

How to use the 2 kW two-channel interleaved PFC based on the STNRGPF02 digital controller

Introduction

The STEVAL-IPFC02V1 2 kW interleaved PFC kit is based on the [STNRGPF02](#) digital controller and consists of a power board, control board and adapter board. The digital configurable ASIC can drive up to two channels in an interleaved PFC for industrial applications.

The STNRGPF02 embedded on the control board implements mixed signal (analog/digital) average current mode control in CCM at fixed frequency. The analog section ensures cycle-by-cycle current regulation, while digital control manages the non-time-critical operations. You can use the [eDesignSuite](#) software available on the ST website to configure the digital controller according to specific application requirements.

Figure 1. STEVAL-IPFC02V1 evaluation kit with power, control and adapter boards



1 Safety instructions

Danger:

The evaluation board uses voltage levels that can cause serious injury and even death.

Do not touch any components immediately after disconnecting the input power supply as the charged capacitors need time to discharge.

Due to the high power density, board components and heat sinks can become very hot and cause severe burns when touched.

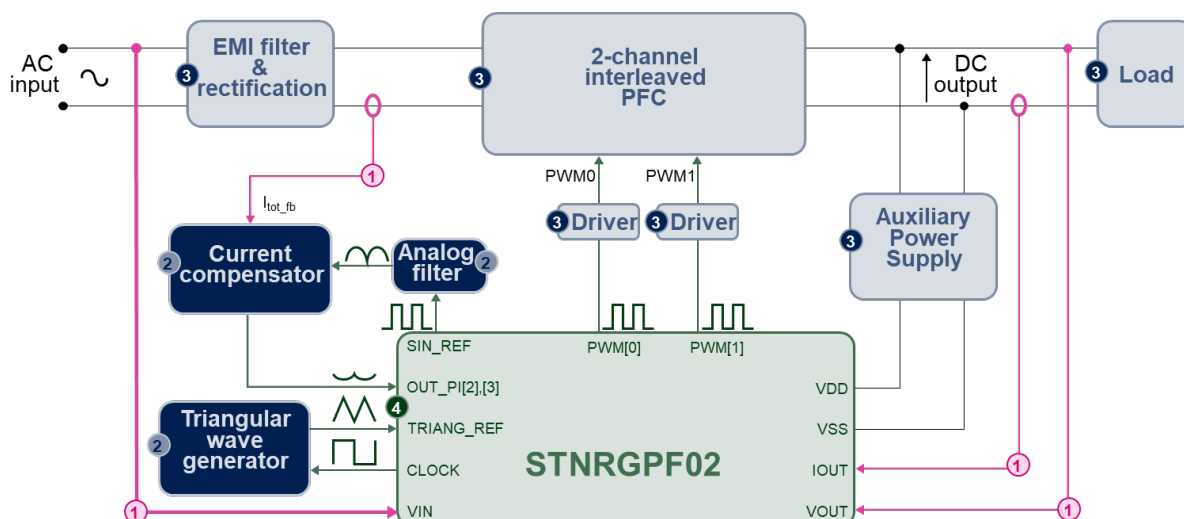
This board is intended for use by skilled technical personnel who are suitably qualified and familiar with the installation, use and maintenance of power electronic systems. The same personnel must be aware of and must apply national accident prevention rules.

The electrical installation shall be completed in accordance with the appropriate requirements (e.g., cross-sectional areas of conductors, fusing, and GND connections).

2 STEVAL-IPFC02V1 evaluation kit overview

Figure 2. STEVAL-IPFC02V1 block diagram

1. I/O measurement signals
2. Analog circuitry
3. Power stages
4. Digital control section



The STEVAL-IPFC02V1 implements mixed signal (analog/digital) control, combining the flexibility of a programmable high end digital solution with the responsiveness and accuracy of analog componentry. The inner current loop consists of an analog proportional-integral (PI) compensator that ensures the highest possible bandwidth and cycle-by-cycle regulation. The outer voltage loop is performed by a digital PI controller with fast dynamic response.

2.1 Board features

The 2 kW interleaved PFC evaluation kit features:

- A modular design with the following separate boards:
 - STEVAL-IPFC02P1 power board
 - STEVAL-IPFC02C1 control board
 - STEVAL-IPFC01A1 adapter board
- 2-channel interleaved PFC
- Input voltage range: 90 to 265 V_{AC} (50 or 60 Hz)
- Maximum output power: 2 kW at 230 V_{AC}; 1 kW at 115 V_{AC};
- Output voltage: 400 V
- Fixed frequency average current mode control and CCM operation
- Mixed-signal, semi-digital approach
- Programmable phase shedding
- Cooling System management
- Programmable fast overcurrent and thermal protection
- Digital inrush current limiter function performed with relay
- Soft startup and burst mode management
- Load current and input voltage feed forward
- Channel current balance function

- Two status LEDs to signal nominal and fault conditions
- Browser GUI tool ([eDesignSuite](#)) for driver customization
- Serial communication port for
 - [STNRGPF02](#) programming
 - PFC parameter monitoring

3 How to use the STEVAL-IPFC02V1 evaluation board

To perform functional and efficiency testing, you need the following equipment:

- Programmable AC source with power > 2 kW
- DC electronic load or load resistor > 2 kW
- Power analyzer
- Digital oscilloscope

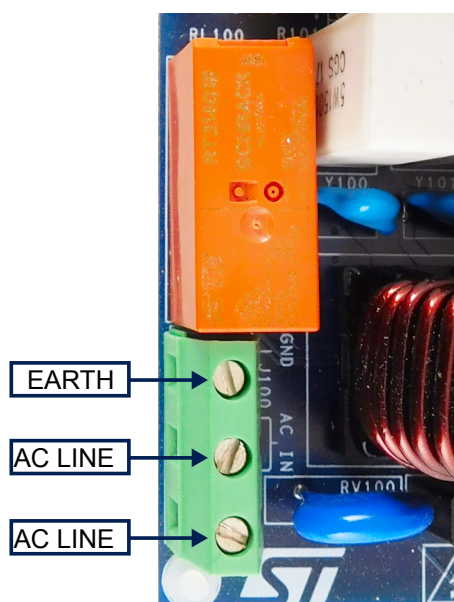
The STEVAL-IPFC02V1 board can be tested up to 2 kW at 230 V_{RMS} and 1 kW at 115 V_{RMS}, in a frequency range between 47 and 63 Hz.

Note: Any load or passive oscilloscope probe must be isolated from the input source of the PFC.

