BCM® Bus Converter

BCM384x480y325Bzz

Isolated Fixed Ratio DC-DC Converter

Features & Benefits

- $384V_{DC}$ – $48V_{DC}$ 325W Bus Converter
- High efficiency (95%) reduces system power consumption
- High power density (1106W/in^3) reduces power system footprint by >40%
- Contains built-in protection features:
  - Undervoltage
  - Overvoltage Lockout
  - Overcurrent Protection
  - Short circuit Protection
  - Overtemperature Protection
- Provides enable/disable control, internal temperature monitoring
- Can be paralleled to create multi-kW arrays

Typical Applications

- High End Computing Systems
- Automated Test Equipment
- High Density Power Supplies
- Communications Systems

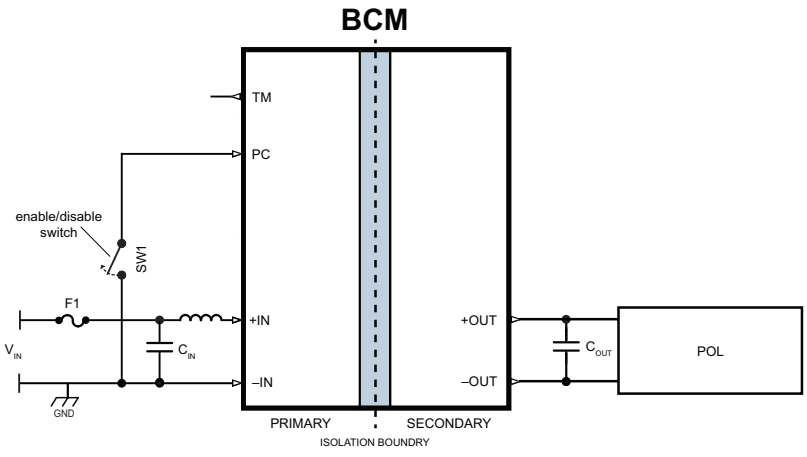
Product Ratings	
V_{IN} = 384V (360 – 400V)	P_{OUT} = up to 325W
V_{OUT} = 48V (45 – 50V) (NO LOAD)	K = 1/8

Description

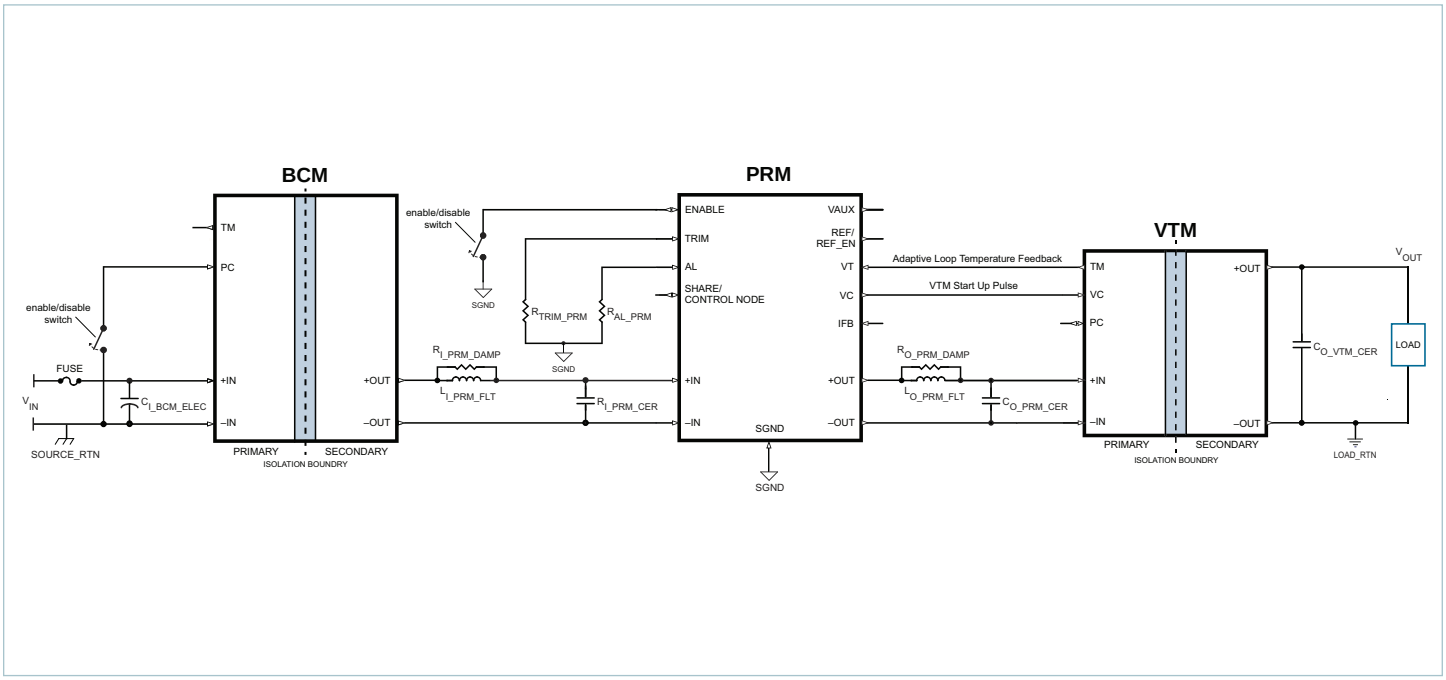
The VI Chip® bus converter is a high efficiency (95%) Sine Amplitude Converter™ (SAC™) operating from a 360 to 400V_{DC} primary bus to deliver an isolated, ratiometric output voltage from 45 to 50V_{DC}. The Sine Amplitude Converter offers a low AC impedance beyond the bandwidth of most downstream regulators; therefore capacitance normally at the load can be located at the input to the Sine Amplitude Converter. Since the transformation ratio of the BCM384x480y325Bzz is 1/8, the capacitance value can be reduced by a factor of 64x, resulting in savings of board area, materials and total system cost.

The BCM384F480y325Bzz is provided in a VI Chip package compatible with standard pick-and-place and surface mount assembly processes. The co-molded VI Chip package provides enhanced thermal management due to a large thermal interface area and superior thermal conductivity. The high conversion efficiency of the BCM384x480y325Bzz increases overall system efficiency and lowers operating costs compared to conventional approaches.

