STEVAL-IPFC12V1

Data brief

2 kW two-channel interleaved PFC reference design based on the STNRGPF12 digital controller with digital inrush current control





Features

- Input voltage range: 90 to 265 V_{AC}
- Line frequency range: 47 to 63 Hz
- Maximum output power: 2 kW at 230 V
- Digital Inrush Current Limiter function performed with SCR
- Output voltage: 400 V
- Power factor: > 0.98 at 20% load
- Total Harmonic Distortion: <5% at 20% load
- Mixed-signal Average Current Mode control, CCM fixed frequency operation
- Switching Frequency (f_{sw}): 60 kHz
- Cycle-by-cycle regulation (analog current control loop)
- Input voltage and load feed-forwards
- Phase shedding
- Current balance
- Burst-mode operation
- Overvoltage protection
- Overcurrent protection
- Thermal protection
- Status indicator LEDs
- Cooling function

Product summary	
2 kW two-channel interleaved PFC based on the STNRGPF12 digital controller	STEVAL-IPFC12V1
two-channel interleaved CCM PFC digital controller	STNRGPF12
automotive-grade SCR Thyristor	TN3050H-12WY
high voltage rectifier for bridge applications	STBR3012
trench gate field-stop IGBT	STGW20H65FB
power Schottky silicon carbide diode	STPSC12065D
Application	PFC Converter - Single Phase Input
Articles	Digital PFC blog article

Description

The STEVAL-IPFC12V1 2 kW interleaved PFC reference design features the performance of analog cycle-by-cycle current regulation and the flexibility of digital control to generate sinusoidal supplies with very high power factor and very low harmonic distortion.

Digital power control is based on the STNRGPF12 digital PFC controller, which in combination with the TN3050H-12WY thyristor implements digital inrush current limitation, and can drive up to two interleaved PFC channels using mixed signal (analog and digital) average current mode control in CCM at fixed frequency.

The 2 kW interleaved PFC reference design consists of a power board with 2-ch interleaved CCM boost power stage, input rectifier controlled bridge and auxiliary power supply, a control board with embedded STNRGPF12 digital controller and analog control circuitry, and a USB to UART (FTDI cable required - not included in the kit) bridge for programming the STNRGPF12 and performance monitoring.

You can use the eDesignSuite software available on the ST website to configure the STNRGPF12 according to specific design requirements for each interleaved PFC.

1 Design overview: 2 kW 2-ch interleaved PFC

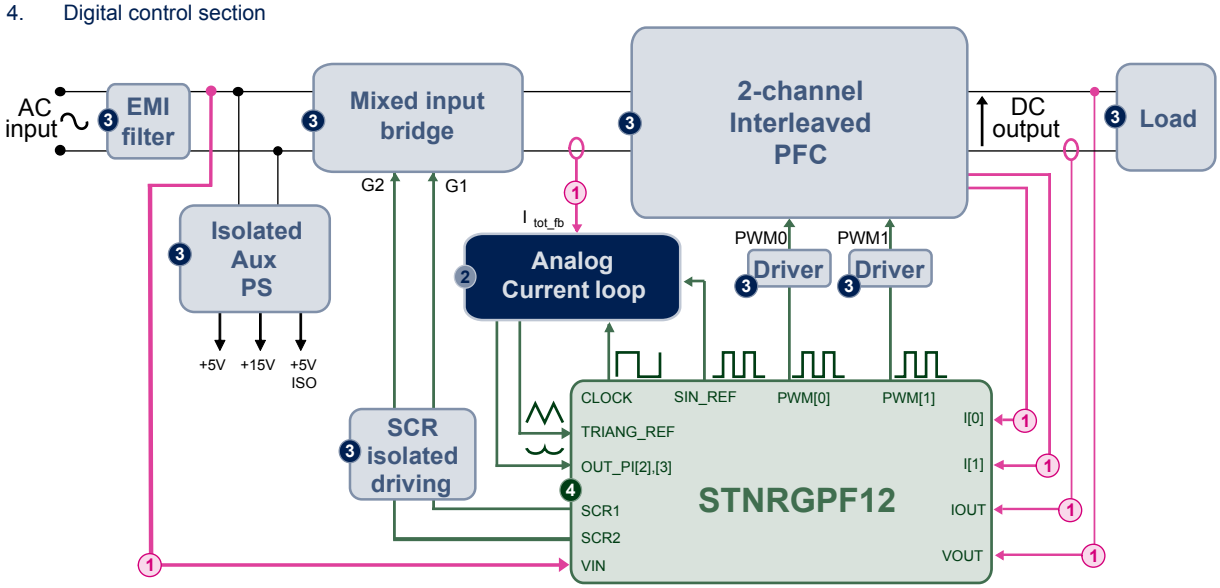
The aim of this reference design is to provide a flexible PFC converter that can accept a wide input range (90 to 265 V at 50/60 Hz) for high power applications (600 W to 2 kW) that require supply power with very high PF and very low THD, in an efficient and cost effective package that can be easily configured for specific performance criteria.