3.1 How to connect and start the STEVAL-IPFC02P1 power board

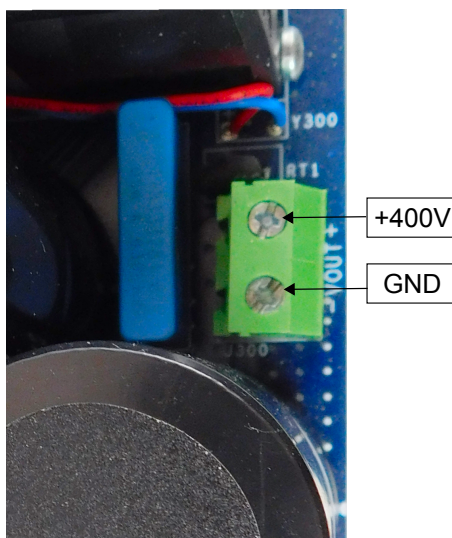
Step 1. Insert the STEVAL-IPFC02C1 control board in connector J100 on the STEVAL-IPFC02P1 power board.

Figure 3. STEVAL-IPFC02P1 AC supply connection



- Step 2.** Connect the load wires to the output terminals on J300 of the STEVAL-IPFC02P1 power board. The actual load (electronic dc load, load resistors, inverter, etc.) must remain disconnected until the soft startup sequence has completed. The correct polarity is indicated on the board.

Figure 4. STEVAL-IPFC02P1 DC output connection



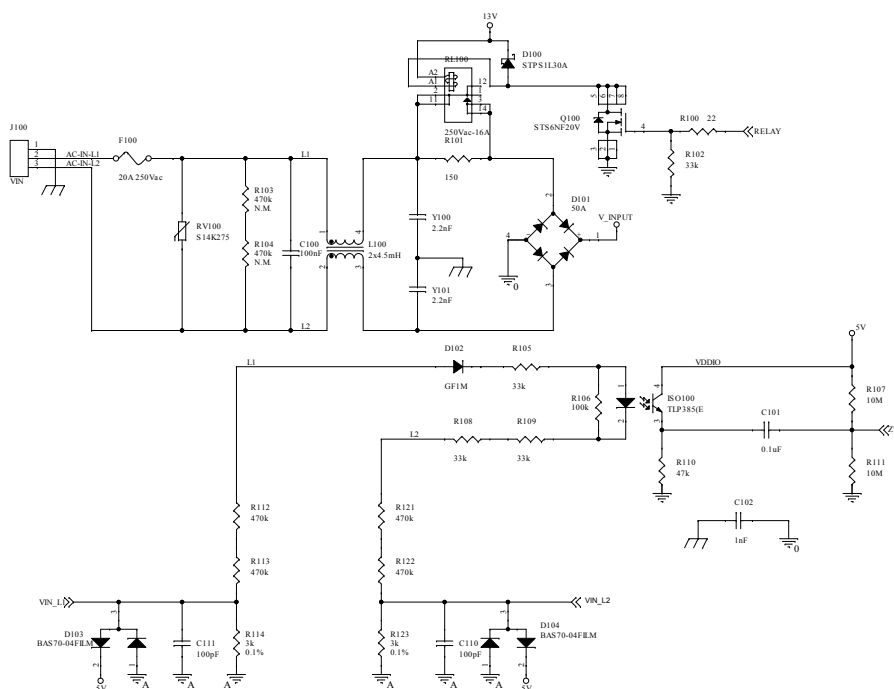
- Step 3.** Supply the following input voltage while no load is connected on the output:
- 90 – 265 V_{AC} (50 or 60 Hz)
- Step 4.** Apply the load.
- max: 2 kW at 230 V_{AC}, 1 kW at 115 V_{AC}

3.1.1 STEVAL-IPFC02P1 power board startup sequence

1. The appropriate AC input voltage is applied under a no load condition.
2. When the input voltage rises above 60 V, the auxiliary power supply starts and generates the auxiliary voltages (13 V_{DC} and 5 V_{DC}) for the drivers and the signal conditioning circuitry.

3. Once the auxiliary voltages are nominal, the inrush current limiter phase begins by charging the output capacitor until the DC voltage reaches the peak input voltage. The current is limited by resistor R101 until it is shorted by the relay RL100 at the end of inrush phase.

Figure 5. STEVAL-IPFC02P1 input section



4. After the inrush limiter phase, the soft startup procedure is activated and the output voltage rises up to 436 VDC, at which point the PFC enters burst mode to regulate the output voltage between 416 and 436 VDC.
5. The green LED D2 on the control board indicates when the sequence has finished and the PFC is ready for the load to be connected.
6. Once you connect the load:
 - the output voltage is regulated to 400 V $\pm$ 2 V.
 - for 185 – 265 V_{AC}, the maximum output power is 2000 W
 - for 90 – 140 V_{AC}, the maximum output power is 1000 W

4 PFC controller customization with eDesignSuite

The eDesignSuite software tool developed by STMicroelectronics helps you configure ST products for power conversion applications. You can use it to customize the PFC controller for a specific application by entering the main specifications for your application and generating an automatic design, or by following a guided process for more specific designs.

Figure 6. PFC specifications

Design Wizard

Design Steps

- IPFC Specifications
- Input Stage
- Boost Inductor
- Power Switch
- Boost Diode
- Output Stage
- Input Voltage Sensing
- Input Current Sensing
- Switch Current Sensing
- Input Over Current Protection
- Output Voltage Sensing
- Output Current Sensing
- Triangular Waveform Generator
- Current Control Loop
- Voltage Control Loop
- Additional Features

IPFC Specifications

Mains EU Range Line -> Neutral

min max
voltage range 185 Vac 265 Vac
min max
frequency range 47 Hz 53 Hz
1st 2nd
Nominal Voltages 230 Vac Vac

Output

Nominal Output Voltage 400 V
Maximum Power or Current 2000 W 5 A
Output Voltage Ripple 20 Vpp 5 %
Hold-up time 20 ms
Minimum voltage after line drop 300 V
Maximum Voltage 448 V

Other Parameters

Number of interleaved Channels 2
Switching Frequency or Period 60 kHz 16.67 µs
Inductor Current Ripple Percentage 55 %
Expected Power Factor 0.99
Expected Average Efficiency 97 %

Prev Next Auto Complete Cancel

5 Status LEDs and fault conditions

The STEVAL-IPFC02C1 control board has the following status LEDs:

- a green LED connected to STNRGPF02 pin 15 (PFC_OK)
- a red LED connected to STNRGPF02 pin 14 (PFC_FAULT)

5.1 Normal operation

During normal operation, the green LED (D2) on the STEVAL-IPFC02C1 control board remains lit to indicate that the PFC is operating under allowable conditions.

