



# VTM<sup>®</sup> Current Multiplier

## V048F060T040

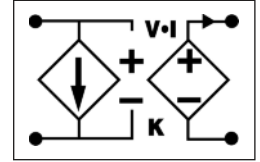
## V048F060M040



### High Efficiency, Sine Amplitude Converter™

- 48 V to 6 V VI Chip<sup>®</sup> Converter
- 40 A (60.0 A for 1 ms)
- High density – 813 W/in<sup>3</sup>
- Small footprint – 210 W/in<sup>2</sup>
- Low weight – 0.5 oz (15 g)
- Pick & Place / SMD or Through hole
- 125°C operation (T<sub>j</sub>)
- 1 μs transient response
- 3.5 million hours MTBF
- Typical efficiency 95%
- No output filtering required

**V<sub>F</sub> = 26 - 55 V**  
**V<sub>OUT</sub> = 3.25 - 6.87 V**  
**I<sub>OUT</sub> = 40 A**  
**K = 1/8**  
**R<sub>OUT</sub> = 8.1 mΩ max**



### Product Description

The V048F060T040 VI Chip<sup>®</sup> current multiplier excels at speed, density and efficiency to meet the demands of advanced power applications while providing isolation from input to output. It achieves a response time of less than 1 μs and delivers up to 40 A in a volume of less than 0.295 in<sup>3</sup> with unprecedented efficiency. It may be paralleled to deliver higher power levels at an output voltage settable from 3.25 to 6.87 Vdc.

The VTM V048F060T040's nominal output voltage is 6 Vdc from a 48 Vdc input Factorized Bus, V<sub>F</sub>, and is controllable from 3.25 to 6.87 Vdc at no load, and from 2.93 to 6.58 Vdc at full load, over a V<sub>F</sub> input range of 26 to 55 Vdc. It can be operated either open- or closed-loop depending on the output regulation needs of the application. Operating open-loop, the output voltage tracks its V<sub>F</sub> input voltage with a transformation ratio, K = 1/8, for applications requiring an isolated output voltage with high efficiency. Closing the loop back to an input PRM<sup>®</sup> regulator or DC-DC converter enables tight load regulation.

The 6 V VTM module achieves a power density of 813 W/in<sup>3</sup> in a VI Chip package compatible with standard pick-and-place and surface mount assembly processes. The VTM modules fast dynamic response and low noise eliminate the need for bulk capacitance at the load, substantially increasing system density while improving reliability and decreasing cost.

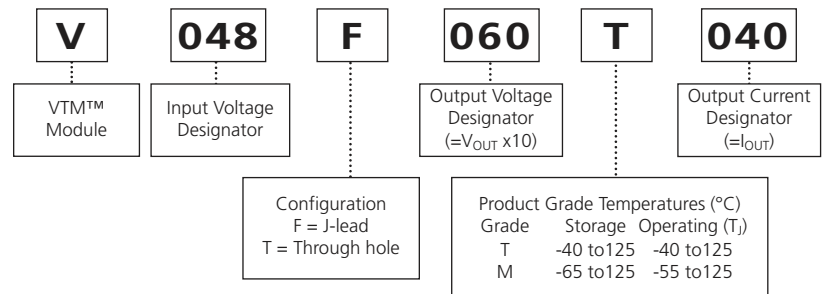
### Absolute Maximum Ratings

Parameter	Values	Unit	Notes
+In to -In	-1.0 to 60	Vdc	
	100	Vdc	For 100 ms
PC to -In	-0.3 to 7.0	Vdc	
VC to -In	-0.3 to 19.0	Vdc	
+Out to -Out	-0.5 to 12	Vdc	
Isolation voltage	2,250	Vdc	Input to output
Output current	40	A	Continuous
Peak output current	60.0	A	For 1 ms
Output power	263	W	Continuous
Peak output power	395	W	For 1 ms
Case temperature during reflow <sup>[a]</sup>	225	°C	MSL 5
	245	°C	MSL 6, TOB = 4 hrs
Operating junction temperature <sup>[b]</sup>	-40 to 125	°C	T-Grade
	-55 to 125	°C	M-Grade
Storage temperature	-40 to 125	°C	T-Grade
	-65 to 125	°C	M-Grade

#### Notes:

- [a] 245°C reflow capability applies to product with manufacturing date code 1001 and greater.  
 [b] The referenced junction is defined as the semiconductor having the highest temperature. This temperature is monitored by a shutdown comparator.

### Part Numbering



## Specifications

### Input Specs (Conditions are at 48 V<sub>IN</sub>, full load, and 25°C ambient unless otherwise specified)

Parameter	Min	Typ	Max	Unit	Note
Input voltage range	26	48	55	Vdc	Max Vin = 53 V, operating from -55°C to -40°C
Input dV/dt			1	V/μs	
Input overvoltage turn on	55.0			Vdc	
Input overvoltage turn off			59.7	Vdc	
Input current			5.5	Adc	
Input reflected ripple current		275		mA p-p	Using test circuit in Figure 15; See Figure 1
No load power dissipation		2.0	2.70	W	
Internal input capacitance		1.9		μF	
Internal input inductance			5	nH	

### Output Specs (Conditions are at 48 V<sub>IN</sub>, full load, and 25°C ambient unless otherwise specified)

Parameter	Min	Typ	Max	Unit	Note
Output voltage	3.25		6.87	Vdc	No load
	2.93		6.58	Vdc	Full load
Rated DC current	0		40	Adc	26 - 55 V <sub>IN</sub>
Peak repetitive current			60.0	A	Max pulse width 1ms, max duty cycle 10%, baseline power 50%
Short circuit protection set point	47.4			Adc	Module will shut down
Current share accuracy		5	10	%	See Parallel Operation on Page 9
Efficiency					
Half load	94.0	95.6		%	See Figure 3
Full load	93.5	93.9		%	See Figure 3
Internal output inductance		1.1		nH	
Internal output capacitance		35.6		μF	Effective value
Output overvoltage set point	6.9			Vdc	Module will shut down
Output ripple voltage					
No external bypass		145	275	mVp-p	See Figures 2 and 5
10 μF bypass capacitor		13		mVp-p	See Figure 6
Effective switching frequency	2.1	2.5	3.1	MHz	Fixed, 1.3 MHz per phase
Line regulation					
K	0.1238	1/8	0.1263		V <sub>OUT</sub> = K•V <sub>IN</sub> at no load
Load regulation					
R <sub>OUT</sub>		7.5	8.1	mΩ	See Figure 16
Transient response					
Voltage overshoot		180		mV	40 A load step with 100 μF C <sub>IN</sub> ; See Figures 7 and 8
Response time		200		ns	See Figures 7 and 8
Recovery time		1		μs	See Figures 7 and 8

Specifications

Waveforms

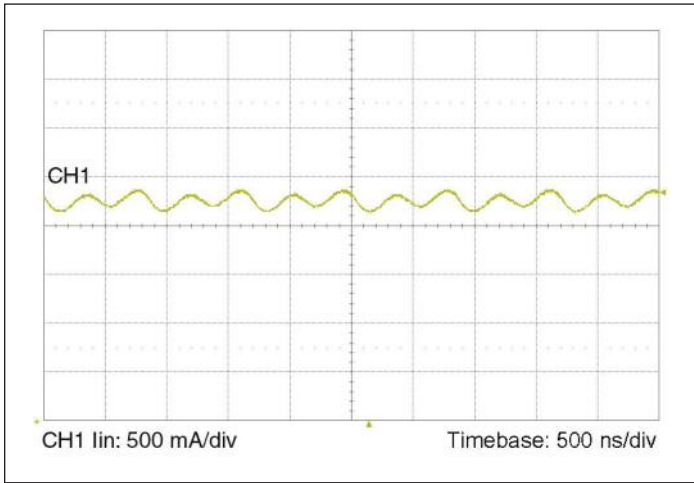


Figure 1 — Input reflected ripple current at full load and 48 V<sub>F</sub>.