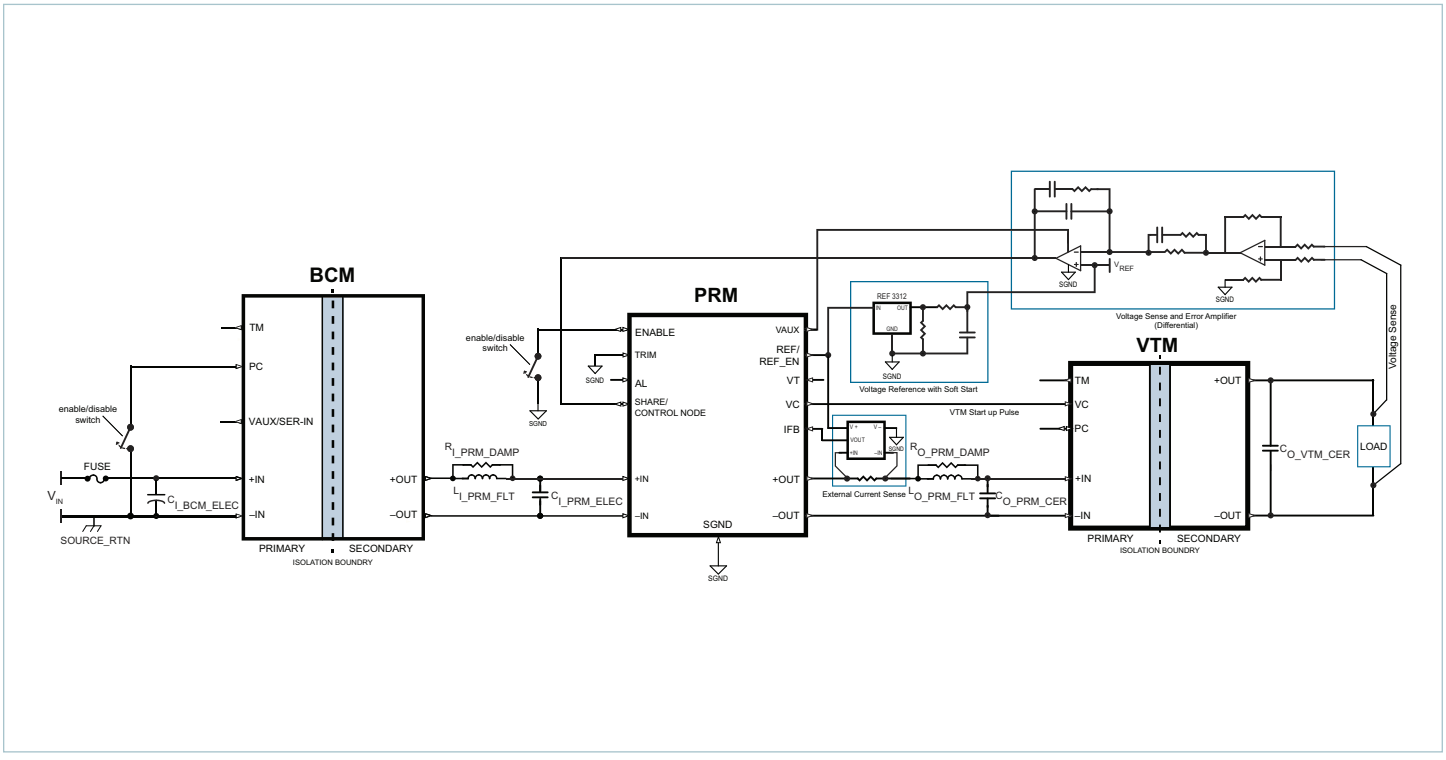
Typical Application



Typical Application

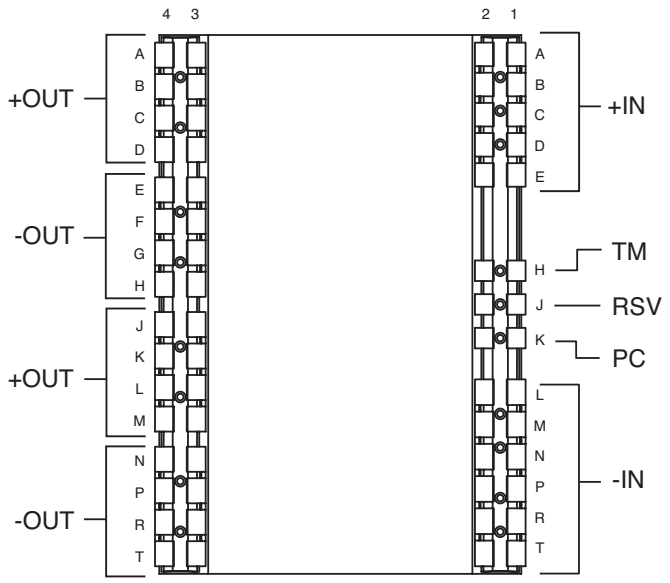


BCM384x480y325Bzz + PRM + VTM, Adaptive Loop Configuration



BCM384x480y325Bzz + PRM + VTM, Remote Sense Configuration

Pin Configuration



Bottom View

Pin Descriptions

Pin Number	Signal Name	Type	Function
A1-E1, A2-E2	+IN	INPUT POWER	Positive input power terminal
L1-T1, L2-T2	–IN	INPUT POWER RETURN	Negative input power terminal
H1, H2	TM	OUTPUT	Temperature monitor, input side referenced signal
J1, J2	RSV	NC	No connect
K1, K2	PC	OUTPUT/INPUT	Enable and disable control, input side referenced signal
A3-D3, A4-D4, J3-M3, J4-M4	+OUT	OUTPUT POWER	Positive output power terminal
E3-H3, E4-H4, N3-T3, N4-T4	–OUT	OUTPUT POWER RETURN	Negative output power terminal

Part Ordering Information

Device	Input Voltage Range	Package Type	Output Voltage x 10	Temperature Grade	Output Power	Revision	Version
BCM	384	x	480	y	325	B	zz
BCM = BCM	384 = 360 – 400V	F = Full VIC SMD	480 = 48V	T = -40 – 125°C	325 = 325W	B	00 = standard
		T = Full VIC TH		M = -55 – 125°C			>00 = Customer specific version

Standard Models

Part Number	V_{IN}	Package Type	V_{OUT}	Temperature	Power	Version
BCM384F480T325B00	360 – 400V	Full VIC SMD	48V (45 – 50V)	-40 – 125°C	325W	00 = standard
BCM384F480M325B00				-55 – 125°C		
BCM384T480T325B00	360 – 400V	Full VIC TH	48V (45 – 50V)	-40 – 125°C	325W	00 = standard
BCM384T480M325B00				-55 – 125°C		

Absolute Maximum Ratings

The absolute maximum ratings below are stress ratings only. Operation at or beyond these maximum ratings can cause permanent damage to the device.

Parameter	Comments	Min	Max	Unit
+IN to –IN		-1	440	V
V_{IN} slew rate	Operational		1	V / µs
Isolation voltage, input to ouput			4242	V
+OUT to –OUT		-1	60	V
Output current transient	≤ 1ms, ≤ 10% DC		10.5	A
Output current average			7.05	A
PC to –IN		-0.3	20	V
TM to –IN		-0.3	7	V
Operating IC junction temperature	T–Grade	-40	125	°C
Storage temperature	T–Grade	-40	125	°C

Electrical Specifications

Specifications apply over all line and load conditions, unless otherwise noted; **boldface** specifications apply over the temperature range of -40°C ≤ T_{CASE} ≤ 100°C (T-Grade); all other specifications are at T_{CASE} = 25°C unless otherwise noted.

Attribute	Symbol	Conditions / Notes	Min	Typ	Max	Unit
Powertrain						
Input voltage range, continuous	V_{IN_DC}		**360**		**400**	V
Quiescent current	I_Q	Disabled, PC Low		1	**1.2**	mA
V_{IN} to V_{OUT} time	T_{ON1}	V_{IN} = 384V, PC floating			620	ms
No load power dissipation	P_{NL}	V_{IN} = 384V, T_{CASE} = 25°C		7.2	10	W
		V_{IN} = 384V	**3**		**18**	
		V_{IN} = 360V to 400V, T_{CASE} = 25°C			12	
		V_{IN} = 360V to 400V			**15**	
Inrush current peak	I_{INR_P}	Worse case of: V_{IN} = 400V, C_{OUT} = 100µF, R_{LOAD} = 7Ω		2	**4**	A
DC input current	I_{IN_DC}	At P_{OUT} = 325W			**0.9**	A
Transformation ratio	K	K = V_{OUT} / V_{IN}, at no load		1/8		V / V
Output power (average)	P_{OUT_AVG}	I_{OUT_AVG} ≤ 7.05A			**325**	W
Output power (peak)	P_{OUT_PK}	1ms max, P_{OUT_AVG} ≤ 325W			**450**	W
Output current (average)	I_{OUT_AVG}	P_{OUT_AVG} ≤ 325W			**7.05**	A
Output current (peak)	I_{OUT_PK}	1ms max, I_{OUT_AVG} ≤ 7.05A			**10.5**	A
Efficiency (ambient)	η_{AMB}	V_{IN} = 384V, I_{OUT} = 7.05A; T_{CASE} = 25°C	95.0	96.0		%
		V_{IN} = 360V to 400V, I_{OUT} = 7.05A; T_{CASE} = 25°C	94.9			
		V_{IN} = 384V, I_{OUT} = 3.53A; T_{CASE} = 25°C	93.5	94.9		
Efficiency (hot)	η_{HOT}	V_{IN} = 384V, I_{OUT} = 7.05A; T_{CASE} = 100°C	94.3	95.4		%
Efficiency (over load range)	$\eta_{20\%}$	1.41A < I_{OUT} < 7.05A	**80.0**			%
Output resistance	R_{OUT_COLD}	I_{OUT} = 7.05A, T_{CASE} = -40°C	60	100	130	mΩ
	R_{OUT_AMB}	I_{OUT} = 7.05A, T_{CASE} = 25°C	110	135	150	
	R_{OUT_HOT}	I_{OUT} = 7.05A, T_{CASE} = 100°C	130	165	260	
Switching frequency	F_{SW}		**1.56**	1.65	**1.73**	MHz
Output voltage ripple	V_{OUT_PP}	C_{OUT} = 0F, I_{OUT} = 7.05A, V_{IN} = 384V, 20MHz BW		200	**400**	mV
Input inductance (parasitic)	L_{IN_PAR}	Simulated J-lead model		5.6		nH
Output inductance (parasitic)	L_{OUT_PAR}	Frequency up to 30MHz, Simulated J-lead model		600		pH
Input capacitance (internal)	C_{IN_INT}	Effective value at 384V_{IN}		0.1		µF
Output capacitance (internal)	C_{OUT_INT}	Effective value at 48V_{OUT}		5.6		µF
Output capacitance (external)	C_{OUT_EXT}		**0**		**100**	µF

Signal Characteristics

Specifications apply over all line and load conditions, unless otherwise noted; **boldface** specifications apply over the temperature range of -40°C ≤ T_{CASE} ≤ 100°C (T-Grade); all other specifications are at T_{CASE} = 25°C unless otherwise noted.