5.2 Fault conditions

When a fault is detected, the red LED (D1) on the STEVAL-IPFC02C1 control board lights up and the green LED (D2) turns off. The device stops all switching activities and turns off the fan.

After a fault condition, the board must be reset by switching off the AC input voltage and discharging the output capacitors.

Note:

Warning: Do not short the output terminals to discharge the capacitors as the high discharge current may damage the output current sensing circuitry.

The following conditions will trigger a fault protection:

- Highly distorted input voltage waveforms that inhibit frequency measurement. For example, if the mains frequency out of the accepted range (e.g., 47-63 Hz).
- Overcurrent condition on at least one PFC channel. This protection prevents PFC inductor saturation.
- Overvoltage protection on output voltage if the output voltage exceeds 450 V_{DC}
- Overvoltage protection on input voltage:
 - for 115 V_{AC} nominal supply: above 140 V
 - for 230 V_{AC} nominal supply: above 265 V
- Over-temperature protection when the ambient temperature of the board exceeds the threshold setting.

5.3 Wait conditions

In addition to the conditions that trigger PFC_OK and PFC_FAULT, there are other conditions that are indicated with both LEDs are off:

- Undervoltage condition on the output when the DC bus voltage falls below 340 V.
- Undervoltage condition on input when the input rms voltage falls below 90 V_{AC} for 115 V_{AC} nominal (or 185 V_{AC} for 230 V_{AC} nominal).
- Input voltage dropout when the input voltage signal disappears for more than 25 ms.

Under these conditions, the STNRGPF02 will drive both LEDs on the control board off and will wait until the conditions have cleared before repeating the startup sequence.

6 STEVAL-IPFC02V1 schematic diagrams

Figure 7. STEVAL-IPFC02P1 schematic - input section

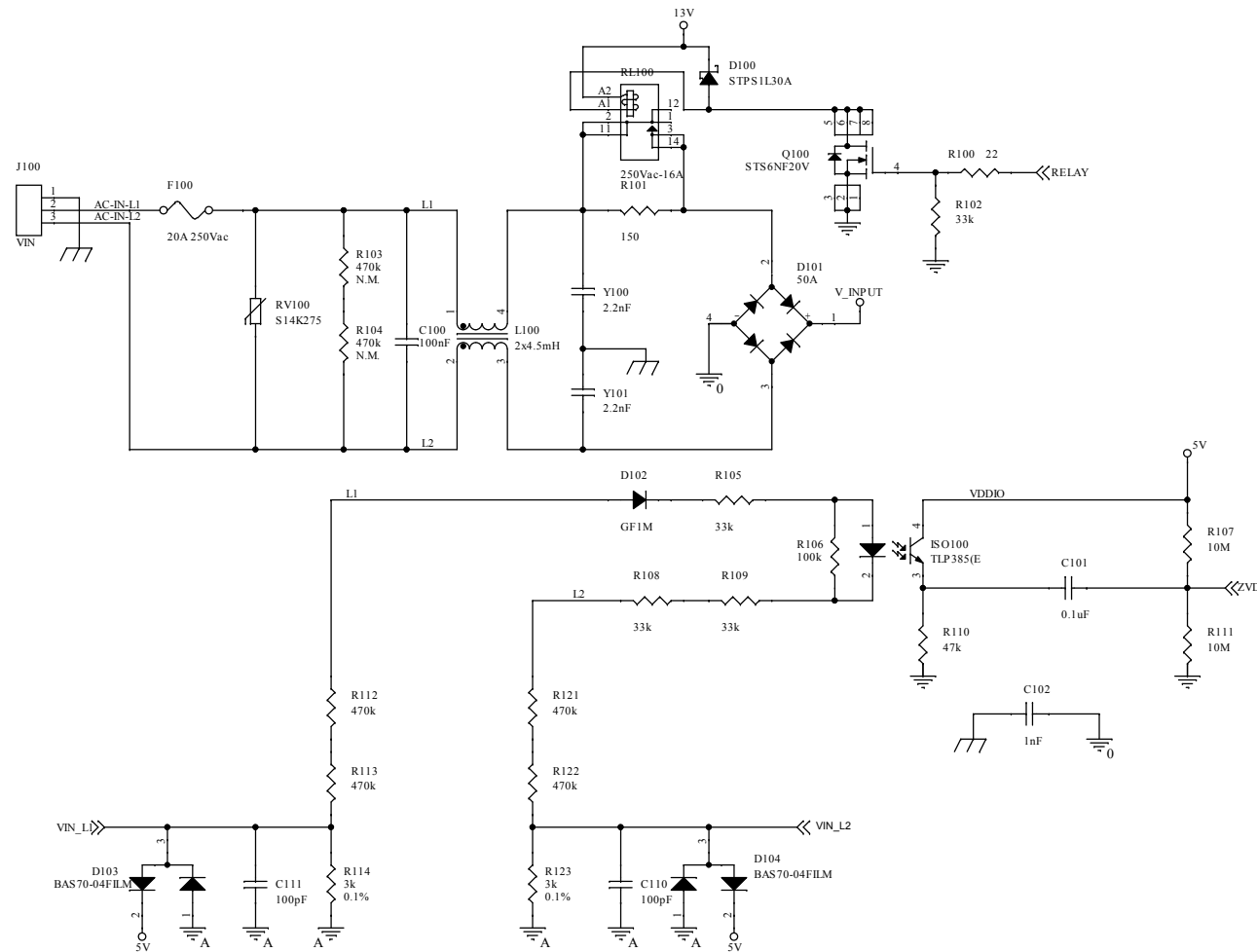
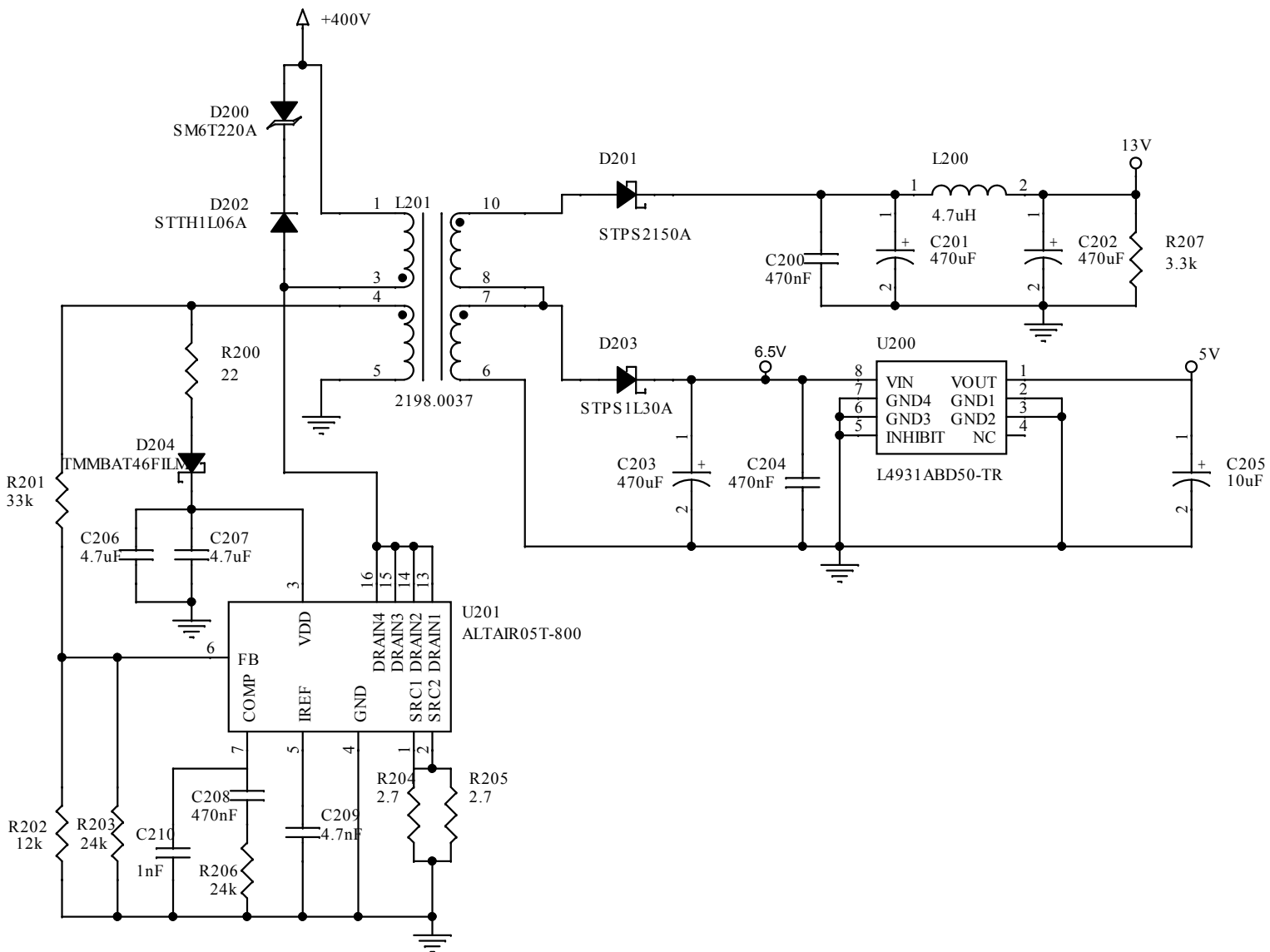


