EP525XHVM EVK User Guide

Power Application ControllerTM

Marc Sousa
Director, PAC Systems and Applications





Table of Contents

1 Overview	3
2 System Description	4
2.1 Solution Benefits	4
3 Getting Started	5
3.1 PAC5250 EVK (EP5250HVM)	5
3.2 PAC5253 EVK (EP5253HVM)	6
4 Hardware Overview	7
4.1 Motor Drive Configurations	7
4.2 Hardware Feature Overview	7
4.3 Setting up the Hardware	g
5 EVK Resources	13
5.1 SWD Header (J4)	13
5.2 UART Header (J2)	13
5.3 PWM DAC (J5)	13
5.4 Expansion Header (P1)	14
5.5 Power Input Connector (J1)	14
5.6 Inverter	14
6 PAC5250 Design	15
6.1 Schematic	15
6.2 Bill of Materials	16
6.3 Layout	17
7 PAC5253 Design	18
7.1 Schematic	18
7.2 BOM	19
7.3 Layout	20
8 PAC Hardware Resources	21
About Active Comi	22



OVERVIEW

Active-Semi's family of Power Application Controllers contains devices that can be used for high-voltage motor control applications. The PAC5250 and PAC5253 each have their own Evaluation Kit (EVK) that can be used for evaluation and characterization of AC or DC BLDC and PMSM motors.

These EVKs have been developed for 3-phase BLDC and PMSM motors, but other topologies and drive types are also possible. These EVKs can take their input from a high-voltage DC supply, or from an AC source. Each EVK has a flyback DC-DC converter that is controlled by the PAC525X device on-board to generate the power supply for the IC as well as for the gate drive for the inverter stage.

These EVKs support either one, two or three current-shunt configurations and can be used with either BEMF or FOC control algorithms just by changing firmware.

Each EVK has a programming interface for updating the PAC525X firmware, as well as a UART connector for host communication from a GUI or other host MCU.

CAUTION!!!

Dangerously high voltages exposed and may lead to injury.

This unit should only be handled by qualified individuals.



SYSTEM DESCRIPTION

The following diagrams show a picture of the EVKs for the PAC5250 and PAC5253 and the major connectors and sub-systems.

2.1 **Solution Benefits**

- Quick Prototyping of PMSM or BLDC High-Voltage Motor Control applications
- Ideal for most high-voltage motor driving applications
- Both BEMF and FOC control may be used by firmware change
- Integrated DC/DC Flyback Controller
- **Integrated Differential Amplifiers**
- Integrated Ultra High-Voltage Gate Drivers (up to 600V)
- SWD header for firmware programming of PAC525X
- UART header for GUI control and configuration of PAC525X
- Uplink Expansion header for connecting to other processor subsystems like a host MCU, or possibly a wireless uplink card
- Schematics, BOM and Layout drawings available
- Firmware and PAC52XX SDK available



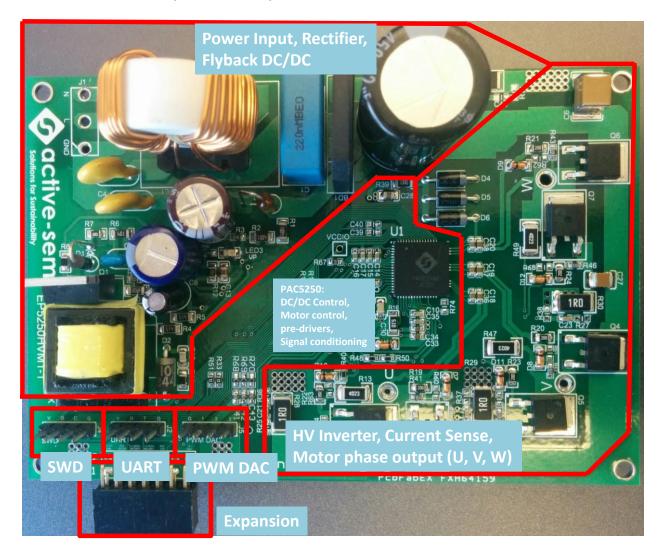
GETTING STARTED

The EP525XHVM EVK comes with connectors for the three phase motor, as well as DC input voltage connector.

The PAC525X EVK works with the following Active-Semi EVKs:

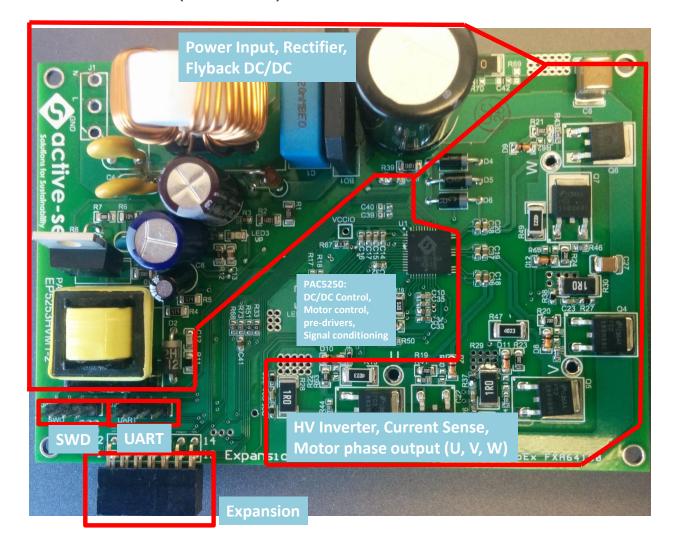
- ET-COLINK-1: An isolated USB to SWD adapter for programming and debugging of the PAC525X IC on the EVK. This includes the USB and serial ribbon cable used to interface to the EP525XHVM EVK.
- ET-UARTISO-1: An isolated USB to UART adapter for communication between the user PC for GUI configuration and control of the EVK. This includes the USB and serial ribbon cable used to interface to the EP525XHVM EVK.

3.1 **PAC5250 EVK (EP5250HVM)**





3.2 PAC5253 EVK (EP5253HVM)





4 HARDWARE OVERVIEW

4.1 Motor Drive Configurations

The EP525XHVM EVK can be used to drive a wide variety of high-voltage motors. It is capable of driving a motor in either of the following configurations:

- Three-shunt FOC, for high-speed FOC applications. This is the default configuration.
- Two-shunt FOC plus one motor-current shunt FOC applications.
- Single-shunt for motor current for single-shunt FOC and BEMF applications.

To reconfigure the EVK for two-shunt plus one motor current shunt, move the current sense resistor from R30 (phase W current) to R72 (motor current) and populate R71, R73 and C44 with the correct value components for the motor current sense circuit. R30 should be populated with a 0 ohm resistor.

To reconfigure the EVK for a single-shunt, the user should populate the current sense resistor for the motor current (R72) as well as the rest of the passive components for the motor current (R71, R73 and C44). Then the user should replace the three motor phase current sense resistors (R28, R29, R30) with zero-ohm resistors. The user should also remove the three motor phase current sense circuit passive components (R25, R36, C21, R26, R37, C22, R27, R38 and C23).

4.2 Hardware Feature Overview

Some of the key features of the EP525XHVM are:

- IGBT inverter stage paired with the PAC525X integrated gate drivers reduces BOM cost by eliminating the need for an expensive IPM.
- PAC5250 integrated power controller is used to drive a flyback converter.
- Current measurement for over-current protection is done via the shunt resistor network (one, two
 or three current-shunt). Current measurement is used for both control in FOC and protection in
 FOC/BEMF applications.
- ADC is used to measure DC bus voltage to adjust the driver duty cycles
- UART capability allows users to interface with the IC via a Windows GUI. The UART module is isolated from the AC line voltage.
- SWD programming port for programming the flash memory. The SWD programming module is isolated from the AC line voltage.
- Input voltage range: 110-240VAC
- Recommend 1A max per phase. This is limited by the current sense resistor installed on the board. Sense resistor values can be changed if a higher current is desired.



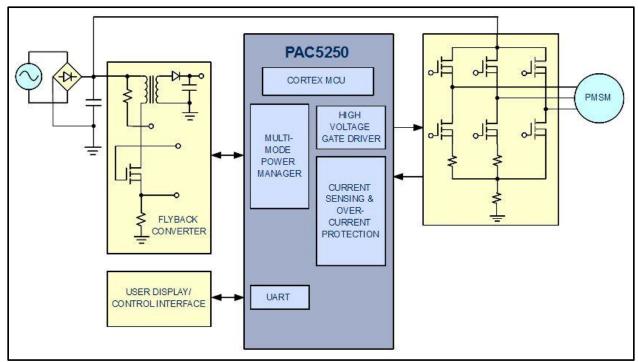


Figure 1: FOC Application Diagram

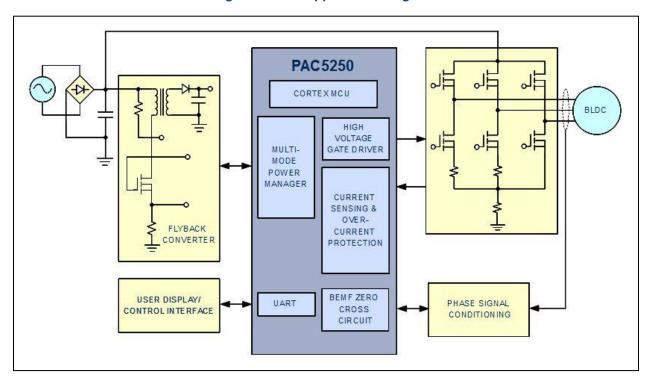


Figure 2: Sensor-less BEMF Application Diagram



4.3 Setting up the Hardware

To connect the evaluation unit, please refer to in Figure 3 and Figure 4 below while following the following steps:

- 1) Connect the UART isolation module to a USB port in the computer. Please take care to connect with the correct polarity as shown in Figure 3.
- 2) Connect the SWD programmer/debugger to a USB port in the computer. This is only necessary if it is necessary to flash a new firmware into the evaluation board. The evaluation board should already be pre-loaded with the necessary firmware. Please take care to connect with the correct polarity as shown in Figure 3.
- 3) Connect the motor to the motor output connector as shown in Figure 4.
- 4) Connect a power source to the input power port. The supply can be 110VAC-220VAC. If desired, a DC voltage ranging 150VDC-400VDC may also be supplied through this port.
- 5) Proceed to set up the GUI interface and GUI user guide that were supplied by Active-Semi.