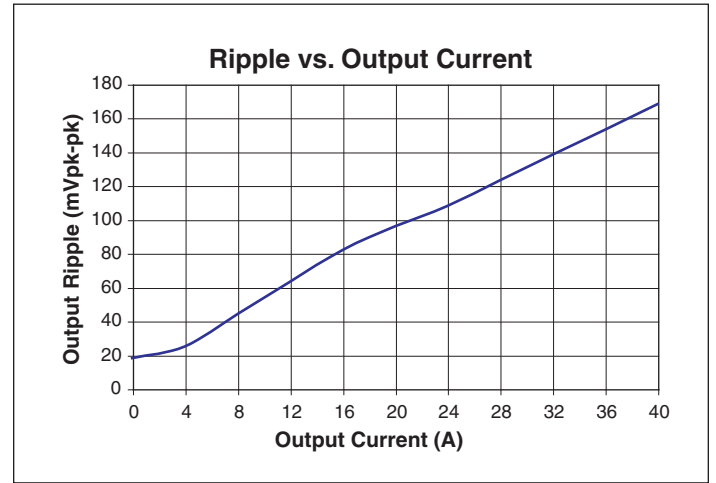


Figure 2 — Output voltage ripple vs. output current at 48 V<sub>F</sub> with no POL bypass capacitance.

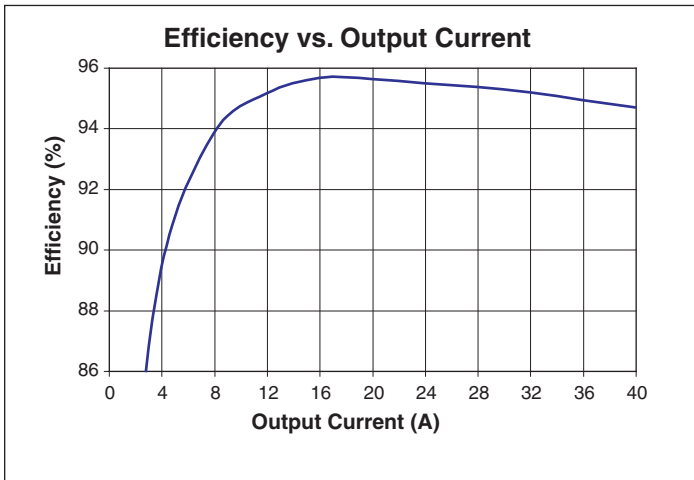


Figure 3 — Efficiency vs. output current.

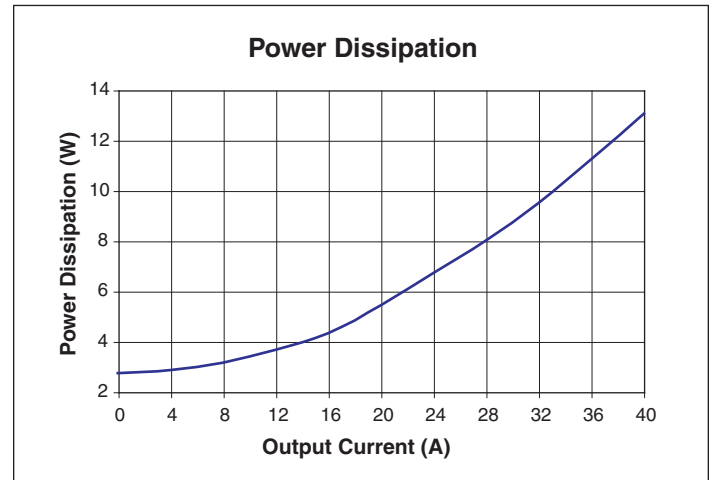


Figure 4 — Power dissipation vs. output current.

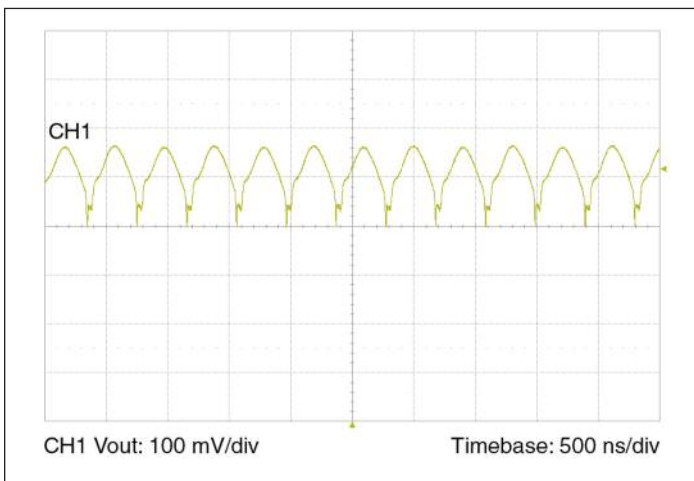


Figure 5 — Output voltage ripple at full load and 48 V<sub>F</sub> with no POL bypass capacitance.

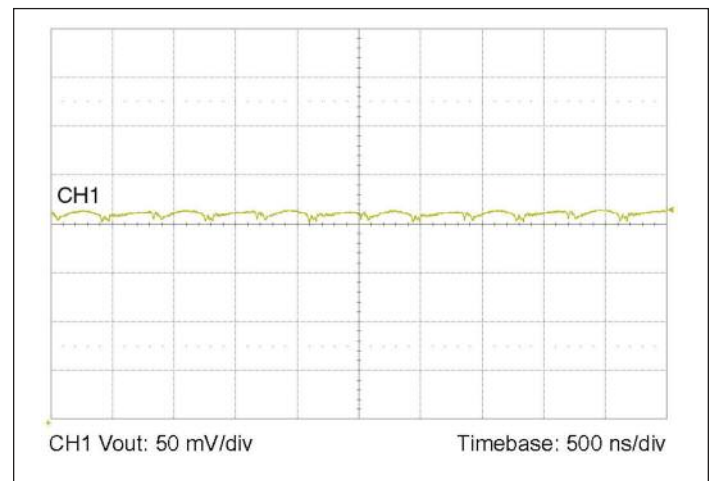
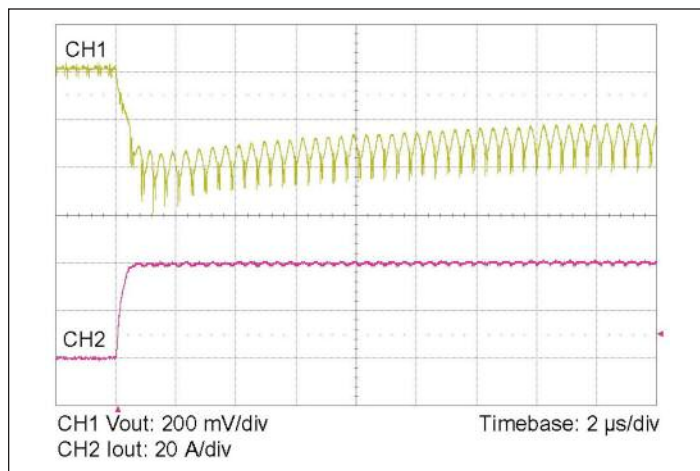
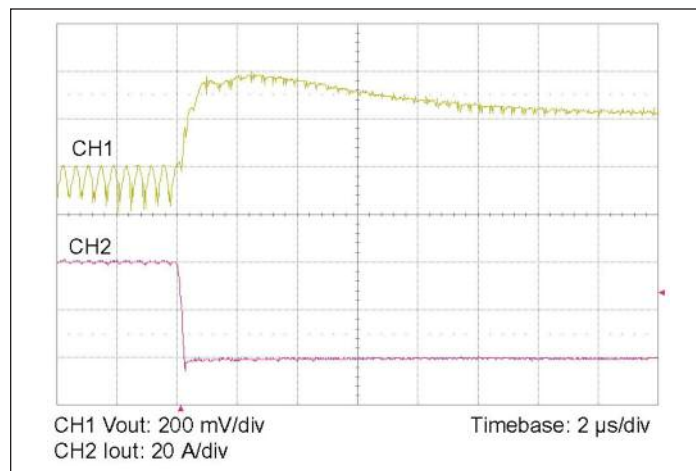