Figure 8. STEVAL-IPFC02P1 schematic - auxiliary power supply



Schematic diagrams

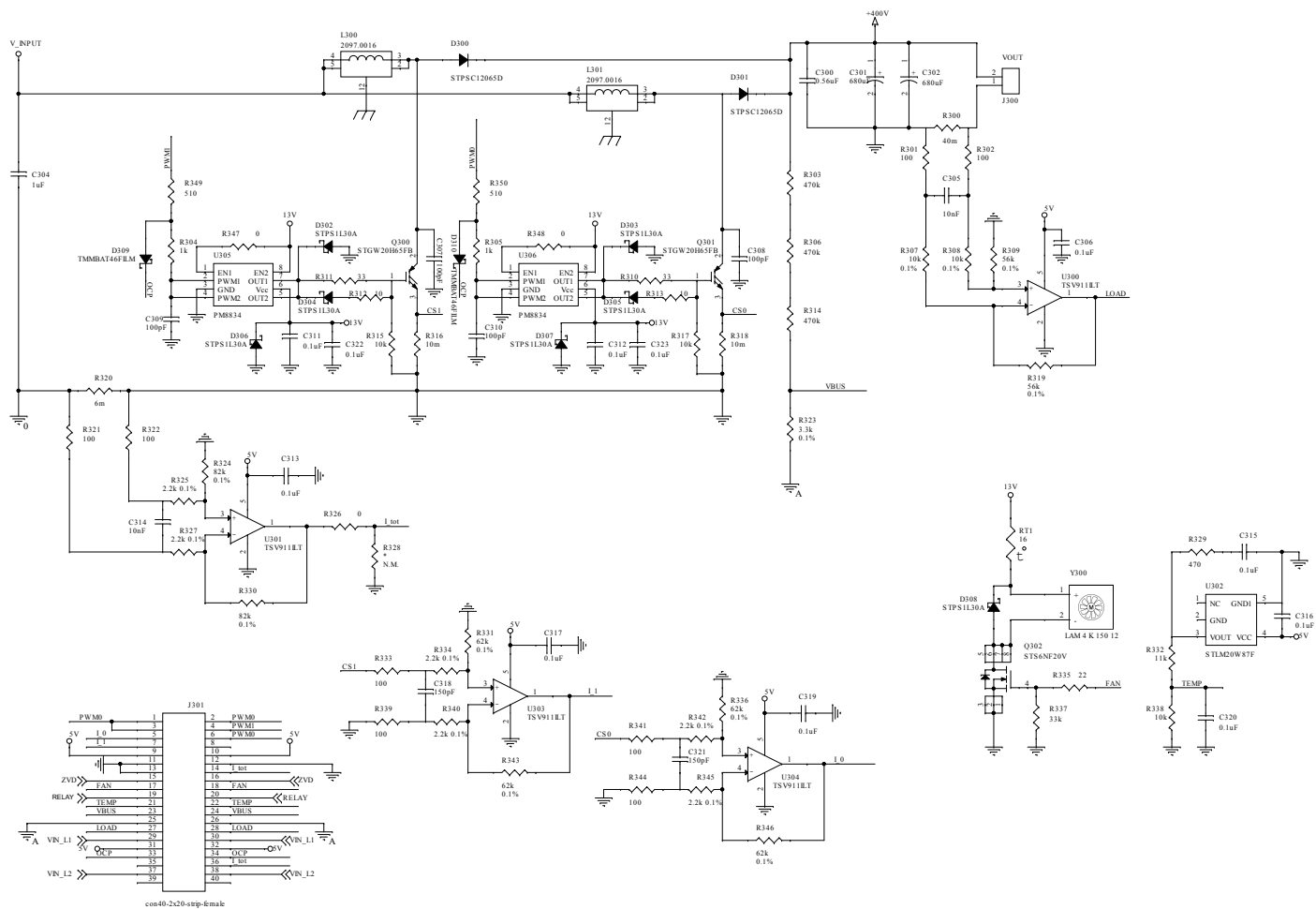


Figure 10. STEVAL-IPFC02C1 schematic

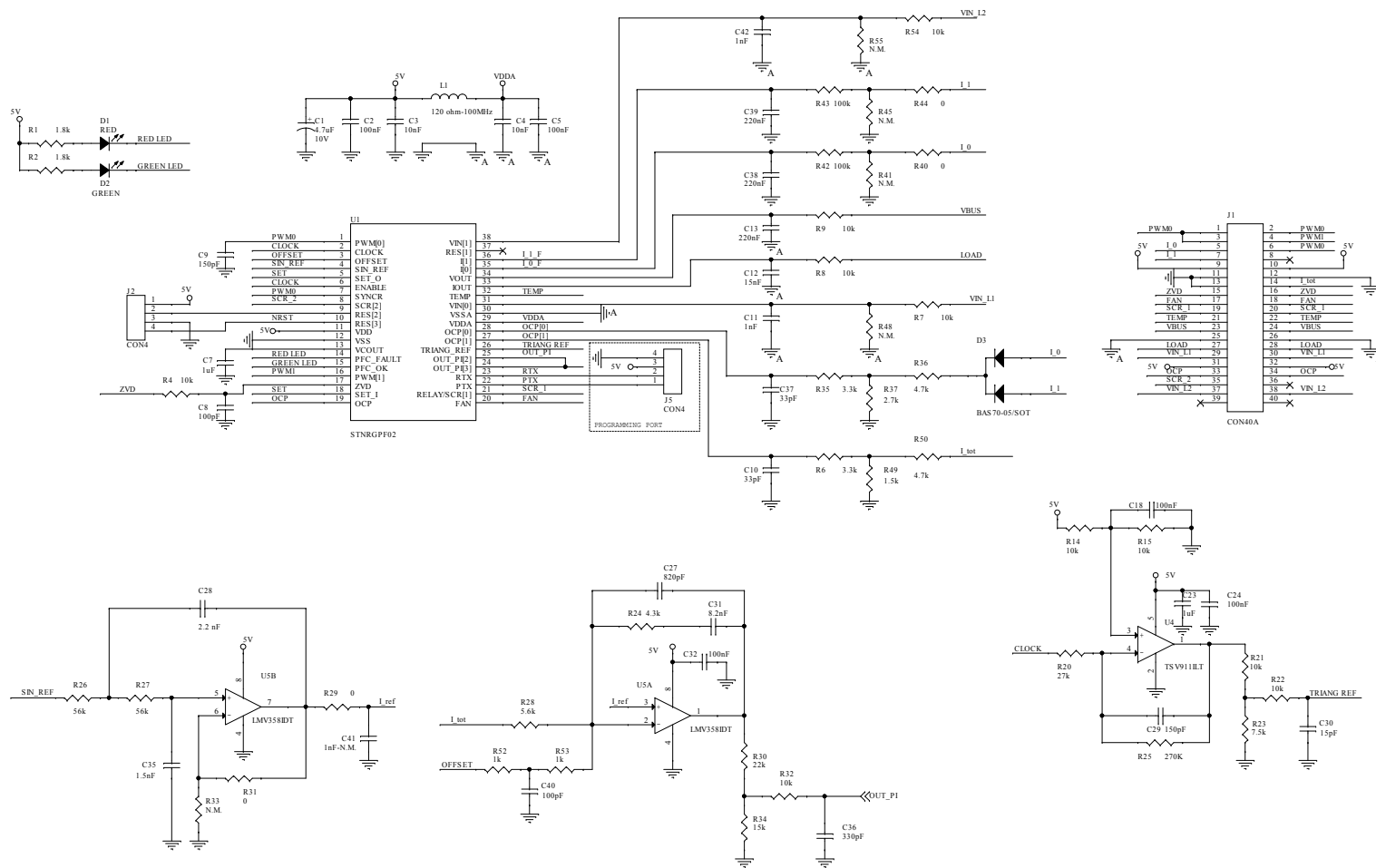
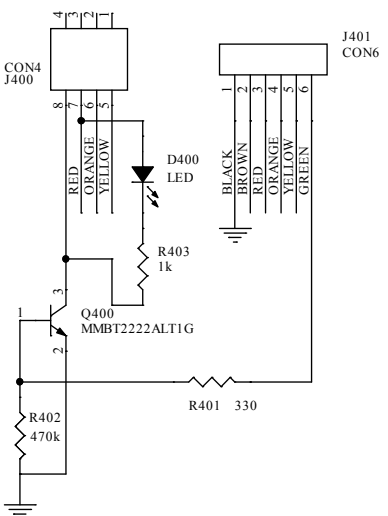


Figure 11. STEVAL-IPFC01A1 schematic



7 STEVAL-IPFC02V1 bill of materials

Table 1. STEVAL-IPFC02V1 bill of materials

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
1	1	-	STEVAL-IPFC02P1	Power board	ST	not available separately
2	1	-	STEVAL-IPFC02C1	Control board	ST	not available separately
3	1	-	STEVAL-IPFC01A1	Adapter board	ST	not available separately

7.1 STEVAL-IPFC02P1 power board bill of materials

Table 2. STEVAL-IPFC02P1 bill of materials

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
1	1	C100	100nF, 275VAC, $\pm 20\%$	Safety Capacitors MPP L/ S=15mm, Radial, 17.5x5x12mm, LS 15mm	Panasonic	ECQ-UAAF104MA
2	1	C101	0.1 μ F, 25V, $\pm 10\%$	CAP CER X7R 0603, 0603 (1608 Metric)	KEMET	C0603C104K3RACTU