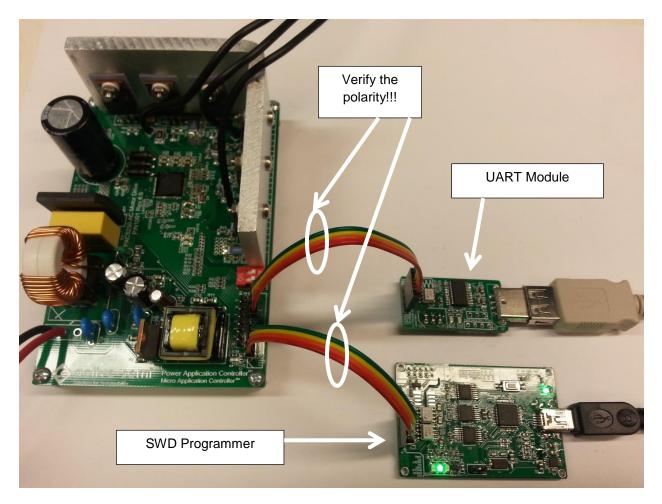


Figure 3: SWD Programmer and UART Module Connection



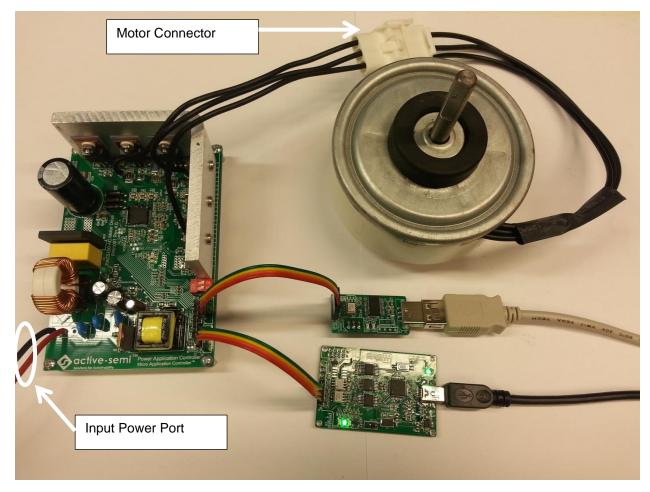


Figure 4: Motor and Input Power Connection







EVK RESOURCES

SWD Header (J4)

The SWD Header is used for updating the firmware in the PAC525X device. Users should connect the isolated CoLinkEx adapter to this header from the PC to update the firmware.

See the documentation for the IDE for more information on how to download code to the device.

The table below shows the pinout of this connector.

Pin	Name	Description
1	VCCIO	SWD Power Supply connected to VCCIO (+5V) generated from PAC525X
2	SWDD	SWD Bi-directional Data
3	SWDC	SWD Clock
4	GND	Ground

5.2 **UART Header (J2)**

The UART Header is used to connect to the USB to UART interface board, for communications with a Windows GUI. The GUI can be used to configure and monitor the operation of the motor from a Windows PC.

The table below shows the pinout of this connector.

Pin	Name	Description
1	VCCIO	SWD Power Supply connected to VCCIO (+5V) generated from PAC525X
2	UARTRX	PAC525X UART Receive
3	UARTTX	PAC525X UART Transmit
4	GND	Ground

5.3 **PWM DAC (J5)**

The PWM DAC Header is used to output a filtered analog output that can be used for debugging or motor tuning of the application. The PAC525X device outputs a PWM signal that is connected to a RC Filter on the EVK, and the filtered output is connected to these pins for the user to observe.

Because of the reduced pin count on the PAC5253, this header is not available on the PAC5253.

The table below shows the pinout of this connector.

Pin	Name	Description
1	GND	Ground
2	DAC1	PWM DAC output 1
3	DAC2	PWM DAC output 2
4	DAC3	PWM DAC output 3



5.4 Expansion Header (P1)

The Expansion Header may be used to connect to another processing board that may contain a host MCU or a wireless uplink.

The table below shows the pinout of this connector.

	PAC5250	PAC5253					
1	Ground						
2	NC VSYS						
3	PE0/S	SPICLK					
4	Р	C2					
5	PE1/SPIMOSI/UARTTX						
6	PE5/SPICS2/I2CSDA						
7	PE2/SPIMISO/UARTRX						
8	PE4/SPICS1/I2CSCL						
9	PE3/SPICS0						
10	PD2						
11	PD3 PWMDAC						
12	PC3 NC						
13	Ground						
14	VP						

5.5 Power Input Connector (J1)

The EP525XHVM EVK can be supplied by a high-voltage DC supply (up to 330V) or AC input. The EVK has a rectifier as well as a Flyback converter controlled by the PAC525X controller. The High-voltage rectified DC input to the flyback converter is converted into a 12V output (VP) that is used to supply the IC as well as power the gate drive outputs from the PAC525X.

The EVK has an unpopulated connector for Neutral, Line and Ground AC inputs. For a DC supply, the power supply positive terminal can be connected to line and the return may be connected to neutral.

5.6 Inverter

The inverter stage contains 6 600V, 10A FETs for high-voltage motor drive applications. These are driven directly from the PAC525X device, which has integrated high and low-side gate drivers.

Each of the motor phases are also connected to a voltage divider so they may be sampled directly from the PAC525X device, for applications that need to measure the BEMF voltage for different control techniques.

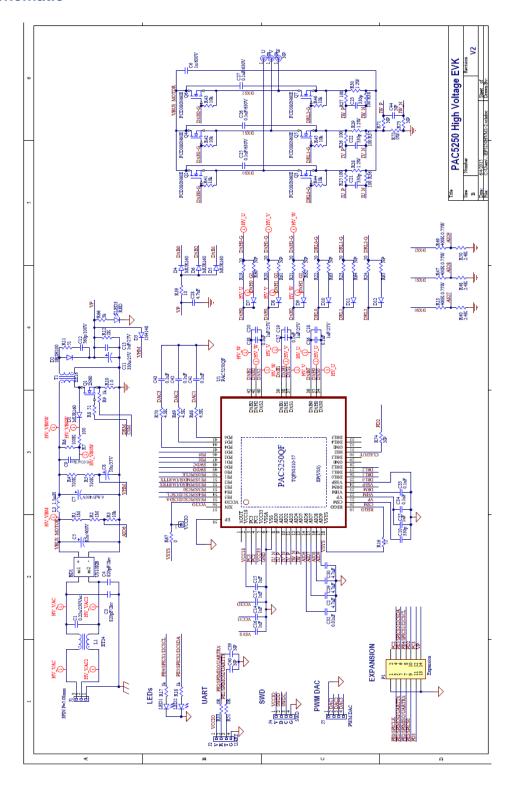
In addition, the EVK supports one, two or three current sense resistors for the control applications. The default hardware configuration is for three current sense resistors, which are required for high-speed FOC control applications, that require accurate current readings.

For lower speed FOC applications, or for BEMF control applications that user may re-arrange the current sense resistors to remove the V-phase current sense resistor and add one for the total motor current that may be sampled instead.



