

Fairchild Reference Design RD-405

This reference design supports inclusion of three-phase PMSM / BLDC controller, FCM8531QY; Motion Smart Power Module 55 Series, FNB50560; Boundary Mode PFC Controller FAN6961SY; and Green Mode Fairchild Buck Switch FSL306LRN; in design of a PMSM motor drive solution up to 200 W. This document should be used in conjunction with the FCM8531QY, FNB50560, FAN6961SY, and FSL306LRN datasheets as well as Fairchild's application notes and technical support team. Please visit Fairchild's website at: <http://www.fairchildsemi.com>.

Application	Fairchild Device	Input Voltage Range	Maximum Motor Power	Rating Voltage of Motor	Topology
PSMS Motor Drive System	FCM8531QY FNB50560 FAN6961SY FSL306LRN	90-265 V _{AC}	200 W	400 V _{DC}	3 Phase Bridge Inverter, CRM Boost PFC, HV Buck.

Key Features

- Total Solution for PMSM Motor Drive
- High Power Factor (PF) Low Total Harmonic Discharge (THD)
- Wide V_{IN} Range: 90-265 V_{AC}
- PFC In/Off Selectable
- Each Functional Block Can Be Evaluated Independently
- Demonstration Program Pre-Programmed
- Rich Protection on Each Circuit Block
- Rotor Position Detecting interface for both Comparator Mode and Operational Amplifier Mode reserved.

1. PFC Stage

For the PFC below 200 W, Boundary Conduction Mode boost topology will be the best choice for the high efficiency, few peripheral components and low cost. In this reference design, we choose FAN6961SY as the PFC controller. Please refer to the [FAN6961 Product Folder](#) to get more information about the device.

1.1. Photographs

Figure 1 shows the PFC stage on the evaluation board and includes the AC socket and EMI filters.

