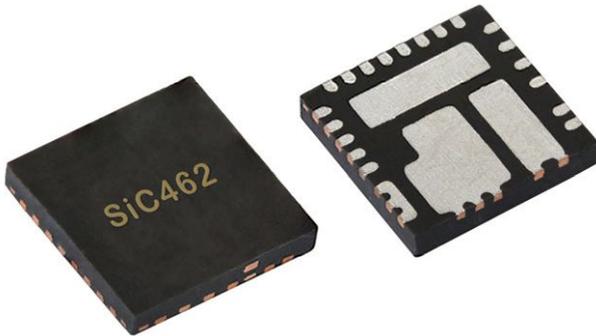




Reference Board User's Manual for SiC464 (2 A), SiC463 (4 A), SiC462 (6 A), and SiC461 (10 A) Synchronous Buck Regulators



DESCRIPTION

This reference board allows the user to evaluate the SiC461 (10 A), SiC462 (6 A), SiC463 (4 A), or the SiC464 (2 A) microBUCK® regulators for their features and functionalities. It can also be a reference design for a user's application. The board is configured for 4.5 V to 60 V input. Output is model dependent. The operating range may be modified by changing components such as the inductor, feedback resistor, and ripple injection networks.

The SiC46x family of microBUCK regulators is a wide input voltage high efficiency synchronous buck regulator with integrated high-side and low-side power MOSFETs. Its power stage is capable of supplying up to 10 A continuous current at up to 2 MHz switching frequency. These regulators produce an adjustable output voltage down to 0.8 V from 4.5 V to 60 V input rail to accommodate a variety of applications, including computing, consumer electronics, telecom, and industrial.

SiC46x's architecture delivers ultrafast transient response with minimum output capacitance and tight ripple regulation at very light load. The device is stable with any type of output capacitor. The device also incorporates a power saving scheme that significantly increases light load efficiency.

This board has UVLO capability on the input rail and a user programmable soft start.

ORDERING INFORMATION	
BOARD PART NUMBER	MAX. OUTPUT CURRENT
SiC464EVB	2 A
SiC463EVB	4 A
SiC462EVB	6 A
SiC461EVB	10 A

FEATURES

- Versatile
 - Single supply operation from 4.5 V to 60 V input voltage
 - Adjustable output voltage down to 0.8 V
 - Scalable solution
 - 2 A (SiC464), 4 A (SiC463), 6 A (SiC462), 10 A (SiC461)
 - Output voltage tracking and sequencing with pre-bias start up
 - $\pm 1\%$ output voltage accuracy at $-40\text{ }^{\circ}\text{C}$ to $+125\text{ }^{\circ}\text{C}$
- Highly efficient
 - 98 % peak efficiency
 - 5 μA supply current at shutdown
 - 250 μA operating current not switching
- Highly configurable
 - Adjustable switching frequency from 100 kHz to 2 MHz
 - Adjustable soft start and adjustable current limit
 - 3 modes of operation, forced continuous conduction, power save or ultrasonic
- Robust and reliable
 - Output over-voltage protection
 - Output under-voltage / short circuit protection with auto retry
 - Power good flag and over temperature protection
- Design support tool
 - PowerCAD online design simulation <https://vishay.transim.com>
 - Inductor selection tool www.vishay.com/inductors/calculator/calculator/

APPLICATIONS

- Industrial and automation
- Home automation
- Industrial computing
- Base station power supplies
- Wall transformer regulation
- Robotics
- Drones
- Battery management systems
- Power tools
- Vending, ATM, and slot machine

SPECIFICATIONS

This reference board allows the end user to evaluate the SiC461 (10 A), SiC462 (6 A), SiC463 (4 A) or the SiC464 (2 A) microBUCK® regulators for their features and functionalities. It can also be a reference design for a user's application. The board is configured for 4.5 V to 60 V input with different output voltages depending on the model number of the board. The operating range may be modified by changing components such as the inductor, feedback resistor, and ripple injection networks.

