TDK·Lambda

Advance Product Data Sheet: iJB Series – Non Isolated Digital POL module

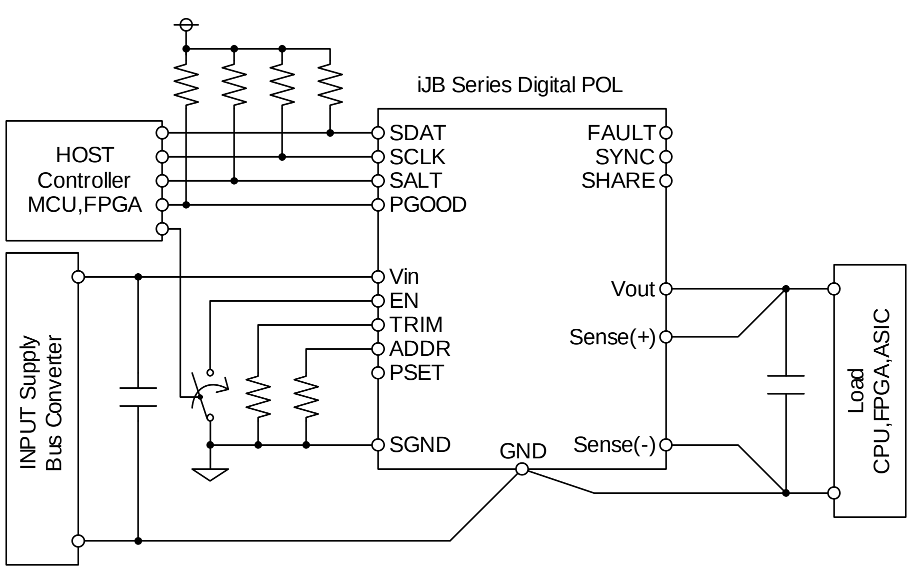
iJB Series DC/DC Power Modules
8.0V – 14.0V input, 60A Output
Surface Mount Power Module with PMBus™

iJB Power modules perform local voltage conversion from a bus voltage in the 12V range. The iJB12060A006V offers an extremely high power density and high operating efficiency from light to full load conditions.
iJB modules are PMBus compliant and digitally controlled, allowing for a great deal of flexibility and customization to end application's needs.
iJB modules support easy paralleling with interleaving for implementation in high current applications.

Features

- Only 1.0 in.[2] board space
  Size:26.80 x 24.08 x 9.50 [mm]
  (1.05 x 0.95 x 0.374 [inch])
- Surface mountable
- Ultra High Current Density , 60A / in.[2]
- Precision output voltage set point as good as 0.5%
- PMBus read and write compliant
- Negative logic on/off
- Power GOOD signal
- Adaptive Control allowed wide range of output capacitor
- Remote sense
- Parameter monitoring via PMBus
- Parallel operation with current sharing up to 100A
- Configurable sequence and Fault management
- Full, Auto-recovery protection
  - o UVLO
  - o Over Current Protection
  - o Over Voltage Protection
  - o Over Temperature Protection

Typical Application Circuit



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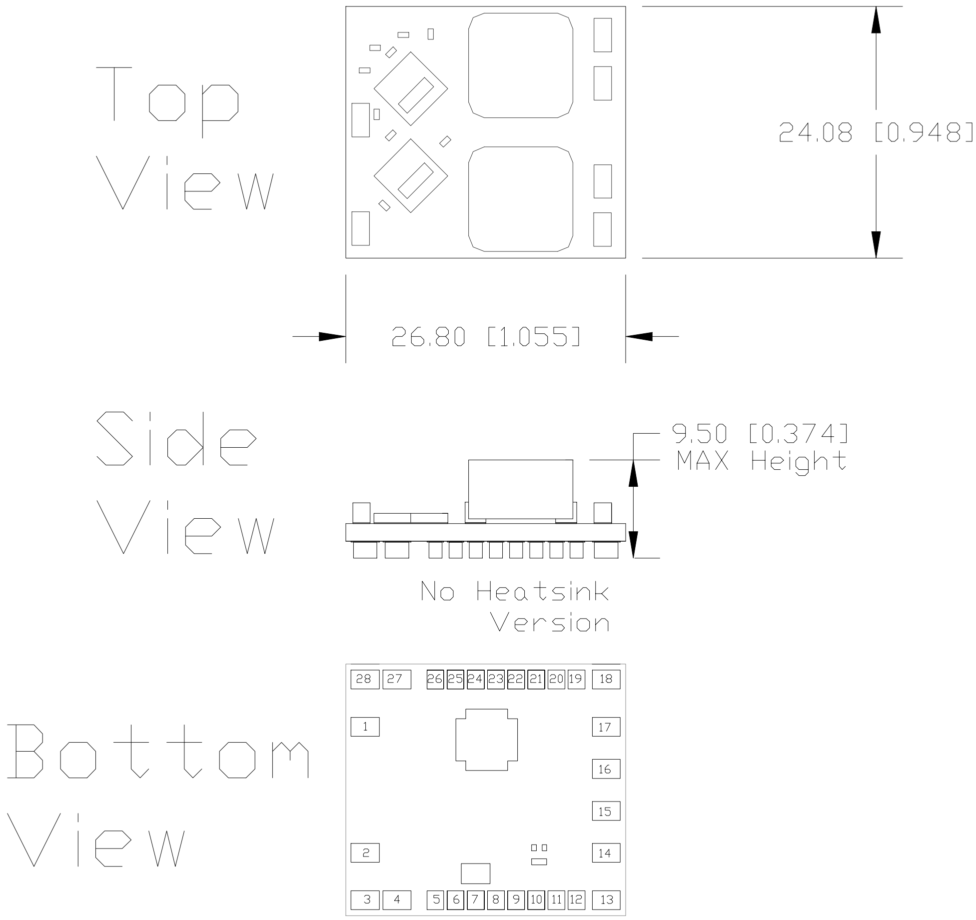
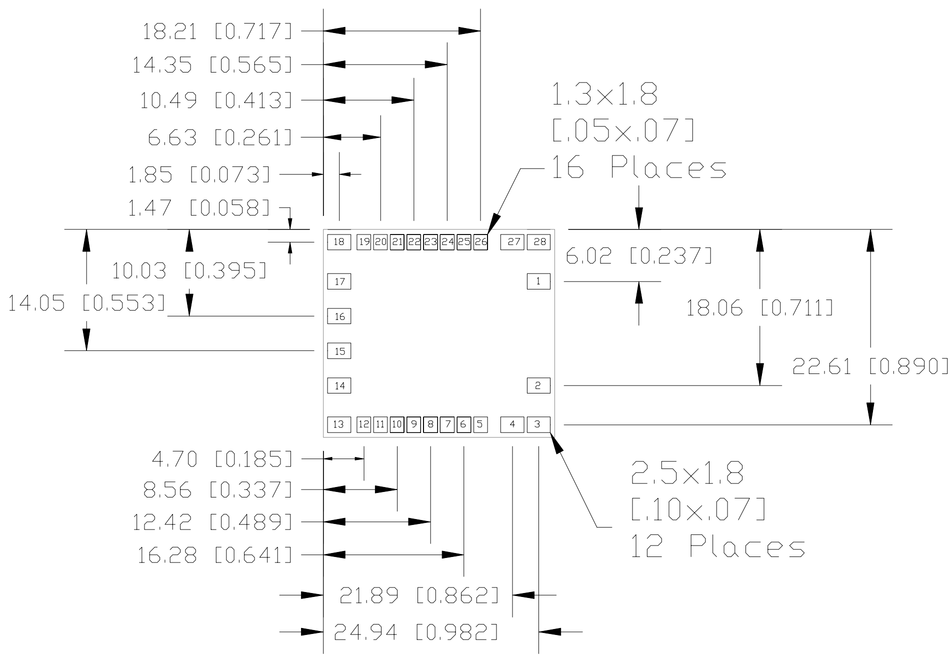
Mechanical Specification

Dimensions are in mm [inch]. Unless otherwise specified tolerance are x.x±0.5 [0.02], x.xx±0.25 [0.010]



Foot print and pin assignment (Top view)

Dimensions are in mm [inch]. Unless otherwise specified tolerance are x.x±0.5 [0.02], x.xx±0.25 [0.010]



Pin	Function	Note	Pin	Function	Note
1	Vin	Input Voltage	15	Vout	Output Voltage
2	Vin	Input Voltage	16	Vout	Output Voltage
3	GND	Power ground pin	17	Vout	Output Voltage
4	GND	Power ground pin	18	GND	Power ground pin
5	SGND	Signal ground pin	19	SCLK	PMBus
6	NC	Don't connect anywhere	20	SDAT	PMBus
7	TRIM	Set Output voltage	21	SALT	PMBus
8	ADDR	PMBus address	22	EN	Remote ON/OFF
9	NC	Don't connect anywhere	23	FAULT	Fault Management
10	PSET	Set Parallel operation mode	24	PGOOD	Power Good
11	SENSE(+)	Remote sense (+)	25	SHARE	Current Share on Parallel Operation
12	SENSE(-)	Remote sense (-)	26	SYNC	Synchronize on Parallel Operation
13	GND	Power ground pin	27	GND	Power Ground pin
14	Vout	Output Voltage	28	GND	Power Ground pin