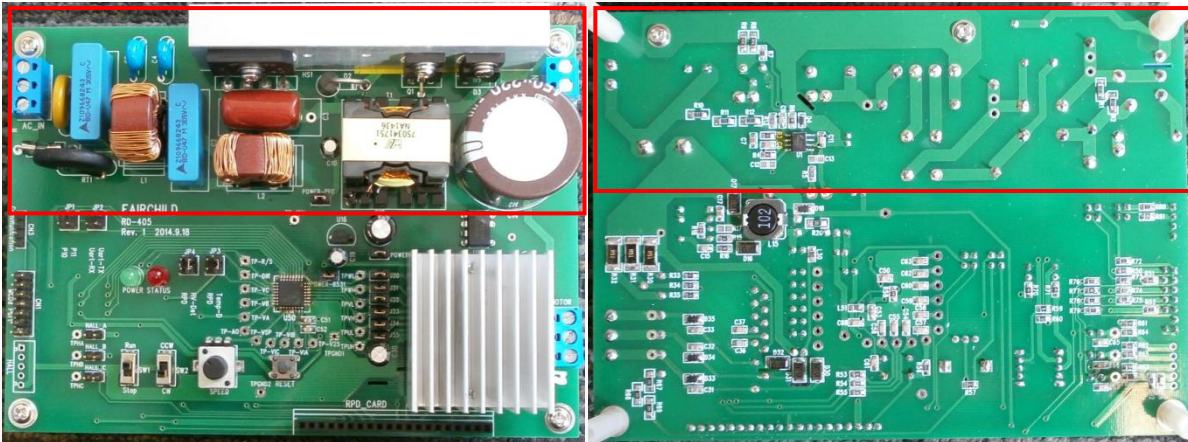


Figure 1. PFC Stage is Red Block

1.2. Schematic

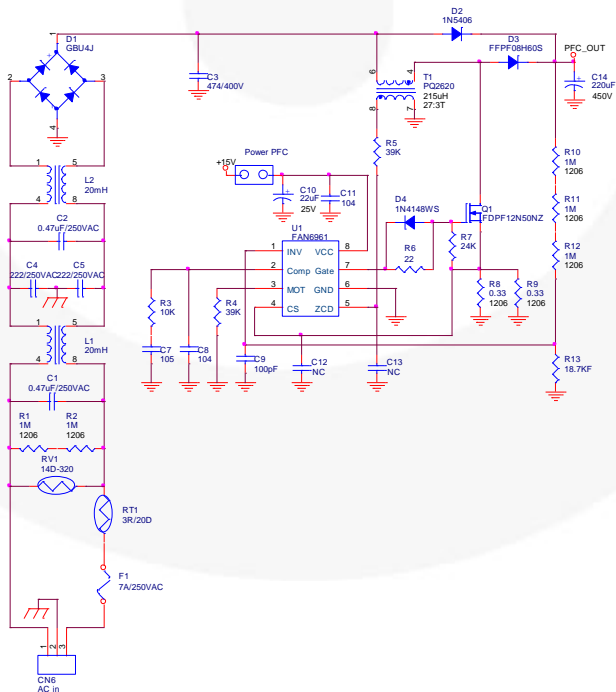


Figure 2. Schematic of PFC Stage

1.3. Mechanical

Figure 3 shows the mechanical dimensions of heat sink which mounting the bridge rectifier, PFC MOSFET and the PFC diode. All dimensions are in mm.

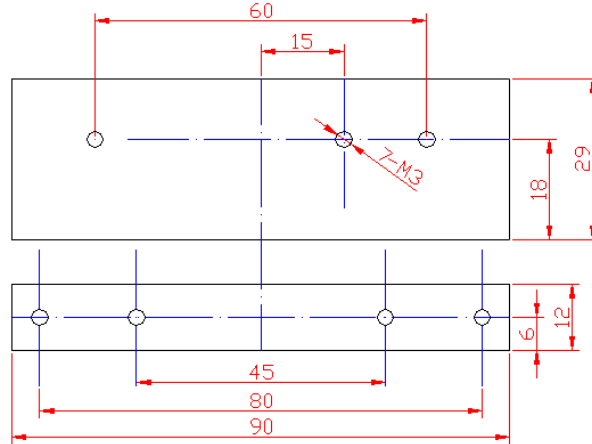


Figure 3. Mechanical Dimension of PFC Heat Sink

1.4. Magnetic Component

CUSTOMER TERMINAL	RoHS	LEAD(Pb)-FREE	
Sn98%, Ag4%	Yes	Yes	

PART MUST INSERT FULLY TO SURFACE A IN RECOMMENDED GRID #.031(7)

TERM. NO.'s FOR REF. ONLY

LOT CODE & DATE CODE

RECOMMENDED P.C. PATTERN, COMPONENT SIZE

Midcom **WÜRTH ELEKTRONIK**

ELECTRICAL SPECIFICATIONS @ 25°C unless otherwise noted:

PARAMETER	TEST CONDITIONS	VALUE
D.C. RESISTANCE	7-12 tie(7+8, 11+12), @20°C	0.041 ohms ±20%
D.C. RESISTANCE	2-1 @20°C	0.493 ohms ±10%
INDUCTANCE	tie(7+8, 11+12), 10kHz, 1.0VAC, Is	210uH max.
SATURATION CURRENT	7-12 20% rollOff from initial	3.0A
LEAKAGE INDUCTANCE	tie(7+8, 11+12 2+1), 100kHz, 100mVAC, Is	50nH max.
DIELECTRIC	tie(7+8), 1250VAC, 1 second	1000VAC, 1 minute
DIELECTRIC	tie(2+7+8), 1250VAC, 1 second	1000VAC, 1 minute
TURNS RATIO	(7-12):(2-1), tie(7+8, 11+12)	9:1, ±2%

GENERAL SPECIFICATIONS:
OPERATING TEMPRATURE RANGE: -40°C to +125°C including temp rise.