CONNECTION AND SIGNAL / TEST POINTS

Power Terminals (J5)

- **V_{IN}, GND (J5, Pin 1 and Pin 2):** (see Fig. 1 below)

Connect to a voltage source: 4.5 V to 60 V. **Note: output voltage will vary depending on model number of the board.** The value of R12 determines V_{OUT}. The minimum input voltage will be ≈ 4.5 V with no UVLO and the output will be active but unregulated when V_{IN}-V_{OUT} is less than 2 V. A UVLO function can be instituted by inserting a suitable value resistor for R17. The start voltage will be reached when the voltage at the enable, pin 3, reaches ≈ 0.8 V. This will keep the output from coming up in an unregulated state during V_{OUT} start up transitions.

- **V_{OUT}, GND (J5, Pin 3 and Pin 4):** (see Fig. 1 below)

Connect to a load that draws no more than:

SiC461 - 10 A, SiC462 - 6 A, SiC463 - 3 A, SiC464 - 2 A

Note

- The output capacitors are rated to 25 V. Should a higher output voltage be required, the output capacitors should be changed to an appropriate higher voltage.

V_{DRV} External Supply

5 V, GND (J7): this is the terminal that enables the user to supply an external MOSFET gate driver supply if an external 5 V supply is available. This should only be used in modes 3 and 4. R14 must also be inserted if an external V_{DRV} is used. The standard version of the board does not have this component. See schematic.

Enable

J9: this is the terminal that enables the part.

The EN pin has an internal pull down resistor and only requires an enable voltage. This needs to be greater than 1.4 V. An input voltage or a resistor connected across V_{IN} and EN can be used. The internal pull down resistance is 5 MΩ. There is a pull up resistor, R3, of 560K which allows the board to start with no external stimulus.

WARNING: attaching the EN input to an external source requires careful consideration as this pin will be at V_{IN} in series with R3. This will cause a standard GPIO to be damaged.

Ultrasonic

J8: this is jumper that will enable the user to select the ultrasonic mode of operation. In ultrasonic mode the minimum frequency of operation is 20 kHz, above the audible range. When not in ultrasonic mode the frequency can drop below 20 kHz.

OPEN J8 - Ultrasonic disabled

SHORT J8 - Ultrasonic enabled

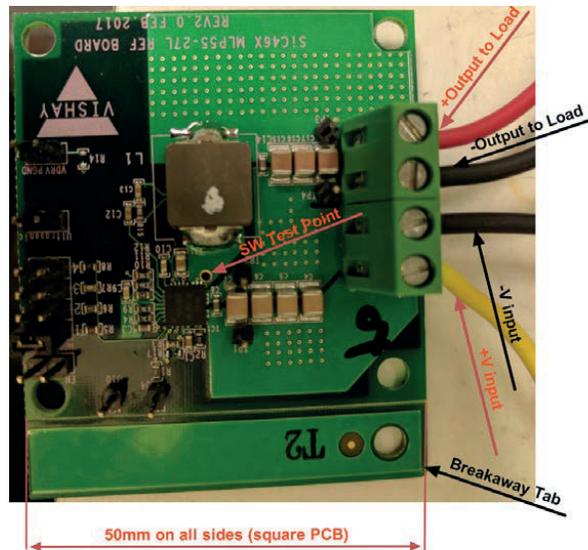


Fig. 1 - PCB Showing Power Terminal Connections

SELECTION JUMPERS

Mode Select

J1, J2, J3, and J4: there are 4 jumpers which allow the user to select one of four modes of operation.

MODE 1 - SHORT J1 power save, V_{DRV}, and pre-reg on

MODE 2 - SHORT J2 forced PWM, V_{DRV}, and pre-reg on

MODE 3 - SHORT J3 forced PWM, V_{DRV}, and pre-reg off - external 5 V supply

MODE 4 - SHORT J4 power save, V_{DRV}, and pre-reg off - external 5 V supply

SIGNALS AND TEST LEADS

Input Voltage Sense

V_{IN_SENSE} (TP1), GND_{IN_SENSE} (TP2): this allows the user to measure the voltage directly at the input of the regulator bypassing any losses generated by connections to the board. These test points can also be as a remote sense port of a power source with remote sense capability.