See Feature descriptions for more detail

Supported Standard PMBus command

Functionality	Command	Code (Hex)	Read/ Write	Number of Byte	Coefficient (Decimal)
Control	OPERATION	01	R/W	1	N/A
	ON_OFF_CONFIG	02	R/W	1	N/A
Memory	STORE_DEFAULT_ALL*1	11	W	0	N/A
	RESTORE_DEFAULT_ALL	12	W	0	N/A
Output Voltage	VOUT_MODE	20	R	1	N/A
	VOUT_COMMAND	21	R/W	2	m=5120,R=b=0
	VOUT_TRIM	22	R/W	2	m=5120,R=b=0
	VOUT_MAX	24	R/W	2	m=5120,R=b=0
	VOUT_MARGIN_HIGH	25	R/W	2	m=5120,R=b=0
	VOUT_MARGIN_LOW	26	R/W	2	m=5120,R=b=0
	VOUT_TRANSITION_RATE	27	R/W	2	m=256,R=b=0
	VOUT_SCALE_LOOP	29	R/W	2	m=16384,R=b=0
	VOUT_SCALE_MONITOR	2A	R	2	m=16384,R=b=0
Fault Management	CLEAR_FAULT	03	W	0	N/A
	VIN_ON	35	R/W	2	m=1862,R=b=0
	VIN_OFF	36	R/W	2	m=1862,R=b=0
	VOUT_OV_FAULT_LIMIT	40	R/W	2	m=5120,R=b=0
	VOUT_UV_FAULT_LIMIT	44	R/W	2	m=5120,R=b=0
	IOUT_OC_FAULT_LIMIT	46	R/W	2	m=10.24,R=b=0
	OT_FAULT_LIMIT	4F	R/W	2	m=1,R=b=0
	OT_WARN_LIMIT	51	R/W	2	m=1,R=b=0
	UT_WARN_LIMIT	52	R/W	2	m=1,R=b=0
	UT_FAULT_LIMIT	53	R/W	2	m=1,R=b=0
	VIN_OV_FAULT_LIMIT	55	R/W	2	m=1862,R=b=0
Vout Sequencing	TON_DELAY	60	R/W	2	m=62.56,R=b=0
	TON_RISE	61	R/W	2	m=32,R=b=0
	TOFF_DELAY	64	R/W	2	m=62.56,R=b=0
Status	STATUS_BYTE	78	R	1	N/A
	STATUS_WORD	79	R	2	N/A
	STATUS_VOUT	7A	R	1	N/A
	STATUS_IOUT	7B	R	1	N/A
	STATUS_INPUT	7C	R	1	N/A
	STATUS_TEMPERATURE	7D	R	1	N/A
	STATUS_CML	7E	R	1	N/A
Telemetry	READ_VIN	88	R	2	m=1862,R=b=0
	READ_VOUT	8B	R	2	m=640,R=b=0
	READ_IOUT	8C	R	2	m=10.24,R=b=0
	READ_TEMPERATURE	8D	R	2	m=1,R=b=0
Security	PASSWORD	EA	W	2	N/A
	SECURITY_LEVEL	EB	R/W	1	N/A

*1 The “STORE_DEAFULT_ALL” command can be used 2 times to write to NVM before the memory used up. When using the “STORE_DEFAULT_ALL” command, please allow 3 seconds before powering down or the memory could be corrupted.

For more detail information about use of the supported PMBus commands please contact your TDK Lambda sales or technical support person.

Absolute Maximum Rating

Stress in excess of Absolute Maximum Rating may cause permanent damage to the device

Characteristic	Symbol	Min.	Max.	Unit	Note & Condition
Input Voltage	Vin	-0.3	16	V	Vin
Logic pin Voltage	Vlogic	-0.3	5.5	V	EN,FAULT,PGOOD,SCLK,SDAT,SALT
Operating Temperature range	Tc	-40	(120)*	°C	Maximum temperature as measured at the location specified in thermal measurement figure varies with output current. See curve in the thermal performance of the data sheet.
Storage Temperature	Tstg	-55	125	°C	

()*engineering estimate

Electrical specification

Unless otherwise specified, specifications apply over all rated Input Voltage, Resistive Load, and Temperature conditions.

Input Specification

Characteristic	Symbol	Min.	Typ.	Max.	Unit	Note & Condition
Operating Input Voltage	Vin	8.0	12.0	14.0	V	See "Static Characteristics" section for more detail
Maximum Input Current	Iin(max)			20	A	8Vin, 2.0Vo , Io = 60A
Turn-On Input Voltage(1)	Vin(on)		7.6		V	
Turn-Off Input Voltage(1)	Vin(off)		7.0		V	
Input Over Voltage Protection(1)	Vin(ov)		15.0		V	Vhys = 1.0V
Turn-On delay time from Vin(1)	Td(vin,on)		12		ms	Vo=0 to 0.1*Vo,set; on/off=on, Io=Io,max, Tc=25˚C
Turn-On delay time from EN(1)	Td(on)		2		ms	Vo=0 to 0.1*Vo,set; Vin=Vi,nom, Io=Io,max,Tc=25˚C
Output Rise time(1)	Trise		3		ms	Vo=0.1 to 0.9*Vo,set; Io=Io,max,Tc=25˚C,
Inrush Current	Irush			1.0	A^2s	
Input ripple rejection			50		dB	@120Hz

Note (1): User can change the value by PMBus command. Please contact TDK-Lambda for more detail

Caution: The power modules are not internally fused. An external input line normal blow fuse with a maximum value of 40A is required, see "Safety Considerations" section of the data sheet.

Output Specification

Characteristic	Symbol	Min.	Typ.	Max.	Unit	Note & Condition
Output Voltage Adjustment Range	Vout	0.6		2.0	V	Contact TDK Lambda if higher output voltage setting is required
Output Current	Iout	0		60	A	
Efficiency Vo = 0.6V Vo = 1.0V Vo = 1.5V Vo = 2.0V	Eff		85.0 89.5 92.0 93.0		%	12Vin, Io = 0.8*Iout(max), Tc = 25°C
Switching Frequency	fsw		375		kHz	fixed
Remote sense range			0.5	V		
Output Voltage Set point Accuracy	Vset	-0.5		0.5	%	0.6V ≤ Vset ≤ 1.2V and VOUT_SCALE_LOOP = 0x4000 Please see Output Voltage setting on “Operating Information” section for more detail.
Output Voltage Tolerance			(±1.2)*		%	
Load Regulation (Io = Io, min to Io, max)			4	(8)*	mV	
Line Regulation (Vin = Vin, min to Vin, max)			4	(8)*	mV	
Output Ripple and Noise			15		mVp-p	Cout = Cout(min) BW = 200MHz
Output Capacitance Range (Standard option)	Cout	500		5000	uF	Please contact TDK if higher capacitance is required. Be aware of bias voltage impact when using ceramic capacitors
Output Capacitance Range (enhanced option)	Cout	1000		5000	uF	
Output Voltage Set point Accuracy		-1.0		1.0	%	1.2V < Vset ≤ 2.0V and VOUT_SCALE_LOOP = 0x1249 Please see Output Voltage setting on “Operating Information” section for more detail.
Output Voltage Tolerance			(±1.5)*		%	
Load Regulation (Io = Io, min to Io, max)			8	(12)*	mV	
Line Regulation (Vin = Vin, min to Vin, max)			8	(12)*	mV	
Output Ripple and Noise			25		mVp-p	Cout = Cout(min) BW = 200MHz
Output Capacitance Range (standard option)	Cout	1000		5000	uF	Please contact TDK if higher capacitance is required Be aware of bias voltage impact when using ceramic capacitors
Output Capacitance Range (enhanced option)	Cout	1500		5000	uF	

()*engineering estimate

Feature Specification

Characteristic	Symbol	Min.	Typ.	Max.	Unit	Note & Condition
On/Off(1)	Ven(on)			0.8	V	Pulled up to 3.3V by 100kohm inside of the module. (see Feature description)
	Ven(off)	2.0			V	
Power Good range	Vpg		±12.5		%	
Over Current Protection Threshold(1)	Iocp		65		A	
Over Current Protection delay	Td(ocp)		1500		us	
Output Over Voltage Protection(1)	Vo(ov)		+20		%	
Over Temperature Warning(1)	Totw		125		°C	Configurable by PMBus command. SALT will be asserted but the module keeps running.
Under Temperature Warning(1)	Tutw		-40		°C	
Over Temperature Protection(1)	Totp		125		°C	Junction Temperature of the Control chip The hysteresis is 15°C (typ).
Critical Over Temperature Protection	Totp_crit		150		°C	Junction Temperature of the MOSFET If critical temperature is exceeded, the module will shut down and input power will need to be recycled in order to restart the module.

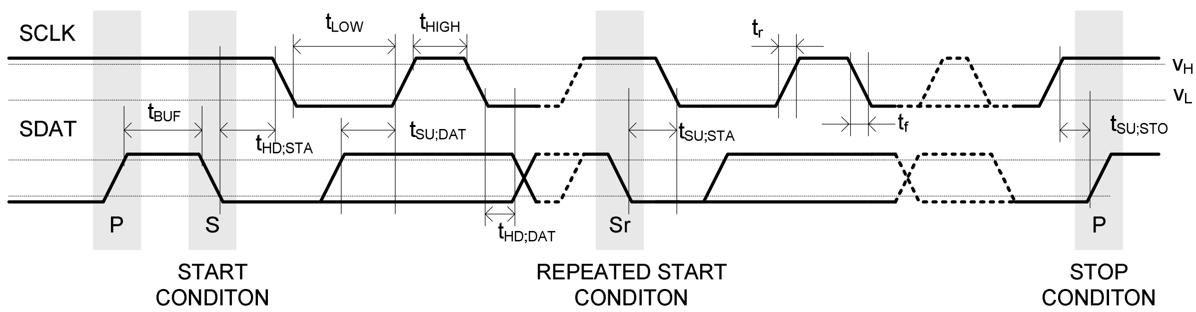
Note (1): User can change the value by PMBus command. Please contact TDK-Lambda for more detail

PMBus Monitoring accuracy

Characteristic	Symbol	Min.	Typ.	Max.	Unit	Note & Condition
Input Voltage Monitoring Accuracy	$Vin_{(PMB)}$	-2.0		2.0	%	1.0Vo, Io = 0.5*Iout(max), Tc = 25°C;
Output Voltage Monitoring Accuracy	$Vo_{(PMB)}$	1.5		1.5	%	12Vin, Io = 0.5*Iout(max), Tc = 25°C;
Output Current Monitoring Accuracy	$Io_{(PMB)}$	-5.0		5.0	%	12Vin, Io > 0.5*Iout(max), Tc = 25°C; Average of 100 readings
Temperature Monitoring Accuracy	$Tj_{(AMB)}$	(-5)		(5)	°C	Junction Temperature of the Control chip

()*engineering estimate

PMBus Timing characteristics



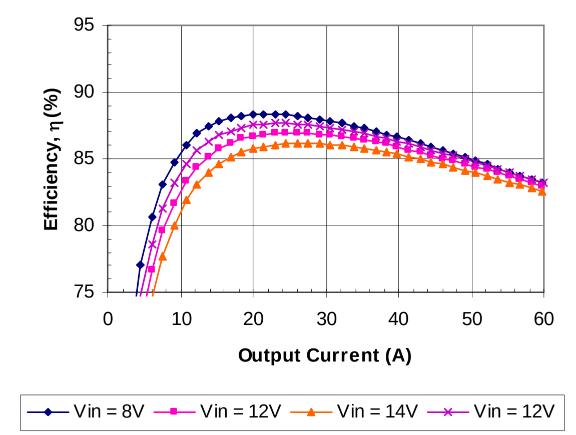
PMBus DC and Timing Characteristics

Characteristic	Symbol	Min.	Typ.	Max.	Unit	Note & Condition
Operating Frequency	f_{PMB}	10	100	400	kHz	
Input High Voltage	V_H	2.1			V	SCLK,SDAT
Input Low Voltage	V_L			0.8	V	SCLK,SDAT
Sink current	$I_{S,PMB}$	4			mA	SDAT,SALT current sinking capability
Pin Capacitance	C_{PMB}			10	pF	
Bus Free Time	t_{BUF}	1.3			us	Between Stop and Start Condition
Hold Time	$t_{HD;STA}$	0.6		50	us	Wait time after Start Condition
Repeated Start Condition Setup Time	$t_{SU;STA}$	0.6		50	us	Wait time after Repeated Start Condition
Stop Condition Setup Time	$t_{SU;STO}$	0.6		50	us	
Data Setup Time	$t_{SU;DAT}$	100			ns	
Data Hold Time	$t_{HD;DAT}$	300			ns	
Clock Low Period	t_{LOW}	1.3			us	
Clock High Period	t_{HIGH}	0.6		50	us	
Clock/Data Rise Time	t_R	20		300	ns	
Clock/Data Fall Time	t_F	20		300	ns	

