AN4338
Application note

EVLSTNRG-170W: 170 W SMPS with digitally controlled PFC and resonant LLC stage based on the STNRG388A

Introduction

This application note describes the characteristics and features of a 170 W, wide input mains range, power factor corrected, evaluation board for evaluating the STNRG388A digital controller in off-line power conversion applications such as digital industrial power supplies. The solution implements a PFC stage followed by a resonant LLC stage supporting up to 170 W with multiple output rails: a high power 24 V (6 A) channel for the main application, 1 auxiliary 12 V (2 A) for the controller and an always-on 5 V (2 A) standby.

The STNRG388A power conversion dedicated peripherals (SMEDs) offer the flexibility to drive the PFC in transition mode (DCM-CCM boundary) while the resonant LLC is controlled with timeshift control (TSC). In parallel to managing the two conversion stages, the STNRG388A device guarantees all the protections required by the application as well as implementing the advanced anti-capacitive protection. Thanks to the digital core of the STNRG388A device, it is also possible to monitor, control and debug the EVLSTNRG-170W board via a convenient HyperTerminal control.

The EVLSTNRG-170W evaluation kit (*Figure 1*) is comprised of a power board, accommodating power circuits and gate drivers L6382D, and a control card with a digital control CORE based on the STNRG388A device. The control module receives status signals from the power circuit and provides control signals to the power board. Two different control cards are provided:

- “Slim”: this board shows how small a real application could be
- “Debug”: this board allows to easily monitor all STNRG388A signals, in order to understand the operation of the system or debugging a new code.

Figure 1. EVLSTNRG-170W with “slim“ control board configuration

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1 Main characteristics and circuit description

The main features of the SMPS are listed here below:
- Universal input mains range: 90 ÷ 264 V ac - frequency 45 ÷ 65 Hz
- Full load power 170 W
- Output voltage 1: 24 V ± 5% at 6 A for backlight and audio supply
- Output voltage 2: 12 V ± 3% at 2 A for panel supply
- Output voltage 3: 5 V ± 2% at 2 A for microprocessor supply
- Mains harmonics: according to EN61000-3-2 Class-D or JEITA-MITI Class-D
- Standby mains consumption: at 230 V ac < 150 mW with 50 mW load
- Overall efficiency at full load: better than 90% at full load
- EMI: according to EN55022-Class-B
- Safety: according to EN60950
- Power board size: 195 x 115 mm, 25 mm max. components height from PCB
- Control board size: “debug” 88 x 118 mm, “slim” 25 x 76 mm
- Power board PCB: dual layers, 35 µm, mixed PTH/SMT
- Control board PCB: four layers, 35 µm, mixed PTH/SMT

The circuit is composed of two sections:
1. A 10 W standby based on the VIPER27L, a high-voltage switcher for off-line applications. This auxiliary converter delivers 5 V/2 A and is dedicated to supply the TV microprocessor, the IR receiver, the logic and supervisory circuitry, as well as the control devices of the main converter.
2. The main converter composed of a front-end PFC and a LLC resonant converter, both controlled by the STNRG388A digital controller. The PFC stage delivers 400 V constant voltage and acts as a pre-regulator for both the LLC stage and the standby supply; the LLC resonant converter delivers two output voltages, one dedicated to supply the TV panel and the other for the backlight and audio power amplifiers.

An external signal, referred to secondary ground, turns on and off the main converter.

The drive function for the discrete MOSFETs of the main converter is provided by the L6382D: this dedicated companion driver integrates also the high voltage startup generator and a precise reference voltage (3.3 V) able to provide up to 30 mA to supply the STNRG388A.