6 PAC5250 DESIGN

6.1 Schematic



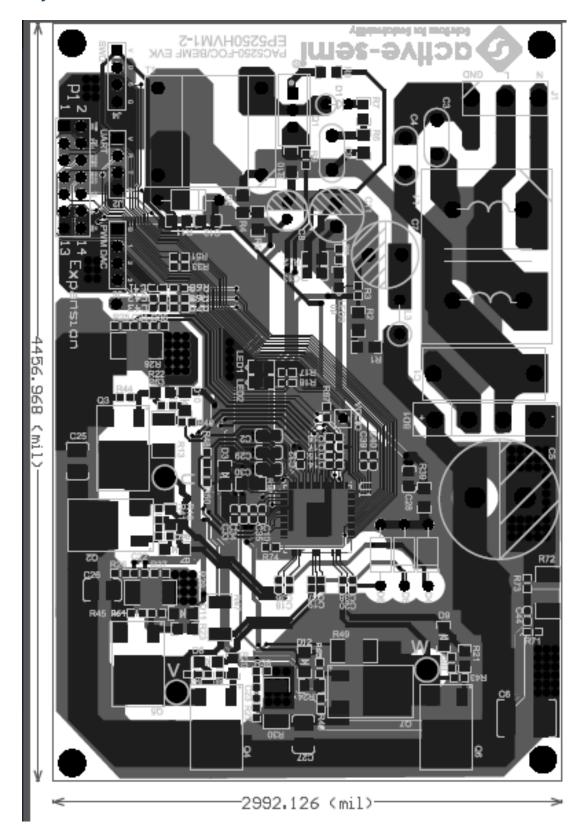


6.2 Bill of Materials

C1	Desc GPP 10A 1000V GBU 2UF 760VDC RADIAL FF 50V 10% X7R 0603 0UF 50V 20% RADIAL FF 100V 5% NP0 0805 50V 10% JB 0805 25V 10% X5R 0603 30F 50V 10% X7R 0805 FF 630V 20% X7T 1210 FF 25V 10% X5R 0805 FF 25V 10% X5R 0603 FF 25V 10% RADIAL FF 25V 20% RADIAL FF 50V 20% RADIAL FF 50V 20% RADIAL FF 450V 20% RADIAL FF 50V 20% RADIAL	Digikey Active-Sen	490-1612- 445-1149(311-1445- 445-7468- 311-1133- 445-4116- P4485A-N 445-1311- 311-1343- 445-7456- CK45-B3D 445-5942- 1189-1391 445-7110- 493-7386- P5567-ND 399-9793-	Didoes Kemet Yageo Panasonic Murata TDK Yageo TDK Yageo TDK TDK Panasonic TDK Panasonic TDK Rubycon TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	Manufact PN GBU1010 PHE840MX6220MB06R17 CC0603KRX7R9BB331 ECA-1HM331 GRM2165C2A561JA01D C2012JB1H105K085AB CC0603KRXSR8BB105 C1608X5R1H105K080AB CC0805KRX7R9BB472 C3225X7T2J104M160AC C2012X5R1E475K125AB ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KVNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C1 1 0.22uF CAP FILM 0.2 C10, C21, C22, C23 4 330pF CAP CER 330 C11 1 330uF CAP ALUM 3: C12 1 560pF CAP CER 560 C13 1 1uF CAP CER 1UF C14, C15, C16, C17, C35 5 1uF CAP CER 1UF C18, C19, C20 3 1uF CAP CER 1UF C2, C29, C30 3 4.7nF CAP CER 1UF C28 1 4.7uF CAP CER 0.1L C3 1 820pF CAP CER 820 C32 1 0.01uF CAP CER 10 C32 1 0.01uF CAP CER 10 C33, C34 2 0.1uF CAP CER 0.1L C36, C37, C38 3 0.1uF CAP CER 0.1L C36, C37, C38 3 0.1uF CAP CER 0.1L C37, C42, C43 3 0.1uF CAP CER 0.1L C4 1 820pF CAP CER 820 C41, C42, C43 3 0.1uF CAP CER 0.1L C5 1 82u CAP ALUM 8: C6 1 1uF CAP CER 1UF C7 1 6.8uF CAP ALUM 6: C8 1 10u CAP ALUM 10 C9 1 0.01uF CAP CER 100 D1, D4, D5, D6 4 N/A DIODE SUPEI D2 1 N/A Schottky Dio D3, J4, J5 3 N/A CONN HEAD L1 1 1.5mH CHOKE RF 15 LED1, LED2, LED3 3 Red LED RED CLE D4, C42, Q3, Q4, Q5, Q6, Q7 6 N/A N-CH 600V 1 R1, R2 1 1 10 RES 1 0HM 18 R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	2UF 760VDC RADIAL 2F 50V 10% X7R 0603 0UF 50V 20% RADIAL 2F 100V 5% NP0 0805 50V 10% JB 0805 25V 10% X5R 0603 50V 10% X5R 0603 50V 10% X5R 0603 2F 50V 10% X7R 0805 F 630V 20% X7T 1210 F 25V 10% X5R 0805 2F 2KV 10% RADIAL 200F 50V 10% X7R 0603 F 50V 10% X5R 0603 2F 50V 10% X5R 0603 2F 50V 10% X5R 0603 2F 2KV 10% RADIAL 2F 50V 20% RADIA	Digikey Active-Sen	399-5427 311-1186- P5184-ND 490-1612- 445-1149(311-1445- 445-7468- 311-1133- 445-4116- P4485A-N 445-311- 311-1343- 445-7456- CK45-B3D 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	Kemet Yageo Panasonic Murata TDK Yageo TDK Yageo TDK TDK Panasonic TDK Yageo TDK TDK Panasonic TDK Yageo TDK TOK TOK Yageo TOK	PHE840MX6220MB06R17 CC0603KRX7R9BB331 ECA-1HM331 GRM2165C2A561JA01D C2012JB1H105K085AB CC0603KRX5R8BB105 C1608X5R1H105K080AB CC0805KRX7R9BB472 C3225X772J104M160AC C2012X5R1E475K125AB ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C10, C21, C22, C23	F 50V 10% X7R 0603 0UF 50V 20% RADIAL F 100V 5% NP0 0805 50V 10% JB 0805 25V 10% X5R 0603 50V 10% X5R 0603 F 50V 10% X7R 0805 F 630V 20% X7T 1210 F 25V 10% X5R 0805 F 630V 20% X7T 1210 F 25V 10% X5R 0805 F 50V 10% X5R 0805 F 50V 10% X5R 0805 F 50V 10% X7R 0603 F 50V 10% X5R 0603 F 50V 20% RADIAL 15 50V 20% RADIAL 16 50V 20% RADIAL 16 50V 20% RADIAL 17 50V 20% RADIAL 18 450V 20% RADIAL 19 50V 20% RADIAL 19 50V 20% RADIAL 10 10 10 10 10 10 10 10 10 10 10 10 10 1	Digikey Active-Sen	311-1186- P5184-ND 490-1612- 445-1149(311-1445- 445-7468- 311-1133- 445-4116- P4485A-N 445-1311- 311-1343- 445-7456- CK45-B3D 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	Yageo Panasonic Murata TDK Yageo TDK Yageo TDK TDK Panasonic TDK Yageo TDK TDK Panasonic TDK Yageo TDK TOK TOK Yageo TOK	CC0603KRX7R9BB331 ECA-1HM331 GRM2165C2A561JA01D C2012JB1H105K085AB CC0603KRXSR8BB105 C1608X5R1H105K080AB CC0805KRX7R9BB472 C3225X772J104M160AC C2012X5R1E475K125AB ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C11	OUF 50V 20% RADIAL PF 100V 5% NP0 0805 50V 10% JB 0805 25V 10% X5R 0603 50V 10% X5R 0603 50V 10% X5R 0603 PF 50V 10% X7R 0805 F 630V 20% X7T 1210 F 25V 10% X5R 0805 PF 50V 10% X7R 0805 PF 50V 10% X7R 0603 PF 50V 10% X7R 0603 F 50V 10% X5R 0603 PF 50V 20% RADIAL F 50V 20% RADIAL F 50V 20% RADIAL UF 50V 20% RADIAL	Digikey Active-Sen	P5184-ND 490-1612- 445-1149(311-1445- 445-7468- 311-1133- 445-4116- P4485A-N 445-1311- 311-1343- 445-7456- CK45-B3D 445-5942- 1189-1391 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	Panasonic Murata TDK Yageo TDK Yageo TDK TDK Panasonic TDK Yageo TDK TDK Panasonic TDK Yageo TDK TOK TOK TOK TOK TOK TOK TOK TOK TOK TO	ECA-1HM331 GRM2165C2A561JA01D C2012JB1H105K085AB CC0603KRXSR8BB105 C1608X5R1H105K080AB CC0805KRX7R9BB472 C3225X772J104M160AC C2012X5R1E475K125AB ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C12 1 560pF CAP CER 560 C13 1 1uF CAP CER 1UF C14, C15, C16, C17, C35 5 1uF CAP CER 1UF C18, C19, C20 3 1uF CAP CER 1UF C2, C29, C30 3 4.7nF CAP CER 470 C25, C26, C27 3 0.1uF CAP CER 4.7 C3 1 820pF CAP CER 820 C32 1 0.01uF CAP CER 100 C33, C34 2 0.1uF CAP CER 0.1L C36, C37, C38 3 0.1uF CAP CER 0.1L C4 1 820pF CAP CER 820 C4 1 820pF CAP CER 0.1L C5 1 82u CAP ALUM 82 C6 1 1uF CAP CER 1UF C7 1 6.8uF CAP ALUM 62 C8 1 10u CAP ALUM 63 C9 1 0.01uF CAP CER 100 D1, D4, D5, D6 4 N/A DIODE SUPEI D2 1 N/A Schottky Dio J2, J4, J5 3 N/A CONN HEAD L1 1 N/A Inductor 5A LED1, LED2, LED3 3 Red LED RED CLE P1	F 100V 5% NP0 0805 50V 10% JB 0805 25V 10% X5R 0603 50V 10% X5R 0603 50V 10% X5R 0603 F 50V 10% X7R 0805 F 630V 20% X7T 1210 F 25V 10% X5R 0805 F 52V 10% X5R 0805 F 52V 10% X5R 0805 F 50V 10% X5R 0603 F 50V 20% RADIAL 630V 20% X7T SMD 8UF 450V 20% RADIAL 630V 20% X7T SMD 8UF 450V 20% RADIAL 630V 20% RADIAL	Digikey Active-Sen	490-1612- 445-1149(311-1445- 445-7468- 311-1133- 445-4116- P4485A-N 445-311- 311-1343- 445-7456- CK45-B3D 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	Murata TDK Yageo TDK Yageo TDK TDK Panasonic TDK Yageo TDK TDK Rubycon TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	GRM2165C2A561JA01D C2012JB1H105K085AB CC0603KRXSR8BB105 C1608X5R1H105K080AB CC0805KRX7R9BB472 C3225X7T2J104M160AC C2012X5R1E475K125AB ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C13 1 Juf CAP CER 1UF C14, C15, C16, C17, C35 5 Juf CAP CER 1UF C18, C19, C20 3 Juf CAP