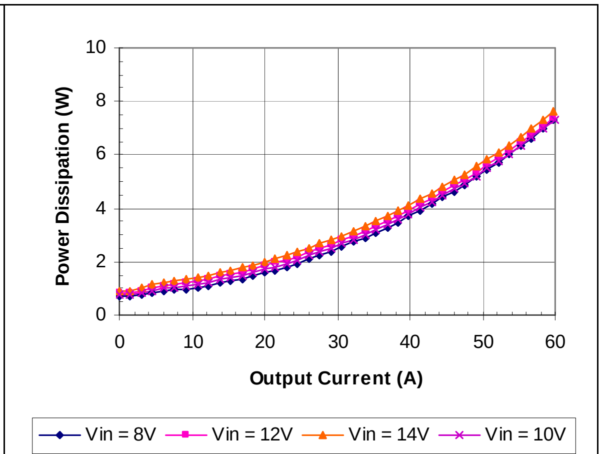
These specs are guaranteed by design. Not production test

Static Characteristics

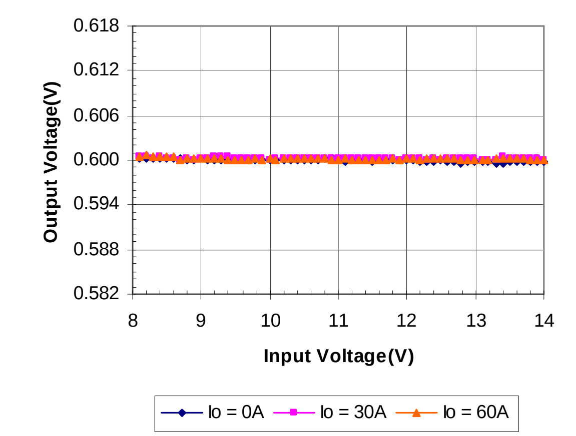
Static Characteristics 0.6V (R_{TRIM} = 10.0kΩ)



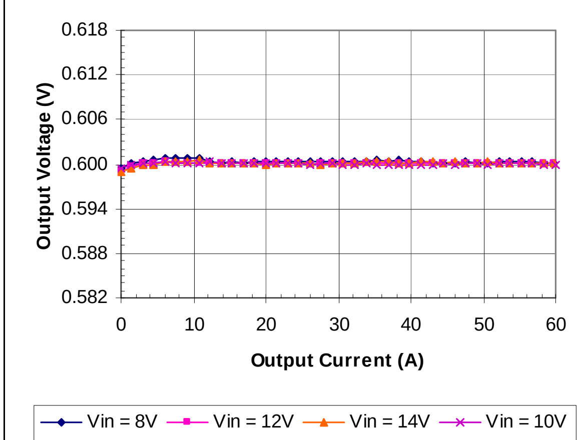
Typical Efficiency vs. Input Voltage
Vout = 0.6V, Ta = 25°C



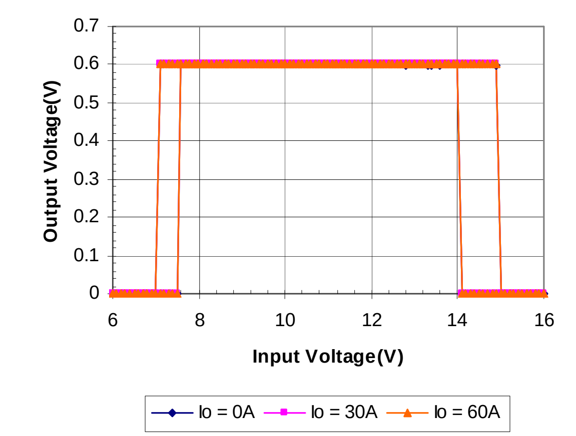
Typical Power Dissipation vs. Input Voltage
Vout = 0.6V, Ta = 25°C



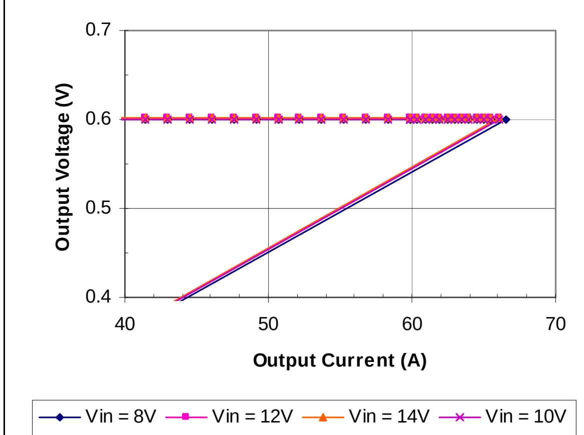
Typical Line Regulation
Vout = 0.6V, Ta = 25°C



Typical Load Regulation
Vout = 0.6V, Ta = 25°C

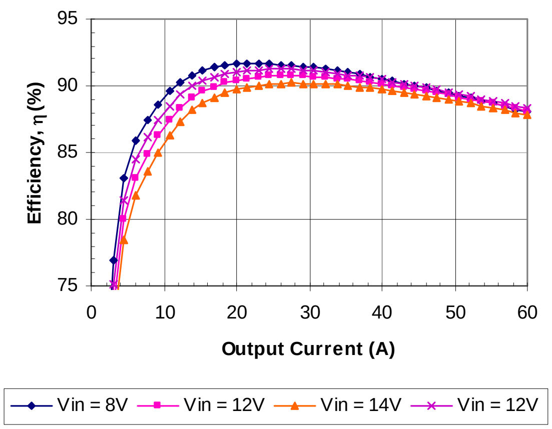


Typical Output Voltage vs. Input Voltage Characteristic
Vout = 0.6V, Ta = 25°C

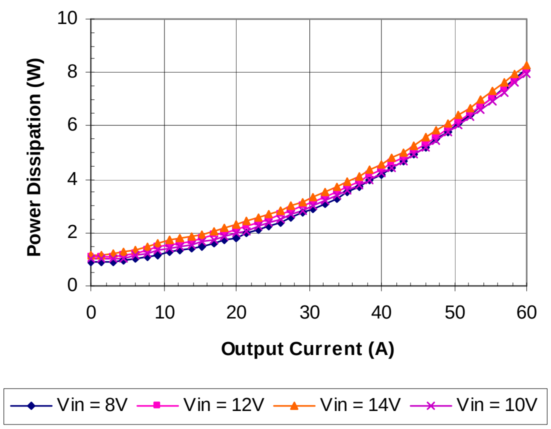


Typical Current Limit Characteristic
Vout = 0.6V, Ta = 25°C

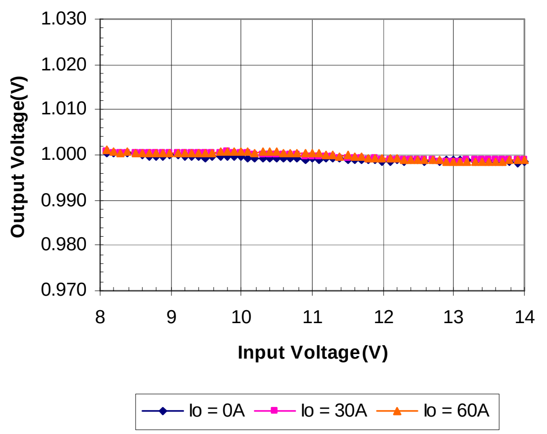
Static Characteristics 1.0V (R_{TRIM} = 52.3kΩ)



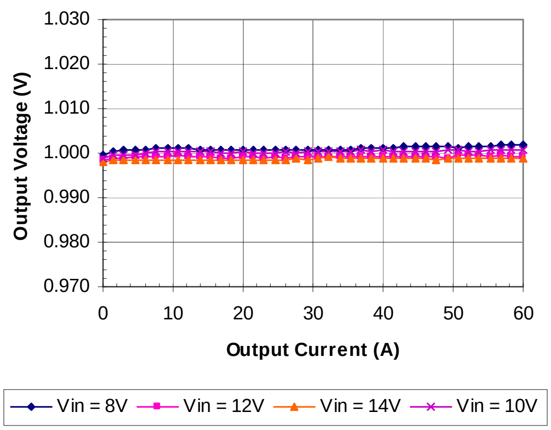
Typical Efficiency vs. Input Voltage
Vout = 1.0V, Ta = 25°C



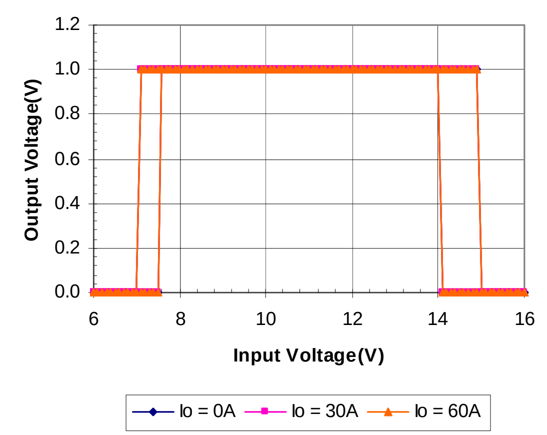
Typical Power Dissipation vs. Input Voltage
Vout = 1.0V, Ta = 25°C



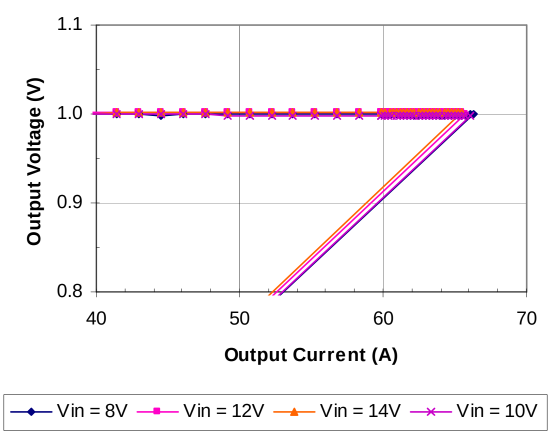
Typical Line Regulation
Vout = 1.0V, Ta = 25°C