1.1 Boost PFC stage features

- Digitally controlled PFC pre-regulator
- Transition-mode (DCM-CCM boundary) operation with valley switching
- Enhanced constant on-time control with line voltage feedforward
- Valley skipping with valley lock and burst mode operation
- OCP with LEB on current sense
- Protections:
  - Brownout
  - Overvoltage
  - Undervoltage
  - Overcurrent
  - Anti-continuous conduction mode
- Programmable soft-start
- Digital control loop with programmable PI frequency compensator

1.2 LLC resonant HB converter features

- Time-shift control with min. and max. frequency limitation
- Self-adjustable dead time
- Protections:
  - 2 levels overcurrent
  - Overvoltage
  - Anti-capacitive mode
- Safe start and digitally adjustable soft-start

1.3 Flyback converter features

- Fixed switching frequency (60 kHz) with frequency jittering
- CCM - DCM operation according to mains voltage and load amount

1.4 Related documents

Additional information and details about firmware and the parameters setting can be found in the following documents:

- UM1881 - EVLSTNRG-170W: user interface manual
- UM1760 - STLUX™ SMED configurator 1.0

This evaluation board has been developed starting from the existing EVL170W-FTV evaluation board, based on full analog control. Its application note (AN3329) can be used to have a description and relevant waveforms of the standby supply.

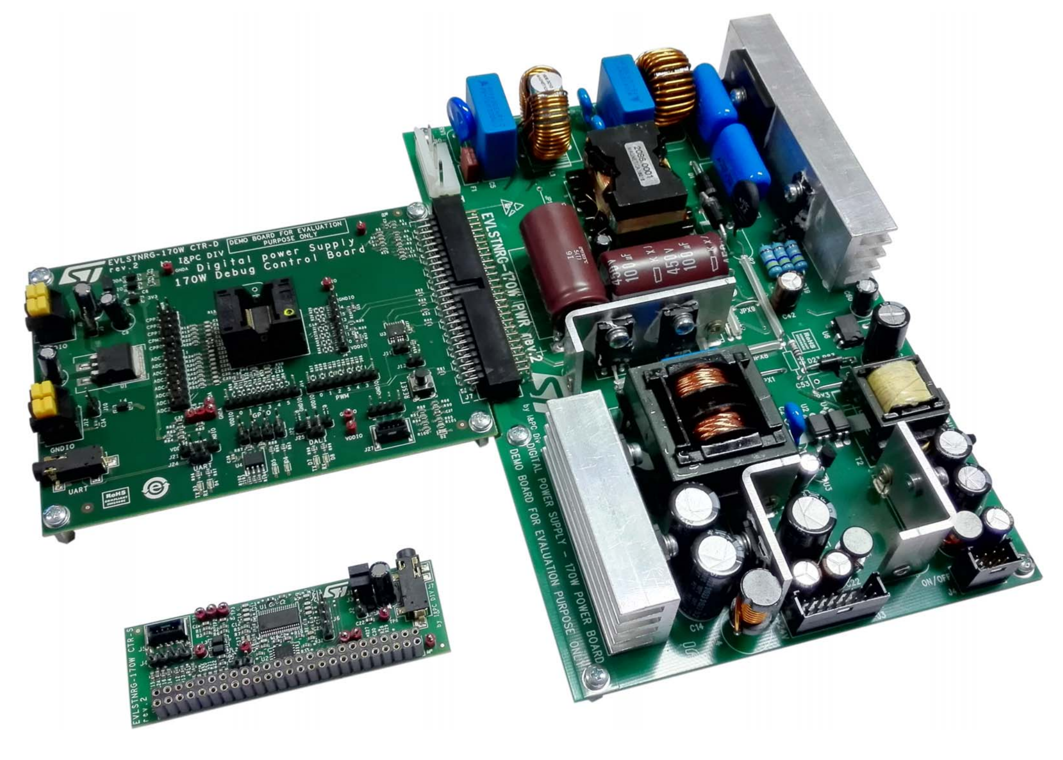
Since that evaluation board refers to the same application and uses the same power components, it is a good means for comparison between the analog and digital performance.

1.5 HW configuration

As already said, the EVLSTNRG-170W includes two different control boards. They work exactly in the same way, using the same STNRG388A resources and sharing the same FW. The “Slim” version has been thought to show the actual size of the digital control in a real application. Since its height is only 25 mm it is mounted vertically on the power board. Therefore the total footprint of the SMPS is the same of the power board.

The “debug” version allows accessing all the STNRG388A signal with convenient test points. The STNRG388A is housed in a socket making very easy to remove / replace it. The board has also dedicated supply connectors that allow using it as a standalone board to develop a code for the STNRG388A device. *Figure 2* shows the complete system using the “debug” control board.