CER 1UF C2, C29, C30 3 4.7nf CAP CER 470 C25, C26, C27 3 0.1uf CAP CER 4.7L C28 1 4.7uf CAP CER 4.7L C3 1 820pf CAP CER 820 C32 1 0.01uf CAP CER 100 C33, C34 2 0.1uf CAP CER 0.1L C36, C37, C38 3 0.1uf CAP CER 0.1L C4 1 820pf CAP CER 820 C4 1 82u CAP ALUM 82 C5 1 82u CAP ALUM 83 C6 1 1uf CAP CER 1Uf C7 1 6.8uf CAP ALUM 60 C8 1 10u CAP ALUM 10 C9 1 0.01uf CAP CER 100 D1, D4, D5, D6 4 N/A DIODE SUPEI D2 1 N/A Schottky Dio J2, J4, J5 3 N/A CONN HEAD L1 1 N/A Inductor 5A LED1, LED2, LED3 3 Red LED RED CLE P1	50V 10% JB 0805 25V 10% X5R 0603 50V 10% X5R 0603 50V 10% X5R 0603 6PF 50V 10% X7R 0805 F 630V 20% X7T 1210 F 25V 10% X5R 0805 6PF 26V 10% RADIAL 600PF 50V 10% X7R 0603 F 50V 10% X5R 0603 6PF 50V 10% X5R 0603 6PF 50V 10% RADIAL 6F 50V 20% RADIAL	Digikey Active-Sen	445-1149(311-1445- 445-7468- 311-1133- 445-1416- P4485A-N 445-311- 311-1343- 445-7456- CK45-B3D 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	TDK Yageo TDK Yageo TDK TDK TDK Panasonic TDK Yageo TDK TDK Yageo TDK	C2012JB1H105K085AB CC0603KRXSR8BB105 C1608X5R1H105K080AB CC0805KRX7R9BB472 C3225X7T2J104M160AC C2012X5R1E475K125AB ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C14, C15, C16, C17, C35 C18, C19, C20 3	25V 10% X5R 0603 50V 10% X5R 0603 50V 10% X5R 0603 FF 50V 10% X7R 0805 F 630V 20% X7T 1210 F 25V 10% X5R 0805 F 26V 10% X5R 0805 F 50V 10% X5R 0603 F 50V 20% RADIAL 630V 20% X7T SMD 8UF 450V 20% RADIAL UF 50V 20% RADIAL	Digikey Active-Sen	311-1445- 445-7468- 311-1133- 445-1494! 445-4116- P4485A-N 445-1311- 311-1343- 445-7456- CK45-B3D 445-5942- 1189-1391 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	Yageo TDK Yageo TDK TDK Panasonic TDK Yageo TDK TDK Yageo TDK TDK TDK TDK RUbycon TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	CC0603KRXSR8BB105 C1608X5R1H105K080AB CC0805KRX7R9BB472 C3225X7T2J104M160AC C2012X5R1E475K125AB ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C18, C19, C20 C2, C29, C30 3	50V 10% XSR 0603 PF 50V 10% X7R 0805 F 630V 20% X7T 1210 F 25V 10% XSR 0805 PF 2KV 10% RADIAL POPF 50V 10% X7R 0603 F 50V 10% X5R 0603 PF 50V 10% X5R 0603 PF 50V 10% RADIAL F 50V 20% RADIAL G30V 20% X7T SMD BUF 450V 20% RADIAL UF 50V 20% RADIAL UF	Digikey Active-Sen	445-7468- 311-1133- 445-14941 445-4116- P4485A-N 445-1311- 311-1343- 445-7456- CK45-B3D 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	TDK Yageo TDK TDK Panasonic TDK Yageo Yageo TDK TDK TDK RUbycon TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	C1608X5R1H105K080AB CC0805KRX7R9BB472 C3225X7T2J104M160AC C2012X5R1E475K125AB ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C2, C29, C30 3 4.7nF CAP CER 470 C25, C26, C27 3 0.1uF CAP CER 0.1t CAP CER 0.1t CAP CER 4.7t CAP CER 8.20 CAP CER 1.0t CAP CER 8.20 CAP CER 1.0t CAP CAP CAP CAP CAP CAP CAP CAP CAP CAP CAP CAP CAP CAP CAP CAP CAP CAP CAP CAP CAP	PF 50V 10% X7R 0805 F 630V 20% X7T 1210 F 25V 10% X5R 0805 F 2KV 10% RADIAL 10PF 50V 10% X7R 0603 F 50V 10% X5R 0603 F 50V 10% X5R 0603 F 50V 10% RADIAL 630V 20% RADIAL 630V 20% RADIAL UF 450V 20% RADIAL UF 50V 20% RADIAL 10PF 1KV 10% RADIAL	Digikey Active-Sen	311-1133 445-1494! 445-4116- P4485A-N 445-1311- 311-1343- 445-7456- CK45-B3D 445-5942- 1189-139: 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	Yageo TDK TDK Panasonic TDK Yageo Yageo TDK TDK TDK TDK TDK TDK TDK TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	CC0805KRX7R9BB472 C3225X7T2J104M160AC C2012X5R1E475K125AB ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C25, C26, C27 3 0.1uF CAP CER 0.1L C28 1 4.7uF CAP CER 4.7L C3 1 820pF CAP CER 820 C32 1 0.01uF CAP CER 100 C33, C34 2 0.1uF CAP CER 0.1L C36, C37, C38 3 0.1uF CAP CER 0.1L C4 1 820pF CAP CER 820 C41, C42, C43 3 0.1uF CAP CER 0.1L C5 1 82u CAP ALUM 82 C6 1 1uF CAP CER 1UF C7 1 6.8uF CAP ALUM 6. C8 1 10u CAP ALUM 10. C9 1 0.01uF CAP CER 100. D1, D4, D5, D6 4 N/A DIODE SUPEI D2 1 N/A Schottky Dio J2, J4, J5 3 N/A CONN HEAD L1 1 N/A Inductor 5A: LED1, LED2, LED3 3 Red LED RED CLE. P1 1 7x2 HDR F 7x2 HDR F Fer Q1 1 N/A N-CH 600V 1 R1, R2 2 1M (1%) RES 1.0MM 0 R10 1 1.0 (1%) RES 1.0HM 1 R12 <td< td=""><td>F 630V 20% X7T 1210 F 25V 10% X5R 0805 F 2KV 10% RADIAL 10PF 50V 10% X7R 0603 F 50V 10% X5R 0603 F 50V 10% X5R 0603 F 50V 10% X5R 0603 F 50V 10% RADIAL F 50V 20% RADIAL 630V 20% X7T SMD 8UF 450V 20% RADIAL UF 50V 20% RADIAL UF 50V 20% RADIAL 10PF 1KV 10% RADIAL 10PF</td><td>Digikey Digikey Active-Sen</td><td>445-14941 445-4116- P4485A-N 445-1311- 311-1343- 445-7456- CK45-B3D 445-5942- 1189-1391 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-</td><td>TDK TDK Panasonic TDK Yageo Yageo TDK TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial</td><td>C3225X7TZJ104M160AC C2012X5R1E475K125AB ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7TZJ105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP</td></td<>	F 630V 20% X7T 1210 F 25V 10% X5R 0805 F 2KV 10% RADIAL 10PF 50V 10% X7R 0603 F 50V 10% X5R 0603 F 50V 10% X5R 0603 F 50V 10% X5R 0603 F 50V 10% RADIAL F 50V 20% RADIAL 630V 20% X7T SMD 8UF 450V 20% RADIAL UF 50V 20% RADIAL UF 50V 20% RADIAL 10PF 1KV 10% RADIAL 10PF	Digikey Active-Sen	445-14941 445-4116- P4485A-N 445-1311- 311-1343- 445-7456- CK45-B3D 445-5942- 1189-1391 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	TDK TDK Panasonic TDK Yageo Yageo TDK TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	C3225X7TZJ104M160AC C2012X5R1E475K125AB ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7TZJ105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C28 1 4.7uF CAP CER 4.7u C3 1 820pF CAP CER 820 C32 1 0.01uF CAP CER 100 C33, C34 2 0.1uF CAP CER 0.1u C36, C37, C38 3 0.1uF CAP CER 0.1u C4 1 820pF CAP CER 820 C41, C42, C43 3 0.1uF CAP CER 0.1u C5 1 82u CAP ALUM 82 C6 1 1uF CAP CER 1UF C7 1 6.8uF CAP ALUM 10 C8 1 10u CAP ALUM 60 C9 1 0.01uF CAP CER 100 D1, D4, D5, D6 4 N/A DIODE SUPEI D2 1 N/A Schottky Dio J2, J4, J5 3 N/A CONN HEAD L1 1 N/A Inductor 5A 3 LED1, LED2, LED3 3 Red LED RED CLE P1 1 7x2 HDR F 7x2 HDR F 7x2 HDR F 6r Q1 1 N/A N-CH 600V 1r R1, R2 2	F 25V 10% X5R 0805 F 2KV 10% RADIAL 10PF 50V 10% X7R 0603 F 50V 10% X5R 0603 F 50V 10% X5R 0603 F 50V 10% RADIAL F 50V 20% RADIAL 630V 20% X7T SMD 8UF 450V 20% RADIAL UF 50V 20% RADIAL UF 50V 20% RADIAL 10PF 1KV 10% RADIAL 10P	Digikey Active-Sen	445-4116- P4485A-N 445-1311- 