Typical Load Regulation
Vout = 1.0V, Ta = 25°C

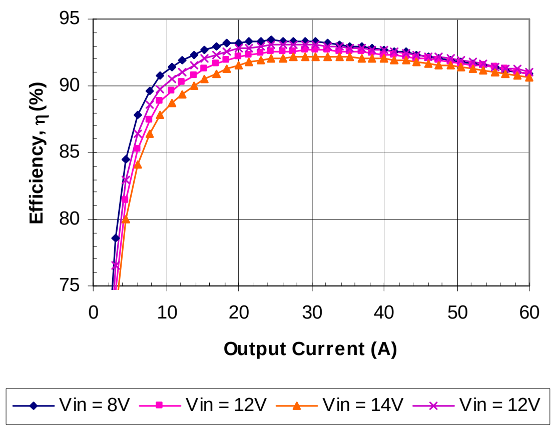


Typical Output Voltage vs. Input Voltage Characteristic
Vout = 1.0V, Ta = 25°C

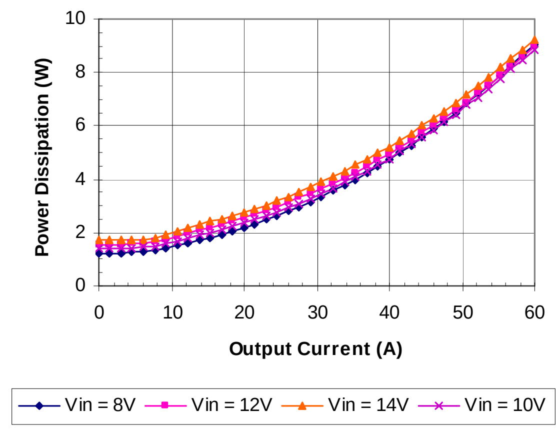


Typical Current Limit Characteristic
Vout = 1.0V, Ta = 25°C

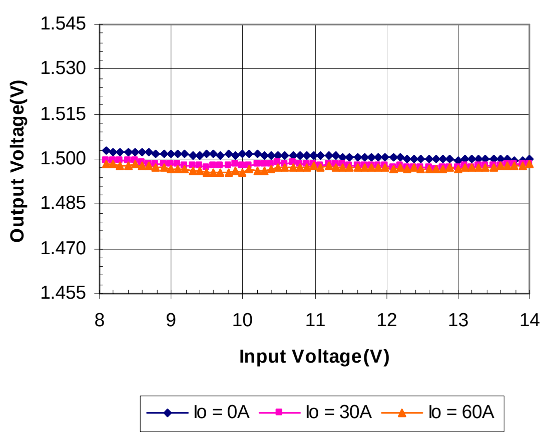
Static Characteristics 1.5V (R_{TRIM} = 80.6kΩ)



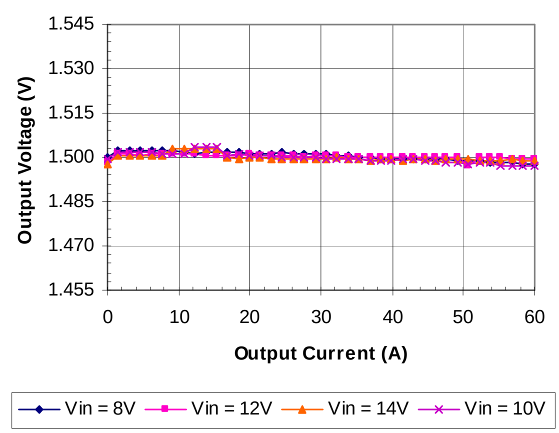
Typical Efficiency vs. Input Voltage
Vout = 1.5V, Ta = 25°C



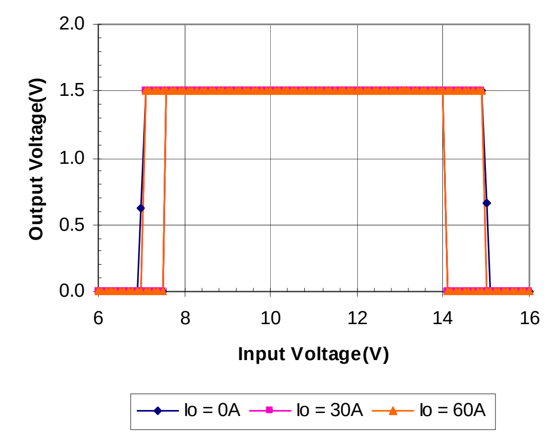
Typical Power Dissipation vs. Input Voltage
Vout = 1.5V, Ta = 25°C



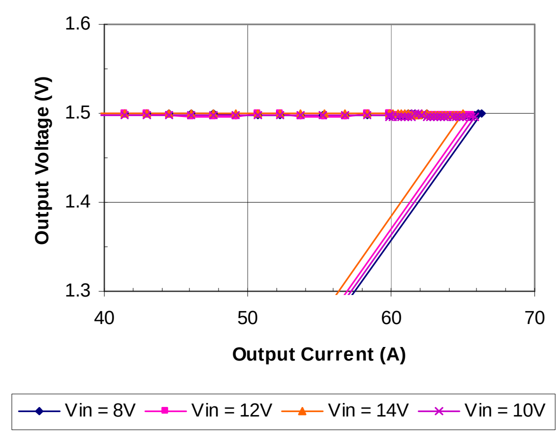
Typical Line Regulation
Vout = 1.5V, Ta = 25°C



Typical Load Regulation
Vout = 1.5V, Ta = 25°C

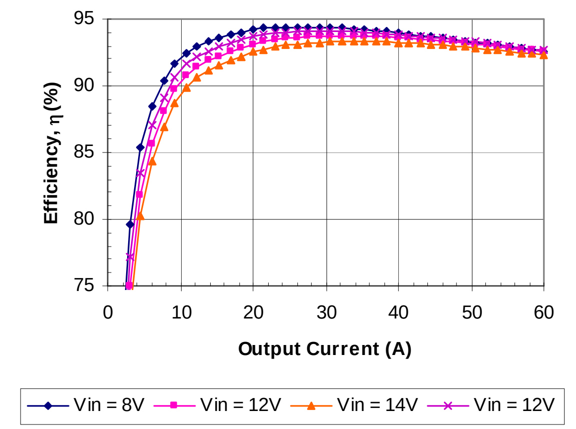


Typical Output Voltage vs. Input Voltage Characteristic
Vout = 1.5V, Ta = 25°C

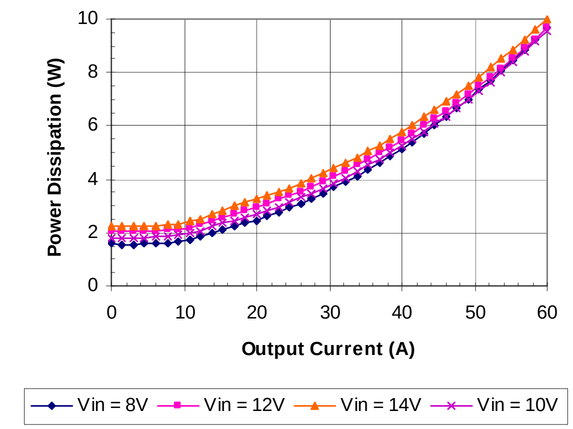


Typical Current Limit Characteristic
Vout = 1.5V, Ta = 25°C

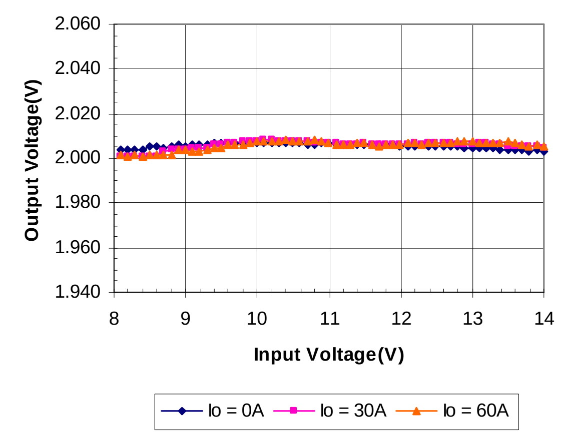
Static Characteristics 2.0V (VOUT_COMMAND = 0x2800, VOUT_SCALE_LOOP = 0x1249)



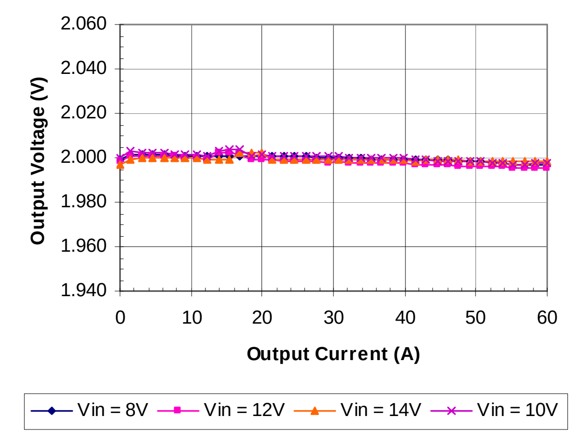
Typical Efficiency vs. Input Voltage
Vout = 2.0V, Ta = 25°C



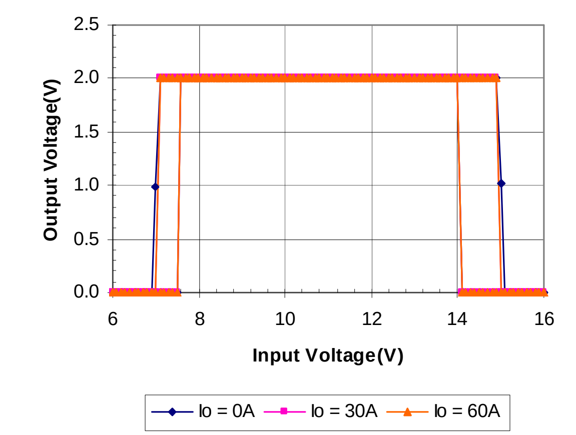
Typical Power Dissipation vs. Input Voltage
Vout = 2.0V, Ta = 25°C



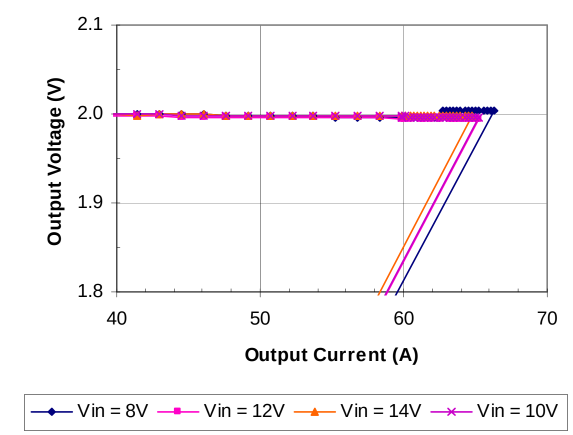
Typical Line Regulation
Vout = 2.0V, Ta = 25°C