Figure 2. EVLSTNRG-170W with “debug” control board connected



1.6 Digital PFC description

The PFC block diagram and STNRG388A pins used for PFC control are shown in *Figure 3*.

The gate drive signal for the power MOSFET is generated by two coupled SMEDs (“State Machine Event Driven”) and delivered through the gate driver L6382. The schematic also shows that four signals are sensed and opportunely scaled and conditioned. The PFC output voltage and AC line are sensed using the STNRG388A device. These signals are scaled to a range from 0 V to 1.25 V which corresponds to the ADC full scale. The demagnetization detection and power MOSFET current sensing for the cycle-by-cycle current limiting and current threshold detection are implemented with high speed analog comparators available in the STNRG388A.

The PFC operates in transition mode using a proprietary enhanced constant on-time technique. The on-time calculated by the voltage loop is kept constant for a given mains voltage and load condition during each line half cycle to obtain a good power factor and low harmonic content of the line current. The actual on-time is the sum of two times: the calculated one and that required for the current to reach a predefined threshold.

As a consequence, the on-time is not rigorously constant over a line half cycle.

Figure 3. PFC block diagram and signals description

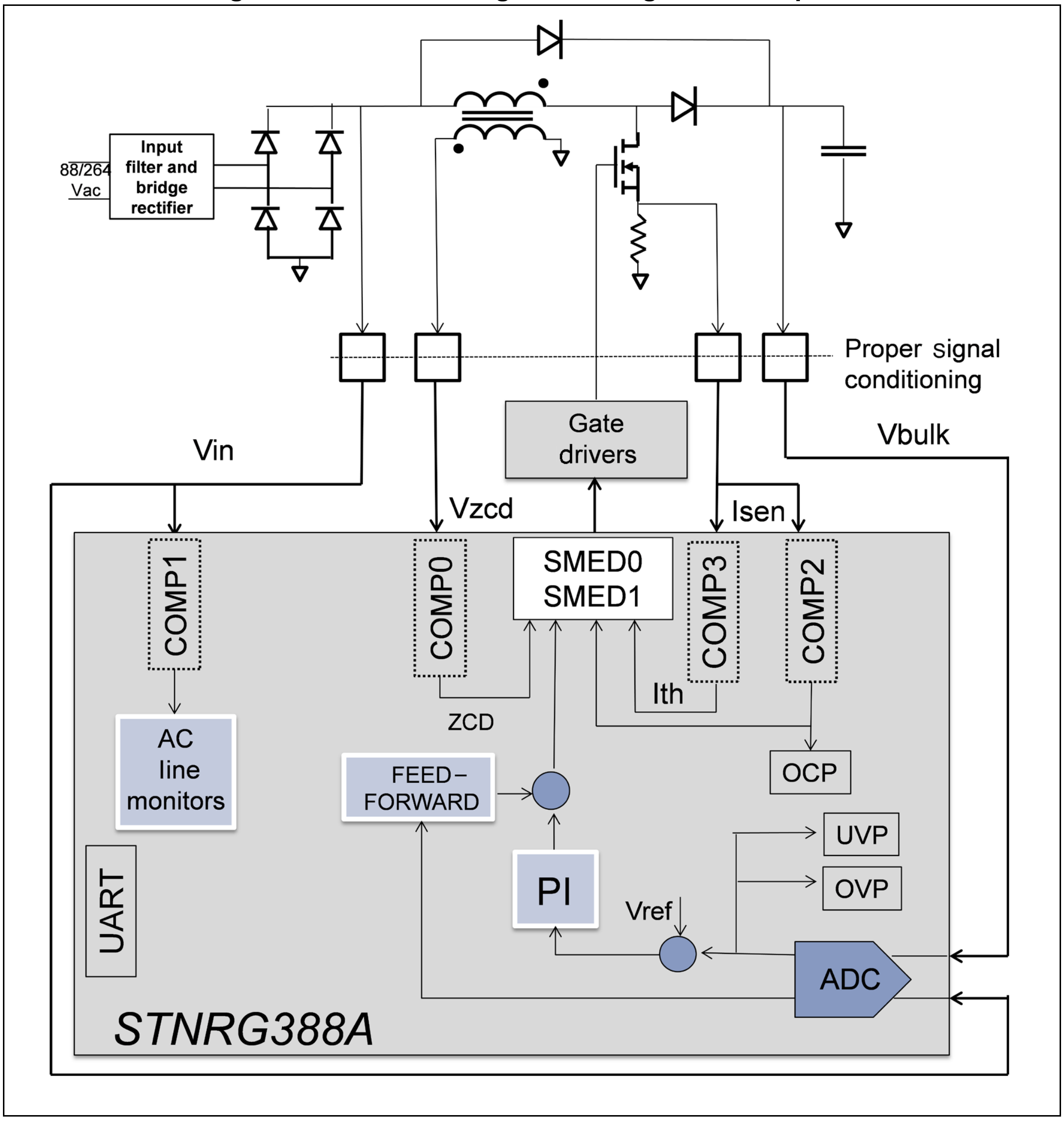
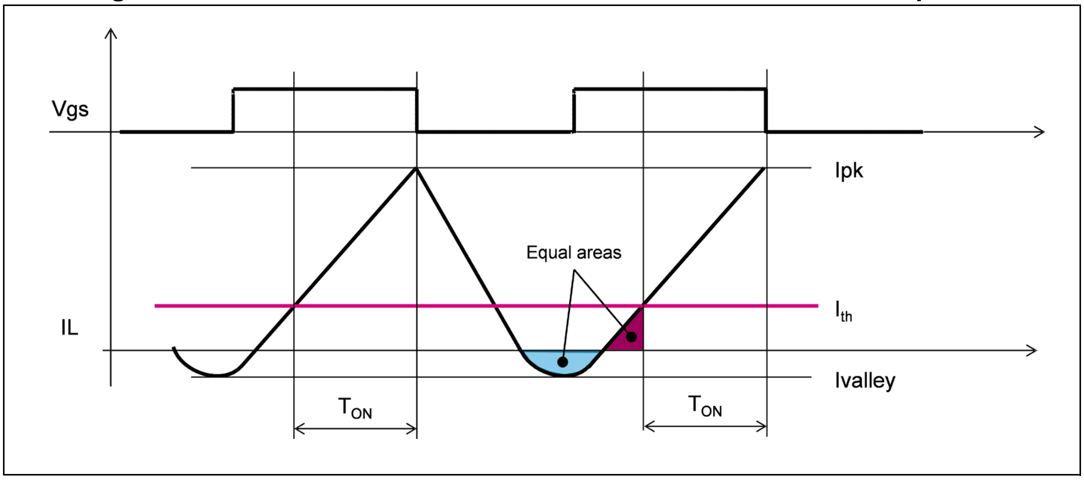