Figure 6 — Output voltage ripple at full load and 48 V<sub>F</sub> with 10 μF ceramic POL bypass capacitance and 20 nH distribution inductance.

## Specifications



**Figure 7** — 0-40 A load step with 100  $\mu$ F input capacitance and no output capacitance.



**Figure 8** — 40-0 A load step with 100  $\mu$ F input capacitance and no output capacitance.

## General

Parameter	Min	Typ	Max	Unit	Note
MTBF					
MIL-HDBK-217F		3.5		Mhrs	25°C, GB
Isolation specifications					
Voltage	2,250			Vdc	Input to output
Capacitance		3,000		pF	Input to output
Resistance	10			M $\Omega$	Input to output
		cTÜVus			UL/CSA 60950-1, EN 60950-1
Agency approvals		CE Marked for Low Voltage Directive and RoHS Recast Directive, as applicable			
Mechanical					
Weight		0.53/15		oz/g	
Dimensions					
Length		1.28/32,5		in/mm	
Width		0.87/22		in/mm	
Height		0.265/6,73		in/mm	
Peak compressive force applied to case (Z axis)		5	6	lbs.	Supported by J-leads only
Thermal					
Over temperature shutdown	125	130	135	°C	Junction temperature
Thermal capacity		9.3		Ws/°C	
Junction-to-case thermal impedance ( $R_{\theta JC}$ )		1.1		°C/W	See Thermal Considerations on Page 9
Junction-to-board thermal impedance ( $R_{\theta JB}$ )		2.1		°C/W	

## Auxiliary Pins (Conditions are at 48 Vin, full load, and 25°C ambient unless otherwise specified)

Parameter	Min	Typ	Max	Unit	Note
Primary Control (PC)					
DC voltage	4.8	5.0	5.2	Vdc	
Module disable voltage	2.4	2.5		Vdc	
Module enable voltage		2.5	2.6	Vdc	VC voltage must be applied when module is enabled using PC
Current limit	2.4	2.5	2.9	mA	Source only
Disable delay time		10		$\mu$ s	PC low to Vout low
VTM Control (VC)					
External boost voltage	12	14	19	Vdc	Required for VTM current multiplier start up without PRM <sup>®</sup> regulator
External boost duration		10		ms	Maximum duration of VC pulse = 20 ms

## Pin / Control Functions

### +In / -In DC Voltage Ports

The VTM current multiplier input should be connected to the PRM<sup>®</sup> regulator output terminals. Given that both the regulator and current multiplier have high switching frequencies, it is often good practice to use a series inductor to limit high frequency currents between the PRM module output and VTM module input capacitors. The input voltage should not exceed the maximum specified. If the input voltage exceeds the overvoltage turn-off, the VTM module will shutdown. The VTM module does not have internal input reverse polarity protection. Adding a properly sized diode in series with the positive input or a fused reverse-shunt diode will provide reverse polarity protection.

### TM – For Factory Use Only

### VC – VTM Control

The VC port is multiplexed. It receives the initial  $V_{CC}$  voltage from an upstream PRM regulator, synchronizing the output rise of the VTM module with the output rise of the regulator. Additionally, the VC port provides feedback to the PRM to compensate for the current multiplier output resistance. In typical applications using VTM modules powered from PRM regulators, the regulators VC port should be connected to the VTM module VC port.

The VC port is not intended to be used to supply  $V_{CC}$  voltage to the VTM module for extended periods of time. If VC is being supplied from a source other than the PRM regulators, the voltage should be removed after 20 ms.

### PC – Primary Control

The Primary Control (PC) port is a multifunction port for controlling the current multiplier as follows:

**Disable** – If PC is left floating, the VTM module output is enabled. To disable the output, the PC port must be pulled lower than 2.4 V, referenced to -In. Optocouplers, open collector transistors or relays can be used to control the PC port. Once disabled, 14 V must be re-applied to the VC port to restart the VTM module.

**Primary Auxiliary Supply** – The PC port can source up to 2.4 mA at 5 Vdc.

### +Out / -Out DC Voltage Output Ports

The output and output return are through two sets of contact locations. The respective +Out and -Out groups must be connected in parallel with as low an interconnect resistance as possible. Within the specified input voltage range, the Level 1 DC behavioral model shown in Figure 16 defines the output voltage of the VTM module. The current source capability of the VTM module is shown in the specification table.

To take full advantage of the VTM current multiplier, the user should note the low output impedance of the device. The low output impedance provides fast transient response without the need for bulk POL capacitance. Limited-life electrolytic capacitors required with conventional converters can be reduced or even eliminated, saving cost and valuable board real estate.