Typical Load Regulation
Vout = 2.0V, Ta = 25°C

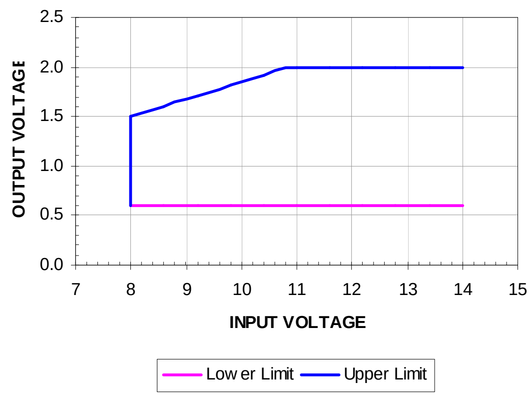


Typical Output Voltage vs. Input Voltage Characteristic
Vout = 2.0V, Ta = 25°C

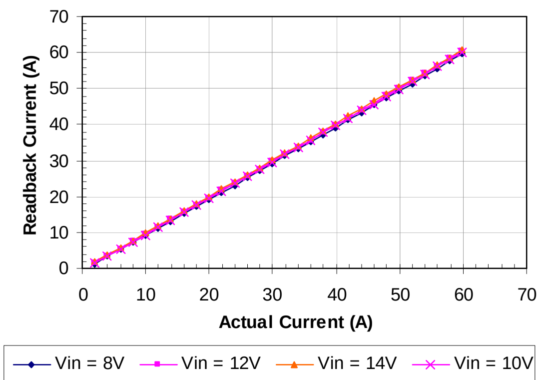


Typical Current Limit Characteristic
Vout = 2.0V, Ta = 25°C

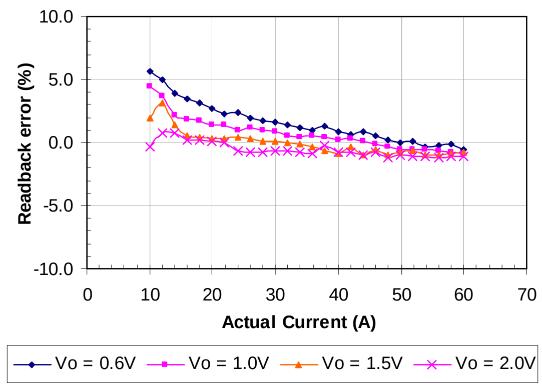
Other static characteristics



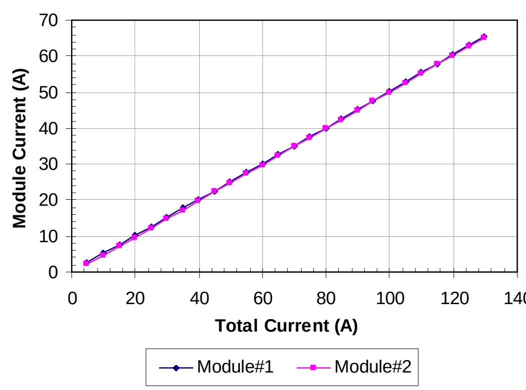
Operation Range
Input voltage vs output voltage



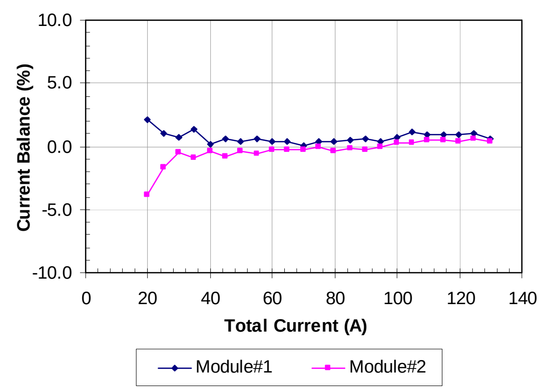
Typical Reported current accuracy
Vout = 1.0V, Ta = 25°C



Typical current read back error at various output voltage
Vin = 12V, Ta = 25°C



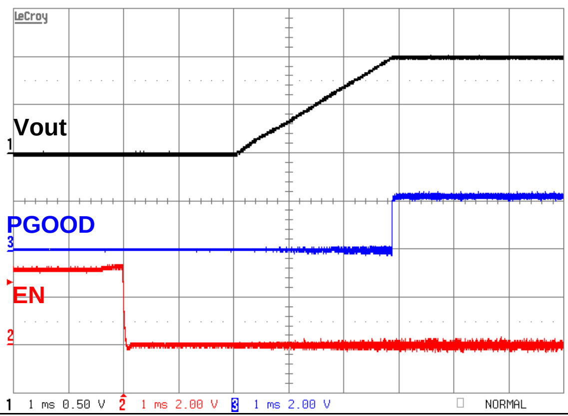
Typical current balance with parallel operation
Vin = 12V, Vout = 1.0V, Ta = 25°C



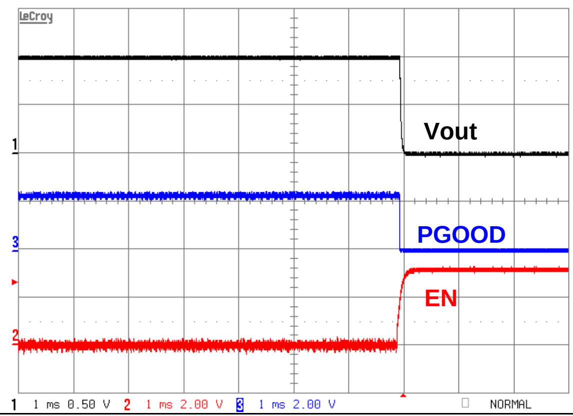
Typical error between master and slave
Vin = 12V, Vout = 1.0V, Ta = 25°C

Dynamic Characteristics (waveforms)

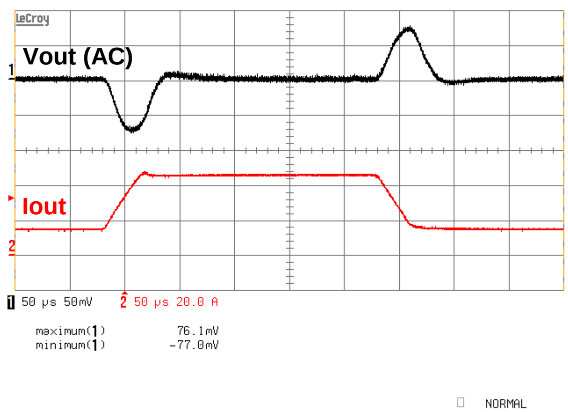
Dynamic Characteristics 1.0V



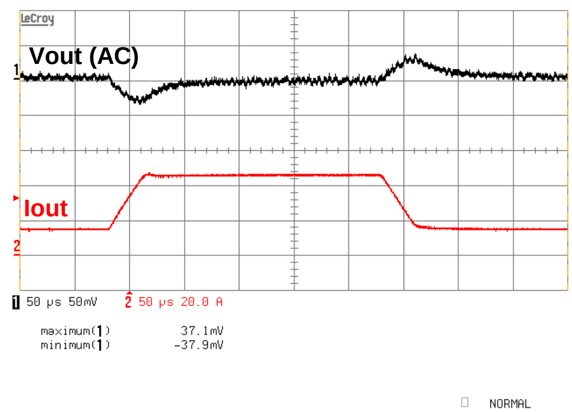
Typical startup characteristic from EN at full load.
Vin = 12V, Vout = 1.0V, Io = 60A, Ta = 25°C



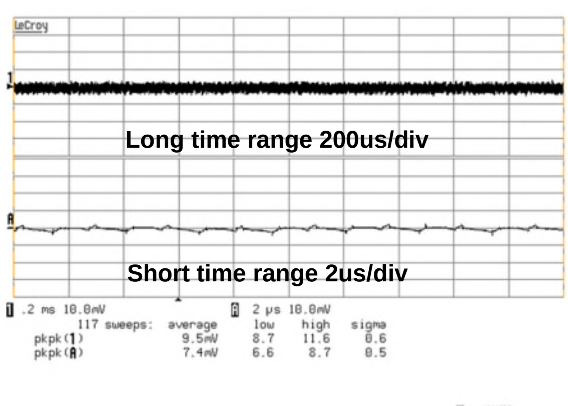
Typical Shut down characteristic from EN at full load.
Vin = 12V, Vout = 1.0V, Io = 60A, Ta = 25°C



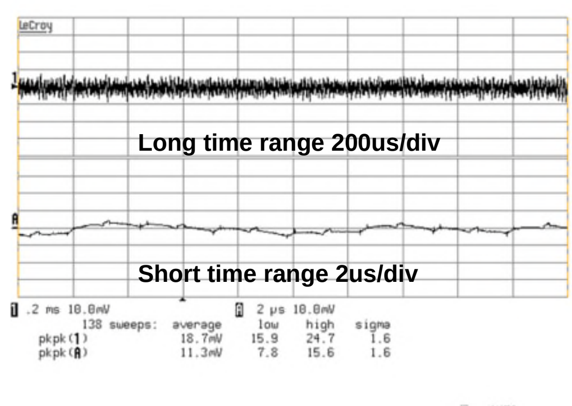
Typical Load transient response (Standard Option)
Vin = 12V, Vout = 1.0V, Slew rate = 1A/us, Ta = 25°C
Cext = 1000uF (C3225X5R0J107MT)



Typical Load transient response (Enhanced Option)
Vin = 12V, Vout = 1.0V, Slew rate = 1A/us, Ta = 25°C
Cext = 1000uF (C3225X5R0J107MT)



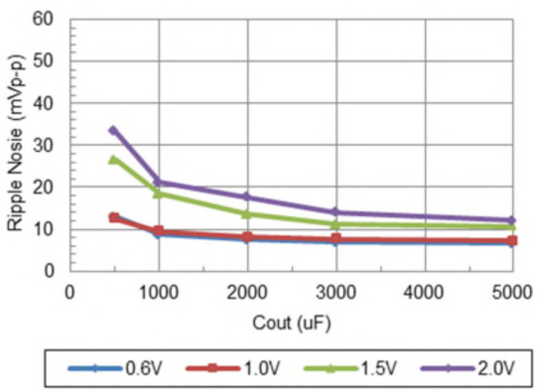
Typical Output ripple and noise (Standard Option)
Vin = 12V, Vout = 1.0V, Io = 60A, Ta = 25°C
Cext = 1000uF (C3225X5R0J107MT)