Table 1. PFC signals description

Name	Description
Vin	AC line monitor for: line synchronization, peak voltage sampling, brown-in/out
Vbulk	Output voltage sampled for control loop PI and OVP, UVP
Vzcd	Demagnetization detection from auxiliary for TM
Isen	Current sensing for minimum current threshold and OCP

As shown in *Figure 4*, defining the minimum current level before starting the calculated Ton period allows the PFC to process more energy as compared to the case using only the on-time calculated by the control loop. This is a good way to balance the energy lost in MOS charging, nearly compensating constant on-time non-idealities. This operation allows also to artificially increase the on-time near the mains voltage zero crossing. As a result the energy transfer is more efficient and the input current distortion is reduced.

Figure 4. Enhanced constant on-time PFC boost inductor current profile



The frequency compensation of the feedback loop that controls the output voltage is implemented using firmware execution by the STNRG388A.

The voltage feedback loop is compensated using a PI algorithm. More in detail it uses two different loop speeds according to the operating conditions.

During steady-state operation the algorithm implements a slow response loop with crossover frequency designed around 10 Hz, which guarantees excellent THD and PF.

During transient operations that cause large bulk voltage deviation, the loop speed becomes faster and the recovery time is dramatically reduced. This effect is obtained using a different set of PI coefficients applied when the controller detects a variation of the bulk voltage greater than a defined threshold.

This control technique, available only with the digital approach, allows the best performance in both steady-state and transient conditions.

A feedforward compensation based on mains input voltage measurement is also introduced in order to keep the regulation loop bandwidth constant over the complete mains input voltage range.