Output Voltage Sense

V_{OUT_SENSE} (TP5), GND_{OUT_SENSE} (TP6): This allows the user to measure the output voltage directly at the sense point of the regulator bypassing any losses generated by connections to the board. These test points can also be as a remote sense port of an external load with remote sense capability.

Power GOOD Indicator

PGOOD: is an open drain output and is pulled up with a 100 k Ω resistor, R1, to V_{DD1} (\approx 5 V). When FB or V_{OUT} are within -10 % to +20 % of the set voltage this pin will go HI to indicate the output is okay.

Power Up Procedure

Before turning on the reference board, the user needs to select one of the four modes by shorting one jumper (see section on mode selection). If mode 3 or 4 is selected, make sure V_{DRV} pin is supplied by external 5 V. There is no specific power sequence requirement to power up the board. The recommended power sequence is as follow:

V_{IN} \rightarrow V_{DRV} (if any) \rightarrow ENABLE. Enable is tied to V_{IN} through R3 so in most instances and external enable is not required. See enable section before attaching an enable signal from an external source.

Snubber Circuit

When applying higher than 48 V to the input it is reasonable to install a RC snubber from LX to GND if needed however this will affect efficiency. Snubbers are needed when the peak voltage during turn on of the high side switch may exceed the absolute maximum rating on the datasheet of the device under evaluation. There are place holders on the reference board, R16 and C21, for the snubber. Values of 4 Ω and 1 nF are a reasonable starting point.

Adjustments to the Reference Board

An excel spread sheet is provided, if some adjustments are required to modify the board. Based on the spread sheet, user can modify output voltage; switching frequency; inductor value; input capacitance; output capacitance; soft start time; voltage injection network; compensation circuit, and overcurrent limit.

A Note on Input and Output Capacitors

Input and output capacitors for the board are all ceramic. Should the user wish to add a larger POSCAP capacitor as a bulk capacitance on the output, the bottom layer of the board has a provision for both 2 terminal and 3 terminal POSCAPs (see bottom layer on page 5).

If the user's test set up has long leads or if the user wishes to conduct EMC testing using a Line Impedance Stabilization Network (LISN), it is recommended that a 100 μ F, 63 V Electrolytic Cap be used on the input as shown below (Cext in schematic shown on page 4). An example part number for this capacitor would be Vishay MAL215058101E3.