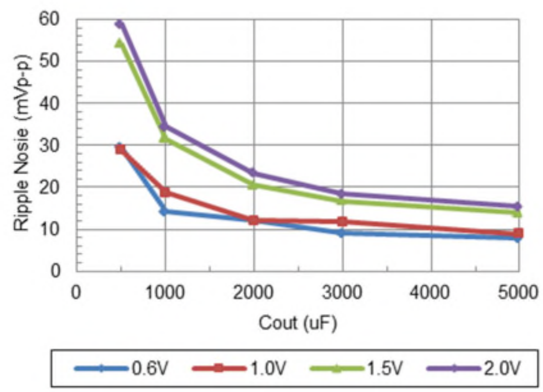
Typical Output ripple and noise (Enhanced Option)
Vin = 12V, Vout = 1.0V, Io = 60A, Ta = 25°C
Cext = 1000uF (C3225X5R0J107MT)

Comparison of standard option and enhanced option

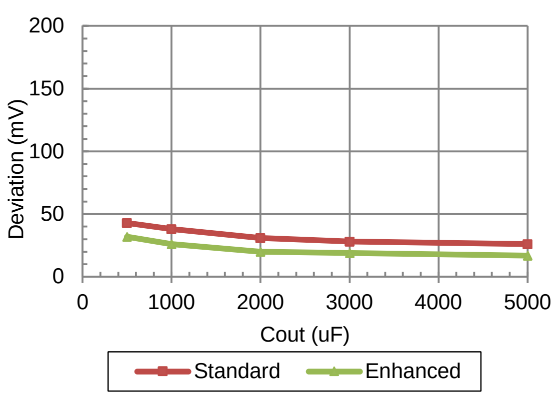
Measured by TDK Evaluation board, the result may vary with the board design / capacitor layout.



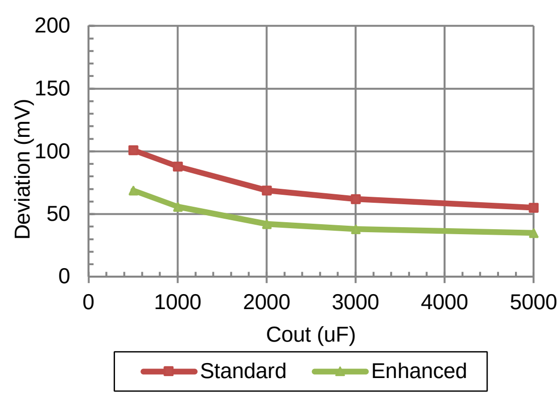
Typical Output ripple with standard option
Vin = 12V, Io = 60A, Ta = 25°C



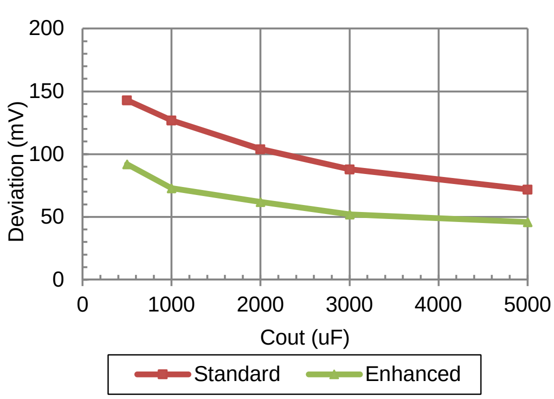
Typical Output ripple with enhanced option
Vin = 12V, Io = 60A, Ta = 25°C



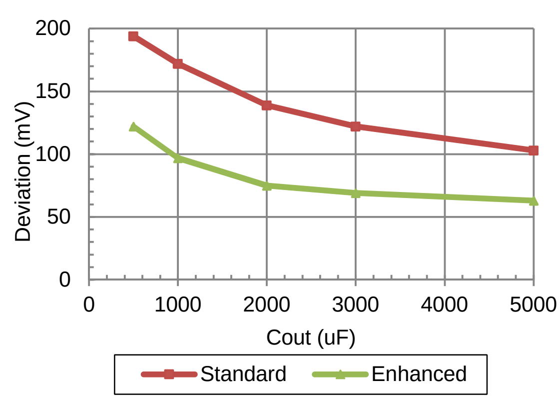
Comparison between standard and enhanced
transient response for load change 10% - 20%
Vin = 12V, Vout = 1.0V, Slew rate = 10A/us, Ta = 25°C



Comparison between standard and enhanced
transient response for load change 10% - 40%
Vin = 12V, Vout = 1.0V, Slew rate = 10A/us, Ta = 25°C



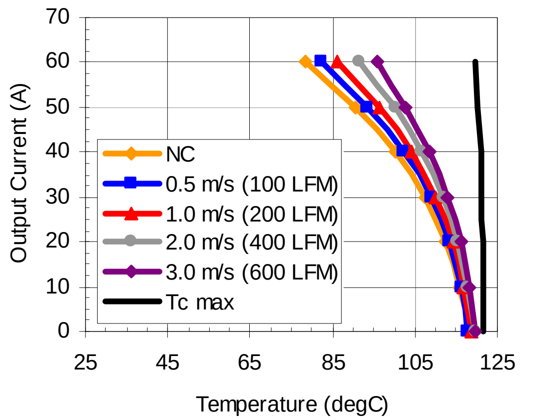
Comparison between standard and enhanced
transient response for load change 10% - 60%
Vin = 12V, Vout = 1.0V, Slew rate = 10A/us, Ta = 25°C



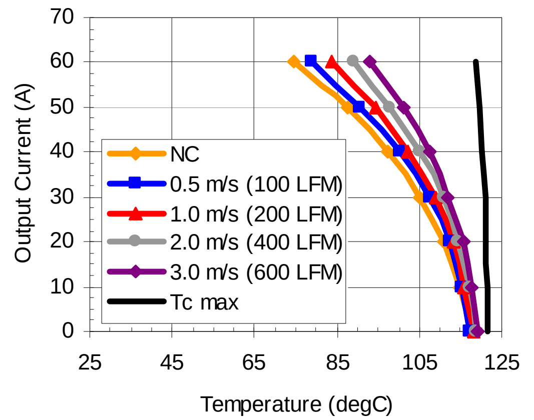
Comparison between standard and enhanced
transient response for load change 10% - 80%
Vin = 12V, Vout = 1.0V, Slew rate = 10A/us, Ta = 25°C

Thermal Performance

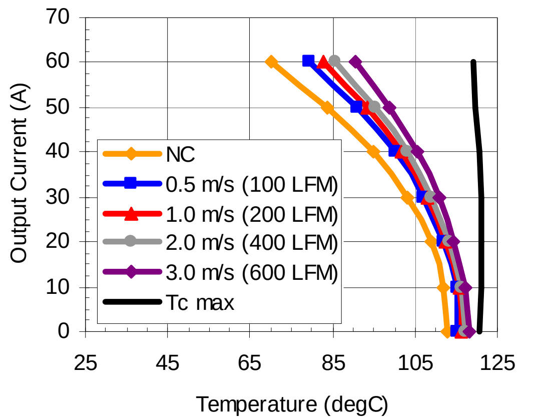
Derating curve and measurement point



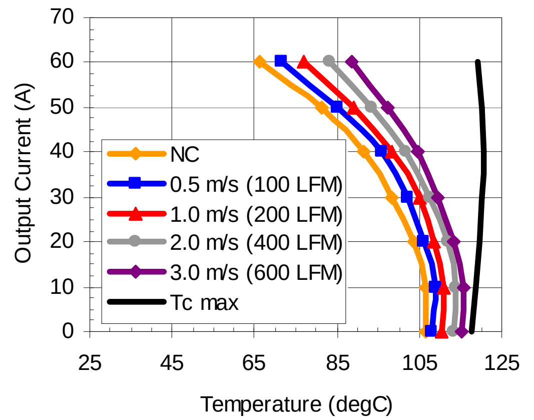
Vin = 12V, Vout = 0.6V preliminary maximum output current vs. ambient temperature at nominal input voltage for natural convection (60lfm) to 600lfm



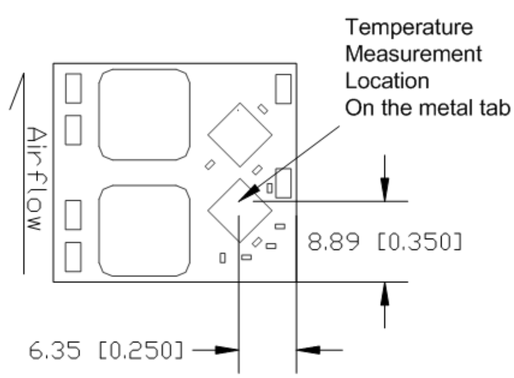
Vin = 12V, Vout = 1.0V preliminary maximum output current vs. ambient temperature at nominal input voltage for natural convection (60lfm) to 600lfm



Vin = 12V, Vout = 1.5V preliminary maximum output current vs. ambient temperature at nominal input voltage for natural convection (60lfm) to 600lfm



Vin = 12V, Vout = 2.0V preliminary maximum output current vs. ambient temperature at nominal input voltage for natural convection (60lfm) to 600lfm



iJB12060A006V thermal measurement location (top view)

The thermal curves provided are based upon measurements made in TDK-Lambda Dallas Technical Center’s experimental test setup that is described in the Thermal Management section. Due to the large number of variables in system design, TDK-Lambda recommends that the user verify the module’s thermal performance in the end application. The critical component should be thermo coupled and monitored, and should not exceed the temperature limit specified in the derating curve. It is critical that the thermocouple be mounted in a manner that gives direct thermal contact or significant measurement errors may result. TDK-Lambda can provide modules with a thermocouple pre-mounted to the critical component for system verification tests

Thermal management

An important part of the overall system design process is thermal management; thermal design must be considered at all levels to ensure good reliability and lifetime of the final system. Superior thermal design and the ability to operate in severe application environments are key elements of a robust, reliable power module.

A finite amount of heat must be dissipated from the power module to the surrounding environment. This heat is transferred by the three modes of heat transfer: convection, conduction and radiation. While all three modes of heat transfer are present in every application, convection is the dominant mode of heat transfer in most applications. However, to ensure adequate cooling and proper operation, all three modes should be considered in a final system configuration.

The open frame design of the power module provides an air path to individual components. This air path improves convection cooling to the surrounding environment, which reduces areas of heat concentration and resulting hot spots.