The PI compensation algorithm calculates the required on-time near the zero-crossings of the mains voltage. The calculation is based on the last taken sixteen output voltage samples.

The PWM signal is generated using two coupled high speed “State Machine, Event Driven” (SMED). SMEDs are software configurable peripherals able to manage very fast asynchronous events without CPU intervention. SMEDs inputs are the zero current detection signal, used for valley switching, minimum current detection for enhanced constant on-time implementation and overcurrent information for power stage protection. All these three signals use the analog comparators inside the STNRG388A device.

In critical condition, such as when the mains voltage approaches the PFC DC output, a proprietary algorithm guarantees that the “Continuous Conduction Mode” (CCM) is avoided.

The PFC can be operated in valley skipping and burst mode for improved efficiency at low output loads.

Valley skipping condition is directly managed by properly configured SMEDs states. If the calculated on-time is lower than a minimum configurable thresholds, the system inserts valley skipping, up to three valleys.

The system continuously checks that the PFC output voltage is under a reference value. If the limit is exceeded, the PFC enters the burst mode switching off the MOS. As soon as the PFC output voltage goes below a recovery value, the PFC is restarted.

1.7 Digital LLC description

The LLC block diagram and STNRG388A pins used for LLC control are shown in *Figure 5*.

The schematic shows that the voltage feedback loop is implemented with a typical analog approach.

The loop is closed sensing both the output voltages with a circuit using a TL431 device modulating the current in the optocoupler diode.

The resulting feedback voltage is then sampled by the 10-bit ADC of the STNRG388A device.

In order to avoid half bridge (HB) switching noise effects, feedback voltage sampling instants are opportunely chosen by means of a dedicated ADC hardware triggering function.

The resonant stage average current is also sampled by the ADC to implement the first level of overcurrent protection (OCP). The intervention level is calculated taking into account the input voltage to the resonant stage. This approach allows limiting the maximum output power.

A second level OCP is implemented by an external comparator integrated in the L6382D IC which immediately stops the gate drives activity. A digital fault signal is sent to the STNRG388A that resets the system and attempts a restart after about 1 s. This protection has therefore an auto-restart behavior but can be easily modified into a latched one.

The HB power MOSFETs are driven by the controller's coupled SMEDs through the half bridge gate driver in the L6382. The input signals to the SMEDs include the resonant stage zero current detection signal and a signal for adaptive dead time management generated by a dedicated circuitry.

The zero current detection information is used to implement a proprietary control technique named “Time-Shift Control” (TSC). The TSC methodology consists in controlling the amount of time elapsing from a zero-crossing of the tank current to the switch-off of the MOSFET currently on, as shown in *Figure 6*. Conceptually, with TSC an inner loop is closed and the outer loop that regulates the output voltage provides the reference for the inner loop. This inner loop is completely managed by SMEDs using the zero current detection information.

Time-shift control outperforms the direct frequency control method.

In particular, one of the advantages of the TSC method is that the power stage, as a first approximation, behaves like a first order system. As a consequence, the compensator design is considerably simplified and can be obtained better dynamic performance to input voltage and load transients.

A dedicated anti-capacitive protection mechanism prevents the harmful switching in the capacitive mode operation. This protection acts in two different ways.

If the HB operation approaches the capacitive mode (i.e.: the ZCD signal becomes closer to the HB transition than a predefined time) the STNRG388A decreases linearly the time-shift applied. This means an increase of the HB switching frequency that moves the system away from the capacitive mode. If the operation is still close to the capacitive mode after a certain timeout value, the system is shut down.

If the capacitive mode is detected (i.e.: the current waveform leads the HB voltage) the system is immediately shut down.