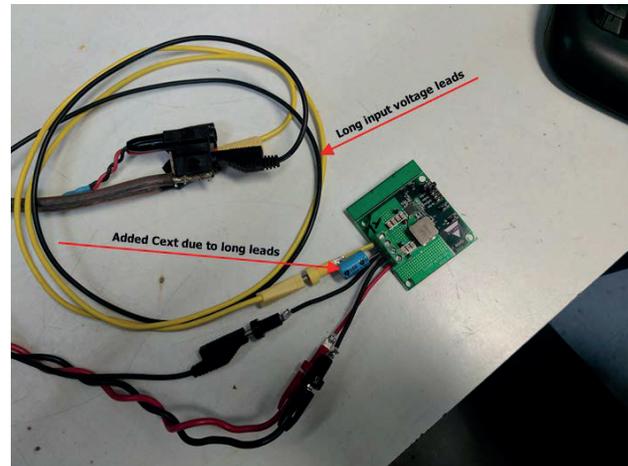


Fig. 2 - Capacitor external in Schematic



PCB LAYOUT

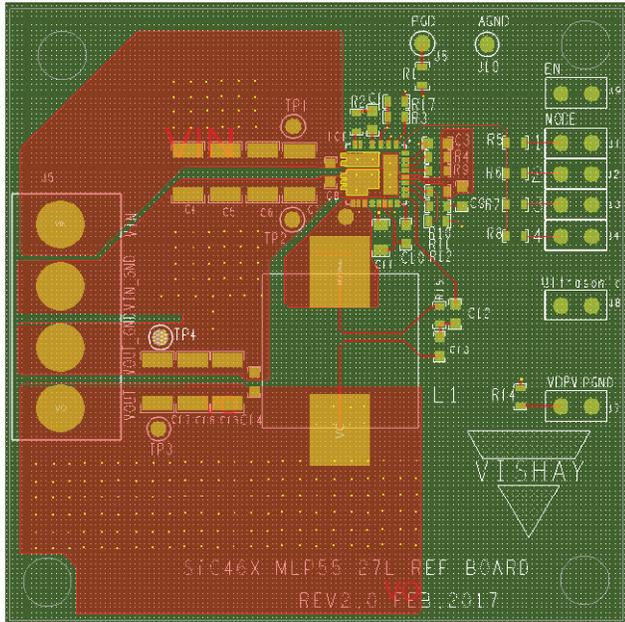


Fig. 4 - Top Layer

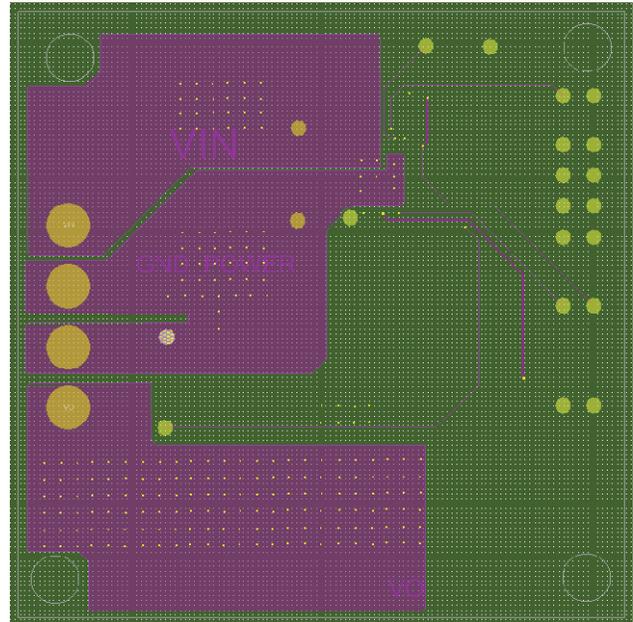


Fig. 6 - Inner Layer 3

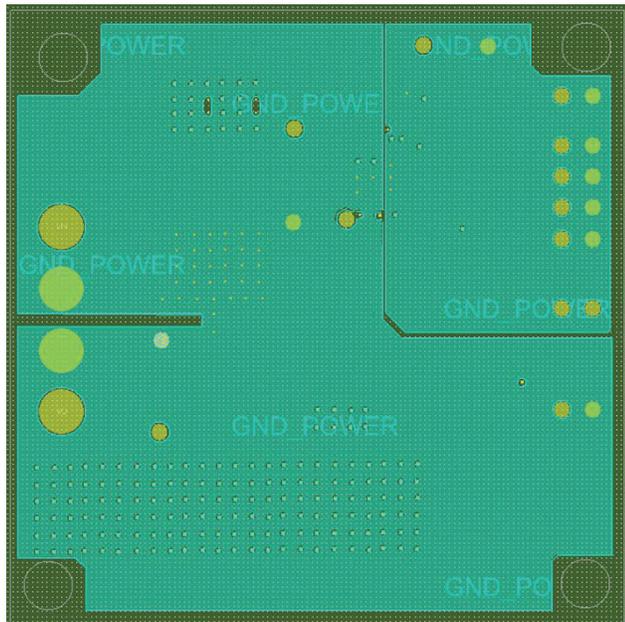


Fig. 5 - Inner Layer 2

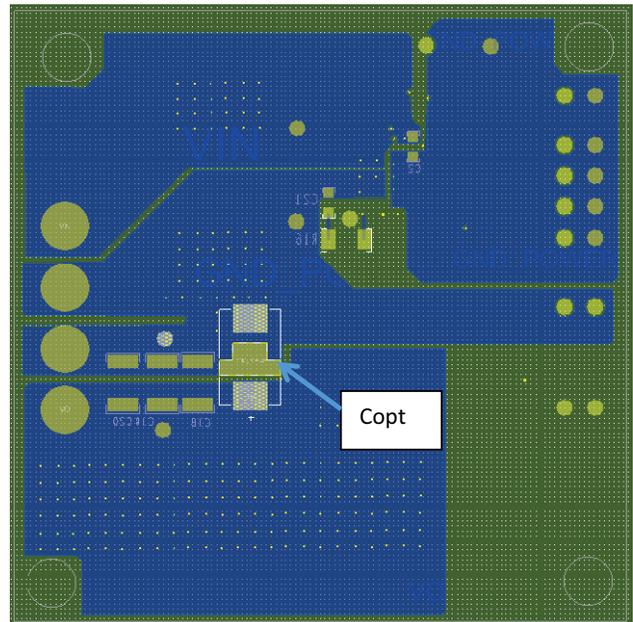


Fig. 7 - Bottom Layer



BILL OF MATERIAL REPORT FOR 12 V _{OUT} , f _{sw} = 500 kHz						
DESIGNATOR	QTY	VALUE	DESCRIPTION	PACKAGE	MANUFACTURER PART NUMBER	MANUFACTURER
IC1 SiC461/2/3/4	1	SiC46X	4.5 V to 60 V, 2 A to 10 A, High Voltage microBUCK®	5 mm x 5 mm	SIC462CD-T1-GE3	Vishay
C1, C2, C8	2	0.1 µF	Ceramic cap: 0.1 µF / 100 V / X7R / 10 % / 0603	0603	VJ0603Y104KXB	Vishay
C3	1	1 µF	Ceramic cap: 1 µF / 50 V / X7R / 0603 / 10 %	0603	VJ0603Y105KXA	Vishay
C4, C5, C6, C7	4	2.2 µF	Ceramic cap: 2.2 µF/100 V/ X7R/ 10 %/1210	1210	VJ1210Y225MXX	Vishay
C9	1	1 nF	Ceramic cap: 1000 pF / 50 V / X7R / 0603 / 10 %	0603	VJ0603Y102KXA	Vishay