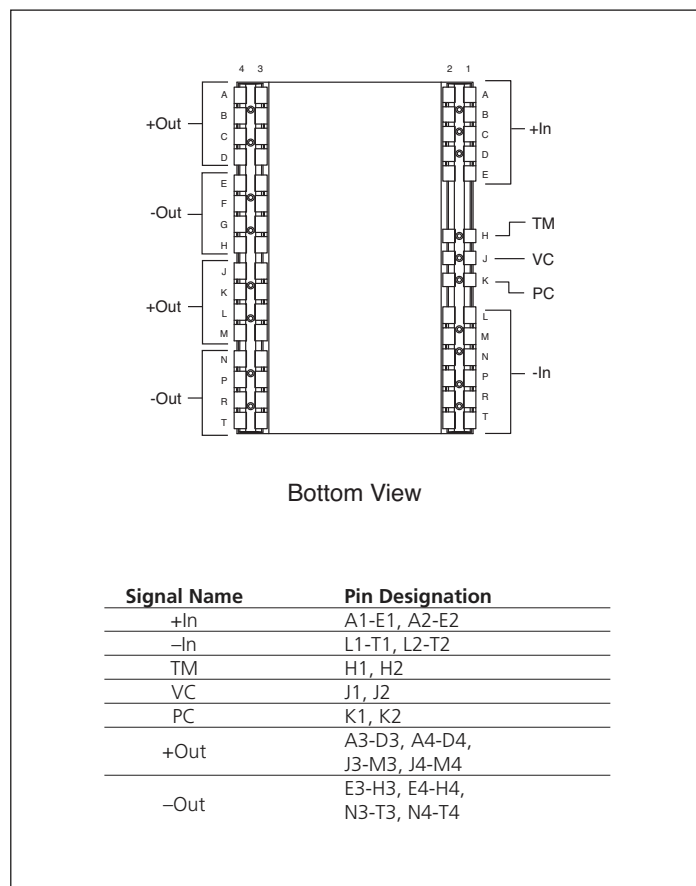


Figure 9 — VTM current multiplier pin configuration

Mechanical Drawings

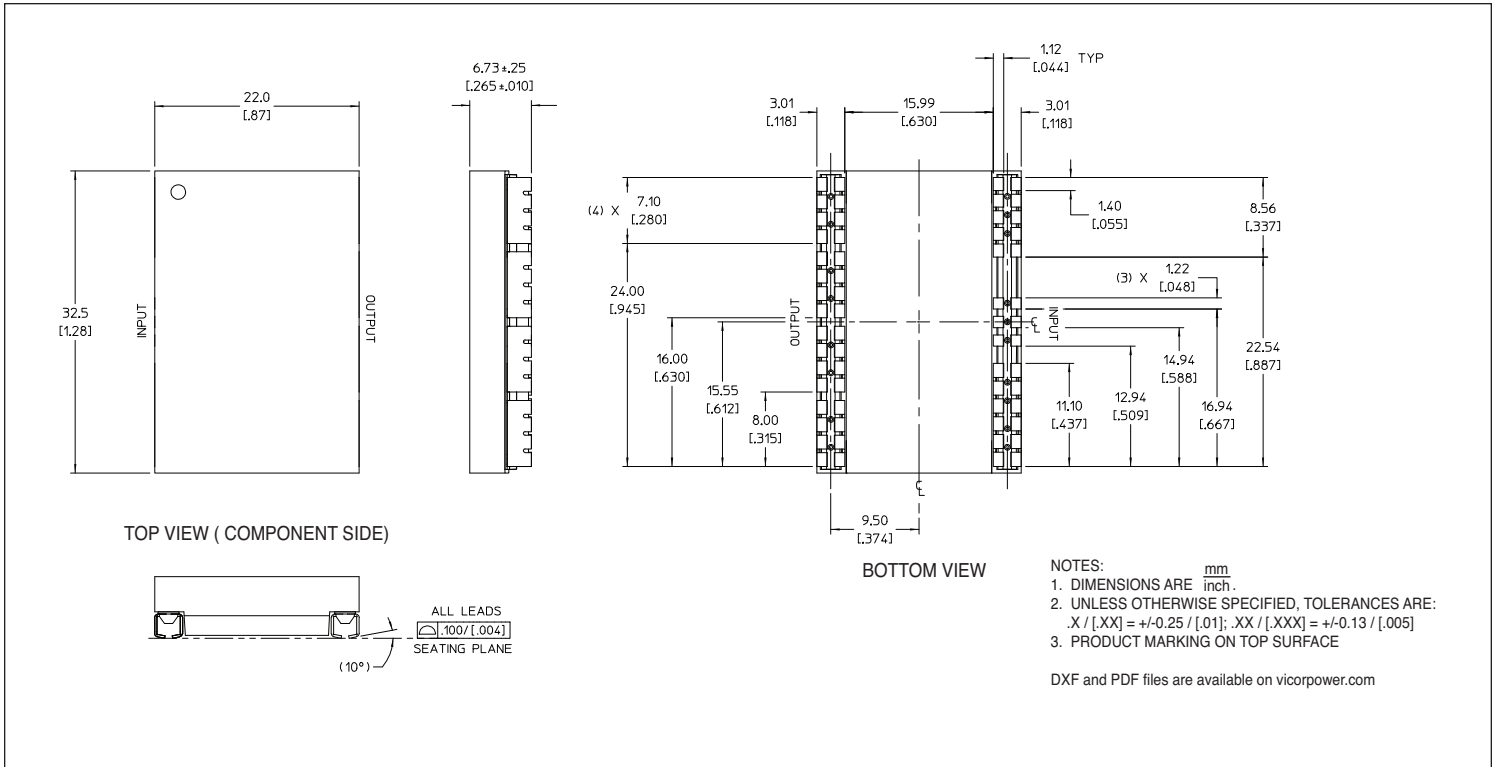


Figure 10 — VTM module J-Lead mechanical outline; Onboard mounting

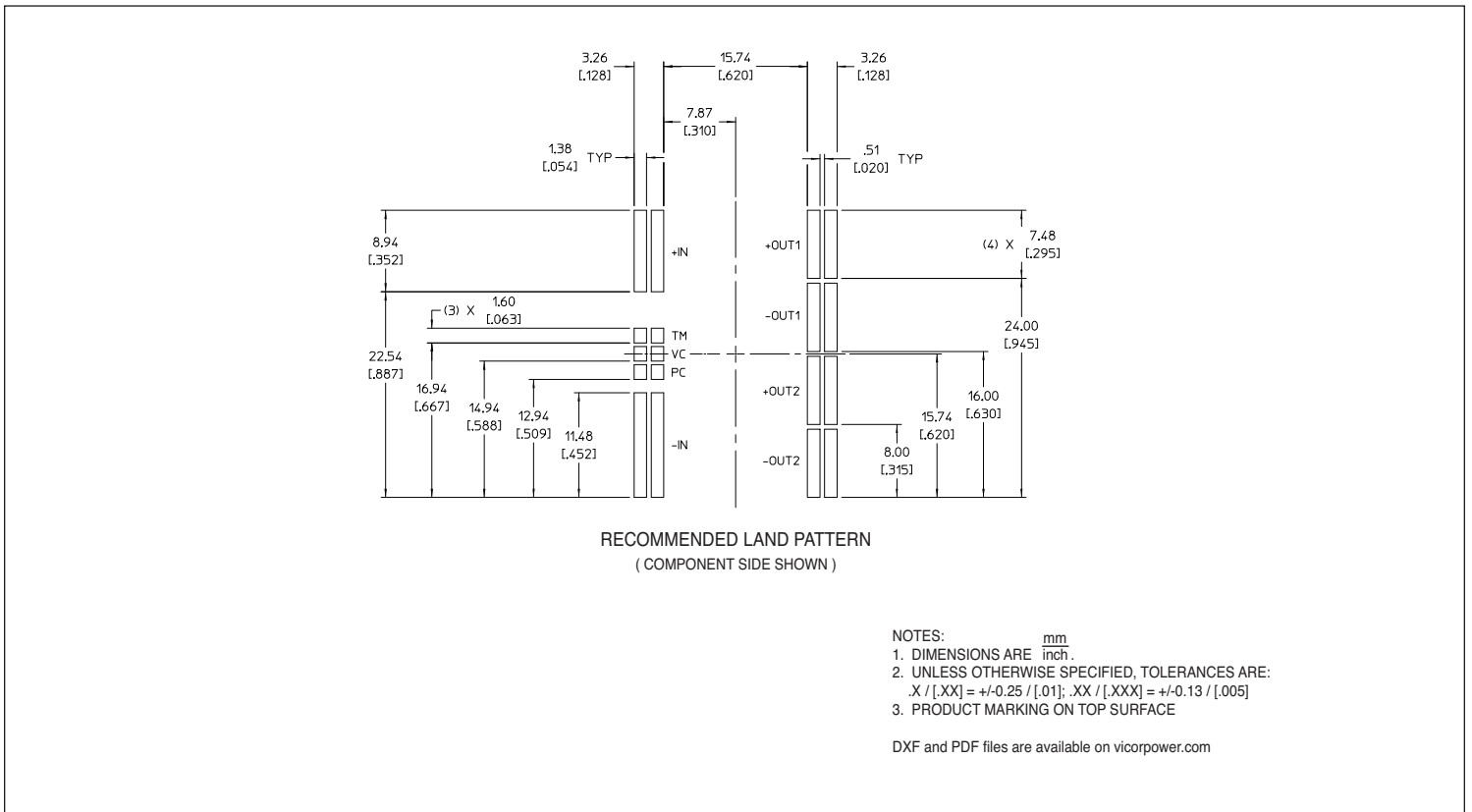


Figure 11 — VTM module J-Lead PCB land layout information; Onboard mounting

Mechanical Drawings (continued)