Figure 5. LLC block diagram and signals description

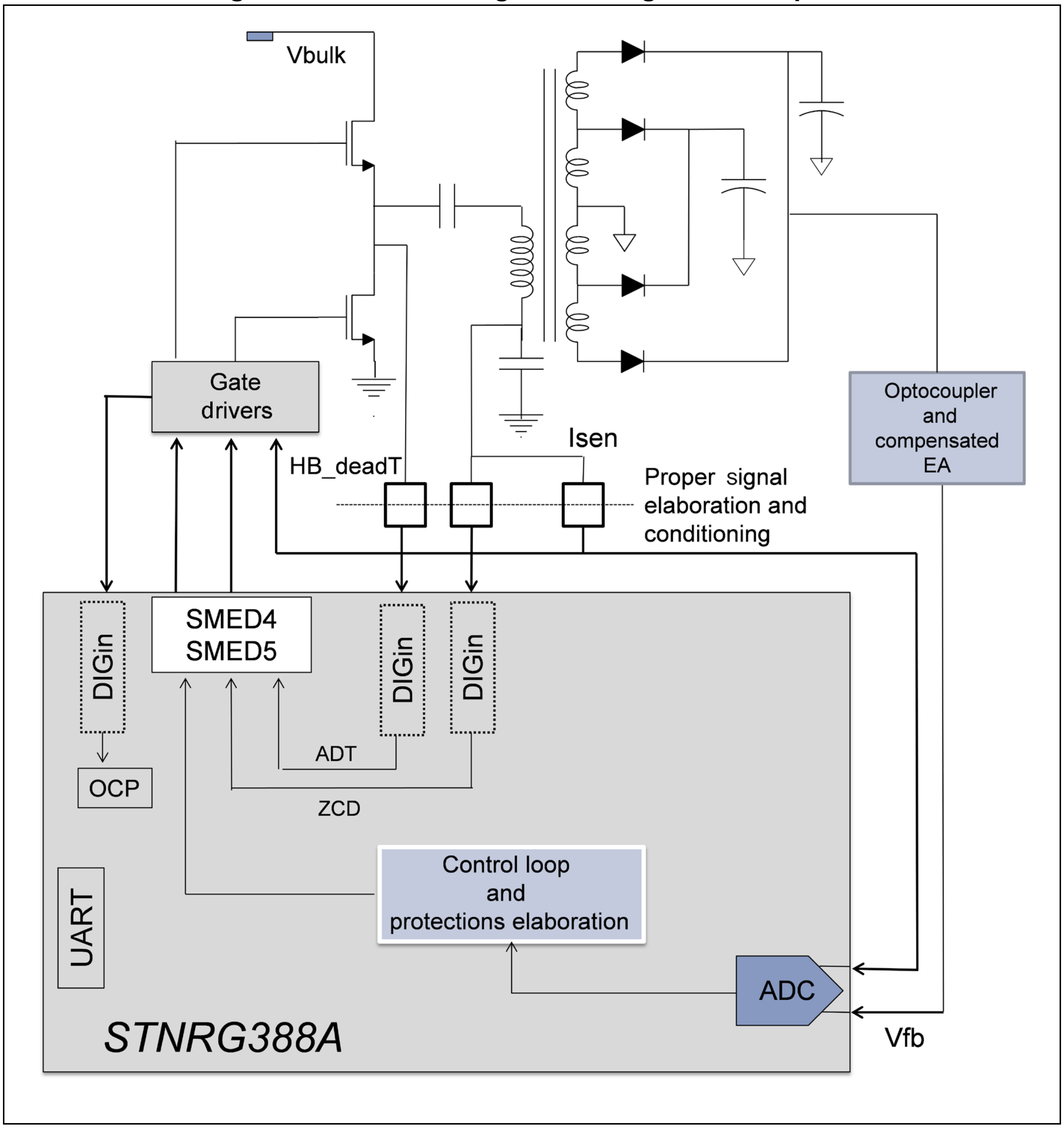
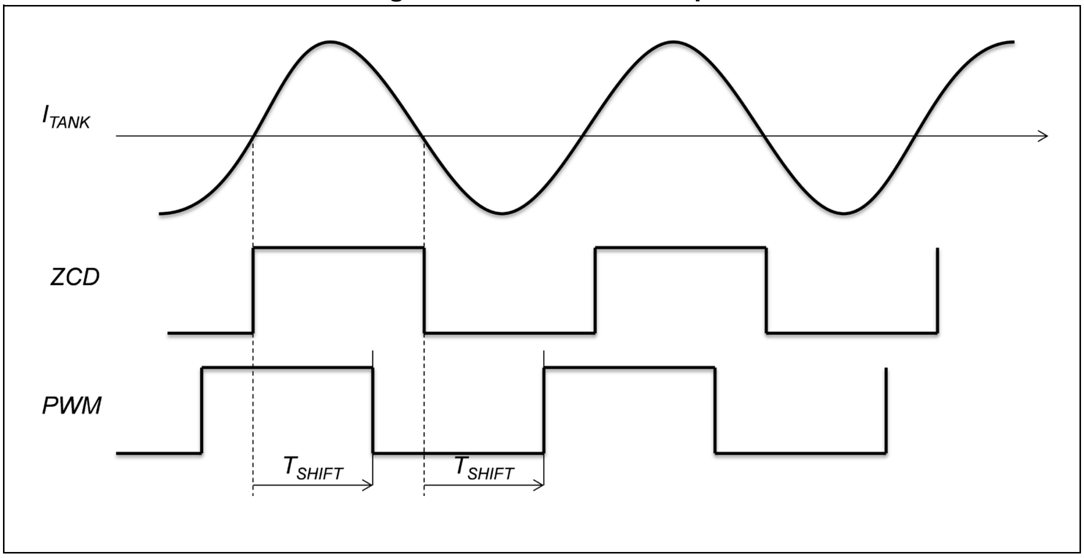