Wire insulation & RoHS status not affected by wire color.
Wire insulation color may vary depending on availability.

REV.	DATE	Packaging Specifications Method: Tray PKG-0807 www.we-online.com/midcom		Tolerances unless otherwise specified: Angles: 21° Fractions: 1/64 Decimals: 0.005 [13] Pospoints: 0.001 [03]	DRAWING TITLE INDUCTOR elSos p/n: 750341751	PART NO. 750341751 SPECIFICATION SHEET 1 OF 1
6A	4/13	SEE REVISION SHEET FOR REVISION LEVEL	REVISION LEVEL	This drawing is dual dimensioned. Dimensions in brackets are in millimeters.		

Figure 4. PFC Inductor Specification

1.5. Performance

V_{OUT} of PFC

V_{IN}	V_{OUT} (V) (No load)	V_{LLUT} (V) (Full Load)	Variance Ratio (%)
90 V	398.55	398.32 (0.3 A)	0.05
110 V	398.37	398.36 (0.3 A)	
220 V	398.36	398.16 (0.5 A)	
265 V	398.39	398.15 (0.5 A)	

Efficiency of PFC

V_{IN} (VAC)	90 V_{AC}	110 V_{AC}	220 V_{AC}	265 V_{AC}
25% Load	94.58%	94.58%	96.28%	97.02%
50% Load	94.05%	95.78%	97.25%	97.37%
75% Load	91.40%	94.89%	97.36%	97.93%
100% Load		92.53%	97.46%	97.94%

PF and THD

V_{IN} (VAC)	90 V_{AC}		110 V_{AC}		220 V_{AC}		265 V_{AC}	
	PF	THD	PF	THD	PF	THD	PF	THD
Load (%)								
10	0.972	16.64%	0.964	10.58%	0.534	51.89%	0.389	58.08
20	0.985	13.09%	0.978	15.68%	0.825	33.52%	0.588	57.63
30	0.995	8.0%	0.990	9.26%	0.924	19.41%	0.749	44.51
40	0.989	13.37%	0.983	9.61%	0.952	14.35%	0.910	21.81
50	0.993	10.58%	0.986	13.52%	0.968	9.34%	0.937	16.64
60	0.993	10.36%	0.987	13.94%	0.978	7.26%	0.954	12.59
70	0.993	10.70%	0.988	13.03%	0.982	7.17%	0.967	8.33
80	0.974	21.92%	0.991	12.17%	0.983	8.51%	0.973	6.53
90			0.991	12.63%	0.981	11.2%	0.977	6.37
100			0.977	20.65%	0.982	13.63%	0.979	7.90

2. PSMS Motor Control and 3 Phase Bridge Driving Stage

2.1. Photographs

Figure 5 shows the motor control and driving stages on the evaluation board.