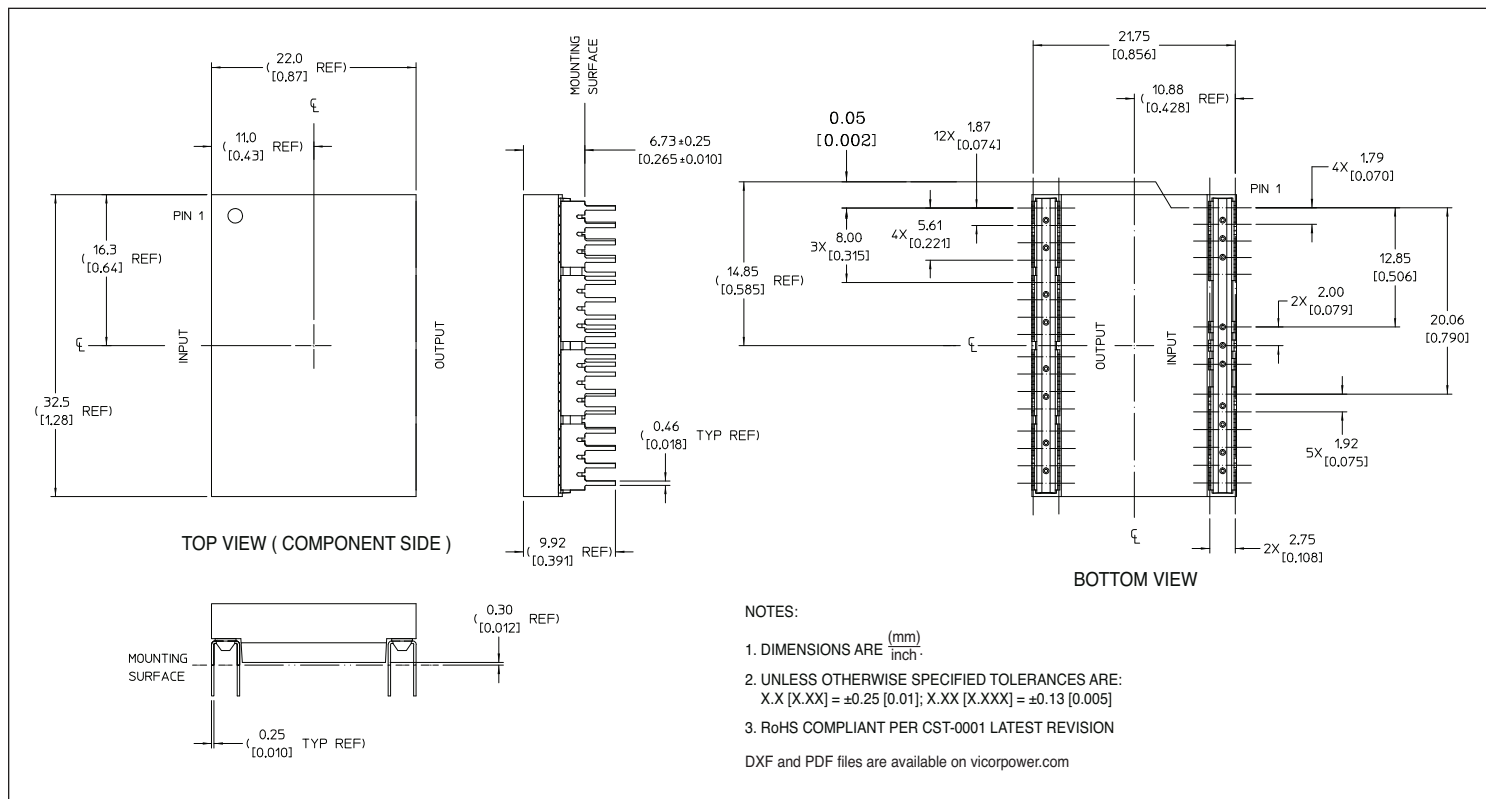


Figure 12 — VTM through-hole module mechanical outline

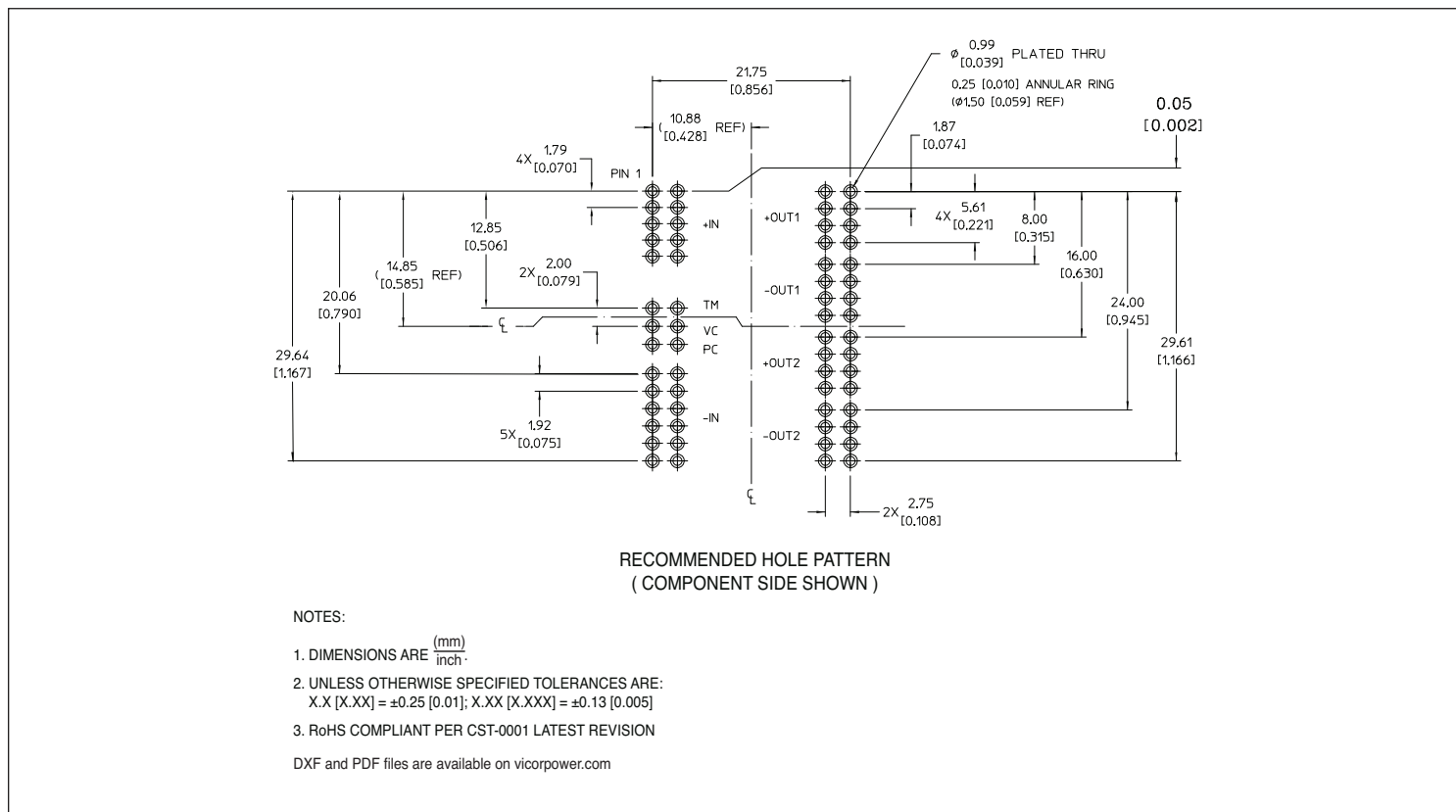


Figure 13 — VTM through-hole module PCB layout information

Mechanical Drawings (continued)

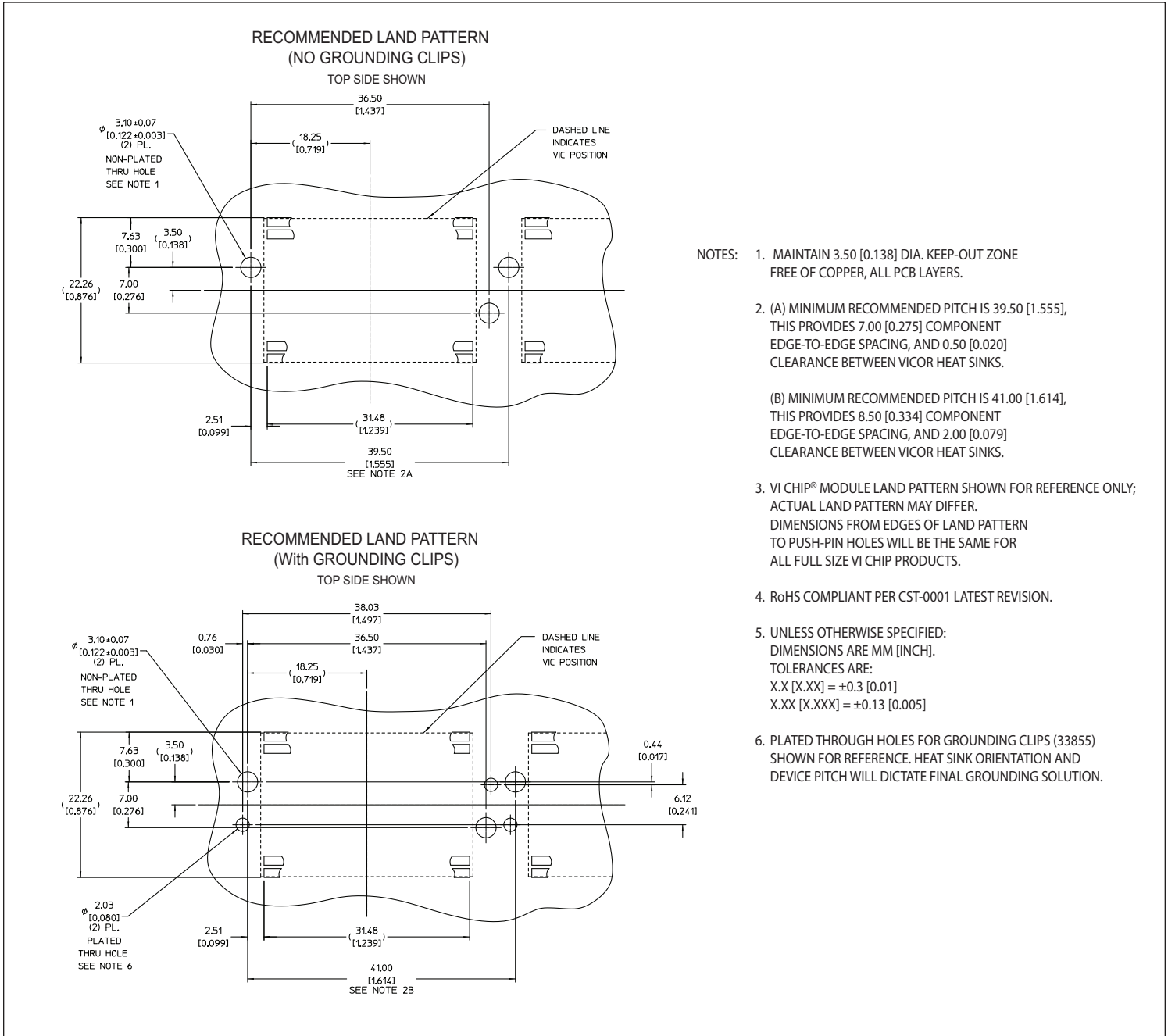


Figure 14 — Hole location for push pin heat sink relative to VI Chip® module



## Application Note

### Parallel Operation

In applications requiring higher current or redundancy, VTM current multipliers can be operated in parallel without adding control circuitry or signal lines. To maximize current sharing accuracy, it is imperative that the source and load impedance on each VTM module in a parallel array be equal. If the modules are being fed by an upstream PRM<sup>®</sup> regulator, the VC nodes of all VTM modules must be connected to the PRM module VC.

To achieve matched impedances, dedicated power planes within the PC board should be used for the output and output return paths to the array of paralleled VTMs. This technique is preferable to using traces of varying size and length.

The VTM module power train and control architecture allow bi-directional power transfer when the module is operating within its specified ranges. Bi-directional power processing improves transient response in the event of an output load dump. The module may operate in reverse, returning output power back to the input source. It does so efficiently.

### Thermal Considerations

VI Chip<sup>®</sup> 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 V048F060T040 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 board 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.

### Input Impedance Recommendations

To take full advantage of the current multiplier's capabilities, the impedance of the source (input source plus the PC board impedance) must be low over a range from DC to 5 MHz. Input bypass capacitance may be added to improve transient performance or compensate for high source impedance. The VTM module has extremely wide bandwidth so the source response to transients is usually the limiting factor in overall output response of the module.