Primary Control: PC

- The PC pin enables and disables the BCM. When held low, the BCM is disabled.
- In an array of BCM modules, PC pins should be interconnected to synchronize start up and permit start up into full load conditions.
- PC pin outputs 5V during normal operation. PC pin internal bias level drops to 2.5V during fault mode, provided V_{IN} remains in the valid range.

SIGNAL TYPE	STATE	ATTRIBUTE	SYMBOL	CONDITIONS / NOTES	MIN	TYP	MAX	UNIT
ANALOG OUTPUT	Regular Operation	PC voltage	V_{PC}		**4.7**	5.0	**5.3**	V
		PC available current	I_{PC_OP}		**2.0**	3.5	**5.0**	mA
	Standby	PC source (current)	I_{PC_EN}		**50**	100		µA
		PC resistance (internal)	R_{PC_INT}	Internal pull down resistor	**50**	150	**400**	kΩ
	Transition	PC capacitance (internal)	C_{PC_INT}				**1000**	pF
	Start Up	PC load resistance	R_{PC_S}	To permit regular operation	**60**			kΩ
DIGITAL INPUT / OUTPUT	Start Up	PC time to start	T_{ON1}				**620**	ms
	Regular Operation	PC enable threshold	V_{PC_EN}		**2.0**	2.5	**3.0**	V
		PC disable threshold	V_{PC_DIS}				**1.95**	V
	Standby	PC disable duration	$T_{PC\_DIS\_T}$	Minimum time before attempting re-enable	**1**			s
	Transition	PC threshold hysteresis	V_{PC_HYSTER}			50		mV
		PC enable to V_{OUT} time	T_{ON2}	V_{IN} = 384V for at least T_{ON1} ms	50	100	150	µs
		PC disable to standby time	T_{PC_DIS}			4	**10**	µs
		PC fault response time	T_{FR_PC}	From fault to PC = 2V		100		µs

Temperature Monitor: TM

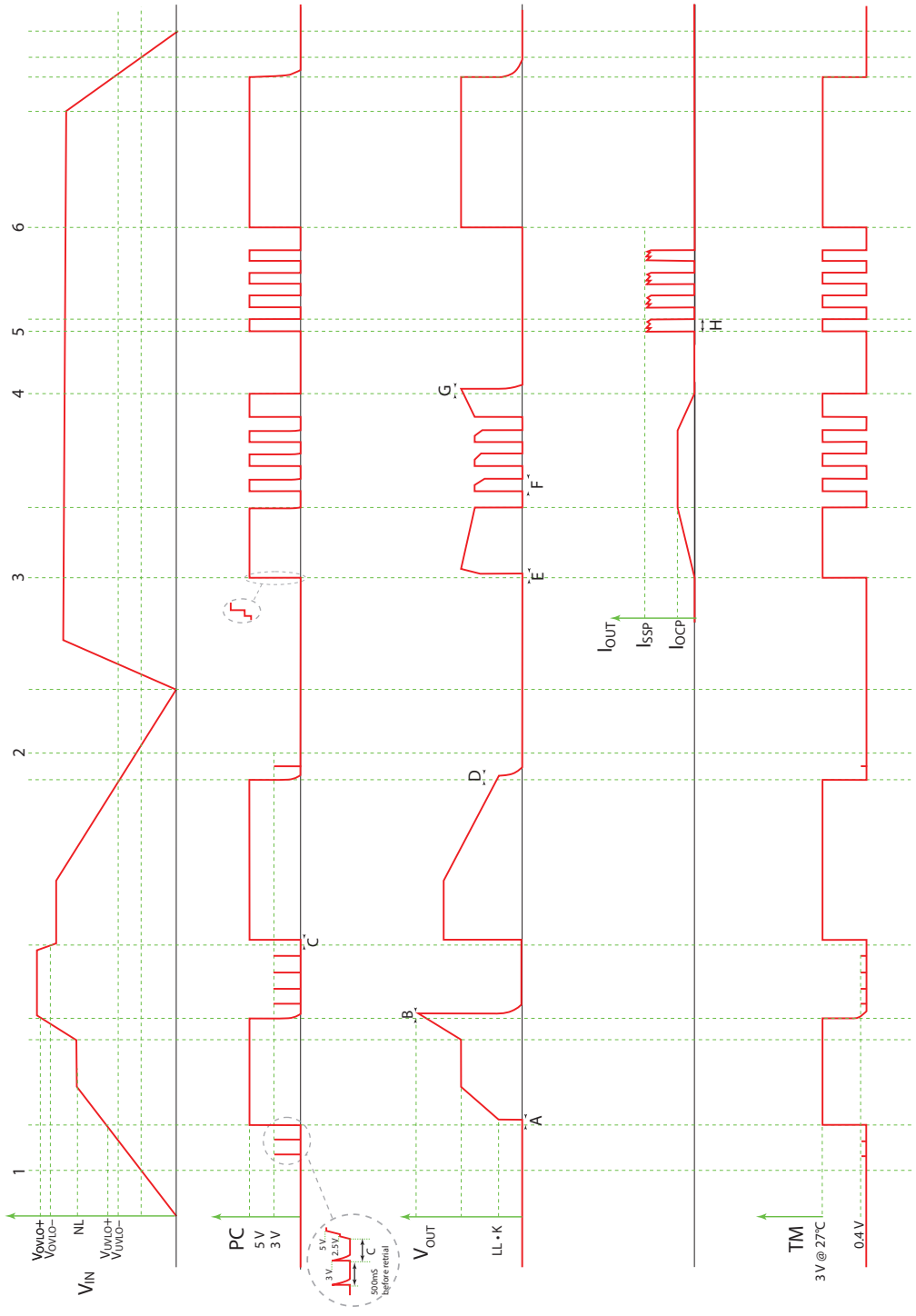
- The TM pin monitors the internal temperature of the controller IC within an accuracy of ±5°C.
- Can be used as a "Power Good" flag to verify that the BCM module is operating.
- Is used to drive the internal comparator for Overtemperature Shutdown.

SIGNAL TYPE	STATE	ATTRIBUTE	SYMBOL	CONDITIONS / NOTES	MIN	TYP	MAX	UNIT
ANALOG OUTPUT	Regular Operation	TM voltage range	V_{TM}		**2.12**		**4.04**	V
		TM voltage reference	V_{TM_AMB}	T_J controller = 27°C	2.95	3.00	3.05	V
		TM available current	I_{TM}				**100**	µA
		TM gain	A_{TM}			10		mV/°C
		TM voltage ripple	V_{TM_PP}	C_{TM} = 0pF, V_{IN} = 352V, I_{OUT} = 28.5A		120	**200**	mV
DIGITAL INPUT / OUTPUT	Transition	TM capacitance (external)	C_{TM_EXT}				**50**	pF
		TM fault response time	T_{FR_TM}	From fault to TM = 1.5V		10		µs
	Standby	TM voltage	V_{TM_DIS}			0		V
		TM pull down (internal)	R_{TM_INT}	Internal pull down resistor	**25**	40	**50**	kΩ

Reserved: RSV

Reserved for factory use. No connection should be made to this pin.

Timing Diagram



Notes:
– Timing and signal amplitudes are not to scale
– Error pulse width is load dependent

A: T_{ON1}
B: T_{OVLO*}
C: $T_{AUTO\_RESTART}$
D: T_{UVLO}
E: T_{ON2}
F: T_{OCP}
G: T_{PC-DIS}
H: T_{SCP**}

1: Controller start
2: Controller turn off
3: PC release
4: PC pulled low
5: PC released on output SC
6: SC removed

*Min value switching off
**From detection of error to power train shut down

Application Characteristics

The following values, typical of an application environment, are collected at T_{CASE} = 25ºC unless otherwise noted.
See associated figures for general trend data.