If we equate programmable digital control with flexibility, and analog logic with high performance, then the STNRGPF12 digital controller is the ideal choice, specifically designed for interleaved CCM boost PFC for applications above 600 watts.

The controller supports mixed signal (analog/digital) architecture, with an analog loop providing cycle-by-cycle current control and the reference signals for PWM modulation, and a digital voltage loop managing all the non-time critical functions/protections, and calculating rapid feed forward responses to fluctuations in the input voltage or step changes in the load.

Figure 1. STEVAL-IPFC12V1 block diagram

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



Regarding inrush current control, which is a critical protection feature also managed by the STNRGPF12 controller, we use a comprehensive approach involving firing angle control of high side TN3050H-12WY SCRs in a mixed input bridge; the low side of the bridge consists of STBR3012 rectifier diodes. Both silicon devices are well above the required current rating to minimize voltage drops across the bridge, and offer low forward voltage drop and surge current/voltage handling.

The PFC stage is based on a boost circuit design with two parallel channels to take advantage of the controller's ability to support interleaving through a secondary PWM channel that is phase-shifted 180° with respect to the master channel. While two channels increase circuit complexity, the interleaving operation ensures that there is less ripple and higher apparent switching frequency in the PFC input current, which allow the use of smaller and less expensive input EMI filters, boost inductors and switching devices.

The STGW20H65FB IGBTs used for the boost switches are cost effective devices especially designed to minimize losses in power converters thanks to their low $V_{CE(sat)}$ and reduced tail current profile.