C10	1	10 nF	Ceramic cap: 0.01 µF / 50 V / X7R / 0603 / 5 %	0603	VJ0603Y103JXA	Vishay
C11	1	4.7 µF	Ceramic cap: 4.7 µF / 25 V / X7R / 10 % / 0805	0805	VJ0805Y475KXX	Vishay
C12	1	2.2 nF	Ceramic cap: 2200 pF / 50 V / X7R / 0603 / 10 %	0603	VJ0603Y222KXA	Vishay
C13	1	22 nF	Ceramic cap: 22 nF / 50 V / X7R / 0603 / 10 %	0603	VJ0603Y223KXA	Vishay
C14	1	0.1 µF	Ceramic cap: 0.1 µF / 100 V / X7R / 10 % / 0603	0603	VJ0603Y104KXB	Vishay
C15, C16, C17, C18, C19, C20	6	22 µF	Ceramic cap: 22 µF / 25 V / X7R / 10 % / 1210	1210	VJ1210Y226KXX	Vishay
C21	1	DNP	DNP	0603	DNP	
L1	1	10 µH	Inductor: 10 µH / 20 % / 17.2 m DCR / 15.5 A saturation	5050	IHLP5050FDER100M01	Vishay
R1	1	100K	SMD / 100K / 1 % / 0603	0603	CRCW0603100KFKTA	Vishay
R2	1	0	SMD / 0 Ω / 0603	0603	CRCW06030000ZSTA	Vishay
R3	1	560K	SMD / 560K / 1 % / 0603	0603	CRCW0603560KFKTA	Vishay
R4	1	53.6K	SMD / 53.6K / 1 % / 0603	0603	TNPW060353K6BEEN	Vishay
R5	1	2K	SMD / 2K / 1 % / 0603	0603	CRCW06032K00FKTA	Vishay
R6	1	301K	SMD / 301K / 1 % / 0603	0603	CRCW0603301KFKTA	Vishay