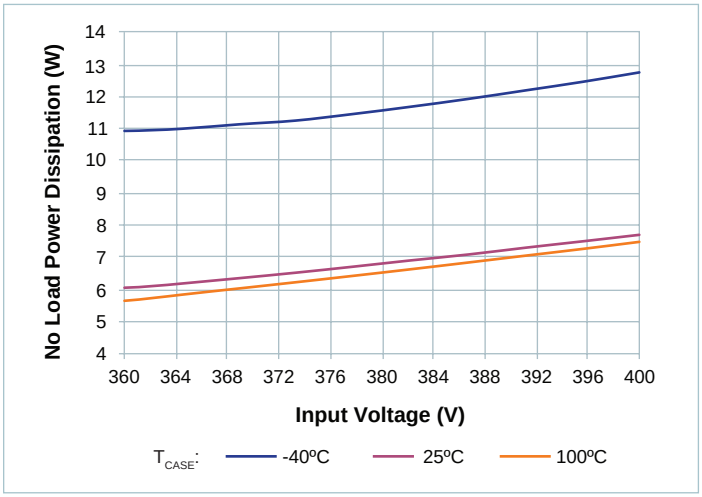


Figure 2 No load power dissipation vs. V_{IN}

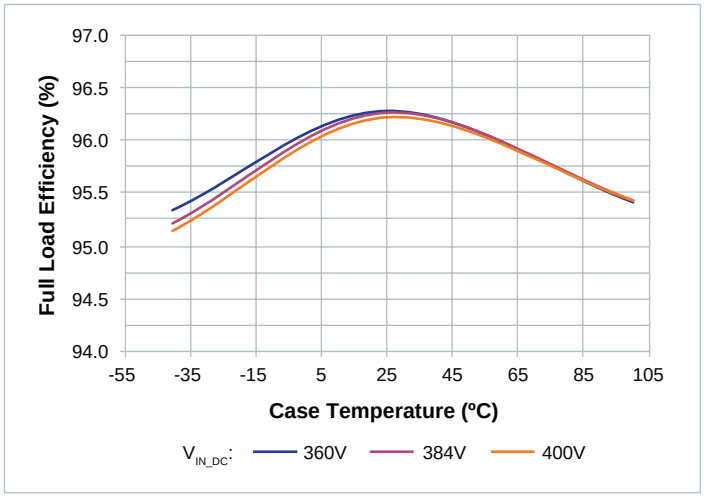


Figure 3 Full load ef ciency vs. temperature; V_{IN}

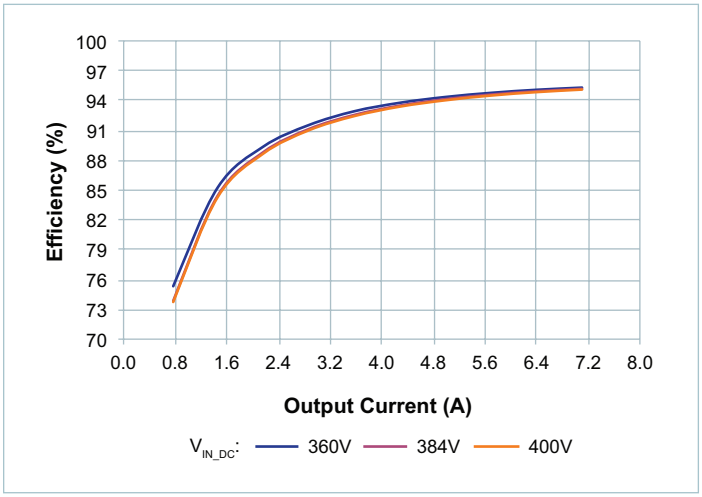


Figure 4 Ef ciency at T_{CASE}= -40ºC

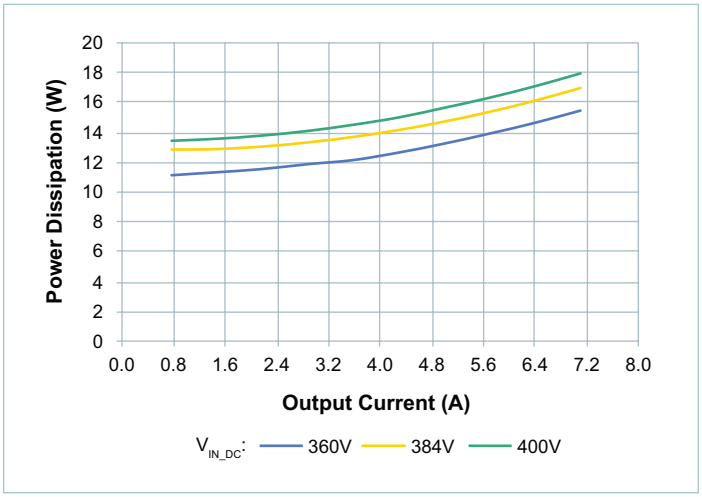


Figure 5 Power dissipation at T_{CASE}= -40ºC

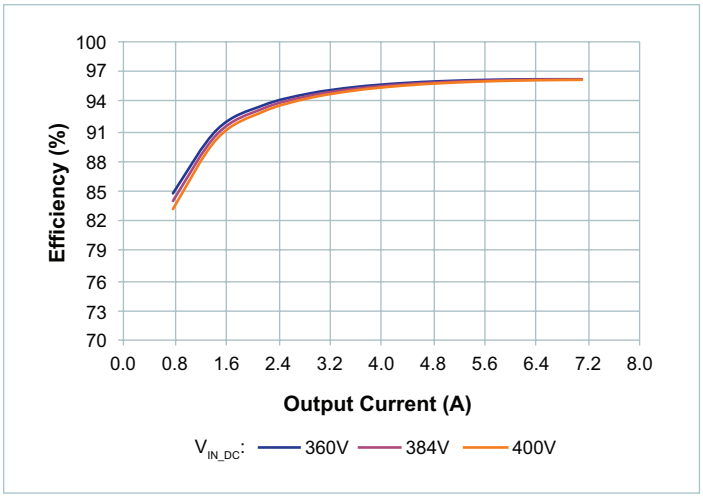


Figure 6 Ef ciency at T_{CASE}= 25ºC

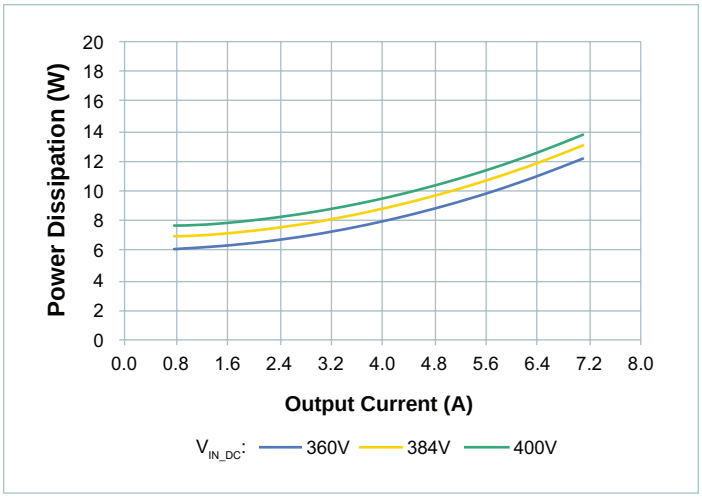


Figure 7 Power dissipation at T_{CASE}= 25ºC

Application Characteristics (Cont.)

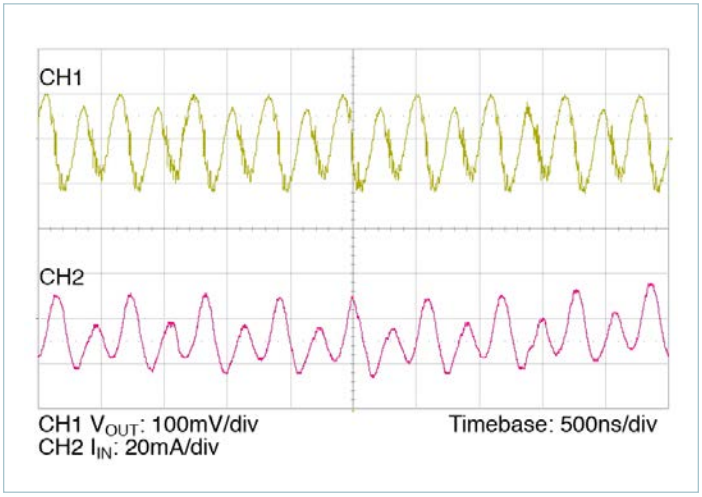


Figure 12 Full load ripple, 2.2µF C_{IN}: No external C_{OUT}, Board mounted module, scope setting : 20MHz analog BW

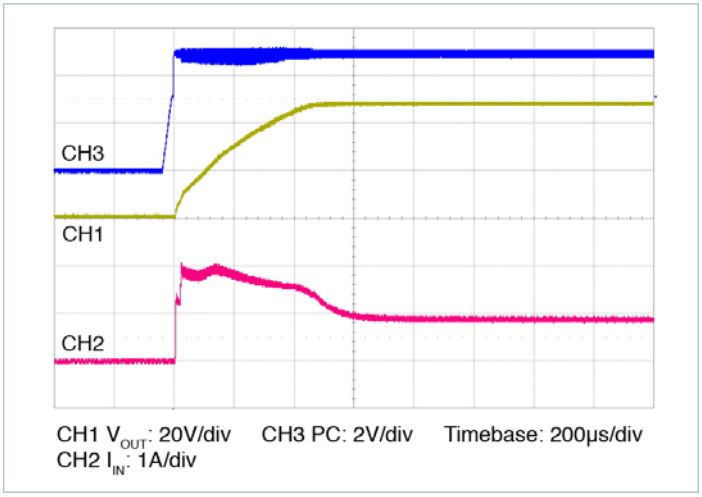


Figure 13 Start up from application of PC; V_{IN} pre-applied C_{OUT} = 100µF, 100% I_{OUT} R-load