2 STEVAL-IPFC12P1 power board schematics

Figure 2. STEVAL-IPFC12P1 schematic - input section

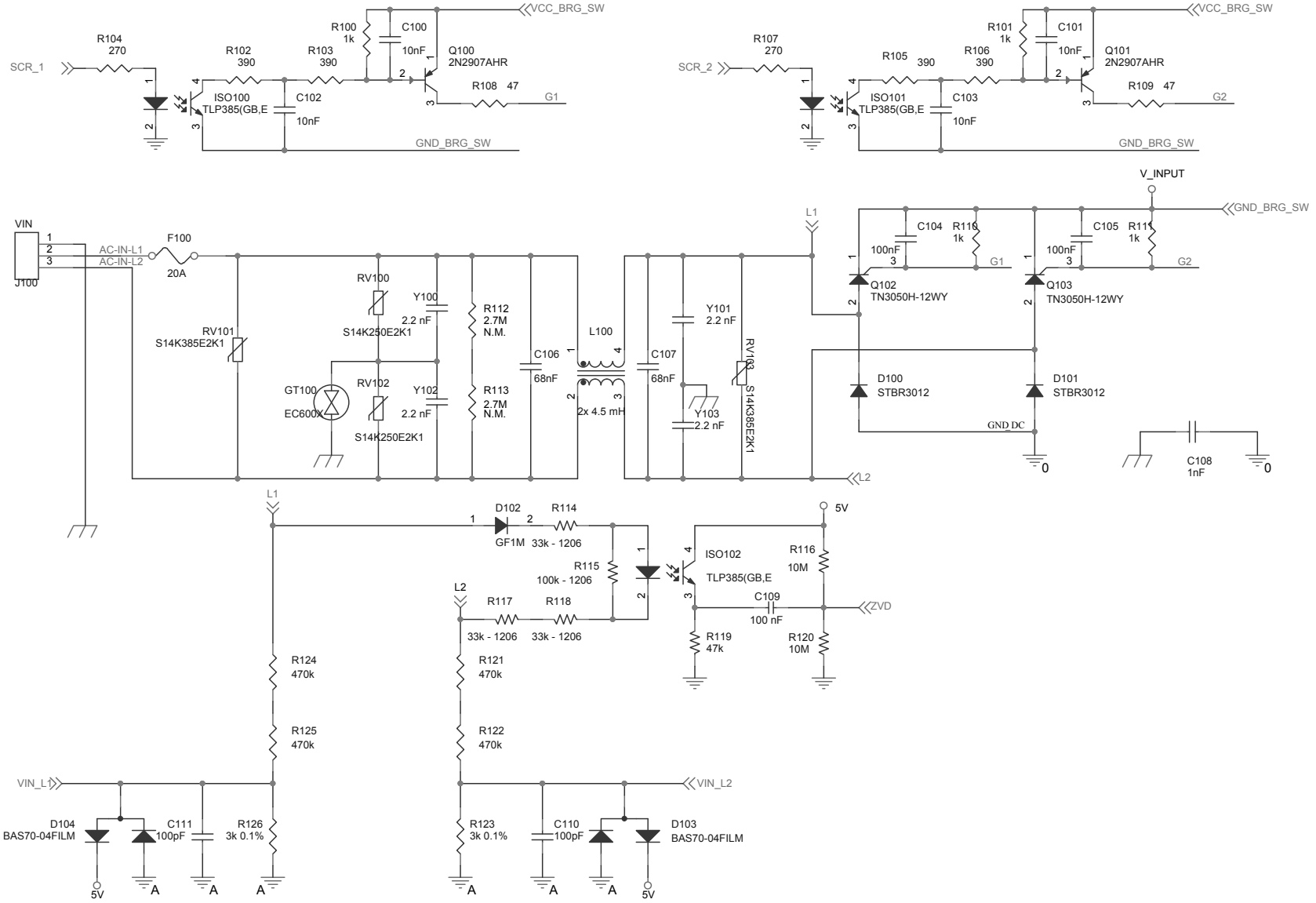


Figure 3. STEVAL-IPFC12P1 schematic - auxiliary power supply