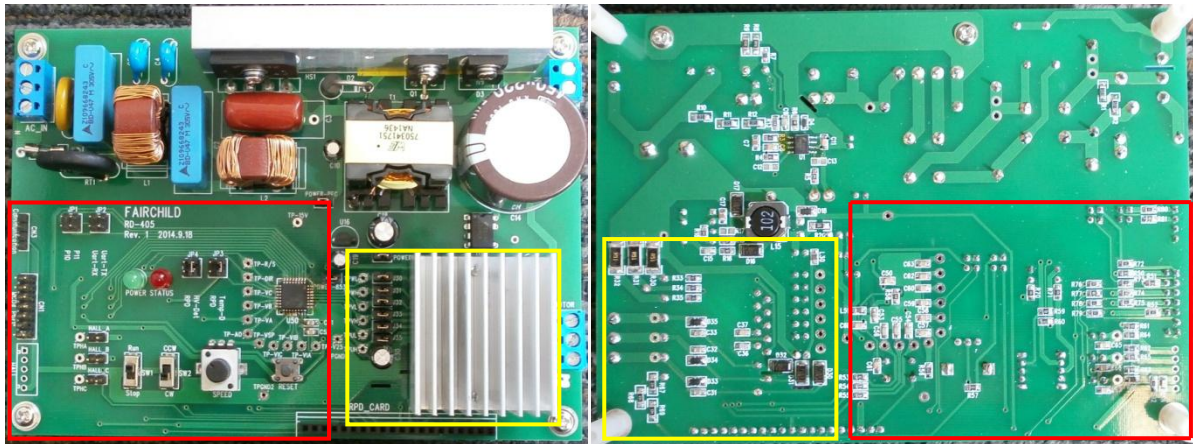


Figure 5. Motor Control in Red Block, Motor Drive in Yellow Block

2.2. Schematic

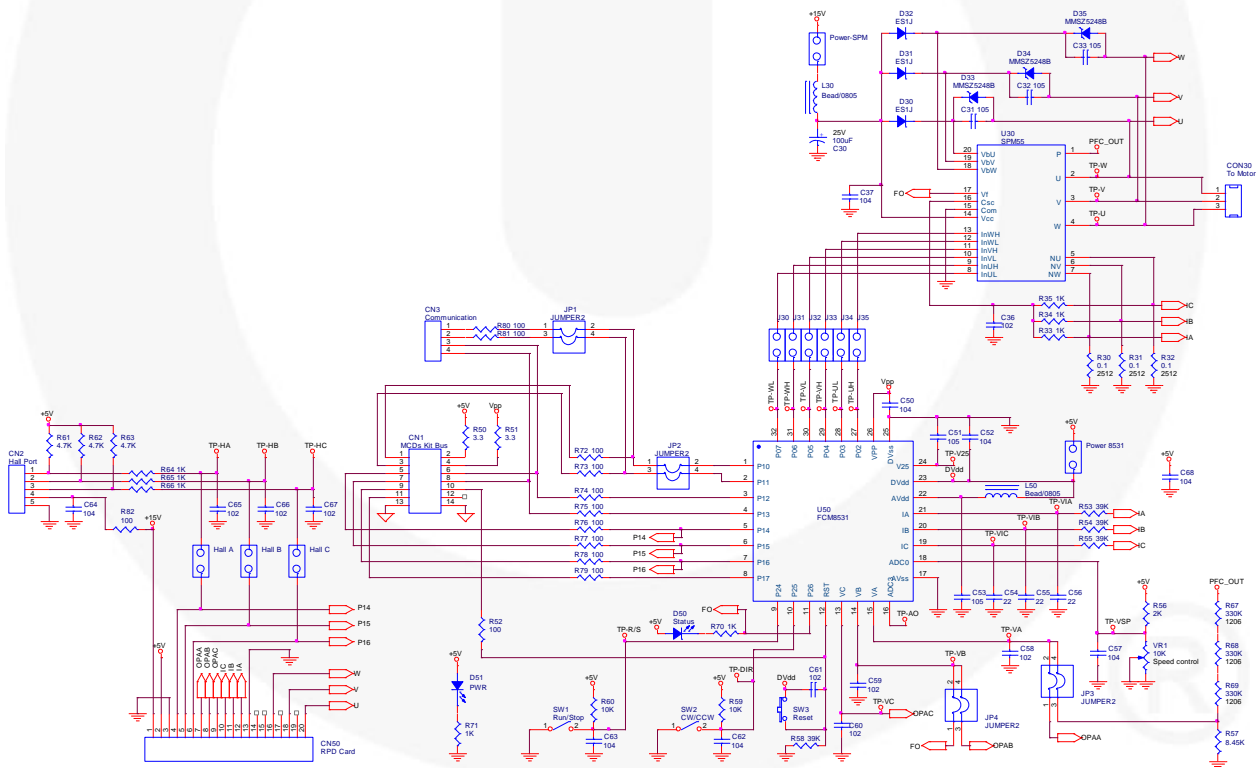


Figure 6. Motor Control and Driving Stages Schematic

2.3. Mechanical

Figure 7 shows the mechanical dimensions of heat sink which mounting the U30. All dimensions are in mm.