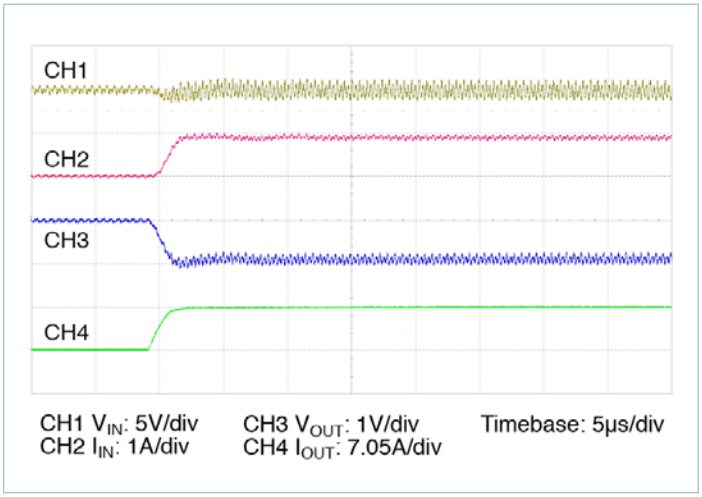


Figure 14 0A 7.05A transient response: C_{IN} = 2.2µF, I_{IN} measuredprior to C_{IN} , no external C_{OUT}

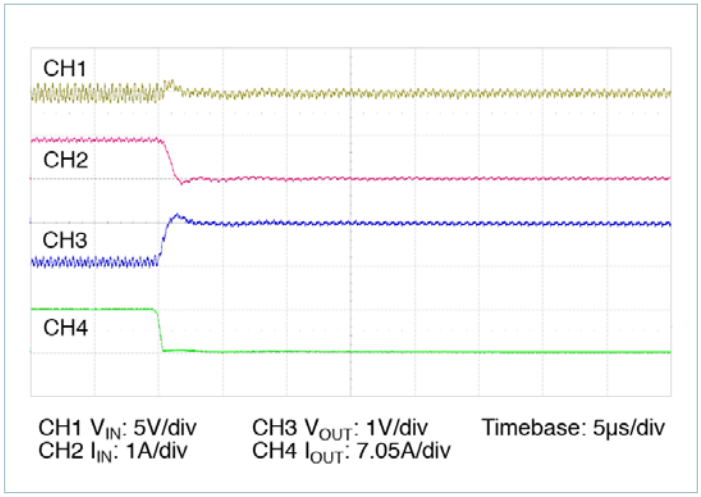


Figure 15 7.05A 0A transient response: C_{IN} = 2.2µF, I_{IN} measured prior to C_{IN}, no external C_{OUT}

General Characteristics

Specifications apply over all line and load conditions, unless otherwise noted; **boldface** specifications apply over the temperature range of -40°C ≤ T_{CASE} ≤ 100°C (T-Grade); All other specifications are at T_{CASE} = 25°C unless otherwise noted.

Attribute	Symbol	Conditions / Notes	Min	Typ	Max	Unit
Mechanical						
Length	L		32.25 / [1.270]	32.50 / [1.280]	32.75 / [1.289]	mm / [in]
Width	W		21.75 / [0.856]	22.00 / [0.866]	22.25 / [0.876]	mm / [in]
Height	H		6.48 / [0.255]	6.73 / [0.265]	6.98 / [0.275]	mm / [in]
Volume	Vol	No heat sink		4.81 / [0.294]		cm^3/ [in^3]
Weight	W			14.5 / [0.512]		g / [oz]
Lead Finish		Nickel	0.51		2.03	µm
		Palladium	0.02		0.15	
		Gold	0.003		0.051	
Thermal						
Operating temperature	T_J	BCM384x480T325B00 (T-Grade)	-40		125	°C
		BCM384x480M325B00 (M-Grade)	-55		125	
Thermal resistance	ϕ_{JC}	Isothermal heatsink and isothermal internal PCB		1		°C/W
Thermal capacity				9		Ws/°C
Assembly						
Peak compressive force applied to case (Z-axis)		Supported by J-lead only			6	lbs
					5.41	lbs/ in^2
Storage Temperature	T_{ST}	BCM384x480T325B00 (T-Grade)	-40		125	°C
		BCM384x480M325B00 (M-Grade)	-55		125	°C
ESD Withstand	ESD_{HBM}	Human Body Model, "JEDEC JESD 22-A114C.01" Class 1C	2000			V
	ESD_{CDM}	Charge Device Model, "JEDEC JESD 22-C101-D"	500			
Soldering						
Peak temperature during reflow		MSL 4 (Datecode 1528 and later)			245	°C
Peak time above 217°C				60	90	s
Peak heating rate during reflow				1.5	3	°C/s
Peak cooling rate post reflow				1.5	6	°C/s
Safety						
Working voltage (IN – OUT)	V_{IN_OUT}				**500**	V_{DC}
Isolation voltage (hipot)	V_{HIPOT}		**4242**			V_{DC}
Isolation capacitance	C_{IN_OUT}	Unpowered unit	**500**	**660**	**800**	pF
Isolation resistance	R_{IN_OUT}	At 500V_{DC}	**10**			MΩ
MTBF		MIL-HDBK-217Plus Parts Count - 25°C Ground Benign, Stationary, Indoors / Computer Profile		3.2		MHrs
		Telcordia Issue 2 - Method I Case III; 25°C Ground Benign, Controlled		7.2		MHrs
Agency approvals / standards		cTUVus				
		cURus				
		CE Marked for Low Voltage Directive and ROHS recast directive, as applicable.				

Using the Control Signals PC, TM

Primary Control (PC) pin can be used to accomplish the following functions:

- *Logic enable and disable for module:* Once T_{ON1} time has been satisfied, a PC voltage greater than V_{PC_EN} will cause the module to start. Bringing PC lower than V_{PC_DIS} will cause the module to enter standby.
- *Auxiliary voltage source:* Once enabled in regular operational conditions (no fault), each BCM module PC provides a regulated 5V, 3.5mA voltage source.
- *Synchronized start up:* In an array of parallel modules, PC pins should be connected to synchronize start up across units. This permits the maximum load and capacitance to scale by the number of paralleled modules.
- *Output disable:* PC pin can be actively pulled down in order to disable the module. Pull down impedance shall be lower than 60Ω.
- *Fault detection flag:* The PC 5V voltage source is internally turned off as soon as a fault is detected.
- Note that PC can not sink significant current during a fault condition. The PC pin of a faulted module will not cause interconnected PC pins of other modules to be disabled.

Temperature Monitor (TM) pin provides a voltage proportional to the absolute temperature of the converter control IC.

It can be used to accomplish the following functions:

- *Monitor the control IC temperature:* The temperature in Kelvin is equal to the voltage on the TM pin scaled by 100. (i.e. 3.0V = 300K = 27°C). If a heat sink is applied, TM can be used to protect the system thermally.
- *Fault detection flag:* The TM voltage source is internally turned off as soon as a fault is detected. For system monitoring purposes microcontroller interface faults are detected on falling edges of TM signal.

Sine Amplitude Converter™ Point of Load Conversion

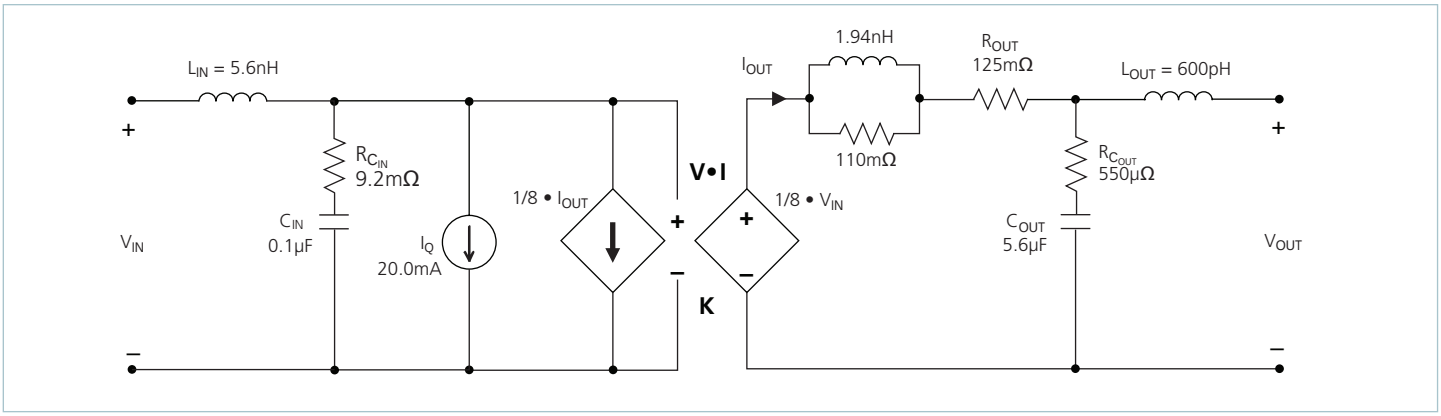


Figure 17 VI Chip ™ module AC model

The Sine Amplitude Converter (SAC™) uses a high frequency resonant tank to move energy from input to output. The resonant LC tank, operated at high frequency, is amplitude modulated as a function of input voltage and output current. A small amount of capacitance embedded in the input and output stages of the module is sufficient for full functionality and is key to achieving power density.