311-1343- 445-7456- CK45-B3D 445-5942- 1189-1393 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	TDK Panasonic TDK Yageo Yageo TDK TDK TDK TDK TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	C2012X5R1E475K125AB ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C3	F 2KV 10% RADIAL 10PF 50V 10% X7R 0603 F 50V Y5V 0603 F 50V 10% X5R 0603 F 50V 10% X5R 0603 F 5V 10% RADIAL F 50V 20% RADIAL 630V 20% X7T SMD 8UF 450V 20% RADIAL UF 50V 20% RADIAL UF 50V 20% RADIAL 10PF 1KV 10% RADIAL 10PF 1KV	Digikey Active-Sen	P4485A-N 445-1311- 311-1343- 445-7456- CK45-B3D 445-5942- 1189-1391 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	Panasonic TDK Yageo Yageo TDK TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	ECK-D3D821KBP C1608X7R1H103K080AA CC0603ZRY5V9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C32	10PF 50V 10% X7R 0603 F 50V Y5V 0603 F 50V 10% X5R 0603 F 50V 10% RADIAL F 50V Y5V 0402 UF 450V 20% RADIAL 630V 20% X7T SMD 8UF 450V 20% RADIAL UF 50V 20% RADIAL 10PF 1KV 10% RADIAL 1: FAST 600V 1A DO41 2: R 4POS .100 STR TIN 0mH(Customized) 00UH 100MA AXIAL	Digikey Active-Sen	445-1311- 311-1343- 445-7456- CK45-B3D 445-5942- 1189-1393- 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	TDK Yageo Yageo TDK TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	C1608X7R1H103K080AA CC0603ZRYSV9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C33, C34 C36, C37, C38 C4 C4 C4 C56, C37, C38 C57 C4 C4 C4 C59 C50 C69 C69 C69 C69 C69 C69 C69 C6	F 50V Y5V 0603 F 50V 10% X5R 0603 F 2KV 10% RADIAL F 50V Y5V 0402 UF 450V 20% RADIAL 630V 20% X7T SMD 8UF 450V 20% RADIAL UF 50V 20% RADIAL 10PF 1KV 10% RADIAL 1: FAST 600V 1A DO41 1: R4POS .100 STR TIN 0mH(Customized) 00UH 100MA AXIAL	Digikey Active-Sen	311-1343- 445-7456- CK45-B3D 445-5942- 1189-1391 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	Yageo Yageo TDK TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	CC0603ZRYSV9BB104 C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C36, C37, C38 C4 C4 C4 C4 C5 C4 C5 C6 C6 C6 C7 C8 C8 C9 C9 C9 C9 C9 C9 C9 C9	F 50V 10% X5R 0603 FF 2KV 10% RADIAL F 50V Y5V 0402 UF 450V 20% RADIAL 630V 20% X7T SMD 8UF 450V 20% RADIAL UF 50V 20% RADIAL 10PF 1KV 10% RADIAL 1: FAST 600V 1A DO41 1: R4POS .100 STR TIN 0mH(Customized) 00UH 100MA AXIAL	Digikey Active-Sen	445-7456- CK45-B3D 445-5942- 1189-1391 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	Yageo TDK TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	C1608X5R1H104K080AA CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C4 1 820pF CAP CER 820 C41, C42, C43 3 0.1uF CAP CER 0.1U C5 1 82u CAP ALUM 82 C6 1 1uF CAP CER 1UF C7 1 6.8uF CAP ALUM 6. C8 1 10u CAP CER 100 C9 1 0.01uF CAP CER 100 D1, D4, D5, D6 4 N/A DIODE SUPEI D2 1 N/A Schottky Dio J2, J4, J5 3 N/A CONN HEAD L1 1 N/A Inductor 5A: LED L1 1 N/A Inductor 5A: LED1, LED2, LED3 3 Red LED RED CLE. P1 1 7x2 HDR F 7x2 HDR F Q1 1 N/A N-CH 600V 1 R1, R2 2 1M (1%) RES 1.00M 0 R10 1 1.0 (1%) RES 1.0HM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1	F 2KV 10% RADIAL F 50V Y5V 0402 UF 450V 20% RADIAL 630V 20% X7T SMD BUF 450V 20% RADIAL UF 50V 20% RADIAL 100F 1KV 10% RADIAL 1FAST 600V 1A DO41 des & Rectifiers Low VF ESD 2A 100V 1R 4POS .100 STR TIN 0mH(Customized) 00UH 100MA AXIAL	Digikey Active-Sen	CK45-B3D 445-5942- 1189-1391 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	TDK TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	CK45-B3DD821KYNR C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C41, C42, C43 3 0.1 uF CAP CER 0.1 L C5 1 82 u CAP ALUM 82 C6 1 1 uF CAP CER 1 UF C7 1 6.8 uF CAP ALUM 6. C8 1 10 u CAP ALUM 10. C9 1 0.01 uF CAP CER 100. D1, D4, D5, D6 4 N/A DIODE SUPEI D2 1 N/A Schottky Dio J2, J4, J5 3 N/A CONN HEAD L1 1 N/A Inductor 5A: L3 1 1.5mH CHOKE RF 15 LED1, LED2, LED3 3 Red LED RED CLE. P1 1 7x2 HDR F 7x2 HDR F err Q1 1 N/A N-CH 600V 10 R1, R2 2 1 M (1%) RES 1.00M O R10 1 1.0 (1%) RES 1 OHM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	F 50V Y5V 0402 UF 450V 20% RADIAL 630V 20% X7T SMD BUF 450V 20% RADIAL UF 50V 20% RADIAL 100FF 1KV 10% RADIAL 1 FAST 600V 1A DO41 des & Rectifiers Low VF ESD 2A 100V 1R 4POS .100 STR TIN 0mH(Customized) 00UH 100MA AXIAL	Digikey Digikey Digikey Digikey Digikey Digi-Key Digikey Digikey Digikey Active-Sen	445-5942- 1189-1391 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	TDK Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	C1005X5R1H104K050BB 450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C5	UF 450V 20% RADIAL 630V 20% X7T SMD 8UF 450V 20% RADIAL UF 50V 20% RADIAL 100PF 1kV 10% RADIAL 1: FAST 600V 1A DO41 des & Rectifiers Low VF ESD 2A 100V R 4POS .100 STR TIN 0mH(Customized) 00UH 100MA AXIAL	Digikey Digikey Digikey Digikey Digi-Key Digikey Digikey Digikey Digikey Active-Sen	1189-1391 445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	Rubycon TDK Corporation Nichicon Panasonic Kemet Micro Commercial	450TXW82MEFC18X30 CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C6 1 1uF CAP CER 1UF C7 1 6.8uF CAP ALUM 6. C8 1 10u CAP ALUM 10 C9 1 0.01uF CAP CER 100 D1, D4, D5, D6 4 N/A DIODE SUPEI D2 1 N/A Schottky Dio J2, J4, J5 3 N/A CONN HEAD L1 1 N/A Inductor 5A: L3 1 1.5mH CHOKE RF 15 LED1, LED2, LED3 3 Red LED RED CLE. P1 1 7x2 HDR F 7x2 HDR F 7x2 HDR Ferr Q1 1 N/A MOSFET N-CI Q2, Q3, Q4, Q5, Q6, Q7 6 N/A N-CH 600V 10 R1, R2 2 1M (1%) RES 1.00M 0 R10 1 1.0 (1%) RES 1.0HM 1 R12 1 2K RES 2K OHM 1 R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	630V 20% X7T SMD 8UF 450V 20% RADIAL UF 50V 20% RADIAL 10PF 1kV 10% RADIAL 1: FAST 600V 1A DO41 des & Rectifiers Low VF ESD 2A 100V R 4POS .100 STR TIN 0mH(Customized) 00UH 100MA AXIAL	Digikey Digikey Digikey Digi-Key Digikey Digikey Digikey Digikey Digikey Active-Sen	445-7110- 493-7386- P5567-ND 399-9793- MUR160- SB2H100-	TDK Corporation Nichicon Panasonic Kemet Micro Commercial	CKG57NX7T2J105M500JH UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C7	BUF 450V 20% RADIAL UF 50V 20% RADIAL 10PF 1KV 10% RADIAL 1: FAST 600V 1A DO41 des & Rectifiers Low VF ESD 2A 100V R 4POS .100 STR TIN 0mH(Customized) 00UH 100MA AXIAL	Digikey Digi-Key Digi-Key Digikey Digikey Digikey Active-Sen	493-7386- P5567-ND 399-9793- MUR160- SB2H100-	Nichicon Panasonic Kemet Micro Commercial	UCS2W6R8MPD1TD ECA-1HHG100 C322C103KDR5TA MUR160-TP
