolution is 1.6V/1024 = 1.56mV / LSB. To compensate for the 25mV droop over 80°C we need to add 25/80 = 0.3125mV/°C = 0.3125/1.56 LSB/°C = 0.2 LSB/°C to the reference DAC. 0.2*256 = 51 so EDAC_TEMP_COMP_SLOPE = 51	Byte Array

MFR_SET_ROM_MODE (0xD9)
Description: Sends system into ROM mode. Issue this command before attempting to download new firmware to the controller.

Bit	Description	Format
31:0	Sends system into ROM mode. Issue this command before attempting to download new firmware to the controller.	ASCII

MFR_ISHARE_THRESHOLD (0xDA)
Description: Mfr. current sharing threshold level

Bit	Function	Description	Format	Unit
31:24	Trim limit	Set the trim limit for output voltage. This limit the output voltage to be trimmed to a certain level to prevent max-trim if the controller sense erroneous current.	Integer Unsigned	1.7mv /LSB
15:8	Positive threshold level	Set the threshold level where the output voltage is incremental trimmed to achieve current balance between paralleled devices. The threshold level represent at what current level the output voltage start increasing. The hysteresis where no current balancing through CTRL pin is done is between the positive and negative threshold levels.	Integer Unsigned	~50m A/LSB
7:0	Negative threshold level	Set the threshold level where the output voltage is decremental trimmed to achieve current balance between paralleled devices. The threshold level represent at what current level the output voltage start decreasing. The hysteresis where no current balancing through CTRL pin is done is between the positive and negative threshold levels.	Integer Unsigned	~50m A/LSB

Bit	Function	Description	Value	Function	Description
56	Enable/Disable	Enable or disable Active Current share	0	Disable	Disables active current share
			1	Enable	Enables active current share

MFR_EVENT_INDEX (0xDB)
Description: Writing to this command sets current index to read by the READ_EVENT command. It also provides means to clear the fault section of the event recorder and finding the newest event (equal to number of events stored in the event recorder). 0–47: same value as written. 254: Index of newest record in the life cycle section of the event recorder. 255: Index of newest record in the fault section of the event recorder. 0xAA: The fault section of the event recorder is cleared.

Bit	Description	Format
7:0	Offset value 0-47. 0 is always the oldest event in the fault section of the event recorder. 24 is the oldest event in the life cycle section.	Integer Unsigned

MFR_SELECT_TEMPERATURE_SENSOR (0xDC)
Description: Select which temperature sensor, internal one or external remote temperature sensor, is used.

Bit	Description	Value	Function	Description
0	Select which temperature sensor, internal one or external remote temperature sensor, is used.	0	Internal IC Sensor	Internal IC temperature sensor selected.
		1	External Sensor	External remote temperature sensor selected.

MFR_VIN_OFFSET (0xDD)
Description: Vin offset at ON and OFF.

Bit	Function	Description	Format
31:16	Mfr. Vin Offset on	Trimmed offset at ON	Byte Array
15:0	Mfr. Vin Offset off	Trimmed offset at OFF	Byte Array

MFR_VOUT_OFFSET_MONITOR (0xDE)
Description: Output voltage trim

Bit	Description	Format	Unit
15:0	Output voltage trim	Vout Mode Signed	V

MFR_SPECIAL_OPTIONS (0xE0)
Description: Special option configuration. Bit 0 - Reserved Bit 1 - Reserved Bit 2 - DBV: 0:Disabled 1:Enabled Bit 3 - ART/DLC: 0:Disabled 1:Enabled Bit 5 - DLS: 0:Linear droop 1:Non-linear droop Bit 6 - HRR: 0:Disabled 1:Enabled Bit 7 - Require PEC

Bit	Function	Description	Value	Function	Description
7	Require Packet Error Check	This bit makes PEC byte mandatory when writing to the unit. This increases system robustness since a master is required to provide a valid PEC byte for a write transaction to have effect.	0		PEC unrequired.
			1		PEC required.
6	Enable HRR, (Hybrid Regulated Ratio)	Enables the HRR, Hybrid Regulated Ratio. This enables the unit to have a duty cycle head room where max duty cycle is avoided. The output voltage will follow the input voltage ratio, below the HRR threshold set in command VIN_UV_WARN_LIMIT (0x58).	0		Disabled
			1		Enabled
5	DLS slope configuration	Setup how the slope of the Vout droop is configured, with linear or non-linear droop.	0	Linear droop	Configured with linear droop
			1	Non-linear droop	Configured with non-linear droop
3	Enable	Enables/Disables ART/DLC.	0		Disabled

Bit	Function	Description	Value	Function	Description
	ART/DLC, (Adaptive Ramp-up Time, Dynamic Load Compensation)		1		Enabled
2	Enable DBV, (Dynamic Bus Voltage)	Enables/Disables DBV.	0		Disabled
			1		Enabled

MFR_TEMP_OFFSET_INT (0xE1)
Description: Internal temperature offset.