The BCM384x480y325Bzz SAC can be simplified into the preceeding model.

At no load:

$$V_{OUT} = V_{IN} \quad K \tag{1}$$

K represents the "turns ratio" of the SAC.
Rearranging Eq (1):

$$K = \frac{V_{OUT}}{V_{IN}} \tag{2}$$

In the presence of load, V_{OUT} is represented by:

$$V_{OUT} = V_{IN} \quad K \quad I_{OUT} \quad R_{OUT} \tag{3}$$

and I_{OUT} is represented by:

$$I_{OUT} = \frac{I_{IN} \quad I_Q}{K} \tag{4}$$

R_{OUT} represents the impedance of the SAC, and is a function of the R_{DSON} of the input and output MOSFETs and the winding resistance of the power transformer. I_Q represents the quiescent current of the SAC control, gate drive circuitry, and core losses.

The use of DC voltage transformation provides additional interesting attributes. Assuming that $R_{OUT} = 0\Omega$ and $I_Q = 0A$, Eq. (3) now becomes Eq. (1) and is essentially load independent, resistor R is now placed in series with V_{IN}.

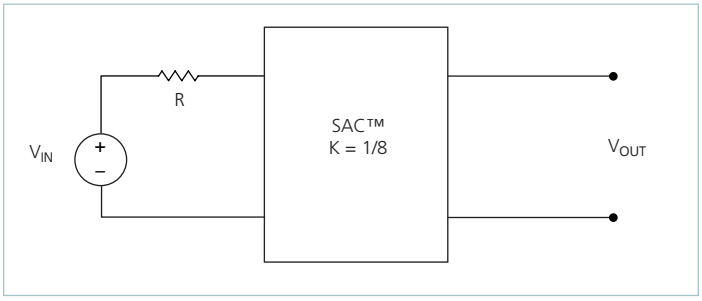


Figure 18 K = 1/8 Sine Amplitude Converter with series input resistor

The relationship between V_{IN} and V_{OUT} becomes:

$$V_{OUT} = (V_{IN} \quad I_{IN} \quad R) \quad K \tag{5}$$

Substituting the simplified version of Eq. (4) (I_Q is assumed = 0A) into Eq. (5) yields:

$$V_{OUT} = V_{IN} \quad K \quad I_{OUT} \quad R \quad K^2 \tag{6}$$

This is similar in form to Eq. (3), where R_{OUT} is used to represent the characteristic impedance of the SAC™. However, in this case a real R on the input side of the SAC is effectively scaled by K^2 with respect to the output.

Assuming that R = 1Ω, the effective R as seen from the secondary side is 15.6mΩ, with K = 1/8.

A similar exercise should be performed with the additon of a capacitor or shunt impedance at the input to the SAC. A switch in series with V_{IN} is added to the circuit. This is depicted in Figure 19.

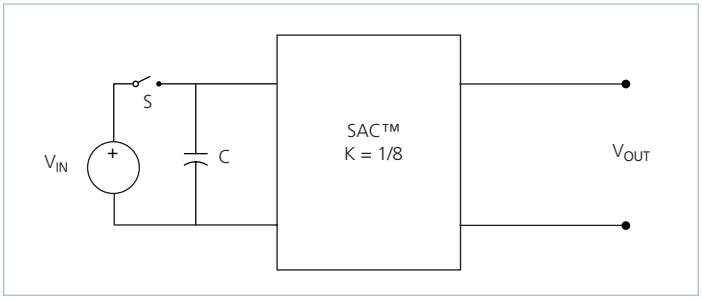


Figure 19 Sine Amplitude Converter with input capacitor

A change in V_{IN} with the switch closed would result in a change in capacitor current according to the following equation:

$$I_C(t) = C \frac{dV_{IN}}{dt} \quad (7)$$

Assume that with the capacitor charged to V_{IN}, the switch is opened and the capacitor is discharged through the idealized SAC. In this case,

$$I_C = I_{OUT} \quad K \quad (8)$$

substituting Eq. (1) and (8) into Eq. (7) reveals:

$$I_{OUT} = \frac{C}{K^2} \quad \frac{dV_{OUT}}{dt} \quad (9)$$

The equation in terms of the output has yielded a K^2 scaling factor for C, specified in the denominator of the equation. A K factor less than unity results in an effectively larger capacitance on the output when expressed in terms of the input. With a K = 1/8 as shown in Figure 19, C = 1µF would appear as C = 64µF when viewed from the output.

Low impedance is a key requirement for powering a high-current, low-voltage load efficiently. A switching regulation stage should have minimal impedance while simultaneously providing appropriate filtering for any switched current. The use of a SAC between the regulation stage and the point of load provides a dual benefit of scaling down series impedance leading back to the source and scaling up shunt capacitance or energy storage as a function of its K factor squared. However, the benefits are not useful if the series impedance of the SAC is too high. The impedance of the SAC must be low, i.e. well beyond the crossover frequency of the system.

A solution for keeping the impedance of the SAC low involves switching at a high frequency. This enables small magnetic components because magnetizing currents remain low. Small magnetics mean small path lengths for turns. Use of low loss core material at high frequencies also reduces core losses.

The two main terms of power loss in the BCM module are:

- No load power dissipation (P_{NL}): defined as the power used to power up the module with an enabled powertrain at no load.
- Resistive loss ($P_{R_{OUT}}$): refers to the power loss across the BCM module modeled as pure resistive impedance.

$$P_{DISSIPATED} = P_{NL} + P_{R_{OUT}} \quad (10)$$

Therefore,

$$P_{OUT} = P_{IN} \quad P_{DISSIPATED} = P_{IN} \quad P_{NL} \quad P_{R_{OUT}} \quad (11)$$

The above relations can be combined to calculate the overall module efficiency:

$$\eta = \frac{P_{OUT}}{P_{IN}} = \frac{P_{IN} \quad P_{NL} \quad P_{R_{OUT}}}{P_{IN}} \quad (12)$$

$$= \frac{V_{IN} \quad I_{IN} \quad P_{NL} \quad (I_{OUT})^2 \quad R_{OUT}}{V_{IN} \quad I_{IN}}$$

$$= 1 \quad \frac{(P_{NL} + (I_{OUT})^2 \quad R_{OUT})}{V_{IN} \quad I_{IN}}$$

Input and Output Filter Design

A major advantage of SAC™ systems versus conventional PWM converters is that the transformers do not require large functional filters. The resonant LC tank, operated at extreme high frequency, is amplitude modulated as a function of input voltage and output current and efficiently transfers charge through the isolation transformer. A small amount of capacitance embedded in the input and output stages of the module is sufficient for full functionality and is key to achieve power density.

This paradigm shift requires system design to carefully evaluate external filters in order to:

1. *Guarantee low source impedance:*

   To take full advantage of the BCM module's dynamic response, the impedance presented to its input terminals must be low from DC to approximately 5MHz. The connection of the bus converter module to its power source should be implemented with minimal distribution inductance. If the interconnect inductance exceeds 100nH, the input should be bypassed with a RC damper to retain low source impedance and stable operation. With an interconnect inductance of 200nH, the RC damper may be as high as 1µF in series with 0.3Ω. A single electrolytic or equivalent low-Q capacitor may be used in place of the series RC bypass.

2. *Further reduce input and/or output voltage ripple without sacrificing dynamic response:*

   Given the wide bandwidth of the module, the source response is generally the limiting factor in the overall system response. Anomalies in the response of the source will appear at the output of the module multiplied by its K factor. This is illustrated in Figures 15 and 16.