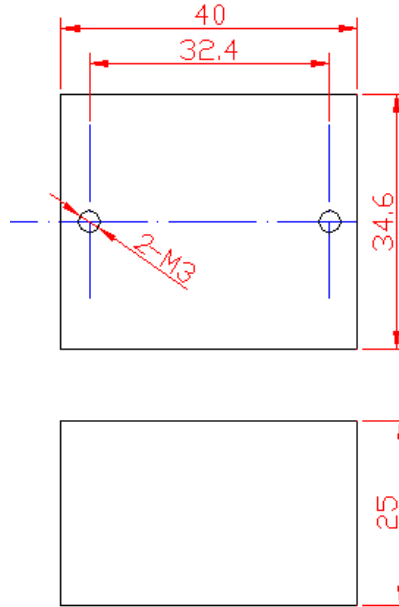


Figure 7. Mechanical Dimension of SPM55 Heat Sink

3. Auxiliary Power

3.1. Photographs

Figure 8 shows the auxiliary power on the evaluation board.

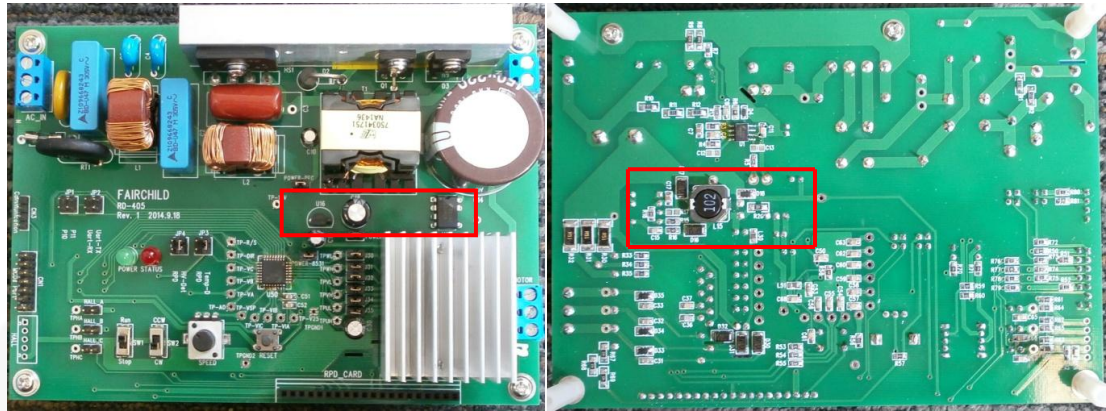


Figure 8. Auxiliary Power in Red Block

3.2. Schematic

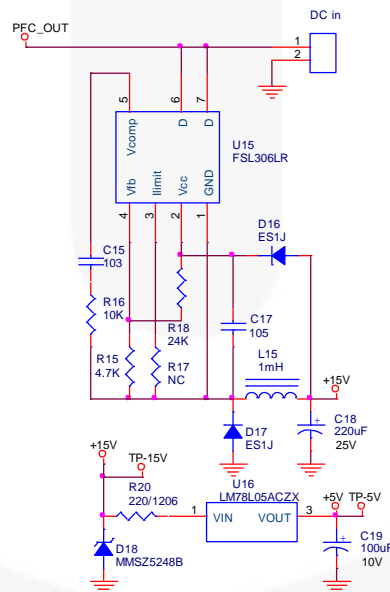


Figure 9. Schematic of auxiliary power

3.3. Performance

V_{OUT} of Auxiliary Power

Output	PFC State	No Load	Full Load	Variance Ratio (%)
15 V	Off	15.16	14.77	1.6
	On	15.06	14.68	
5 V	Off	5.007	5.002	0.13
	On	5.015	5.013	

4. PCB Layout

Figure 10 and Figure 11 shows the PCB layout of Top and Bottom Side. Please be note the PCB is version 2 which move the HALL connector to the bottom from the version 1 on the previous pictures.