C8 1 10u CAP ALUM 10 C9 1 0.01uF CAP CER 100 D1, D4, D5, D6 4 N/A DIODE SUPEI D2 1 N/A Schottky Dio J2, J4, J5 3 N/A CONN HEAD L1 1 N/A Inductor 5A L3 1 1.5mH CHOKE RF 15 LED1, LED2, LED3 3 Red LED RED CLE. P1 1 7x2 HDR F 7x2 HDR F 67 Q1 1 N/A MOSFET N-CI Q2, Q3, Q4, Q5, Q6, Q7 6 N/A N-CH 600V 10 R1, R2 2 1M (1%) RES 1.00M O R10 1 1.0 (1%) RES 1 OHM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	UF 50V 20% RADIAL 10PF 1KV 10% RADIAL 1 FAST 600V 1A DO41 1 Ses & Rectifiers Low VF ESD 2A 100V 1R 4POS .100 STR TIN 10mH(Customized) 100UH 100MA AXIAL	Digikey Digi-Key Digikey Digikey Digikey Active-Sen	P5567-ND 399-9793- MUR160- SB2H100-	Panasonic Kemet Micro Commercial	ECA-1HHG100 C322C103KDR5TA MUR160-TP
C9 1 0.01uF CAP CER 100 D1, D4, D5, D6 4 N/A DIODE SUPEI D2 1 N/A Schottky Dio J2, J4, J5 3 N/A CONN HEAD L1 1 N/A Inductor 5A: L3 1 1.5mH CHOKE RF 15 LED1, LED2, LED3 3 Red LED RED CLE. P1 1 7x2 HDR F 7x2 HDR F 67x2 HDR Ferr Q1 1 N/A MOSFET N-C Q2, Q3, Q4, Q5, Q6, Q7 6 N/A N-CH 600V 10 R1, R2 2 1 M (1%) RES 1.00M O R10 1 1.0 (1%) RES 1 OHM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	OPF 1KV 10% RADIAL FAST 600V 1A DO41 des & Rectifiers Low VF ESD 2A 100V R 4POS .100 STR TIN OmH(Customized) OUH 100MA AXIAL	Digi-Key Digikey Digikey Digikey Active-Sen	399-9793- MUR160- SB2H100-	Kemet Micro Commercial	C322C103KDR5TA MUR160-TP
D1, D4, D5, D6	FAST 600V 1A DO41 des & Rectifiers Low VF ESD 2A 100\ R 4POS .100 STR TIN 0mH(Customized) 00UH 100MA AXIAL	Digikey Digikey Digikey Active-Sen	MUR160- SB2H100-	Micro Commercial	MUR160-TP
D2 1 N/A Schottky Dio J2, J4, J5 3 N/A CONN HEAD L1 1 N/A Inductor 5A L3 1 1.5mH CHOKE RF 15 LED1, LED2, LED3 3 Red LED RED CLE. P1 1 7x2 HDR F 7x2 HDR F 6T 7x2 HDR F 6T Q1 1 N/A MOSFET N-C Q2, Q3, Q4, Q5, Q6, Q7 6 N/A N-CH 600V 1 R1, R2 2 1M (1%) RES 1.00M O R10 1 1.0 (1%) RES 1 OHM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 5.1 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	des & Rectifiers Low VF ESD 2A 100\ R 4POS .100 STR TIN OmH(Customized) 00UH 100MA AXIAL	Digikey Digikey Active-Sen	SB2H100-		
J2, J4, J5 3 N/A CONN HEAD L1 1 N/A Inductor 5A 3 LED1, LED2, LED3 3 Red LED RED CLE. P1 1 7x2 HDR F 7x2 HDR F 6 Q1 1 N/A MOSFET N-C Q2, Q3, Q4, Q5, Q6, Q7 6 N/A N-CH 600V 10 R1, R2 2 1M (1%) RES 1.00M O R10 1 1.0 (1%) RES 1 OHM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	R 4POS .100 STR TIN 0mH(Customized) 00UH 100MA AXIAL	Digikey Active-Sen		Vichou	CD2H100 F2/72
L1 1 N/A Inductor 5A L3 1 1.5mH CHOKE RF 15 LED1, LED2, LED3 3 Red LED RED CLE. P1 1 7x2 HDR F7 7x2 HDR F6r Q1 1 N/A MOSFET N-C Q2, Q3, Q4, Q5, Q6, Q7 6 N/A N-CH 600V 10 R1, R2 2 1M (1%) RES 1.00M O R10 1 1.0 (1%) RES 1 OHM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	0mH(Customized) 00UH 100MA AXIAL	Active-Sen	600-33UE	visitay	SB2H100-E3/73
L3 1 1.5mH CHOKE RF 15 LED1, LED2, LED3 3 Red LED RED CLE. P1 1 7x2 HDR F 7x2 HDR F Fr Q1 1 N/A MOSFET N-C Q2, Q3, Q4, Q5, Q6, Q7 6 N/A N-CH 600V 10 R1, R2 2 1M (1%) RES 1.00M O R10 1 1.0 (1%) RES 1 OHM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	00UH 100MA AXIAL			FCI	68002-404HLF
LED1, LED2, LED3 3 Red LED RED CLE P1 1 7x2 HDR F 7x2 HDR F 7x2 HDR F FR Q1 1 N/A MOSFET N-C Q2, Q3, Q4, Q5, Q6, Q7 6 N/A N-CH 600V 1 R1, R2 2 1M (1%) RES 1.00M O R10 1 1.0 (1%) RES 1 OHM 1 R12 2 K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM			Provided	N/A	ET24
P1 1 7x2 HDR F 7x2 HDR F em Q1 1 N/A MOSFET N-C Q2, Q3, Q4, Q5, Q6, Q7 6 N/A N-CH 600V 10 R1, R2 2 1M (1%) RES 1.00M 0 R10 1 1.0 (1%) RES 1 OHM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	B 000E 01 1B	Digikey	495-5553-	Epcos	B78108S1155J
Q1 1 N/A MOSFET N-C Q2, Q3, Q4, Q5, Q6, Q7 6 N/A N-CH 600V 1/2 R1, R2 2 1M (1%) RES 1.00M O R10 1 1.0 (1%) RES 1 OHM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	AK U8U5 SMD	Digikey	160-1176-	Lite-On	LTST-C170CKT
Q2, Q3, Q4, Q5, Q6, Q7 6 N/A N-CH 600V 1 R1, R2 2 1M (1%) RES 1.00M O R10 1 1.0 (1%) RES 1 OHM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	ale	Digi-Key	S5560-ND	Sullins	PPPC072LJBN-RC
R1, R2 2 1M (1%) RES 1.00M O R10 1 1.0 (1%) RES 1 OHM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	1 600V 2A TO-220	Digikey	FQP2N600	Fairchild	FQP2N60C
R10 1 1.0 (1%) RES 1 OHM 1 R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	0.2A 380mO	Digikey	FCD380N	Fairchild	FCD380N60E
R12 1 2K RES 2K OHM R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	HM 1/4W 1% 1206 SMD	Digikey	311-1.00N	Yageo	RC1206FR-071ML
R13, R47, R49 3 402K (1%) RES 402K OH R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	/2W 1% 1206	Digikey	A109669C	TE Connectivity	RLP73K2B1R0FTDF
R16 1 51 RES 51 OHM R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	1/8W 5% 0805	Digikey	RMCF080	Stackpole	RMCF0805JT2K00
R19, R20, R21, R22, R23, R24 6 20 RES 20 OHM	M 3/4W 1% 2010 SMD	Digikey	P402KACC	Panasonic	ERJ-12SF4023U
	2/3W 5% 1206 SMD	Digikey	P51ALCT-N	Panasonic	ERJ-P08J510V
R25, R26, R27, R36, R37, R38 6 RES 100 O RES 100 OHN	1/8W 5% 0805 SMD	Digikey	311-20AR	Yageo	RC0805JR-0720RL
	1/10W 5% 0603 SMD	0603R	311-100G	Yageo	RC0603JR-07100RL
R28, R29, R30 3 1 RES 1 OHM 2	W 5% 2512 SMD	Digikey	CRM2512	Bourns	CRM2512-JW-1R0ELF
R3 1 10k (1%) RES 10.0K OF	M 1/10W 1% 0603 SMD	Digikey	311-10.0K	Yageo	RC0603FR-0710KL
R33, R51 2 0R RES 0.0 OHM	1/10W JUMP 0603 SMD	Digikey	311-0.0GF	Yageo	RC0603JR-070RL
	/ 1/4W 1% 1206 SMD	Digikey	311-10.0F		RC1206FR-0710RL
	M 1/4W 5% 1206 SMD	Digikey	311-510KE	Yageo	RC1206JR-07510KL
	OHM 1% 1/10W 0603	Digikey		Panasonic	ERJ-3EKF2401V
	1/10W 5% 0603 SMD	Digikey	311-10KG		RC0603JR-0710KL
	M 1/4W 5% 1206 SMD	Digikey	311-100KF		RC1206JR-07100KL
	1/10W 5% 0603 SMD	Digikey	311-2.4KG		RC0603JR-072K4L
	OHM JUMPER 1/10W	Digikey		Panasonic	ERJ-3GEY0R00V
	1/10W 5% 0402 SMD	Digikey		Panasonic	ERJ-2GEJ432X
	1 1/8W 1% 0805 SMD	Digikey	311-100CI		RC0805FR-07100RL
R72 1 00hm RES 0.0 OHM		Digi-key	CR2512-J/		Bourns
	1 /0/A/ E0/ OOOE CNAD	Digikey	311-51AR		RC0805JR-0751RL
	1/8W 5% 0805 SMD	Digikey	311-1.0KG		RC0603JR-071KL
	/ 1/10W 5% 0603 SMD			INI/A	EE16
U1 1 PAC5250 PAC5250QF		Active-Sen	Provided		
D3, D7, D8, D9, D10, D11, D12 1 N/A, NC, N DIODE SMAL C39, C40, C44, J1, R60, R61, R62, R6 4 NP	M 1/10W 5% 0603 SMD mer(Customized)		Provided	Active-Semi	PAC5250QF LL4148