3. *Protect the module from overvoltage transients imposed by the system that would exceed maximum ratings and cause failures:*

   The module input/output voltage ranges shall not be exceeded. An internal overvoltage lockout function prevents operation outside of the normal operating input range. Even during this condition, the powertrain is exposed to the applied voltage and power MOSFETs must withstand it. A criterion for protection is the maximum amount of energy that the input or output switches can tolerate if avalanched.

Total load capacitance at the output of the BCM module shall not exceed the specified maximum. Owing to the wide bandwidth and low output impedance of the module, low-frequency bypass capacitance and significant energy storage may be more densely and efficiently provided by adding capacitance at the input of the module. At frequencies <500kHz the module appears as an impedance of R_{OUT} between the source and load.

Within this frequency range, capacitance at the input appears as effective capacitance on the output per the relationship defined in Eq. 13.

$$C_{OUT} = \frac{C_{IN}}{K^2} \quad (13)$$

This enables a reduction in the size and number of capacitors used in a typical system.

Thermal Considerations

VI Chip® products are multi-chip modules whose temperature distribution varies greatly for each part number as well as with the input / output conditions, thermal management and environmental conditions. Maintaining the top of the BCM384x480y325Bzz case to less than 100°C will keep all junctions within the VI Chip module below 125°C for most applications.

The percent of total heat dissipated through the top surface versus through the J-lead is entirely dependent on the particular mechanical and thermal environment. The heat dissipated through the top surface is typically 60%. The heat dissipated through the J-lead onto the PCB surface is typically 40%. Use 100% top surface dissipation when designing for a conservative cooling solution.

It is not recommended to use a VI Chip module for an extended period of time at full load without proper heat sinking.

Current Sharing

The performance of the SAC™ topology is based on efficient transfer of energy through a transformer without the need of closed loop control. For this reason, the transfer characteristic can be approximated by an ideal transformer with a positive temperature coefficient series resistance.

This type of characteristic is close to the impedance characteristic of a DC power distribution system both in dynamic (AC) behavior and for steady state (DC) operation.

When multiple BCM modules of a given part number are connected in an array they will inherently share the load current according to the equivalent impedance divider that the system implements from the power source to the point of load.

Some general recommendations to achieve matched array impedances include:

- Dedicate common copper planes within the PCB to deliver and return the current to the modules.
- Provide as symmetric a PCB layout as possible among modules
- Apply same input / output filters (if present) to each unit.

For further details see AN:016 Using BCM Bus Converters in High Power Arrays.

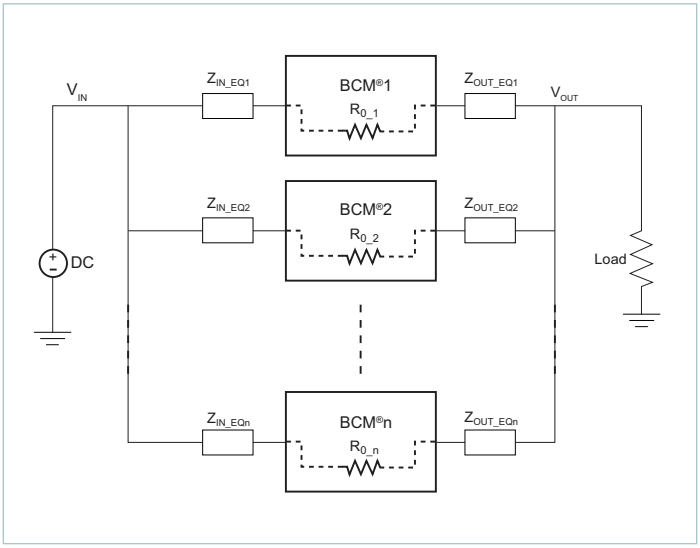


Figure 20 BCM module array

Fuse Selection

In order to provide flexibility in configuring power systems VI Chip® modules are not internally fused. Input line fusing of VI Chip products is recommended at system level to provide thermal protection in case of catastrophic failure.

The fuse shall be selected by closely matching system requirements with the following characteristics:

- Current rating (usually greater than maximum current of BCM module)
- Maximum voltage rating (usually greater than the maximum possible input voltage)
- Ambient temperature
- Nominal melting I^2t
- Recommend fuse: ≤ 2.5A Bussmann PC–Tron Fuse or ≤ 3.15A SOC type 36CFA Fuse.

Reverse Operation

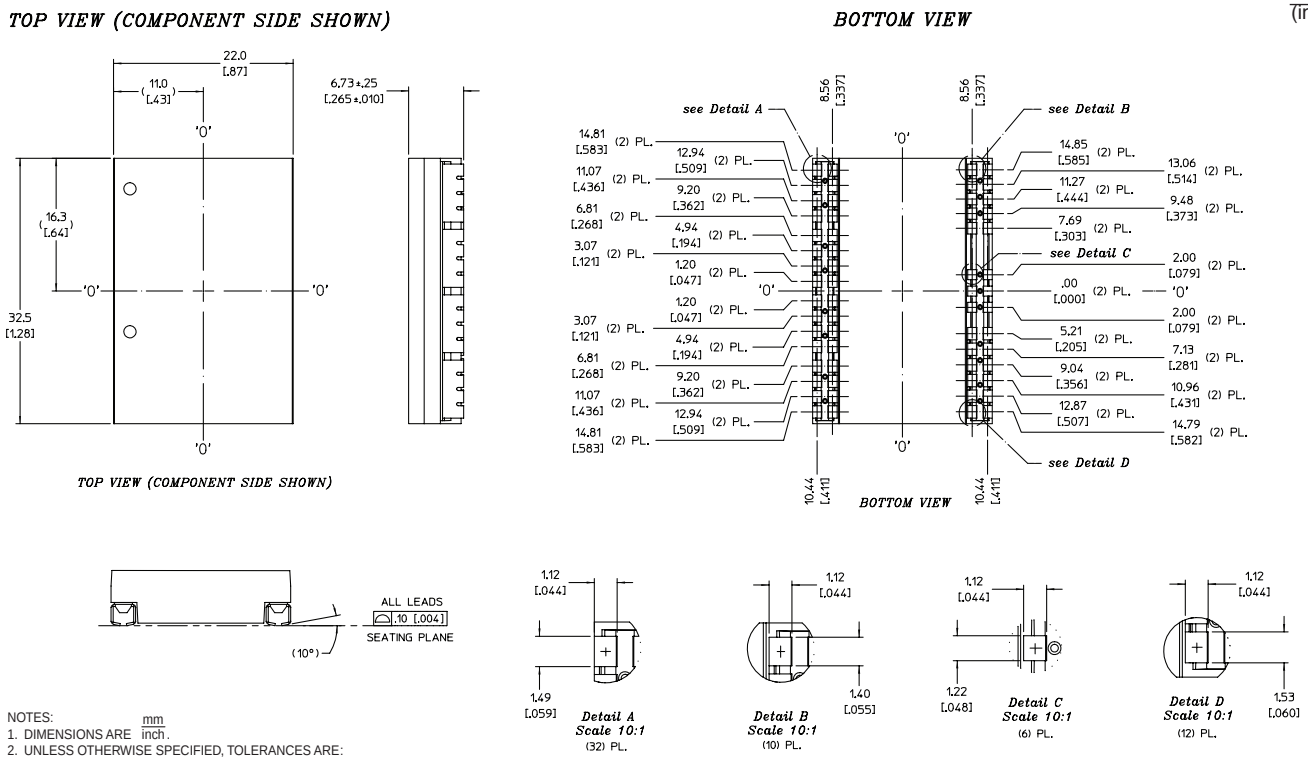
BCM modules are capable of reverse power operation. Once the unit is started, energy will be transferred from secondary back to the primary whenever the secondary voltage exceeds $V_{IN} \bullet K$. The module will continue operation in this fashion for as long as no faults occur.

The BCM384x480y325Bzz has not been qualified for continuous operation in a reverse power condition. However, fault protections which help to protect the module in forward operation will also protect the module in reverse operation.

Transient operation in reverse is expected in cases where there is significant energy storage on the output and transient voltages appear on the input. Transient reverse power operation of less than 1ms, 10% duty cycle is permitted and has been qualified to cover these cases.