Anomalies in the response of the source will appear at the output of the VTM module, multiplied by its K factor of  $\sqrt{1/8}$ . The DC resistance of the source should be kept as low as possible to minimize voltage deviations on the input to the module. If the module is going to be operating close to the high limit of its input range, make sure input voltage deviations will not trigger the input overvoltage turn-off threshold.

### Input Fuse Recommendations

VI Chip products are not internally fused in order to provide flexibility in configuring power systems. However, input line fusing of VI Chip modules must always be incorporated within the power system. A fast acting fuse is required to meet safety agency Conditions of Acceptability. The input line fuse should be placed in series with the +In port.

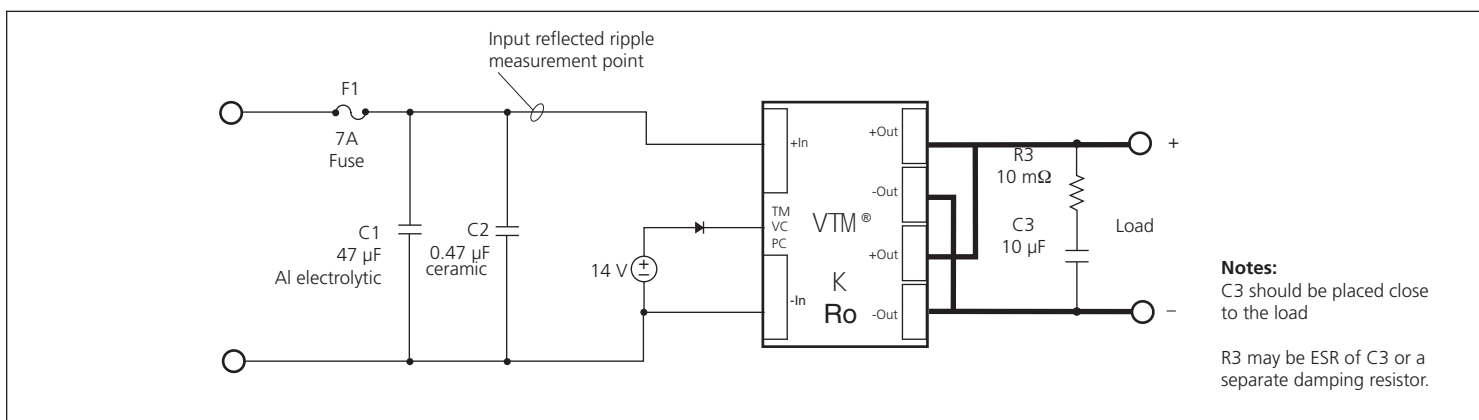
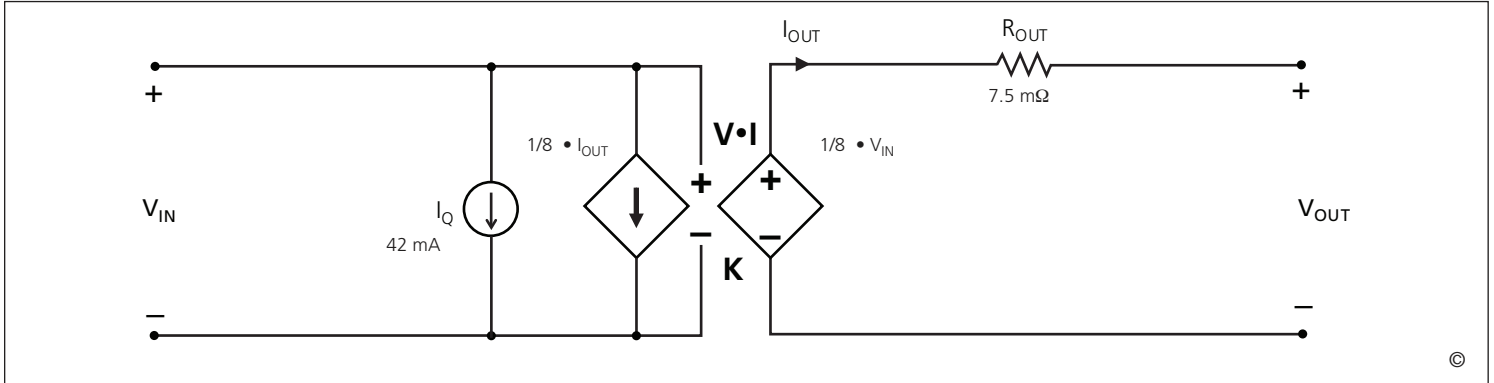


Figure 15 — VTM module test circuit

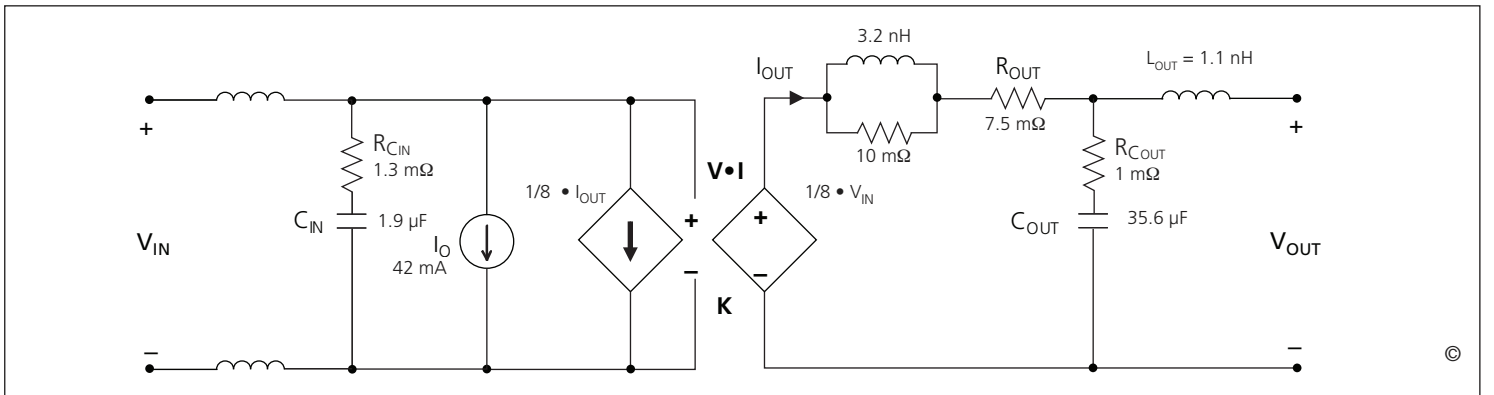
**Application Note** (continued)

**VTM Current Multiplier Level 1 DC Behavioral Model for 48 V to 6 V, 40 A**



**Figure 16** — This model characterizes the DC operation of the VI Chip® VTM, including the converter transfer function and its losses. The model enables estimates or simulations of output voltage as a function of input voltage and output load, as well as total converter power dissipation or heat generation.