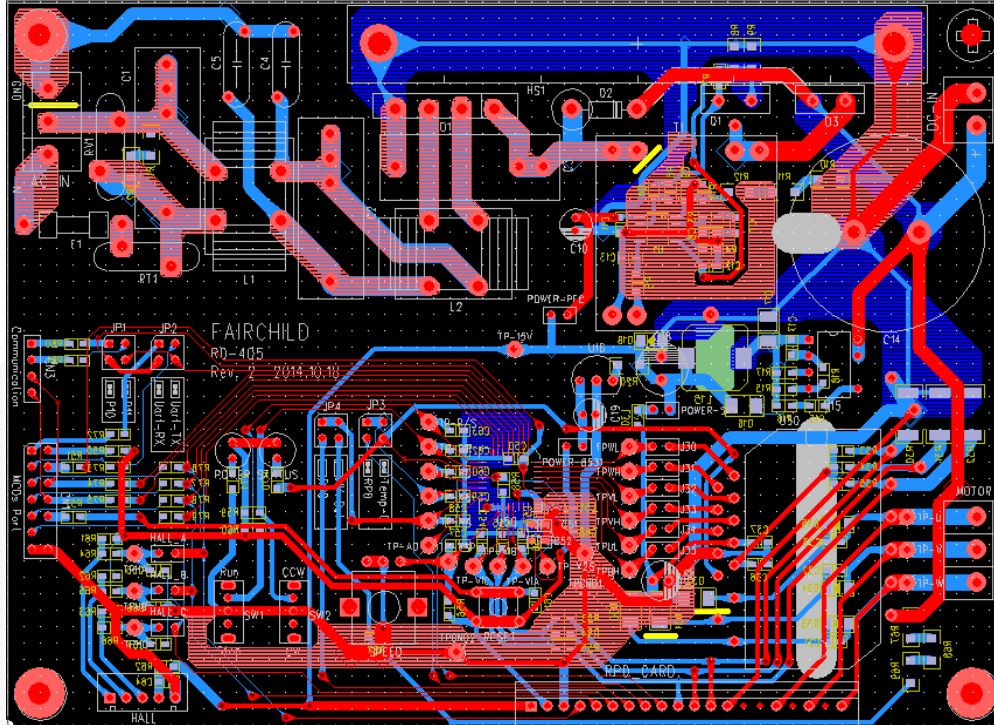


Figure 10. Top Side

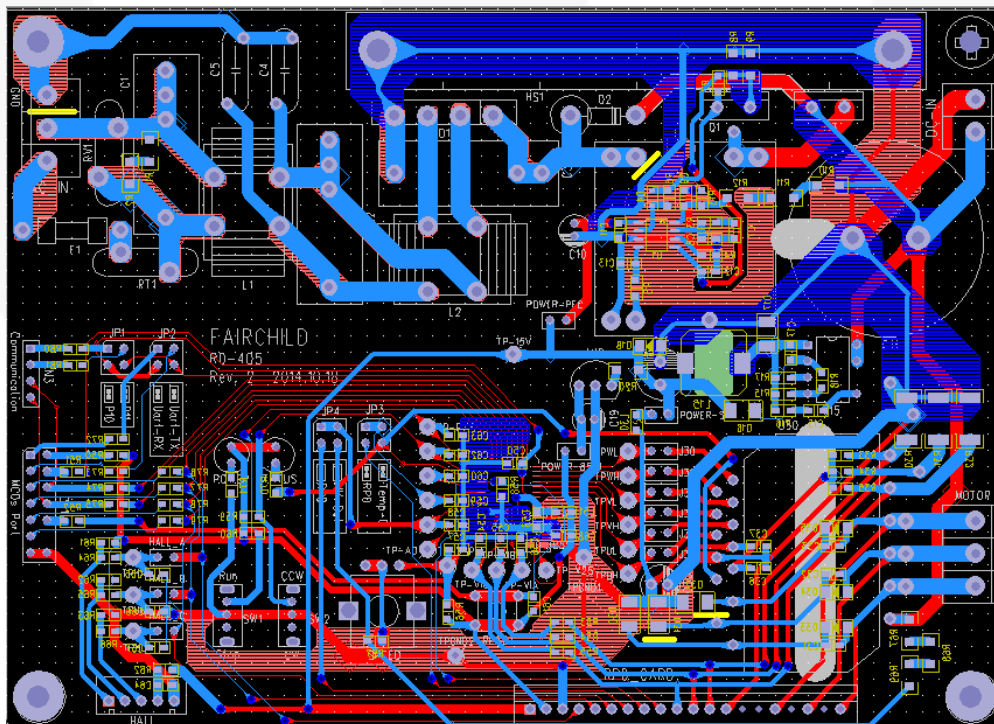


Figure 11. Bottom Side

5. Bill of Materials

(Shaded by component type)

Part Number	Description	Qty.	Designator	Manufacturer
IC 0.5 A 650 V Buck FSL306LRN	DIP-7	1	U15	Fairchild
IC CRM PFC Controller FAN6961SY	SO-8	1	U1	Fairchild
IC 600V 5 A SPM FNB50560T1	SPM55-20L	1	U30	Fairchild
IC BLDC Controller FCM8531QY	LQFP-32	1	U50	Fairchild
IC 5 V 0.1 A LDO LM78L05ACZX	TO-92	1	U16	Fairchild
MOSFET FDPF12N50NZ	TO220F	1	Q1	Fairchild
Bridge Diode GBU4J 4 A 600 V	GBU-4L	1	D1	Fairchild
Diode 1N5406 3 A 600 V	DO201AD	1	D2	Fairchild
Diode FFPF08H60S 3 A 600 V	TO220F-2L	1	D3	Fairchild
Diode ES1J 1 A 600 V 35 ns	SMA	5	D16, D17, D30, D31, D32	Fairchild
Diode 1N4148WS 0.3 A 70 V	SOD-323	1	D4	Fairchild
Zener Diode MMSZ5248B 18 V 0.5 W	SOD123	4	D18, D33, D34, D35	Fairchild
LED Green 151051VS04000	5 mm THT	1	Power	WURTH
LED Red 151051RS11000	5 mm THT	1	Status	WURTH
SMD resistor 0805 3.3 Ω \pm 5%	REEL	2	R50, R51	Any
SMD resistor 0805 22 Ω \pm 5%	REEL	1	R6	Any
SMD resistor 0805 100 Ω \pm 5%	REEL	12	R52, R72-R82	Any