R7	1	499K	SMD / 499K / 1 % / 0603	0603	CRCW0603499KFKTA	Vishay
R8	1	1M	SMD / 1000K / 1 % / 0603	0603	CRCW06031M00FKTA	Vishay
R9	1	127K	SMD / 127K / 1 % / 0603	0603	CRCW0603127KFKTA	Vishay
R10	1	10K	SMD / 10K / 0.1 % / 0603	0603	TNPW060310K0BEEA	Vishay
R11	1	42.2K	SMD / 42.2K / 1 % / 0603	0603	CRCW0603342K2FKTA	Vishay
R12	1	140K	SMD 1 W / 10 W 140 kΩ 0.1 %	0603	TNPW0603140KBEEN	Vishay
R14	1	DNP	DNP	DNP	DNP	
R15	1	4.12K	SMD / 4.12K / 1 % / 0603	0603	CRCW06034K12FKTA	Vishay
R16	1	DNP	DNP	DNP	DNP	
R17	1	DNP	DNP	DNP	DNP	
J1, J2, J3, J4, J8	5	JUMPER	JUMPER_JUMPER2_JUMPER		M20-9990246	Harwin
J5	1	CON4	TERMINAL BLOCK 5.08 mm VERT 4POS		ED120/4DS	On Shore Technology Inc.
J6	1	PGD	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics
J7	1	V _{DRV}	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics
J9	1	EN	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics
J10	1	GND	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics
TP1, TP3, TP2, TP4	4	Test pin	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics



BILL OF MATERIAL REPORT FOR 5 V _{OUT} , f _{sw} = 500 kHz						
DESIGNATOR	QTY	VALUE	DESCRIPTION	PACKAGE	MANUFACTURER PART NUMBER	MANUFACTURER
IC1 SiC461/2/3/4	1	SiC46X	4.5 V to 60 V, 2 A to 10 A, High Voltage microBUCK®	5 mm x 5 mm	SIC462CD-T1-GE3	Vishay
C1, C2, C8	2	0.1 µF	Ceramic cap: 0.1 µF / 100 V / X7R / 10 % / 0603	0603	VJ0603Y104KXB	Vishay
C3	1	1 µF	Ceramic cap: 1 µF / 50 V / X7R / 0603 / 10 %	0603	VJ0603Y105KXA	Vishay
C4, C5, C6, C7	4	2.2 µF	Ceramic cap: 2.2 µF/100 V/ X7R/ 10 %/1210	1210	VJ1210Y225MXB	Vishay
C9	1	1 nF	Ceramic cap: 1000 pF / 50 V / X7R / 0603 / 10 %	0603	VJ0603Y102KXA	Vishay
C10	1	10 nF	Ceramic cap: 0.01 µF / 50 V / X7R / 0603 / 5 %	0603	VJ0603Y103JXA	Vishay
C11	1	4.7 µF	Ceramic cap: 4.7 µF / 35 V / X7R / 10 % / 0805	0805	VJ0805Y475KXX	Vishay
C12	1	2.2 nF	Ceramic cap: 2200 pF / 50 V / X7R / 0603 / 10 %	0603	VJ0603Y222KXA	Vishay
C13	1	22 nF	Ceramic cap: 0.02 µF / 50 V / X7R / 0603 / 10 %	0603	VJ0603Y223KXA	Vishay
C14	1	0.1 µF	Ceramic cap: 0.1 µF / 100 V / X7R / 10 % / 0603	0603	VJ0603Y104KXB	Vishay
C15, C16, C17, C18, C19, C20	6	22 µF	Ceramic cap: 22 µF / 25 V / X7R / 10 % / 1210	1210	VJ1210Y226KXX	Vishay
C21	1	DNP	DNP	0603	DNP	
L1	1	5.6 µH	Inductor: 5.6 µH / 20 % / 19 m DCR / 16 A saturation	4040	IHLP4040DZER5R6M01	Vishay
R1	1	100K	SMD / 100K / 1 % / 0603	0603	CRCW0603100KFKTA	Vishay
R2	1	0	SMD / 0 Ω / 0603	0603	CRCW06030000ZSTA	Vishay
R3	1	560K	SMD / 560K / 1 % / 0603	0603	CRCW0603560KFKTA	Vishay
R4	1	53.6K	SMD / 53.6K / 1 % / 0603	0603	TNPW060353K6BEEN	Vishay
R5	1	2K	SMD / 2K / 1 % / 0603	0603	CRCW06032K00FKTA	Vishay
R6	1	301K	SMD / 301K / 1 % / 0603	0603	CRCW0603301KFKTA	Vishay
R7	1	499K	SMD / 499K / 1 % / 0603	0603	CRCW0603499KFKTA	Vishay
R8	1	1M	SMD / 1000K / 1 % / 0603	0603	CRCW06031M00FKTA	Vishay
R9	1	52.3K	SMD / 52.3K / 1 % / 0603	0603	CRCW060352K3FKTA	Vishay
R10	1	10K	SMD / 10K / 0.1 % / 0603	0603	TNPW060310K0BEEA	Vishay
R11	1	31.6K	SMD / 31.6K / 1 % / 0603	0603	CRCW060331K6FKEA	Vishay
R12	1	52.3K	SMD 1 W / 10 W 52.3 kΩ 0.1 %	0603	TNPW060352K3BEEA	Vishay
R14	1	DNP	DNP	DNP	DNP	
R15	1	2.05K	SMD / 2.05K / 1 % / 0603	0603	CRCW06032K05FKTA	Vishay
R16	1	DNP	DNP	DNP	DNP	
R17	1	DNP	DNP	DNP	DNP	
IC1	1	SiC46X	SIC462W_SIC46X5X5WC_SIC46X			
J1, J2, J3, J4, J8	5	JUMPER	JUMPER_JUMPER2_JUMPER		M20-9990246	Harwin
J5	1	CON4	TERMINAL BLOCK 5.08 mm VERT 4POS		ED120/4DS	On Shore Technology Inc.
J6	1	PGD	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics
J7	1	V _{DRV}	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics
J9	1	EN	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics
J10	1	GND	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics
TP1, TP3, TP2, TP4	4	Test pin	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics



BILL OF MATERIAL REPORT FOR 3.3 V _{OUT} , f _{sw} = 500 kHz						
DESIGNATOR	QTY	VALUE	DESCRIPTION	PACKAGE	MANUFACTURER PART NUMBER	MANUFACTURER
IC1 SiC461/2/3/4	1	SiC46X	4.5 V to 60 V, 2 A to 10 A, High Voltage microBUCK®	5 mm x 5 mm	SIC462CD-T1-GE3	Vishay
C1, C2, C8	2	0.1 µF	Ceramic cap: 0.1 µF / 100 V / X7R / 10 % / 0603	0603	VJ0603Y104KXB	Vishay
C3	1	1 µF	Ceramic cap: 1 µF / 50 V / X7R / 0603 / 10 %	0603	VJ0603Y105KXA	Vishay
C4, C5, C6, C7	4	2.2 µF	Ceramic cap: 2.2 µF/100 V/ X7R/ 10 %/1210	1210	VJ1210Y225MXX	Vishay
C9	1	1 nF	Ceramic cap: 1000 pF / 50 V / X7R / 0603 / 10 %	0603	VJ0603Y102KXA	Vishay
C10	1	10 nF	Ceramic cap: 0.01 µF / 50 V / X7R / 0603 / 5 %	0603	VJ0603Y103JXA	Vishay
C11	1	4.7 µF	Ceramic cap: 4.7 µF / 35 V / X7R / 10 % / 0805	0805	VJ0805Y475KXX	Vishay
C12	1	2.2 nF	Ceramic cap: 2200 pF / 50 V / X7R / 0603 / 10 %	0603	VJ0603Y222KXA	Vishay
C13	1	22 nF	Ceramic cap: 0.02 µF / 50 V / X7R / 0603 / 10 %	0603	VJ0603Y223KXA	Vishay
C14	1	0.1 µF	Ceramic cap: 0.1 µF / 100 V / X7R / 10 % / 0603	0603	VJ0603Y104KXB	Vishay
C15, C16, C17, C18, C19, C20	6	22 µF	Ceramic cap: 22 µF / 25 V / X7R / 10 % / 1210	1210	VJ1210Y226KXX	Vishay
C21	1	DNP	DNP	0603	DNP	
L1	1	3.3 µH	Inductor: 3.3 µH / 20 % / 14 m DCR / 18.6 A saturation		IHLP4040DZER3R3M11	Vishay
R1	1	100K	SMD / 100K / 1 % / 0603	0603	CRCW0603100KFKTA	Vishay
R2	1	0	SMD / 0 Ω / 0603	0603	CRCW06030000ZSTA	Vishay
R3	1	560K	SMD / 560K / 1 % / 0603	0603	CRCW0603560KFKTA	Vishay
R4	1	53.6K	SMD / 53.6K / 1 % / 0603	0603	TNPW060353K6BEEN	Vishay
R5	1	2K	SMD / 2K / 1 % / 0603	0603	CRCW06032K00FKTA	Vishay
R6	1	301K	SMD / 301K / 1 % / 0603	0603	CRCW0603301KFKTA	Vishay
R7	1	499K	SMD / 499K / 1 % / 0603	0603	CRCW0603499KFKTA	Vishay
R8	1	1M	SMD / 1000K / 1 % / 0603	0603	CRCW06031M00FKTA	Vishay
R9	1	34.8K	SMD / 34.8K / 1 % / 0603	0603	CRCW060334K8FKTA	Vishay
R10	1	10K	SMD / 10K / 0.1 % / 0603	0603	TNPW060310K0BEEA	Vishay
R11	1	24.3K	SMD / 24.3K / 1 % / 0603	0603	CRCW060324K3FKTA	Vishay
R12	1	31.2K	SMD 1 W / 10 W 31.2 kΩ 0.1 %	0603	TNPW060331K2BEEA	Vishay
R14	1	DNP	DNP	DNP	DNP	
R15	1	1.4K	SMD / 1.4K / 1 % / 0603	0603	CRCW06031K4FKTA	Vishay
R16	1	DNP	DNP	DNP	DNP	
R17	1	DNP	DNP	DNP	DNP	
J1, J2, J3, J4, J8	5	JUMPER	JUMPER_JUMPER2_JUMPER		M20-9990246	Harwin
J5	1	CON4	TERMINAL BLOCK 5.08 mm VERT 4POS		ED120/4DS	On Shore Technology Inc.
J6	1	PGD	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics
J7	1	V _{DRV}	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics
J9	1	EN	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics
J10	1	GND	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics
TP1, TP3, TP2, TP4	4	Test pin	Circuit Board Hardware - PCB TEST POINT WHITE		Keystone Electronics 5002	Keystone Electronics

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Мы предлагаем:

- Конкуренспособные цены и скидки постоянным клиентам.
- Специальные условия для постоянных клиентов.
- Подбор аналогов.
- Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.
- Приемлемые сроки поставки, возможна ускоренная поставка.
- Доставку товара в любую точку России и стран СНГ.
- Комплексную поставку.
- Работу по проектам и поставку образцов.
- Формирование склада под заказчика.
- Сертификаты соответствия на поставляемую продукцию (по желанию клиента).
- Тестирование поставляемой продукции.
- Поставку компонентов, требующих военную и космическую приемку.
- Входной контроль качества.
- Наличие сертификата ISO.

В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.

Конструкторский отдел помогает осуществить:

- Регистрацию проекта у производителя компонентов.
- Техническую поддержку проекта.
- Защиту от снятия компонента с производства.
- Оценку стоимости проекта по компонентам.
- Изготовление тестовой платы монтаж и пусконаладочные работы.



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