Bit	Description	Format	Unit
15:0	Integer [0.1 °C]	Direct	°C

MFR_REMOTE_TEMP_CAL (0xE2)
Description: External temperature offset and slope.

Bit	Description	Format
31:0	T(C) = slope x ADC(v) + offset, Byte 0 byte 1: offset, Byte 2 byte 3: slope.	Byte Array

MFR_REMOTE_CTRL (0xE3)
Description: Primary Remote Control (RC pin) configuration.

Bit	Function	Description	Value	Function	Description
4	CTRL pin Interaction		0	OR'ed w/ CTRL pin	PriRC is OR:ed with OPERATION and CTRL pin.
			1	AND'ed w/ CTRL pin	PriRC is AND:ed with OPERATION and CTRL pin.
2	Remote CTRL pin Enabled	PriRC Pin Enable: 0:Disabled 1:Enabled	0	Disabled	
			1	Enabled	
1	Remote CTRL pin Polarity	PriRC Polarity: 0:Active High 1:Active Low	0	Active Low	
			1	Active High	
0	Remote Ctrl On/Off	Primary Remote Control (RC Pin) configuration. Bit 0 - PriRC Disable Mode: 0:Soft-Stop 1:Quick Off	0	Soft Stop	Pre-configured ramp down time set TOFF_FALL.
			1	Quick Off	Disables the output immediately.

MFR_TEMP_COEFF (0xE7)
Description: Temperature coefficient

Bit	Function	Description	Format	Unit
47:40	Mfr. Temp level 2 Comp Factor	The temperature compensation factor for current sense above temperature level 2, used to compensate IOUT_READ value.	Integer Unsigned	
39:32	Mfr. Temp level 2 Comp	The second temperature level used to compensate IOUT_READ.	Integer Unsigned	°C
31:24	Mfr. Temp level 1 Comp Factor	The temperature compensation factor for current sense above temperature level 1, used to compensate IOUT_READ value.	Integer Unsigned	
23:16	Mfr. Temp level 1 Comp	The first temperature level used to compensate IOUT_READ.	Integer Unsigned	°C
15:0	Mfr. Temp Coeff Cu	The temperature coefficient for copper.	Direct	

MFR_IOUT_CAL_GAIN (0xEA)
Description: The scale factor for output current measurement.

Bit	Description	Format
15:0	The scale factor for output current measurement.	Direct

MFR_ACTIVE_CLAMP (0xEC)
Description: Active clamp

Bit	Function	Description	Format	Unit
14:8	Mfr. pulse delay	Set the delay of the pulse to the active clamp.	Integer Unsigned	x4 ns
7:0	Mfr. pulse width	Set the pulse width to the active clamp.	Integer Unsigned	x4 ns

Bit	Function	Description	Value	Function	Description
15	Active Clamp mode	Set the mode of the active clamp, 1x frequency A and B output inverted outputs phase/2x frequency on A only non-inverted	0	1x frequency inverted	Set 1x frequency inverted
			1	2x frequency non-inverted	Set2x frequency non-inverted

MFR_ANALOG_DELAY_COMPENSATION (0xED)
Description: Compensate for the analog delay in the primary drivers.

Bit	Description	Format	Unit
7:0	Compensate for the analog delay in the primary drivers.	Integer Unsigned	ns

MFR_OFFSET_ADDRESS (0xEE)
Description: Value (n) add an offset to the address on SA0 pin. It can be used when pin when SA1 pin on the digital connector is used for synchronisation to be able to have more than 8 units on the same bus.

Bit	Description	Format	Unit
7:0		Integer Unsigned	n + SA0

MFR_DEBUG_BUFF (0xF0)
Description: Output contents in debug_buf.

Bit	Description	Format
63:0	Output contents in debug_buf.	Byte Array

MFR_SETUP_PASSWORD (0xF1)
Description: Once a valid new password is sent, the security is turned on.