J-Lead Package Mechanical Drawing

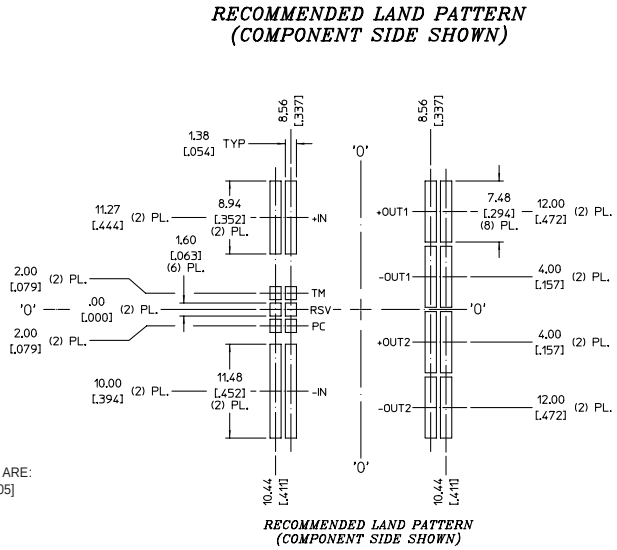
mm
(inch)



NOTES:
1. DIMENSIONS ARE mm / inch.
2. UNLESS OTHERWISE SPECIFIED, TOLERANCES ARE:
   .X / [.XX] = +/-0.25 / [.01]; .XX / [.XXX] = +/-0.13 / [.005]
3. PRODUCT MARKING ON TOP SURFACE

DXF and PDF files are available on vicorpower.com

J-Lead Package Recommended Land Pattern



NOTES:
1. DIMENSIONS ARE mm / inch.
2. UNLESS OTHERWISE SPECIFIED, TOLERANCES ARE:
   .X / [.XX] = +/-0.25 / [.01]; .XX / [.XXX] = +/-0.13 / [.005]
3. PRODUCT MARKING ON TOP SURFACE

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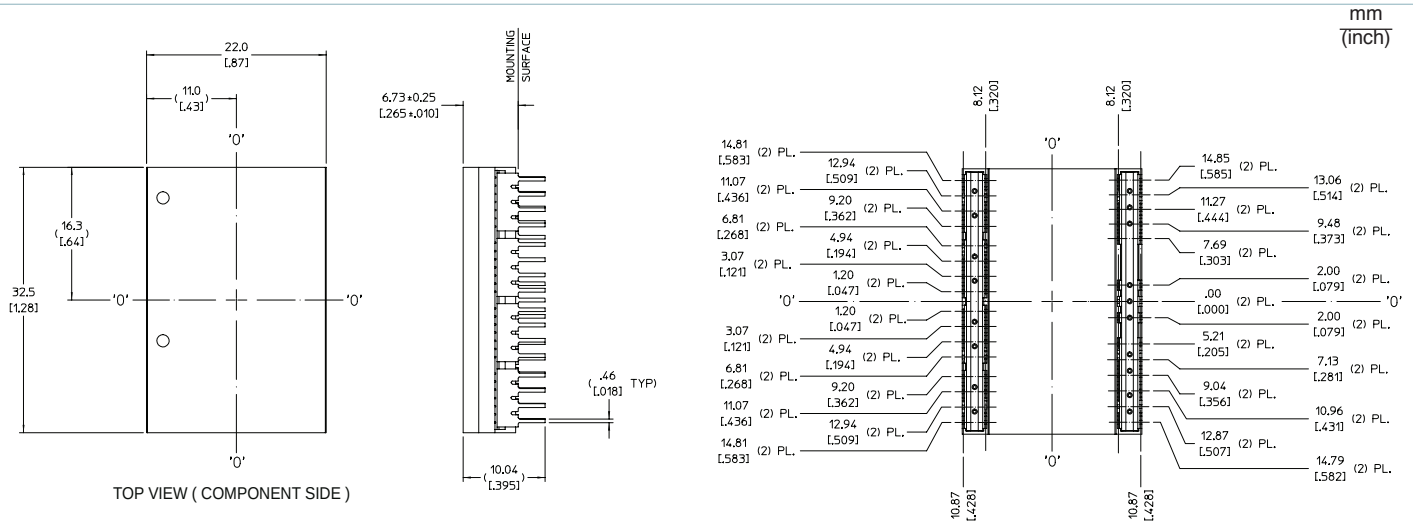
Through Hole Package Mechanical Drawing

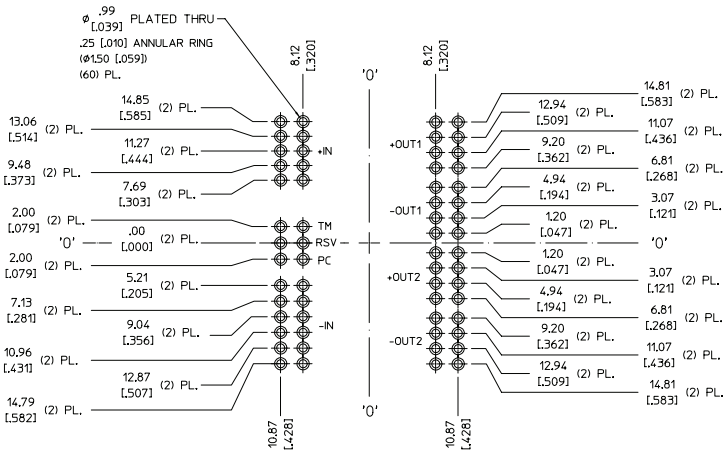


NOTES:

1. DIMENSIONS ARE (mm) inch
2. UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:
   X.X [X.XX] = ±0.25 [0.01]; X.XX [X.XXX] = ±0.13 [0.005]
3. RoHS COMPLIANT PER CST-0001 LATEST REVISION

DXF and PDF files are available on vicorpower.com

Through Hole Package Recommended Land Pattern



NOTES:

1. DIMENSIONS ARE (mm) inch
2. UNLESS OTHERWISE SPECIFIED TOLERANCES ARE:
   X.X [X.XX] = ±0.25 [0.01]; X.XX [X.XXX] = ±0.13 [0.005]
3. RoHS COMPLIANT PER CST-0001 LATEST REVISION

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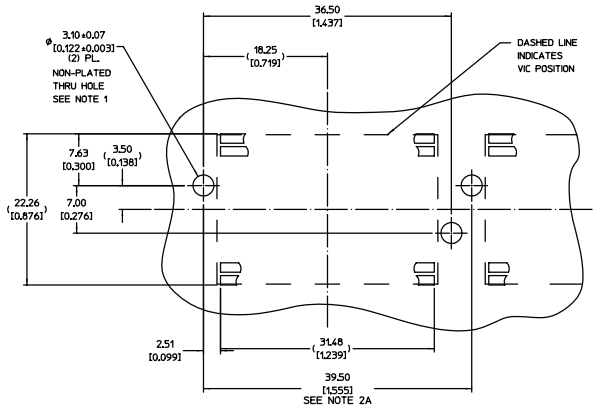
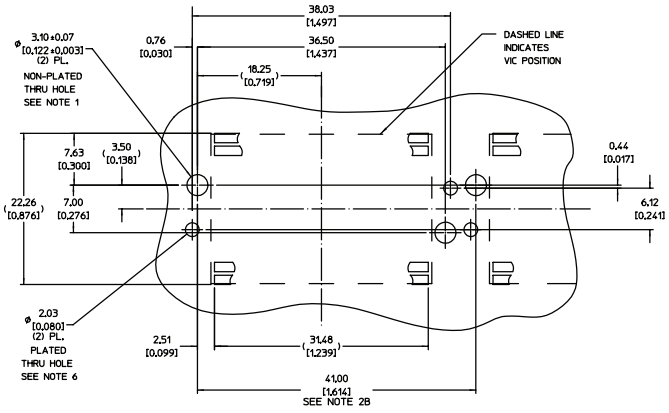
RECOMMENDED HOLE PATTERN
(COMPONENT SIDE SHOWN)

Recommended Heat Sink Push Pin Location



(NO GROUNDING CLIPS)



(WITH GROUNDING CLIPS)

Notes:

1. Maintain 3.50 (0.138) Dia. keep-out zone free of copper, all PCB layers.
2. (A) Minimum recommended pitch is 39.50 (1.555). This provides 7.00 (0.275) component edge-to-edge spacing, and 0.50 (0.020) clearance between Vicor heat sinks.
   (B) Minimum recommended pitch is 41.00 (1.614). This provides 8.50 (0.334) component edge-to-edge spacing, and 2.00 (0.079) clearance between Vicor heat sinks.
3. VI Chip® module land pattern shown for reference only; actual land pattern may differ. Dimensions from edges of land pattern to push–pin holes will be the same for all full-size VI Chip® products.
4. RoHS compliant per CST–0001 latest revision.
5. Unless otherwise specified:
   Dimensions are mm (inches)
   tolerances are:
   x.x (x.xx) = ±0.3 (0.01)
   x.xx (x.xxx) = ±0.13 (0.005)
6. Plated through holes for grounding clips (33855) shown for reference, heat sink orientation and device pitch will dictate final grounding solution.

Revision History

Revision	Date	Description	Page Number(s)
1.0	09/30/16	Initial release	n/a
1.1	10/12/16	Specification corrections	5, 7

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