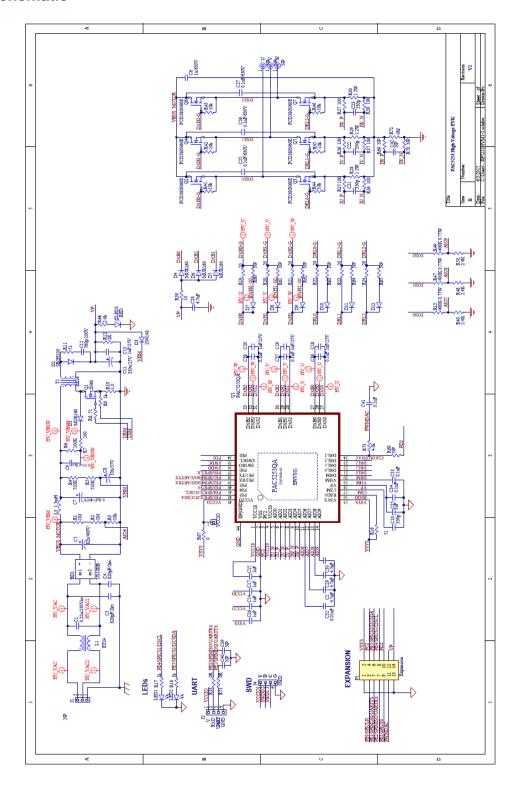
6.3 Layout





7 PAC5253 DESIGN

7.1 Schematic



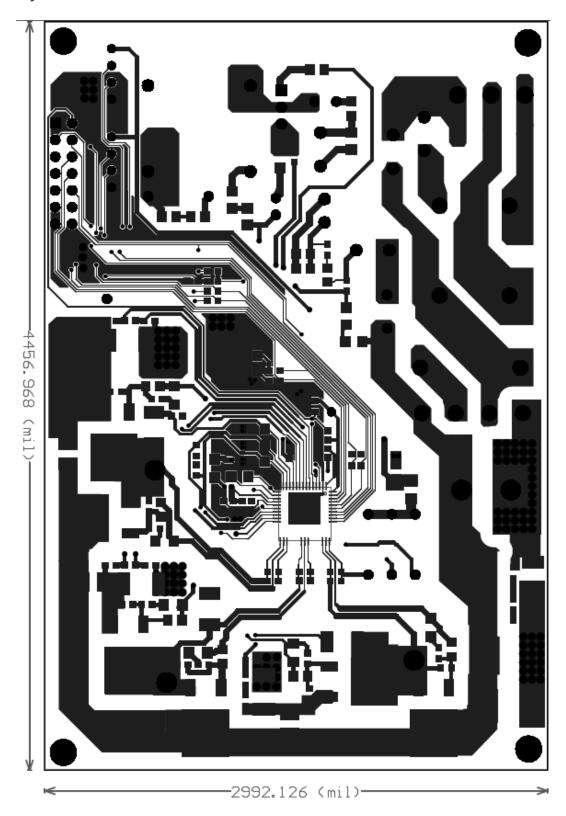


7.2 **BOM**

Designator	Quantity	Value	Desc	Vendor	Vendor PN	Manufacturer	Manufact PN
BD1		N/A	RECT BRIDGE GPP 10A 1000V GBU	Digikey	GBU1010DI-ND	Didoes	GBU1010
C1		0.22uF	CAP FILM 0.22UF 760VDC RADIAL	Digikey	399-5427-ND	Kemet	PHE840MX6220MB06R17
C10, C21, C22, C23	4	330pF	CAP CER 330PF 50V 10% X7R 0603	Digikey	311-1186-1-ND	Yageo	CC0603KRX7R9BB331
C11	1	330uF	CAP ALUM 330UF 50V 20% RADIAL	Digikey	P5184-ND	Panasonic	ECA-1HM331
C12	1	560pF	CAP CER 560PF 100V 5% NP0 0805	Digikey	490-1612-1-ND	Murata	GRM2165C2A561JA01D
C13	1	1uF	CAP CER 1UF 50V 10% JB 0805	Digikey	445-11490-1-ND	TDK	C2012JB1H105K085AB
C14, C15, C16, C17, C35	5	1uF	CAP CER 1UF 25V 10% X5R 0603	Digikey	311-1445-1-ND	Yageo	CC0603KRX5R8BB105
C18, C19, C20	3	1uF	CAP CER 1UF 50V 10% X5R 0603	Digikey	445-7468-1-ND	TDK	C1608X5R1H105K080AB
C2, C29, C30	3	4.7nF	CAP CER 4700PF 50V 10% X7R 0805	Digikey	311-1133-1-ND	Yageo	CC0805KRX7R9BB472
C25, C26, C27	3	0.1uF	CAP CER 0.1UF 630V 20% X7T 1210	Digikey	445-14941-1-ND	TDK	C3225X7T2J104M160AC
C28	1	4.7uF	CAP CER 4.7UF 25V 10% X5R 0805	Digikey	445-4116-1-ND	TDK	C2012X5R1E475K125AB
C3	1	820pF	CAP CER 820PF 2KV 10% RADIAL	Digikey	P4485A-ND	Panasonic	ECK-D3D821KBP
C32	1	0.01uF	CAP CER 10000PF 50V 10% X7R 0603	Digikey	445-1311-1-ND	TDK	C1608X7R1H103K080AA
C33, C34, C41	3	0.1uF	CAP CER 0.1UF 50V Y5V 0603	Digikey	311-1343-1-ND	Yageo	CC0603ZRY5V9BB104
C36, C37, C38	3	0.1uF	CAP CER 0.1UF 50V 10% X5R 0603	Digikey	445-7456-1-ND	Yageo	C1608X5R1H104K080AA
C39, C40, C42, J1, R60, R61, R62, F	16		NP				
C4	1	820pF	CAP CER 820PF 2KV 10% RADIAL	Digikey	CK45-B3DD821KYNR-ND	TDK	CK45-B3DD821KYNR
C5		82u	CAP ALUM 82UF 450V 20% RADIAL	Digikey	1189-1391-ND	Rubycon	450TXW82MEFC18X30
C6		1uF	CAP CER 1UF 630V 20% X7T SMD	Digikey	445-7110-1-ND	TDK Corporation	CKG57NX7T2J105M500JH
C7	1	6.8uF	CAP ALUM 6.8UF 450V 20% RADIAL	Digikey	493-7386-1-ND	Nichicon	UCS2W6R8MPD1TD
C8	1	10u	CAP ALUM 10UF 50V 20% RADIAL	Digikey	P5567-ND	Panasonic	ECA-1HHG100
C9	1	0.01uF	CAP CER 10000PF 1KV 10% RADIAL	Digikey	399-9793-ND	Kemet	C322C103KDR5TA
D1, D4, D5, D6	4	N/A	DIODE SUPER FAST 600V 1A DO41	Digikey	MUR160-TPMSTR-ND	Micro Commercial	
D2	1	N/A	Schottky Diodes & Rectifiers Low VF ESD		SB2H100-E3/73GICT-ND	Comchip	SB2H100-E3/73
D3, D7, D8, D9, D10, D11, D12	7	147.	NP	Digikey	LL4148FSCT-ND	Fairchild	LL4148
J2, J4	2	N/A	CONN HEADER 4POS .100 STR TIN	Digikey	609-3305-ND	FCI	68002-404HLF
L1	1	N/A	Inductor 5A 30mH(Customized)		Provided by Active	N/A	ET24
L3	1		CHOKE RF 1500UH 100MA AXIAL	Digikey	495-5553-1-ND	Epcos	B78108S1155J
LED1, LED2, LED3	_	Red	LED RED CLEAR 0805 SMD	Digikey	160-1176-1-ND	Lite-On	LTST-C170CKT
P1		7x2 HDR Female		DigirKey Digi-Key	S5560-ND	Sullins	PPPC072LJBN-RC
01		N/A	MOSFET N-CH 600V 2A TO-220	Digikey	FQP2N60CFS-ND	Fairchild	FQP2N60C
Q2, Q3, Q4, Q5, Q6, Q7		N/A	N-CH 600V 10.2A 380mO	Digikey	FCD380N60ECT-ND	Fairchild	FCD380N60E
R1, R2		1M (1%)	RES 1.00M OHM 1/4W 1% 1206 SMD	Digikey	311-1.00MFRCT-ND	Yageo	RC1206FR-071ML
R10		1.0 (1%)	RES 1 OHM 1/2W 1% 1206	Digikey	A109669CT-ND	TE Connectivity	RLP73K2B1R0FTDF
R12		2K	RES 2K OHM 1/8W 5% 0805	Digikey	RMCF0805JT2K00CT-ND	Stackpole	RMCF0805JT2K00
R13, R47, R49		402K (1%)	RES 402K OHM 3/4W 1% 2010 SMD	Digikey	P402KACCT-ND	Panasonic	ERJ-12SF4023U
R16		51	RES 51 OHM 2/3W 5% 1206 SMD	Digikey	P51ALCT-ND	Panasonic	ERJ-P08J510V
R19, R20, R21, R22, R23, R24		20	RES 20 OHM 1/8W 5% 0805 SMD	Digikey	311-20ARCT-ND	Yageo	RC0805JR-0720RL
R25, R26, R27, R36, R37, R38		100	RES 100 OHM 1/10W 5% 0603 SMD	Digikey	311-100GRCT-ND	Yageo	RC0603JR-07100RL
R28, R29, R30		1	RES 1 OHM 2W 5% 2512 SMD	Digikey	CRM2512-JW-1R0ELFCT-ND	Bourns	CRM2512-JW-1R0ELF
R3		10k (1%)	RES 10.0K OHM 1/10W 1% 0603 SMD	Digikey	311-10.0KHRCT-ND	Yageo	RC0603FR-0710KL
R33, R51		OR (178)	RES 0.0 OHM 1/10W JUMP 0603 SMD	Digikey	311-0.0GRCT-ND	Yageo	RC0603JR-0710RL
R39		10	RES 10.0 OHM 1/4W 1% 1206 SMD	Digikey	311-0.0GRCT-ND	Yageo	RC1206FR-0710RL
R4, R5		510K	RES 510K OHM 1/4W 5% 1206 SMD	Digikey	311-510KERCT-ND	Yageo	RC1206JR-07510KL
R40, R48, R50		2.4K (1%)	RES SMD 2.4K OHM 1% 1/10W 0603	Digikey	P2.40KHCT-ND	Panasonic	ERJ-3EKF2401V
		10k	RES 10K OHM 1/10W 5% 0603 SMD		311-10KGRCT-ND		RC0603JR-0710KL
R41, R42, R43, R44, R45, R46 R6		100K	RES 100K OHM 1/4W 5% 1206 SMD	Digikey	311-100KERCT-ND	Yageo Yageo	RC1206JR-07100KL
R66		2.4k	RES 2.4K OHM 1/10W 5% 0603 SMD	Digikey	311-2.4KGRCT-ND	Yageo	RC0603JR-072K4L
R67		0	RES SMD 0.0 OHM JUMPER 1/10W	Digikey	P0.0GCT-ND	Panasonic	ERJ-3GEY0R00V
R68, R73		4.3K	RES SMD 4.3K OHM 5% 1/10W 0603	Digikey	P4.3KGCT-ND	Panasonic	ERJ-3GEYJ432V
		100					RC0805FR-07100RL
R7			RES 100 OHM 1/8W 1% 0805 SMD	Digikey Digi kov	311-100CRCT-ND	Yageo	
R72		0ohm 51	RES 0.0 OHM 2512	Digi-key	CR2512-J/-000ELFTR-ND	Bourns	Bourns BC000EIB 07E1BI
R8, R11			RES 51 OHM 1/8W 5% 0805 SMD	Digikey	311-51ARCT-ND	Yageo	RC0805JR-0751RL
R9, R17, R18		1k	RES 1.0K OHM 1/10W 5% 0603 SMD	Digikey	311-1.0KGRCT-ND	Yageo	RC0603JR-071KL
T1		N/A	EE16 transformer(Customized)		Provided by Active	N/A	EE16
U1	1	PAC5253QA	PAC5253	Active-Sen	Provided by Active	Active-Semi	PAC5253QA