SMD resistor 0805 1 K Ω \pm 5%	REEL	8	R33-R35, R64-R66, R70, R71	Any
SMD resistor 0805 2 K Ω \pm 5%	REEL	1	R56	Any
SMD resistor 0805 4.7 K Ω \pm 5%	REEL	4	R15, R61-R63	Any
SMD resistor 0805 8.45 K Ω \pm 1%	REEL	1	R57	Any
SMD resistor 0805 10 K Ω \pm 5%	REEL	4	R3, R16, R59, R60	Any
SMD resistor 0805 18.7 K Ω \pm 1%	REEL	1	R13	Any
SMD resistor 0805 24 K Ω \pm 5%	REEL	2	R7, R18	Any
SMD resistor 0805 39 K Ω \pm 5%	REEL	6	R4, R5, R53-R55, R58	Any
SMD resistor 1206 0.33 Ω \pm 5%	REEL	2	R8, R9	Any
SMD resistor 1206 220 Ω \pm 5%	REEL	1	R20	Any
SMD resistor 1206 330 K Ω \pm 5%	REEL	3	R67-R69	Any
SMD resistor 1206 1 MK Ω \pm 5%	REEL	5	R1, R2, R10-R12	Any
SMD Resistor 2512 0.1 Ω \pm 5%	REEL	3	R67-R69	Any
NTC 3 Ω	D=20	1	RT1	Any
VRC 320 V 820443211E	D=14	1	RV1	WURTH
MLCC 0805 NP0 50 V 22 pF-M	REEL	3	C54-C56	Any
MLCC 0805 NP0 50 V 100 pF-M	REEL	1	C9	Any
MLCC 0805 X7R 50 V 1 nF-M	REEL	8	C58-C61, C65-C67, C36	Any
MLCC 0805 X7R 50 V 10 nF-M	REEL	1	C15	Any
MLCC 0805 Y5V 25 V 100 nF-M	REEL	10	C8, C11, C37, C50, C52, C57, C62-C64, C68	Any
MLCC 0805 Y5V 25 V 1 μ F-M	REEL	7	C7, C17, C31-C33, C51, C53	Any