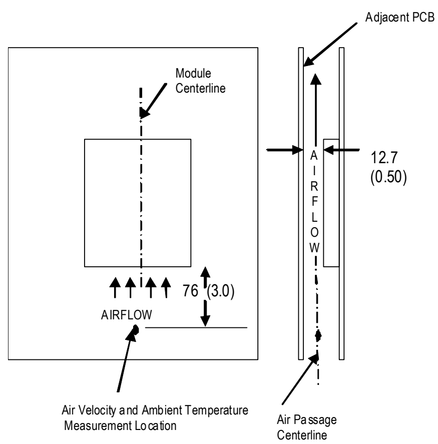
Test Setup

The thermal performance data of the power module is based upon measurements obtained from a wind tunnel test with the setup shown in the wind tunnel figure. This thermal test setup replicates the typical thermal environments encountered in most modern electronic systems with distributed power architectures. The electronic equipment in networking, telecom, wireless, and advanced computer systems operates in similar environments and utilizes vertically mounted PCBs or circuit cards in cabinet racks.

The power module, as shown in the figure, is mounted on a printed circuit board (PCB) and is vertically oriented within the wind tunnel. The cross section of the airflow passage is rectangular. The spacing between the top of the module and a parallel facing PCB is kept at a constant (0.5 in). The power module's orientation with respect to the airflow direction can have a significant impact on the module's thermal performance.

Thermal Derating

For proper application of the power module in a given thermal environment, output current derating curves are provided as a design guideline on the Thermal Performance section for the power module of interest. The module temperature should be measured in the final system configuration to ensure proper thermal management of the power module. For thermal performance verification, the module temperature should be measured at the component indicated in the thermal measurement location figure on the thermal performance page for the power module of interest. In all conditions, the power module should be operated below the maximum operating temperature shown on the derating curve. For improved design margins and enhanced system reliability, the power module may be operated at temperatures below the maximum rated operating temperature.



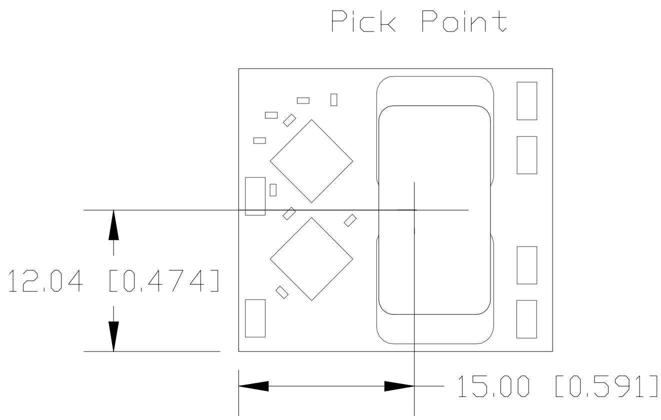
Wind Tunnel Test Setup Figure

Dimensions are in millimeters and (inches)

Heat transfer by convection can be enhanced by increasing the airflow rate that the power module experiences. The maximum output current of the power module is a function of ambient temperature (T_{AMB}) and airflow rate as shown in the thermal performance figures on the thermal performance page for the power module of interest. The curves in the figures are shown for natural convection through 2 m/s (400 ft/min). The data for the natural convection condition has been collected at 0.3 m/s (60 ft/min) of airflow, which is the typical airflow generated by other heat dissipating components in many of the systems that these types of modules are used in. In the final system configurations, the airflow rate for the natural convection condition can vary due to temperature gradients from other heat dissipating components.

Soldering Information

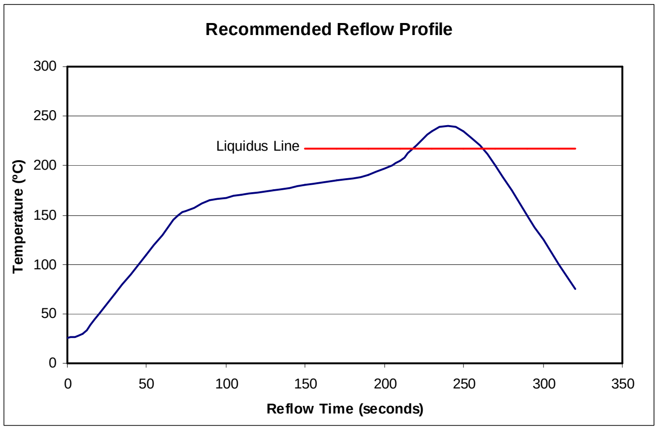
iJB surface mountable power modules are intended to be compatible with standard surface mount component soldering processes and either hand placed or automatically picked and placed. The figure below shows the position for vacuum pick up. The maximum weight of the power module is 12.2g (0.43 oz.). Improper handling or cleaning processes can adversely affect the appearance, testability, and reliability of the power modules. The iJB product is a moisture sensitivity level 2 device. Contact TDK-Lambda technical support for guidance regarding proper handling, cleaning, and soldering of TDK-Lambda's power modules.



Reflow Soldering

The iJB platform is an open frame power module manufactured with SMT (surface mount technology). Due to the high thermal mass of the power module and sensitivity to heat of some SMT components, extra caution should be taken when reflow soldering. Failure to follow the reflow soldering guidelines described below may result in permanent damage and/or affect performance of the power modules.

The iJB power modules can be soldered using natural convection, forced convection, IR (radiant infrared), and convection/IR reflow technologies. The module should be thermally characterized in its application to develop a temperature profile. Thermal couples should be mounted to terminal 8 and terminal 17 and be monitored. The temperatures should be maintained below 260 degrees. Oven temperature and conveyer belt speeds should be controlled to ensure these limits are not exceeded. In most manufacturing processes, the solder paste required to form a reliable connection can be applied with a standard 6 mil stencil.

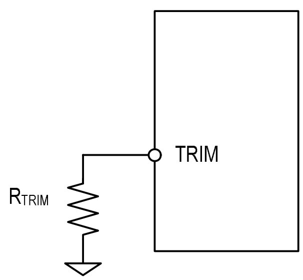


iJB Power Module suggested reflow-soldering profile

Operating Information

Output Voltage Setting (TRIM)

The output voltage of the power module may be set by using an external resistor connected between the TRIM and GND terminal.
The resistor should be selected according to Trim resistor configuration table as below. The resistor should be selected from the standard E96 series with 0.5% (or better) tolerance and 50ppm/K (or better) temperature coefficient. The trim resistor value is only checked during the power up sequence.

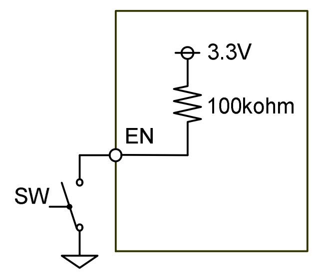


Trim resistor connection

Remote ON/OFF (EN)

The power modules have an internal remote on/off circuit. The user must supply compatible switch between the GND pin and the on/off pin. The module has internal pulled up to 3.3V by 100kΩ.
The maximum allowable leakage current of the switch is 10uA. The switch must be capable of maintaining a Low signal Ven(on) < 0.8V while sinking 1mA.

After the module has been turned off, please wait a minimum of 5mS before restarting to ensure proper turn-on behavior.



ON/OFF circuit logic table

Switch	Positive Logic	Negative Logic
Open	Module ON	Module OFF
Close	Module OFF	Module ON

The method of ON/OFF can be changed by PMBus command "ON_OFF_CONFIG". Please refer to the Application note for more detail.

Trim resistor configuration table

<table>
<tr><th>RTRIM</th><th>Vset</th><th>VOUT_SCALE_LOOP</th><th>VOUT_MAX</th><th>Other parameters automatically configured based on trim resistor value*2</th></tr>
<tr><td>0</td><td>0.60[V]</td><td rowspan="11">0x4000</td><td rowspan="11">1.6[V]</td><td rowspan="14">VOUT_COMMAND = Vset
VOUT_MARGIN_HIGH = 1.05 * Vset
VOUT_MARGIN_LOW = 0.95 * Vset
VOUT_OV_FAULT_LIMIT = 1.20 * Vset
VOUT_UV_FAULT_LIMIT = 0.80 * Vset</td></tr>
<tr><td>11.5[kΩ]</td><td>0.70[V]</td></tr>
<tr><td>18.2[kΩ]</td><td>0.75[V]</td></tr>
<tr><td>24.9[kΩ]</td><td>0.80[V]</td></tr>
<tr><td>31.6[kΩ]</td><td>0.85[V]</td></tr>
<tr><td>38.3[kΩ]</td><td>0.90[V]</td></tr>
<tr><td>45.3[kΩ]</td><td>0.95[V]</td></tr>
<tr><td>52.3[kΩ]</td><td>1.00[V]</td></tr>
<tr><td>59.0[kΩ]</td><td>1.05[V]</td></tr>
<tr><td>66.5[kΩ]</td><td>1.10[V]</td></tr>
<tr><td>73.2[kΩ]</td><td>1.20[V]</td></tr>
<tr><td>80.6[kΩ]</td><td>1.50[V]</td><td rowspan="2">0x1249</td><td rowspan="2">3.5[V]</td></tr>
<tr><td>86.6[kΩ]</td><td>1.80[V]</td></tr>
<tr><td>> 115[kΩ]</td><td>0.60[V]*1</td><td>0x4000</td><td>1.6[V]</td></tr>
</table>

*1 No power conversion until PMBus command "OPERATION" is received.
*2 The stored NVM values are ignored if user sets Vout by TRIM pin.

Remote sense (SENSE (+)/SENSE (-))

The module has differential remote sense to compensate for the effect of output distribution drops. The output voltage sense range defines the maximum voltage allowed between the output power terminals and output sense terminals, and it is found on the electrical specification page for the power module interest. If the remote sense feature is not being used, the sense (+) terminal should be connected to the Vout terminal and the sense (-) terminal should be connected to the GND terminal. Care should be taken when routing the remote sense leads to avoid noise pickup.

Excessive inductance between the output power terminal and output sense terminal can destabilize point of load power modules. Please follow good layout techniques and minimize the distance between the load and power module.

Power Good (PGOOD)

The module has an open-drain power good signal which indicates if the output voltage is being regulated. When power is applied to the module but the output voltage regulation point is more than ±12.5% from the nominal voltage set point, then the power good terminal will be pulled low to ground.

Also power good signal will be pulled low while the output voltage is changed by PMBus.

The power good terminal is weakly pulled up to 2.0V inside of the module. If the power good feature is not used; the pin should be left open.

PMBus signal (SDAT/SCLK/SALT)

The module implements PMBus with a 3-wire bus, SDAT, SCLK and SALT. The module works only as slave device.

PMBus signal pins need external pull up resistor. The recommend value for pull up resistor is 10kΩ for typical application.
See the PMBus specification for full detail.

PMBus Address Configuration (ADDR)

The module has ADDR pin for setting the PMBus address. When multiple devices are connected to PMBus communication line, each module must have unique address.

The resistor should be selected according to ADDR resistor configuration table as below and selected from the standard E96 series with 1% (or better) tolerance and 100ppm/K (or better) temperature coefficient.