7.3 Layout





8 PAC HARDWARE RESOURCES

The following table shows the PAC525X hardware resources used for this EVK and application.

	PA	C5250	PAC5253		
Pin Function	IC pin	Header	IC pin	Header	EVK Function
		Pin		Pin	
XOUT	1				
VCC18	2		1		1.8V supply
PC3	3	P1-12			
PC2	4	P1-4	3	P1-4	
VCC33	5		4		3.3V supply
VSSA	6				Analog Ground
VSS	7		2		Ground
AIO0	8		5		lu, negative terminal
AIO1	9		6		lu, positive terminal
AIO2	10		7		Iv, negative terminal
AIO3	11		8		lv, positive terminal
AIO4	12		9		lw/Imotor, negative terminal
AIO5	13		10		lw/lmotor, positive terminal
AIO6	14		11		Vin
AIO7	15		12		U-phase voltage
AIO8	16		13		V-phase voltage
AIO9	17		14		W-phase voltage
VSYS	18		15		5V supply
REGO	19		16		System regulator output
CSM	20		17		Switching supply current sense input
VP	21		18		DC/DC output
VHM	22		19		Switching supply controller
					supply input
DRM	23		20		Switching supply driver output
VSSP	24				Power ground
DRL0	25		21		U-phase low side gate drive
DRL1	26		22		V-phase low side gate drive
DRL2	27		23		W-phase low side gate drive
OM0	28				
DRL3	29		24		
HS2	30				
OM2	31				
DRL4	32				
DRL5	33				
DXS0	34		25		U-phase ultra-high voltage high-side gate driver source
DXH0	35		26		U-phase ultra-high voltage high-side gate driver
DXB0	36		27		U-phase ultra-high voltage high-side gate driver bootstrap
DXS1	37		28		V-phase ultra-high voltage high-side gate driver source



EP525XHVM EVK User Guide Power Application Controller

DXH1	38		29		V-phase ultra-high voltage high-side gate driver
DXB1	39		30		V-phase ultra-high voltage high-side gate driver bootstrap
DXS2	40		31		W-phase ultra-high voltage high-side gate driver source
DXH2	41		32		W-phase ultra-high voltage high-side gate driver
DXB2	42		33		W-phase ultra-high voltage high-side gate driver bootstrap
PD6	43	J5-2			DAC1 output
PD5	44	J5-3			DAC2 output
PD4	45	J5-4			DAC3 output
PD3	46	P1-11			
PD2	47	P1-10	34	P1-10	
PD1	48	J4-3	35	J4-3	SWD Clock
PD0	49	J4-2	36	J4-2	SWD Data
PE0	50	P1-3	37	P1-3	PE0/SPICLK
PE1	51	P1-3/J2-3	38	P1-3/J2-3	PE1/SPIMOSI/UARTTX
PE2	52	P1-5/J2-2	39	P1-5/J2-2	PE2/SPIMISO/UARTRX
PE3	53	P1-7	40	P1-7	PE3/SPICS0
PE4	54	P1-8	41	P1-8	PE4/SPICS1/I2CSCL
PE5	55	P16	42	P1-6	PE5/SPICS2/I2CSDA
VCCIO	56		43		IO supply (5V)
XIN	57				



ABOUT ACTIVE-SEMI

Active-Semi, Inc. headquartered in Dallas, TX is a leading innovative semiconductor company with proven power management, analog and mixed-signal products for end-applications that require power conversion (AC/DC, DC/DC, DC/AC, PFC, etc.), motor drivers and control and LED drivers and control along with ARM microcontroller for system development.

Active-Semi's latest family of Power Application Controller (PAC)™ ICs offer high-level of integration with 32-bit ARM Cortex M0, along with configurable power management peripherals, configurable analog front-end with high-precision, high-speed data converters, single-ended and differential PGAs, integrated low-voltage and high-voltage gate drives. PAC IC offers unprecedented flexibility and ease in the systems design of various end-applications such as Wireless Power Transmitters, Motor drives, UPS, Solar Inverters and LED lighting, etc. that require a microcontroller, power conversion, analog sensing, highvoltage gate drives, open-drain outputs, analog & digital general purpose IO, as well as support for wired and wireless communication. More information and samples can be obtained from http://www.activesemi.com or by emailing marketing@active-semi.com

Active-Semi shipped its 1 Billionth IC in 2012, and has over 120 in patents awarded and pending approval.

LEGAL INFORMATION & DISCLAIMER

Copyright © 2012-2015 Active-Semi, Inc. All rights reserved. All information provided in this document is subject to legal disclaimers.

Active-Semi reserves the right to modify its products, circuitry or product specifications without notice. Active-Semi products are not intended, designed, warranted or authorized for use as critical components in life-support, life-critical or safety-critical devices, systems, or equipment, nor in applications where failure or malfunction of any Active-Semi product can reasonably be expected to result in personal injury, death or severe property or environmental damage. Active-Semi accepts no liability for inclusion and/or use of its products in such equipment or applications. Active-Semi does not assume any liability arising out of the use of any product, circuit, or any information described in this document. No license, express, implied or otherwise, is granted under any patents, copyrights or other intellectual property rights of Active-Semi or others. Active-Semi assumes no liability for any infringement of the intellectual property rights or other rights of third parties which would result from the use of information contained herein. Customers should evaluate each product to make sure that it is suitable for their applications. Customers are responsible for the design, testing, and operation of their applications and products using Active-Semi products. Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products. All products are sold subject to Active-Semi's terms and conditions of sale supplied at the time of order acknowledgment. Exportation of any Active-Semi product may be subject to export control laws.

Active-Semi™, Active-Semi logo, Solutions for Sustainability™, Power Application Controller™, Micro Application Controller™, Multi-Mode Power Manager™, Configurable Analog Front End™, and Application Specific Power Drivers™ are trademarks of Active-Semi, I. ARM® is a registered trademark and Cortex™ is a trademark of ARM Limited. All referenced brands and trademarks are the property of their respective owners.