3	1	C102	1nF, 760VAC, $\pm 20\%$	CAP CER Y5U RADIAL, Radial, Disc	Vishay BC Components	VY1102M35Y5UG63V0
4	4	C110, C111, C309, C310	100pF, 50V, $\pm 5\%$	CAP CER C0G/NP0 0603, 0603 (1608 Metric)	Murata Electronics North America	GRM1885C1H101JA01D
5	3	C200, C204, C208	470nF, 25V, $\pm 10\%$	CAP CER X7R 0603, 0603 (1608 Metric)	Würth Electronics Inc.	885012206075
6	3	C201, C202, C203	470 μ F, 25V, $\pm 20\%$	Cap Pol Radial (Electrolytic); 3.50 mm C X 8.00 mm Dia X 20.00 mm H body, Radial, 8x20mm	Any	-
7	1	C205	10 μ F, 16V	Cap Pol Radial (Electrolytic); 1.50 mm C X 4.00 mm Dia X 7.00 mm H body, Radial, 4x7mm	-	-
8	2	C206, C207	4.7 μ F, 50V, $\pm 20\%$	CAP CER X7R 1210, 1210 (3225 Metric)	Taiyo Yuden	UMK325B7475MM-T
9	1	C209	4.7nF, 25V, $\pm 10\%$	CAP CER X7R 0603, 0603 (1608 Metric)	Würth Electronics Inc.	885012206063
10	1	C210	1nF, 25V, $\pm 10\%$	CAP CER X7R 0603, 0603 (1608 Metric)	Samsung Electro-Mechanics	CL10B102KA8NNNC