ADDR resistor configuration table

R_{ADDR}	PMBus Address
0[Ω]	0x10
10.0[kΩ]	0x11
13.3[kΩ]	0x12
17.8[kΩ]	0x13
21.5[kΩ]	0x14
26.1[kΩ]	0x15
31.6[kΩ]	0x16
34.8[kΩ]	0x17
38.3[kΩ]	0x18
42.2[kΩ]	0x19
46.4[kΩ]	0x1A
51.1[kΩ]	0x1B
56.2[kΩ]	0x1C
61.9[kΩ]	0x1D
68.1[kΩ]	0x1E
75.0[kΩ]	0x1F
82.5[kΩ]	0x20
90.9[kΩ]	0x21
100[kΩ]	0x22
110[kΩ]	0x23
121[kΩ]	0x24
133[kΩ]	0x25
147[kΩ]	0x26
Open	0x27

Fault management (FAULT)

The module has an open-drain input/output fault signal, which indicates if the module gets fault condition (OVP, OVLO, UVLO, OCP, OTP or SCP). The FAULT pin is pulled low if the module recognizes a fault condition and the module will terminate power conversion as soon as the FAULT pin becomes de-asserted.

The FAULT pin is used for parallel operation. The FAULT pin of each module must be tied together when operating in parallel. If one of the modules used to generate a voltage rail recognizes a fault condition, all other joined modules will thus terminate power conversion. Once the fault condition clears all modules, then all modules will restart and resume normal operation.

The FAULT terminal is weakly pulled up to 2.0V inside of the module. If the fault management feature is not used during single module operation then the FAULT pin should be left open.

Over Current Protection

The module has a dual threshold over load protection scheme to protect the module during overload conditions. During overload conditions, the power modules may protect themselves by entering a hiccup current limit mode. In hiccup mode, the modules will attempt to restart every 500mS and operate normally once the output current returns to the specified operating range. In severe overload or short circuit conditions a faster second level over current protection circuit may engage. Long term operation outside the rated conditions and prior to the over current protection engaging is not recommended unless measures are taken to ensure the module's thermal limits are being observed.

Over Temperature Protection

The power module features over temperature protection to reduce the risk of damage due to overheating. When the power supply detects an over temperature event, the module shuts off. The module will attempt to restart and operate normally after the temperature drops below the over temperature shut down point minus the over temperature fault hysteresis as 15°C.

Over Voltage Protection

The power module features output over voltage protection to reduce the risk of damage. When the power supply detects an over voltage event, the module shuts off. In hiccup mode, the modules will attempt to restart every 2000mS and operate normally once the output voltage returns to the specified operating range. The over voltage protection is set to a nominal threshold based on Trim resistor value, which is 120% of Vout_Command.

Input Voltage cycling

If input voltage supply is removed and the power module turns off, it is recommended to have a 1500mS minimum delay time before input power is reapplied. The input power delay will help to ensure module resets and turns on properly.

The module runs initialize routine 100ms from input voltage applied. Certain condition (i.e hot temperature with heavy load) will cause false fault detection during initializing routine. It is recommended the module should be enabled after 100ms from input voltage applied.

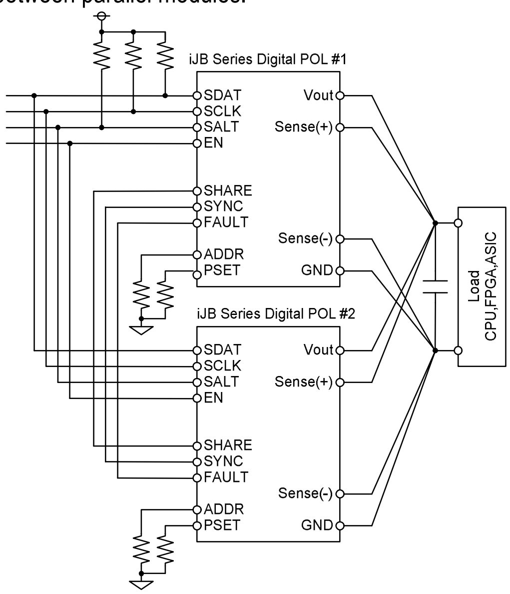
Parallel Operation (SYNC/SHARE/PSET)

The module can be operated in parallel for higher power loads.

The SYNC and SHARE pin of each module must be tied together when operating in parallel.

The SYNC pin provides timing information for a multi-phase, interleave scheme. It can be an output or input in multi-phase configuration depending on whether the module is configured as a master or a slave. One and only one module must be set as a master device. The rest of the modules must be set as slave devices.

The SHARE pin is used to facilitate current sharing between parallel modules.



Parallel operation connection (N=2)

PSET resistor configuration table

The user can choose either external resistor setting or PMBus command in order to configure module settings for parallel operation.
The resistor should be selected according to PSET resistor configuration table as below and selected from the standard E96 series with 1% (or better) tolerance and 100ppm/K (or better) temperature coefficient.

R_{PSET}	SYNC	Interleave	Note
75.0[kΩ]	Master	0°	N = 2
90.9[kΩ]	Slave	90°	N = 2
OPEN	User configure by using PMBus*		

N = number of modules in multi-phase system
* see application note for details

Group command Protocol

In parallel mode the startup should be done using the Enable feature or PMBus command.

Grouped PMBus commands guarantee that each device will execute the command at the same time providing accurate timing between modules for power on/off, voltage margining, etc. Please see application note for more detail.

Security and Password Provisions

The digital content of the power module allows for a broad range of supported PMBus commands which offers great flexibility as well as the ability to store configuration changes in the power module memory. In order to help reduce the risk of unexpected or unauthorized parameter changes, a security system with password protection is implemented in iJB power modules.

There are two levels of password protection, “Field mode” and “Engineering mode”. Only “Engineering mode” allows users to implement “STORE_DEFAULT_ALL” command.
The default setting of the security mode is “Field mode”.

Security mode

Security Mode	Ability to change NVM by “STORE_DEFAULT_ALL”?
Engineering Mode	YES
Field Mode	NO

It is necessary to use PMBus command to change security modes. Please see application note for more detail.

EMC Considerations

TDK-Lambda power modules are designed for use in a wide variety of systems and applications. For assistance with designing for EMC compliance, please contact TDK-Lambda technical support.

Input Impedance

The source impedance of the power feeding the DC/DC converter module will interact with the DC/DC converter. To minimize the interaction, low-esr capacitors should be located at the input to the module. It is required that 100uF of the ceramic input capacitor be placed as close as possible to the module.
Data are provided on this data sheet with six 22uF ceramic capacitors (TDK parts C3225X7R1C226KT) and one 470uF / 35V electrolytic capacitor.

Output Impedance

The power module is designed to be stable and function properly over a wide range of output capacitors, including low esr ceramic capacitors. It is required that 1000uF of ceramic output capacitance be placed as close as possible to the module. Additional capacitors can be added to further improve dynamic response and noise level.
Data are provided on this data sheet with ten 100uF ceramic capacitors (TDK parts C3225X5R0J107MT)

Reliability

The power modules are designed using TDK-Lambda's stringent design guideline for component derating, product qualification, and design reviews. The MTBF is calculated to be greater than 9.9M hours at full output power and Ta = 40°C using the Telcordia SR-332 calculation method.

Quality

TDK-Lambda's product development process incorporates advanced quality planning tools such as FMEA and Cpk analysis to ensure designs are robust and reliable. All products are assembled at ISO certified assembly plant.

Safety Considerations

As of the publishing date, certain safety agency approvals may have been received on the iJB series and others may still be pending. Check with TDK-Lambda for the latest status of safety approvals on the iJB product line.

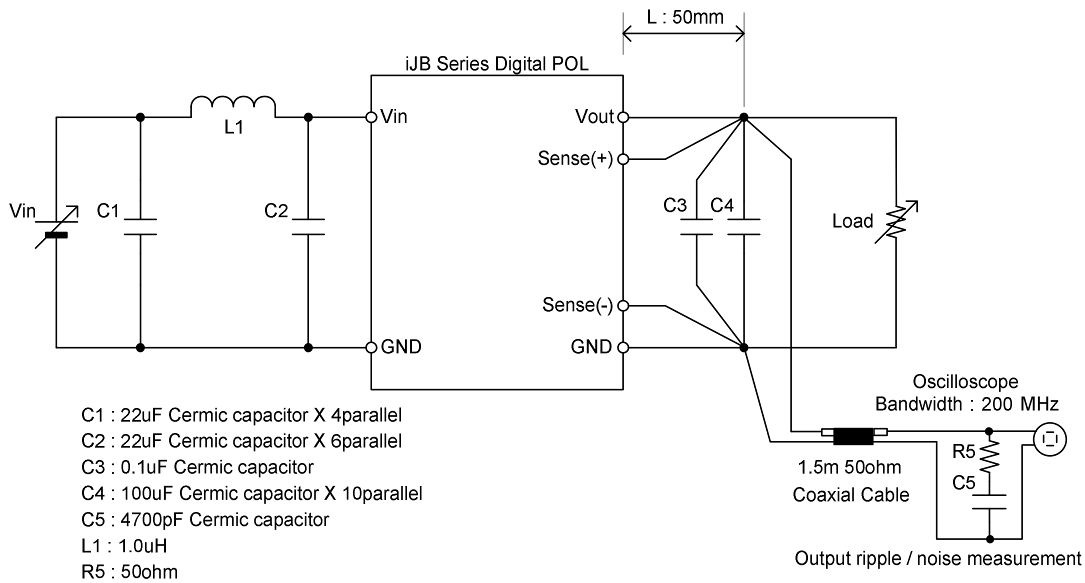
For safety agency approval of the system in which the DC/DC power modules is installed, the power must be installed in compliance with the creepage and clearance requirement of the safety agency. To preserve maximum flexibility, the power modules are not internally fused.

An external input line normal blow fuse with a maximum of 40A is required by safety agencies. A lower value fuse can be selected based upon the maximum DC input current and maximum inrush energy of the power module.

Warranty

TDK-Lambda's comprehensive line of the power solutions includes efficient, high density DC/DC converters. TDK-Lambda offers a three year limited warranty. Complete warranty information is listed on our web site or is available upon request from TDK-Lambda.

Input / Output Ripple and Noise measurement



C1 : 22uF Cermic capacitor X 4parallel
C2 : 22uF Cermic capacitor X 6parallel
C3 : 0.1uF Cermic capacitor
C4 : 100uF Cermic capacitor X 10parallel
C5 : 4700pF Cermic capacitor
L1 : 1.0uH
R5 : 50ohm

The output capacitor location and output ripple measurement are approximately 5 cm (2 in.) from the power module using an oscilloscope and BNC socket.

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