Part Number	Description	Qty.	Designator	Manufacturer
E-Capacitor 22 μ F 35 V 5 x 11 mm	Radial	1	C10	Any
E-Capacitor 100 μ F 10 V 5 x 11 mm	Radial	1	C19	Any
E-Capacitor 100 μ F 25 V 6 x 12 mm	Radial	1	C30	Any
E-Capacitor 220 μ F 35 V D=8 mm	Radial	1	C18	Any
E-Cap 220 μ F 450 V 30 x 30 mm	Snap in	1	C14	Any
Film-Cap 470 nF 400 V		1	C3	Any
X-Cap 470 nF 300 V _{AC} B32923C3474M		2	C1, C2	EPCOS
Y-Cap 2.2 nF 300 V _{AC}		2	C4, C5	Any
Common Choke 744823220	20 mH 1.5 A	2	L1, L2	WURTH
SMD Power Inductor 7447714102	1 mH 0.43 A	1	L15	WURTH
SMD Chip Inductor 7447905	0805 1 μ H	2	L30, L50	WURTH
PFC Inductor 210 μ H 750341751	PQ2625	1	T1	WURTH
Connector 14Pins 61301421121	2.54 mm 2 row	1	MCDs Port	WURTH
Connector 4Pins 61300421121	2.54 mm 2 row	4	JP1, JP2, JP3, JP4	WURTH
Connector 4Pins 61300411121	2.54 mm 1 row	1	CN3	WURTH
Connector 2Pins 61300211121	2.54 mm 1 row	12	J30-J35, Power PFC, Power SPM, Power 8531, HALL A, HALL B, HALL C	WURTH
Jumper with test point 60900213421	2.54 mm	12	Same as above	WURTH
Connector 2Pins Screw type 691101710002	5 mm	1	DC_IN	WURTH
Connector 3Pins Screw type 691101710003	5 mm	2	AC_IN, Motor	WURTH
Socket Header 20Pins 61302011821	2.54 mm 1 row	1	RPD_CARD	WURTH
Switch 1 Connector 2 Position	8.6 x 4.4 mm	2	SW1, SW2	Any
Tact Switch 430186070716	6x 6 mm THT	1	Reset	WURTH
Potentiometer 10 K Ω 10X11 mm	Vertical	1	Speed	Any

Related Resources

[FCM8531 – MCU Embedded and Configurable 3-Phase PMSM / BLDC Motor Controller](#)

[FNB50560T1 – Motion SPM® 55 Series](#)

[FAN6961 - Boundary Mode PFC Controller](#)

[FSL306LRN - Green Mode Fairchild Buck Switch](#)

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