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
11	1	C300	0.56 μ F, 630Vdc, $\pm$ 10%	CAP FILM RAD, Radial, 26.5x6x15mm LS 22.5	EPCOS (TDK)	B32673P6564K000
12	2	C301, C302	680 μ F, 450V, $\pm$ 20%	ALU SNAP IN, Radial, Can - Snap-In	KEMET	ALA7DA681DF450
13	1	C304	1 μ F, 277V-a.c., 520V c.c., $\pm$ 10%	CAP FILM RADIAL, Radial	EPCOS (TDK)	B32673Z5105K000
14	2	C305, C314	10nF, 50V, $\pm$ 10%	CAP CER X7R 0603, 0603 (1608 Metric)	Murata Electronics North America	GRM188R71H103KA01D
15	7	C306, C313, C315, C316, C317, C319, C320	0.1 μ F, 50V, $\pm$ 10%	CAP CER X7R 0603, 0603 (1608 Metric)	KEMET	C0603C104K5RACTU
16	2	C307, C308	100pF, 630Vdc, $\pm$ 5%	CAP FILM RADIAL, Radial	KEMET	PFR5101J630J11L4BULK
17	4	C311, C312, C322, C323	0.1 μ F, 50V, $\pm$ 5%	CAP CER X7R 0603, 0603 (1608 Metric)	KEMET	C0603C104J5RACTU
18	2	C318, C321	150pF, 50 VDC, $\pm$ 1%	Multilayer Ceramic Capacitors MLCC - SMD/SMT 50volts 150pF C0G 1%, 0603 (1608 metric)	KEMET	C0603C151F5GACTU
19	9	D100, D203, D302, D303, D304, D305, D306, D307, D308	STPS1L30A, 30V, 1A	DIODE SCHOTTKY SMA, DO-214AC, SMA	ST	STPS1L30A
20	1	D101	50A, 1kV, 50A	BRIDGE RECT 1PHASE GBJ, 4-SIP, GBJ	Micro Commercial Co	GBJ5010-BP
21	1	D102	GF1M, 1kV, 1A	DIODE GEN PURP SMA, DO-214AC, SMA	ON Semiconductor	GF1M
22	2	D103, D104	70V, 70mA (DC)	DIODE ARRAY SCHOTTKY SOT23-3, TO-236-3, SC-59, SOT-23-3	ST	BAS70-04FILM
23	1	D200	220V	TRANSIL DIODE SMB, DO-214AA, SMB	ST	SM6T220A
24	1	D201	150V, 2A	DIODE SCHOTTKY SMA, DO-214AC, SMA	ST	STPS2150A
25	1	D202	600V, 1A	Ultrafast high voltage rectifier SMA, DO-214AC, SMA	ST	STTH1L06A
26	3	D204, D309, D310	100V, 150mA (DC)	DIODE SCHOTTKY MINMLF, DO-213AA (Glass)	ST	TMMBAT46FILM

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
27	2	D300, D301	650V, 12A	DIODE SCHOTTKY TO220AC, TO-220-2	ST	STPSC12065D
28	1	F100	20A 250Vac, 250VAC 72VDC, 20A	FUSE BOARD MNT, 0.390" L x 0.120" W x 0.125" H (9.80mm x 3.05mm x 3.18mm)	Bel Fuse Inc.	SMM 20
29	1	ISO100	TLP385(E)	TRANSISTOR OPTOCOUPLER; 4-PIN SO, 6-SOIC (0.295", 7.50mm Width), 4 Leads	Toshiba Semiconductor and Storage	TLP385(E)
30	1	J100	VIN	SCREW TERM BLOCK PCB 3POS 7.5MM GREEN	Phoenix Contact	1717033
31	1	J300	VOUT	SCREW TERM BLOCK PCB 2POS 7.62MM	RS Pro	7901130
32	1	J301	con40-2x20-strip-female	CONN RCPT 40POS .100" DUAL GOLD	Samtec Inc.	ESQ-120-37-G-D
33	1	L100	2x4.5mH, 18A	CMC 4.5MH 18A 2LN TH, Vertical, 4 PC Pin	Würth Electronics Inc.	7448051804
34	1	L200	4.7µH, 1.9A, ±20%	Unshielded Wire-wound SMD Inductor 4.7 µH ±20% Wire-Wound 1.9A Idc, SMD 4.3x4x3.2mm	RS PRO	7409372
35	1	L201	11W, 80kHz, 2.2mH, 13V, 0.47A, ±10%	Switch Mode Transformer, Through hole	AQ Magnetica OR Würth Elektronik	2198.0037 OR 750318021
36	2	L300, L301	350µH 12A _{PK} 1kW	Power inductor, through hole	AQ Magnetica OR Würth Elektronik	2097.0016 OR 750318020
37	2	Q100, Q302	20V, 6A	MOSFET N-CH 8SOIC, 8-SOIC (0.154", 3.90mm Width)	ST	STS6NF20V
38	2	Q300, Q301	650V, 40A, 168W	IGBT TO247, TO-247-3	ST	STGW20H65FB
39	1	R100	22, 1/4W, ±1%	CHIP RESISITOR SMD 1206, 1206 (3216 Metric)	-	-
40	1	R101	150, 5W, ±5%	RES RADIAL, Radial	TE Connectivity Passive Product	SQMW5150RJ
41	3	R102, R201, R337	33k, 0.1W, 1/10W, ±1%	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
42	2	R103, R104 (not mounted)	470k, 0.25W, 1/4W, ±1%	RES SMD 1206, 1206 (3216 Metric)	-	-