Bit	Description	Format
95:0	A write is current password (6 bytes, default "000000000000") + new password (6 bytes) A read returns: 0x000000000000000000000000 if security is off 0x000000000000000000000001 if security is on 0x000000000000000000000002 if security setup is locked up due to incorrect password entry	ASCII

MFR_DISABLE_SECURITY_ONCE (0xF2)
Description: When security is on, this command is used to temporarily disable the security before the next power reset of the digital PWM controller so that a host can send any command that is either write-protected or sendbyte-protected based on a security bit mask. When security is off, this command will be NACKed.

Bit	Description	Format
47:0	A write is current password (after it was set up with MFR_SETUP_PASSWORD).	ASCII

MFR_SECURITY_BIT_MASK (0xF4)
Description: This command is used to individually enable or disable security feature for a write-protectable or sendbyte-protectable PMBUS command.

Bit	Description	Format
255:0	When protection is enabled for a PMBUS command and when security is on, the PMBUS command is write-protected or send- byte-protected.	Byte Array

MFR_TRANSFORMER_TURN (0xF5)
Description: Transformer turn ratio.

Bit	Function	Description	Format
7:4	Mfr. Primary Turn	Number of turn on the primary side of transformer.	Integer Unsigned
3:0	Mfr. secondary Turn	Number of turn on the secondary side of transformer.	Integer Unsigned

MFR_OSC_TRIM (0xF6)
Description: Internal clock frequency trim value

Bit	Description	Format
7:0	Internal clock frequency trim value.	Integer Unsigned

MFR_ILIM_SOFTSTART (0xF8)
Description: During soft start ILIM is more than the user setting. The value set in this command is in % added ILIM.

Bit	Description	Format	Unit
7:0		Integer Unsigned	%

MFR_MULTI_PIN_CONFIG (0xF9)
Description: The MFR_MULTI_PIN_CONFIG command can be re-configured to enable or disable different functions and set the pin configuration of the digital header (K400) (pin 6-15).

Bit	Function	Description	Value	Function	Description
9	SALERT as PG	Change function of Pin 12 on the digital header (K400). This pin can be used as PMBus alert signal or Power Good.	0	SALERT Normal	Pin 12 configured to be used as PMBus alert signal.
			1	SALERT as PG	Pin 12 configured to be used as Power Good.
8	PG/CTRL as PG	Change function of Pin 9 on the digital header (K400). This pin can be used as Power Good/SYNC or PMBus remote control or Current Share.	0	PG/CTRL Normal	Pin 9 configured to be used as PMBus remote control or Current Share.
			1	PG/CTRL as PG	Pin 9 configured to be used as Power Good.
7	Or PG with SALERT	Enable/Disable if Power Good shall include SALERT status whenever SALERT is set, regardless of the output voltage.	0	Disabled	
			1	Enabled	
6:5	Sync Mode	These bits enable or disable the SYNC function. When enabling choose between SYNC OUT or SYNC IN.	00	Disabled	
			01	Sync in	When the product is configured to SYNC in it will synchronize its switching frequency to the product configured as SYNC out. The switching phases can be spread individually using the INTERLEAVE command 0x37

Bit	Function	Description	Value	Function	Description
			10	Sync out	When the product is configured to SYNC out it will send out a SYNC signal that other modules can connect its SYNC in pin to. Only 1 product in a group can be configured to SYNC out.
4	SA1 as Sync	Change function of Pin 9 on the digital header (K400). This pin can be used as SA1 or SYNC in/out.	0	SA1 normal	Pin 9 configured to set the PMBus address with a resistor connected to pin 9
			1	SA1 as Sync	Pin 9 configured to be used as SYNC input/output
2	Power Good Enable	This bit enables or disables the Power Good function.	0	Disabled	
			1	Enabled	
1	Power Good Output	Two output options are available for Power Good output, they are Push/Pull or Open Drain.	0	Push/Pull	Power Good configured Push/Pull.
			1	Open Drain	Power Good configured Open Drain.
0	CTRL Internal Resistor	Using CTRL internal resistor can be useful if no external pull up or pull down resistor exist or no Digital header (K400) is mounted.	0	Disabled	
			1	Enabled	

MFR_FIRMWARE_DATA (0xFD)
Description: This is a 20-byte block that contains device ID and versions of the firmware.

Bit	Description	Format
159:0	This is a 20-byte block that contains device ID and versions of the firmware.	Byte Array

MFR_RESTART (0xFE)
Description: Writing the string “ERIC” to this command code forces the unit to restart.

Bit	Description	Format
31:0		ASCII