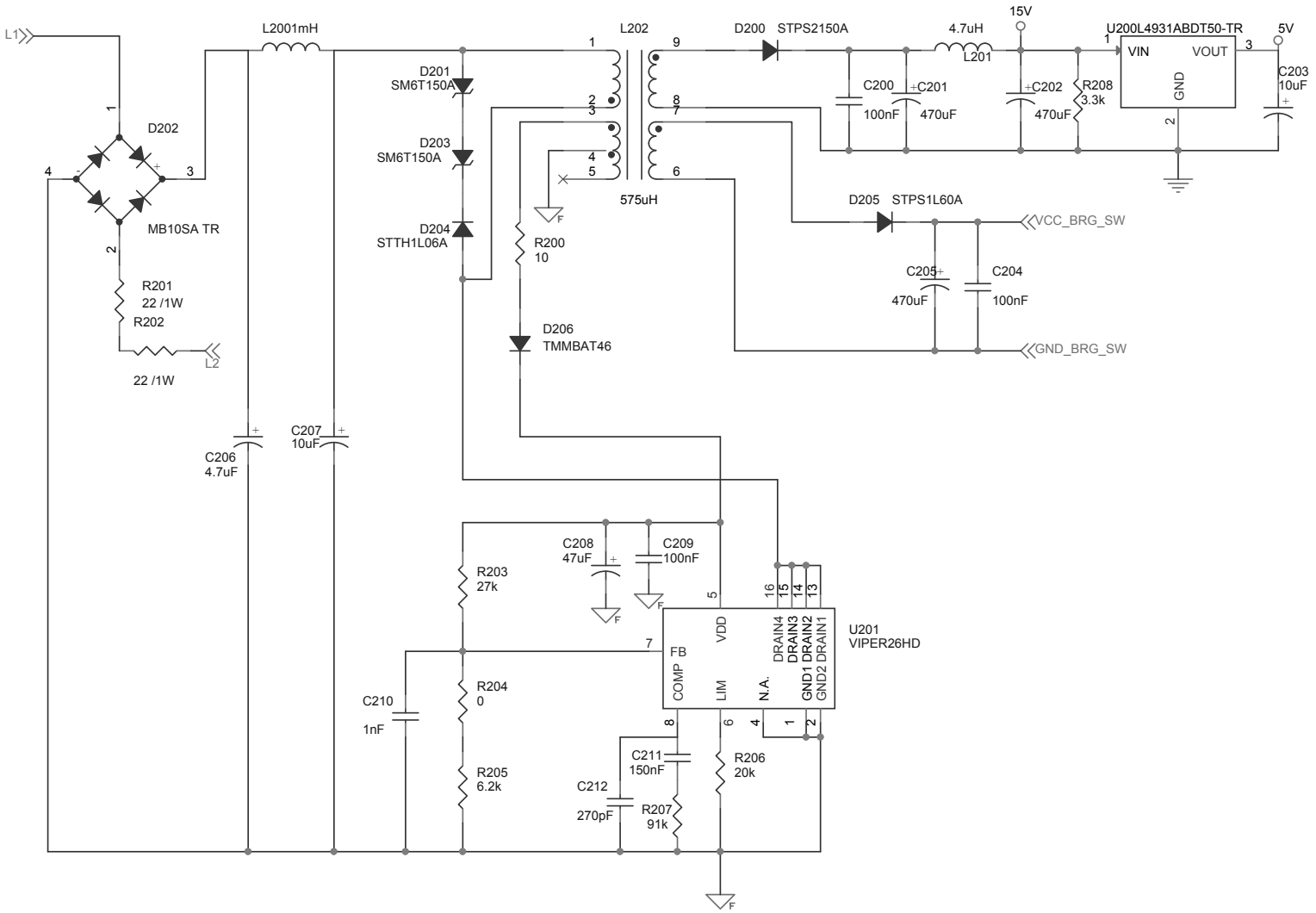
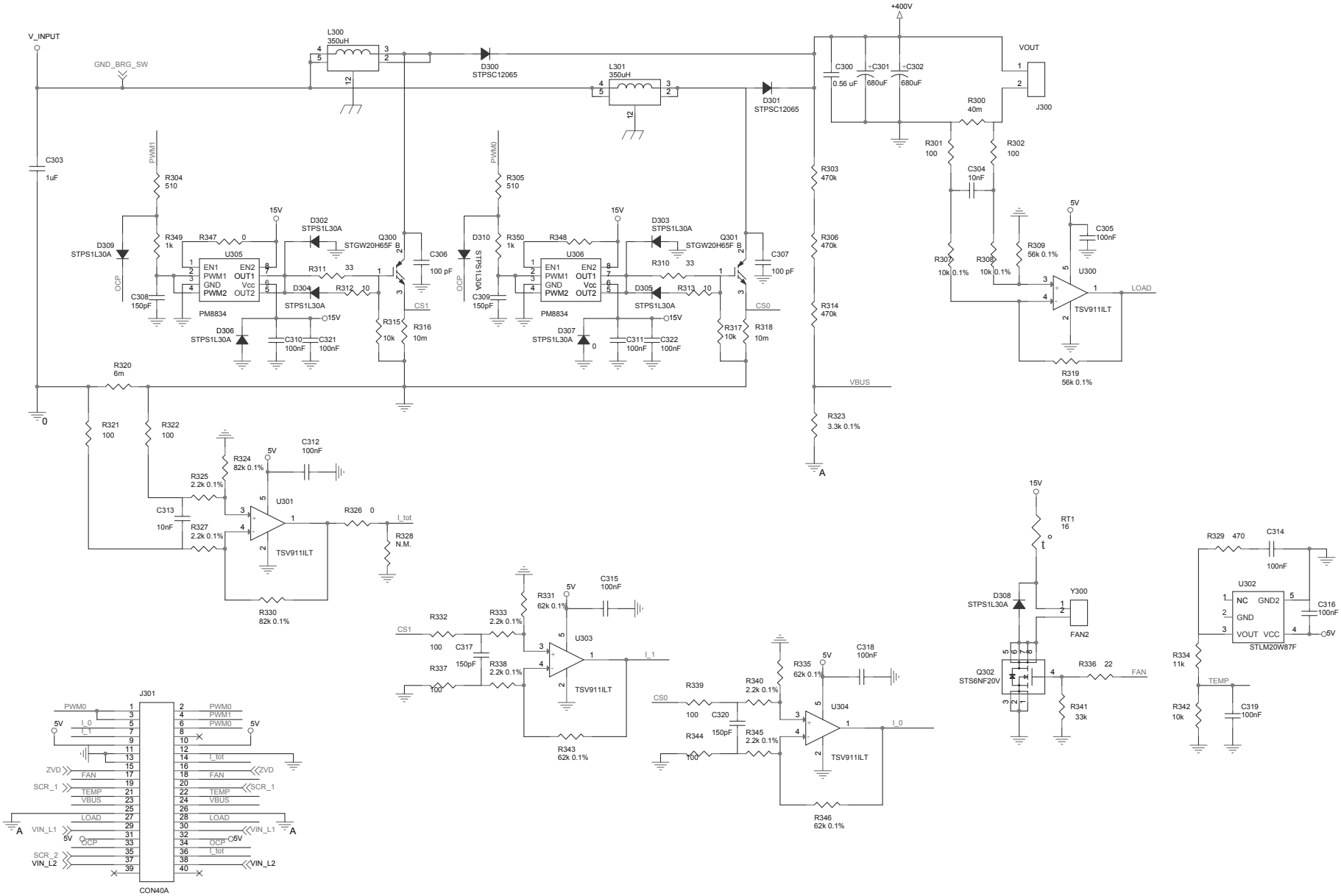
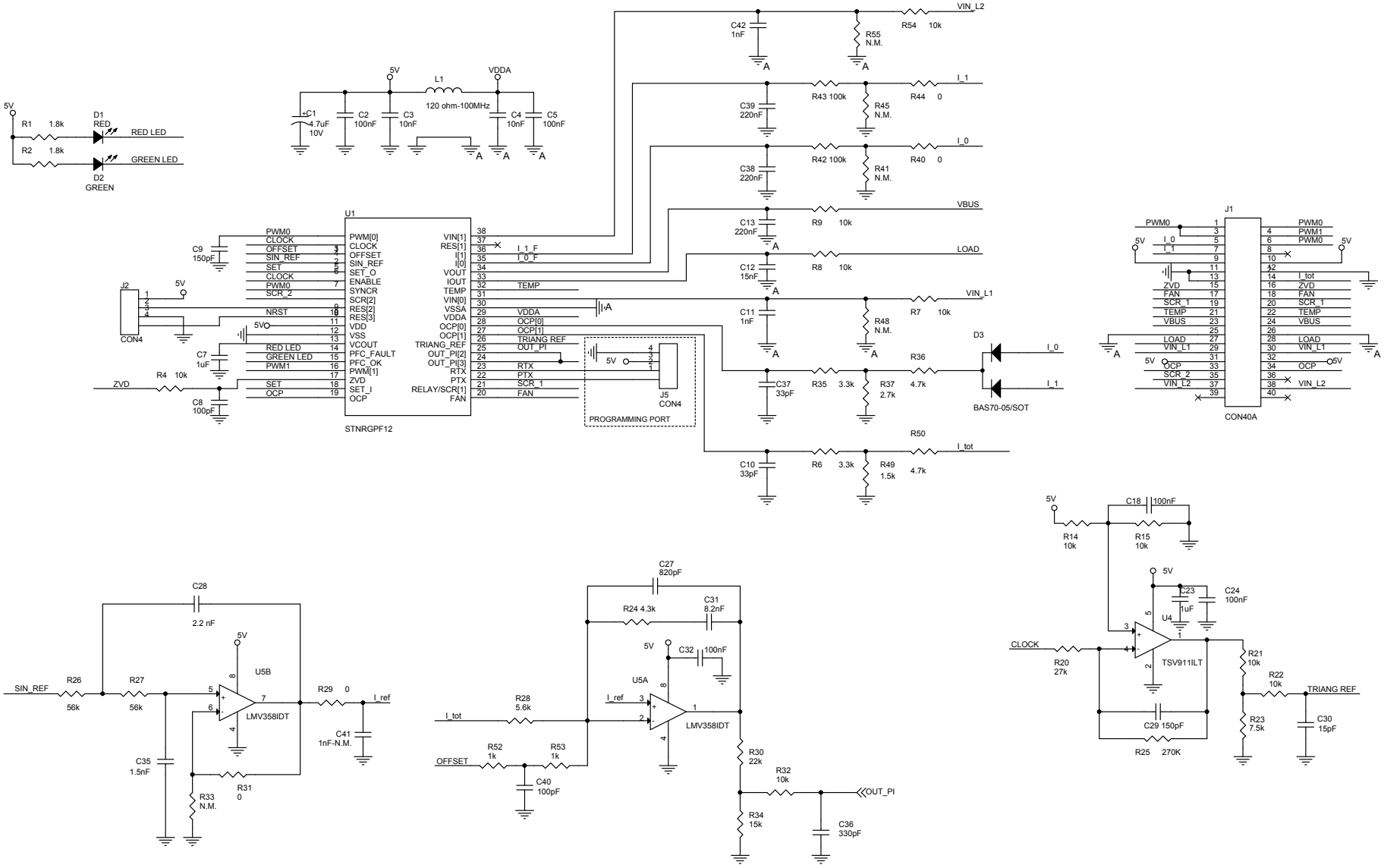