**VI Chip® VTM Current Multiplier Level 2 Transient Behavioral Model for 48 V to 6 V, 40 A**



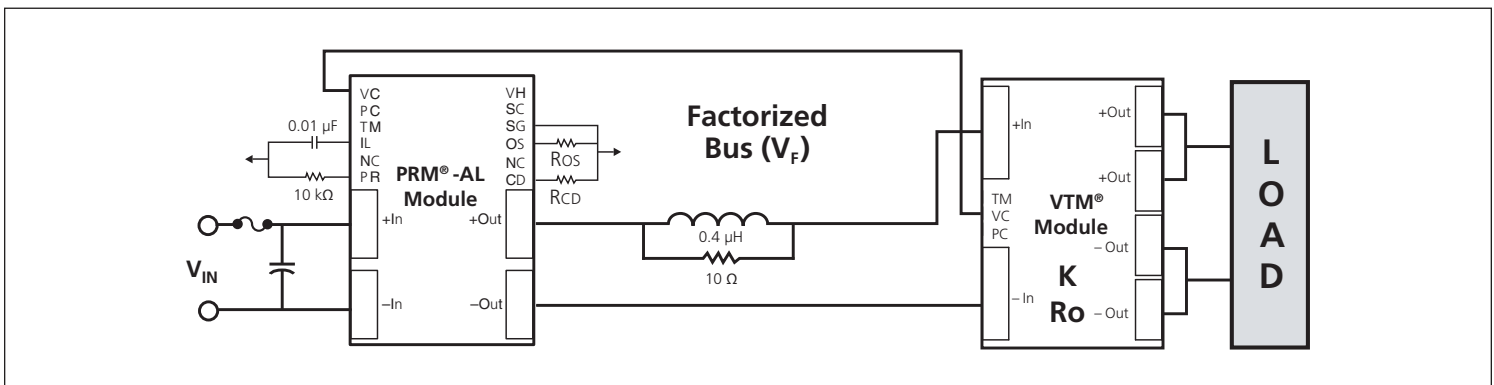
**Figure 17** — This model characterizes the AC operation of the VI Chip VTM including response to output load or input voltage transients or steady state modulations. The model enables estimates or simulations of input and output voltages under transient conditions, including response to a stepped load with or without external filtering elements.

In figures below;

K = VTM current multiplier transformation ratio  
 R<sub>0</sub> = VTM output resistance

V<sub>F</sub> = PRM® output (Factorized Bus Voltage)  
 V<sub>O</sub> = VTM output  
 V<sub>L</sub> = Desired load voltage

**FPA™ Adaptive Loop**



**Figure 18** — The PRM regulator controls the factorized bus voltage, V<sub>F</sub>, in proportion to output current to compensate for the output resistance, R<sub>o</sub>, of the VTM current multiplier. The VTM module output voltage is typically within 1% of the desired load voltage (V<sub>L</sub>) over all line and load conditions.

## **Vicor's comprehensive line of power solutions includes high density AC-DC and DC-DC modules and accessory components, fully configurable AC-DC and DC-DC power supplies, and complete custom power systems.**

Information furnished by Vicor is believed to be accurate and reliable. However, no responsibility is assumed by Vicor for its use. Vicor makes no representations or warranties with respect to the accuracy or completeness of the contents of this publication. Vicor reserves the right to make changes to any products, specifications, and product descriptions at any time without notice. Information published by Vicor has been checked and is believed to be accurate at the time it was printed; however, Vicor assumes no responsibility for inaccuracies. Testing and other quality controls are used to the extent Vicor deems necessary to support Vicor's product warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

**Specifications are subject to change without notice.**

### **Vicor's Standard Terms and Conditions**

All sales are subject to Vicor's Standard Terms and Conditions of Sale, which are available on Vicor's webpage or upon request.

### **Product Warranty**

In Vicor's standard terms and conditions of sale, Vicor warrants that its products are free from non-conformity to its Standard Specifications (the "Express Limited Warranty"). This warranty is extended only to the original Buyer for the period expiring two (2) years after the date of shipment and is not transferable.

UNLESS OTHERWISE EXPRESSLY STATED IN A WRITTEN SALES AGREEMENT SIGNED BY A DULY AUTHORIZED VICOR SIGNATORY, VICOR DISCLAIMS ALL REPRESENTATIONS, LIABILITIES, AND WARRANTIES OF ANY KIND (WHETHER ARISING BY IMPLICATION OR BY OPERATION OF LAW) WITH RESPECT TO THE PRODUCTS, INCLUDING, WITHOUT LIMITATION, ANY WARRANTIES OR REPRESENTATIONS AS TO MERCHANTABILITY, FITNESS FOR PARTICULAR PURPOSE, INFRINGEMENT OF ANY PATENT, COPYRIGHT, OR OTHER INTELLECTUAL PROPERTY RIGHT, OR ANY OTHER MATTER.

This warranty does not extend to products subjected to misuse, accident, or improper application, maintenance, or storage. Vicor shall not be liable for collateral or consequential damage. Vicor disclaims any and all liability arising out of the application or use of any product or circuit and assumes no liability for applications assistance or buyer product design. Buyers are responsible for their products and applications using Vicor products and components. Prior to using or distributing any products that include Vicor components, buyers should provide adequate design, testing and operating safeguards.

Vicor will repair or replace defective products in accordance with its own best judgment. For service under this warranty, the buyer must contact Vicor to obtain a Return Material Authorization (RMA) number and shipping instructions. Products returned without prior authorization will be returned to the buyer. The buyer will pay all charges incurred in returning the product to the factory. Vicor will pay all reshipment charges if the product was defective within the terms of this warranty.

### **Life Support Policy**

VICOR'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS PRIOR WRITTEN APPROVAL OF THE CHIEF EXECUTIVE OFFICER AND GENERAL COUNSEL OF VICOR CORPORATION. As used herein, life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness. Per Vicor Terms and Conditions of Sale, the user of Vicor products and components in life support applications assumes all risks of such use and indemnifies Vicor against all liability and damages.

### **Intellectual Property Notice**

Vicor and its subsidiaries own Intellectual Property (including issued U.S. and Foreign Patents and pending patent applications) relating to the products described in this data sheet. No license, whether express, implied, or arising by estoppel or otherwise, to any intellectual property rights is granted by this document. Interested parties should contact Vicor's Intellectual Property Department.

The products described on this data sheet are protected by the following U.S. Patents Numbers:

5,945,130; 6,403,009; 6,710,257; 6,911,848; 6,930,893; 6,934,166; 6,940,013; 6,969,909; 7,038,917; 7,145,186; 7,166,898; 7,187,263; 7,202,646; 7,361,844; D496,906; D505,114; D506,438; D509,472; and for use under 6,975,098 and 6,984,965.

#### **Vicor Corporation**

25 Frontage Road  
Andover, MA, USA 01810  
Tel: 800-735-6200  
Fax: 978-475-6715

#### **email**

Customer Service: [custserv@vicorpower.com](mailto:custserv@vicorpower.com)  
Technical Support: [apps@vicorpower.com](mailto:apps@vicorpower.com)

# AMEYA360

## Components Supply Platform

Authorized Distribution Brand :



Website :

Welcome to visit [www.ameya360.com](http://www.ameya360.com)

Contact Us :

➤ Address :

401 Building No.5, JiuGe Business Center, Lane 2301, Yishan Rd  
Minhang District, Shanghai , China

➤ Sales :

Direct +86 (21) 6401-6692

Email [amall@ameya360.com](mailto:amall@ameya360.com)

QQ 800077892

Skype [ameyasales1](#) [ameyasales2](#)

➤ Customer Service :

Email [service@ameya360.com](mailto:service@ameya360.com)

➤ Partnership :

Tel +86 (21) 64016692-8333

Email [mkt@ameya360.com](mailto:mkt@ameya360.com)