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
43	3	R105, R108, R109	33k, 0.25W, 1/4W, $\pm 1\%$	CHIP RESISTOR SMD 1206, 1206 (3216 Metric)	-	-
44	1	R106	100k, 0.25W, 1/4W, $\pm 1\%$	CHIP RESISTOR SMD 1206, 1206 (3216 Metric)	-	-
45	2	R107, R111	10M, 0.1W, 1/10W, $\pm 1\%$	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
46	1	R110	47k, 0.1W, 1/10W, $\pm 1\%$	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
47	7	R112, R113, R121, R122, R303, R306, R314	470k, 0.25W, 1/4W, $\pm 1\%$	CHIP RESISTOR SMD 1206, 1206 (3216 Metric)	-	-
48	2	R114, R123	3k, 0.1W, 1/10W, $\pm 0.1\%$	RES SMD 0603, 0603 (1608 Metric)	Panasonic Electronic Components	ERA-3AEB302V
49	2	R200, R335	22, 0.25W, 1/4W, $\pm 1\%$	CHIP RESISTOR SMD 1206, 1206 (3216 Metric)	-	-
50	1	R202	12k, 0.1W, 1/10W, $\pm 1\%$	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
51	2	R203, R206	24k, 0.1W, 1/10W, $\pm 1\%$	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
52	2	R204, R205	2.7, 0.5W, 1/2W, $\pm 1\%$	RES SMD 1206, 1206 (3216 Metric)	Susumu	RL1632R-2R70-F
53	1	R207	3.3k, 0.25W, 1/4W, $\pm 1\%$	CHIP RESISTOR SMD 1206, 1206 (3216 Metric)	Any	-
54	1	R300	40m Ω , 7W, $\pm 1\%$	RES 2818, Nonstandard	Vishay Dale	WSHM2818R0400FEA
55	8	R301, R302, R321, R322, R333, R339, R341, R344	100, 0.1W, 1/10W, $\pm 1\%$	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
56	2	R304, R305	1k, 0.1W, 1/10W, $\pm 1\%$	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
57	2	R307, R308	10k, 0.1W, 1/10W, $\pm 0.1\%$	RES SMD 10K OHM 0603, 0603 (1608 Metric)	Panasonic Electronic Components	ERA-3AEB103V
58	2	R309, R319	56k, 0.1W, 1/10W, $\pm 0.1\%$	RES SMD 56K OHM 0603, 0603 (1608 Metric)	Panasonic Electronic Components	ERA-3AEB563V
59	2	R310, R311	33, 0.25W, 1/4W, $\pm 1\%$	CHIP RESISTOR SMD 1206, 1206 (3216 Metric)	-	-
60	2	R312, R313	10, 0.25W, 1/4W, $\pm 1\%$	CHIP RESISTOR SMD 1206, 1206 (3216 Metric)	-	-

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
61	2	R315, R317	10k, 0.25W, 1/4W, $\pm 1\%$	CHIP RESISTOR SMD 1206, 1206 (3216 Metric)	-	-
62	2	R316, R318	10m Ω , 2W, $\pm 1\%$	RES 3264 current sensing, 2512 (6432 Metric)	Ohmite	MCS3264R010FER
63	1	R320	6m Ω , 3W, $\pm 1\%$	RES 2512, 2512 (6432 Metric)	Panasonic Electronic Components	ERJ-MS4HF6M0U
64	1	R323	3.3k, 0.1W, 1/10W, $\pm 0.1\%$	RES SMD 0603, 0603 (1608 Metric)	Panasonic Electronic Components	ERA-3AEB332V
65	2	R324, R330	82k, 0.1W, 1/10W, $\pm 0.1\%$	RES SMD 0603, 0603 (1608 Metric)	Panasonic Electronic Components	ERA-3AEB823V
66	6	R325, R327, R334, R340, R342, R345	2.2K, 0.1W, 1/10W, $\pm 0.1\%$	RES SMD 0603, 0603 (1608 Metric)	Panasonic Electronic Components	ERA-3AEB222V
67	1	R326	0, 0.1W, 1/10W, $\pm 1\%$	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
68	1	R328 (not mounted)	*, 0.1W, 1/10W, $\pm 1\%$	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
69	1	R329	470, 0.1W, 1/10W, $\pm 1\%$	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
70	4	R331, R336, R343, R346	62k, 0.1W, 1/10W, $\pm 0.1\%$	RES SMD 0603, 0603 (1608 Metric)	Panasonic Electronic Components	ERA-3AEB623V
71	1	R332	11k, 0.1W, 1/10W, $\pm 1\%$	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
72	1	R338	10k, 0.1W, 1/10W, $\pm 1\%$	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
73	2	R347, R348	0, 0.25W, 1/4W, $\pm 1\%$	CHIP RESISTOR SMD 1206, 1206 (3216 Metric)	-	-
74	2	R349, R350	510, 0.1W, 1/10W, $\pm 1\%$	CHIP RESISTOR SMD 0603, 0603 (1608 Metric)	-	-
75	1	RL100	250Vac-16A	RELAY GEN PURPOSE SPDT 16A 18V	TE Connectivity Potter & Brumfield Relays	RT314018
76	1	RT1	16 Ω , 1.7A, $\pm 20\%$	ICL 8.5MM, Diameter 8.5mm	EPCOS (TDK)	B57153S0160M000
77	1	RV100	S14K275, 275VAC	VARISTOR 430V 4.5KA DISC 14MM, Disc 14mm	EPCOS (TDK)	B72214S0271K101
78	1	U200	5V, 250mA	IC REG LINEAR 8SO, 8-SOIC (0.154", 3.90mm Width)	ST	L4931ABD50-TR

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
79	1	U201	-	IC PRIMARY SWITCHING REG 16SOIC, 16-SOIC (0.154", 3.90mm Width)	ST	ALTAIR05T-800
80	4	U300, U301, U303, U304	-	IC OPAMP GP 8MHZ RRO SOT23-5, SC-74A, SOT-753	ST	TSV911ILT
81	1	U302	-	SENS TEMP ANLG VOLT SOT-323-5, 5-TSSOP, SC-70-5, SOT-353	ST	STLM20W87F
82	2	U305, U306	4A	IC MOSFET DVR DUAL 8SOIC, 8-SOIC (0.154", 3.90mm Width)	ST	PM8834
83	2	Y100, Y101	2.2nF, 250VAC, ±20%	CAP CER RADIAL, Radial, Disc	Murata Electronics North America	DE2E3KY222MA3BM02F
84	1	Y300	LAM 4 K 150 12, 12V	Heatsink 40 x 40 x150 mm, with axial fan 12V, integrated	FISCHERELEK TRONIK	LAM 4 K 150 12
85	5	Y3 lock-in-retaining springs	THFU 1	retaining springs	Fischer Elektronik	THFU 1
86	1	Thermal Film 140 x 25 mm	-	Thermal conductivity Thin film 140 X 25 mm	BERGQUIST	BP100-0.005-00-12/12
87	4	Spacer	D01496	Hex Threaded Spacer	DURATOOL	D01496
88	4	Nut	DTRNNE 34814 M3	M3 Hexagon Full Nut Double Chamfer	TR FASTENINGS	DTRNNE 34814 M3
89	2	Screws	M3 x 10 mm	Steel screw	TR FASTENINGS	M310 PRSTMCZ100-
90	2	Steel washers	M3	Steel Plain M3 Washer	ANY	ANY