Figure 4. STEVAL-IPFC12P1 schematic - boost interleaving section



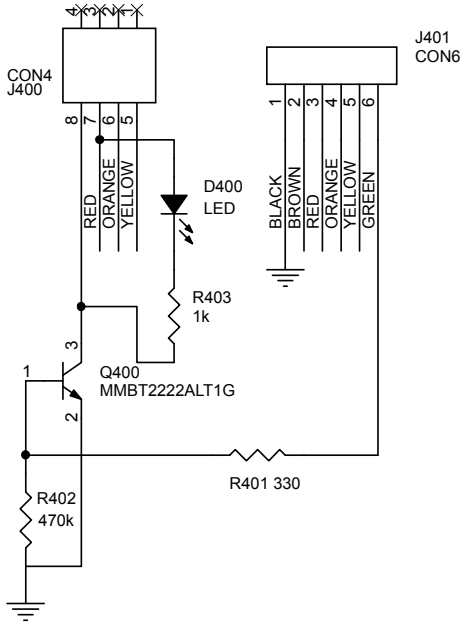
3 STEVAL-IPFC12C1 control board schematic

Figure 5. **STEVAL-IPFC12C1 schematic**



4 STEVAL-IPFC01A1 adapter board schematic

Figure 6. **STEVAL-IPFC01A1 schematic**



Revision history

Table 1. Document revision history

Date	Version	Changes
08-Mar-2019	1	Initial release.
07-Aug-2019	2	Updated cover page Features and Description Renamed (was *Block diagram*) and updated Section 1 Design overview: 2 kW 2-ch interleaved PFC

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