7.2 STEVAL-IPFC02C1 control board bill of materials

Table 3. STEVAL-IPFC02C1 bill of materials

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
1	1	C1	4.7μF, 16V, ±10%	X7R Ceramic Capacitor, SMD 0805	ANY	ANY
2	5	C2, C5, C18, C24, C32	100nF, 50V, ±10%	X7R Ceramic Capacitor, SMD 0603	ANY	ANY
3	2	C3, C4	10nF, 25V, ±10%	X7R Ceramic Capacitor, SMD 0603	AVX	06033C103KAT2A
4	2	C7, C23	1μF, 25V, ±10%	X7R Ceramic Capacitor, SMD 0603	ANY	ANY

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
5	2	C8, C40	100pF, 50V, ±5%	C0G Ceramic Capacitor, SMD 0603	ANY	ANY
6	2	C9, C29	150pF, 50V, ±5%	C0G Ceramic Capacitor, SMD 0604	ANY	ANY
7	2	C10, C37	33pF, 50V, ±5%	C0G Ceramic Capacitor, SMD 0603	ANY	ANY
8	2	C11, C42	1nF, 50V, ±5%	C0G Ceramic Capacitor, SMD 0603	ANY	ANY
9	1	C12	15nF, 50V, ±10%	X7R Ceramic Capacitor, SMD 0603	ANY	ANY
10	3	C13, C38, C39	220nF, 50V, ±10%	X7R Ceramic Capacitor, SMD 0603	ANY	ANY
11	1	C27	820pF, 50V, ±5%	COG Ceramic Capacitor, SMD 0603	ANY	ANY
12	1	C28	2.2 nF, 50V, ±5%	C0G Ceramic Capacitor, SMD 0603	ANY	ANY
13	1	C30	15pF, 50V, ±5%	COG Ceramic Capacitor, SMD 0603	ANY	ANY
14	1	C31	8.2nF, 50V, ±10%	X7R Ceramic Capacitor, SMD 0603	ANY	ANY
15	1	C35	1.5nF, 50V, ±5%	C0G Ceramic Capacitor, SMD 0603	ANY	ANY
16	1	C36	330pF, 50V, ±5%	COG Ceramic Capacitor, SMD 0603	ANY	ANY
17	1	C41 (not mounted)	1nF, 50V, ±5%	X7R Ceramic Capacitor, SMD 0603	ANY	ANY
18	1	D1	RED, 1,85, 20mA	High efficiency red diffused LED 3mm, SMD 0805	Kingbright	KP-2012SRC-PRV
19	1	D2	GREEN, 2.1V, 20mA	High efficiency green diffused LED 3mm, SMD 0805	Kingbright	KPHCM-2012CGCK
20	1	D3	BAS70-05, 70V, 70mA	Low capacitance, series inductance and resistance Schottky diode, SOT23	ST	BAS70-05FILM
21	1	J1	CON40A, 250Vac, 3A	Right angle PIN header connector, dual row, T. H. lead spacing 2.54 x 2.54mm	Würth Elektronik	61304021021

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
22	2	J2, J5	CON4, 250Vac, 3A	T. H. PIN Header Connector, single row, T. H. lead spacing 2.54mm	Wurth Elektronik	61300411121
23	1	L1	120 Ω -100MHz, 500 mA, $\pm 25\%$	Ferrite, SMD 0603	Wurth Elektronik	74279262
24	2	R1, R2	1.8k, 50V, 0.1, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
25	6	R4, R8, R9, R21, R22, R32	10k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
26	4	R7, R14, R15, R54	10k, 50V, 0.1W, $\pm 0.1\%$	Metal film resistor, SMD 0603	Panasonic	ERA3APB103V
27	2	R6, R35	3.3k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
28	1	R20	27k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
29	1	R23	7.5k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
30	1	R24	4.3k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
31	1	R25	270K, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
32	2	R26, R27	56k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
33	1	R28	5.6k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0604	ANY	ANY
34	4	R29, R31, R40, R44	0, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
35	1	R30	22k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
36	5	R33, R41, R45, R48, R55 (not mounted)	(not mounted), 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
37	1	R34	15k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
38	2	R36, R50	4.7k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
39	1	R37	2.7k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
40	2	R42, R43	100k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
41	1	R49	1.5k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
42	2	R52, R53	1k, 50V, 0.1W, $\pm 1\%$	Metal film resistor, SMD 0603	ANY	ANY
43	1	U1	5V	Digital controller, TSSOP38	ST	STNRGPF02
44	1	U4	5V	Single rail to rail I/O 8MHz OpAmp, SOT23-5L	ST	TSV911ILT

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
45	1	U5	5V	Low power I/O rail to rail dual OpAmp, SO8	ST	LMV358IDT

7.3 STEVAL-IPFC01A1 adapter board bill of materials

Table 4. STEVAL-IPFC01A1 bill of materials

Item	Q.ty	Ref.	Part / Value	Description	Manufacturer	Order code
1	1	D400	LED	High Efficiency Red LED 3mm, through hole	Kingbright	L-7104ID
2	1	J400	CON4	4-contact 2.54mm female SIL Board-to-board Socket, through hole	HARWIN	M20-7890446
3	1	J401	CON6	Right angle male connector 1 way 6 circuits 2.54mm, through hole	ANY	ANY
4	1	Q400	40 V, 0.6 A	General Purpose Transistors, NPN Silicon	ON Semiconductor	SMMBT2222ALT1G
5	1	R401	330	Metal film resistor, 0805	ANY	ANY
6	1	R402	470k	Metal film resistor, 0805	ANY	ANY
7	1	R403	1K	Metal film resistor, 0805	ANY	ANY

Revision history

Table 5. Document revision history

Date	Version	Changes
16-Mar-2020	1	Initial release.
10-Jul-2020	2	Updated Table 2. STEVAL-IPFC02P1 bill of materials.
22-Jan-2021	3	Updated Figure 10. STEVAL-IPFC02C1 schematic and Table 2. STEVAL-IPFC02P1 bill of materials

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