Table 2. LLC signals description

Name	Description
Vfb	Control loop feedback voltage
Isen	Current sense for load management and OCP
HB_deadT	Adaptive dead time signal

Figure 6. Time-shift concept



2 Efficiency measurement

Table 3 shows the overall efficiency, measured at different mains voltages.

It is worth reminding that, even if the efficiency results are quite good, this evaluation board is not optimized in this respect. Many circuits, that are not currently used, are still supplied, adversely affecting efficiency results.

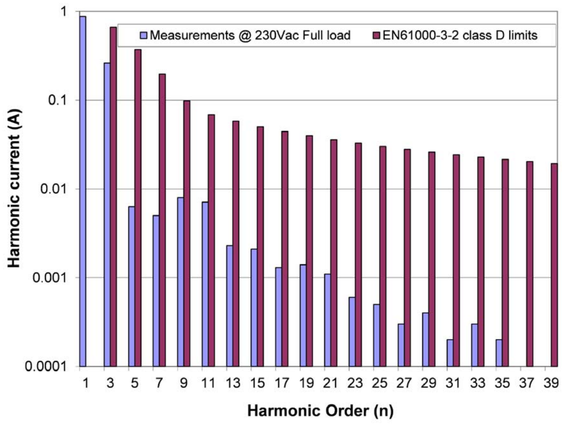
Table 3. Overall efficiency measured at different AC input voltages

	Load = 100%								
Vin [Vrms]	**5 Volt**		**12 Volt**		**24 Volt**		**Pout**	**Pin**	**Eff.**
	Vout [V]	Iout [A]	Vout [V]	Iout [A]	Vout [V]	Iout [A]	[W]	[W]	**[%]**
90	5.013	1.9987	11.95	2.0001	23.96	5.993	177.513	201.71	**88.00%**
115	5.013	1.9987	11.95	2.0001	23.96	5.993	177.513	198.21	**89.56%**
230	5.013	1.9987	11.95	2.0001	23.96	5.993	177.513	194.21	**91.40%**
264	5.013	1.9987	11.95	2.0001	23.96	5.993	177.513	193.75	**91.62%**
	Load = 75%								
Vin [Vrms]	**5 Volt**		**12 Volt**		**24 Volt**		**Pout**	**Pin**	**Eff.**
	Vout [V]	Iout [A]	Vout [V]	Iout [A]	Vout [V]	Iout [A]	[W]	[W]	**[%]**
90	5.011	1.4981	11.95	1.4997	23.99	4.4943	133.2467	150.66	**88.44%**
115	5.01	1.4981	11.95	1.4997	23.99	4.4943	133.2452	148.75	**89.58%**
230	5.01	1.4981	11.95	1.4997	23.99	4.4943	133.2452	146.76	**90.79%**
264	5.01	1.4981	11.95	1.4998	23.99	4.4962	133.2919	146.55	**90.95%**
	Load = 50%								
Vin [Vrms]	**5 Volt**		**12 Volt**		**24 Volt**		**Pout**	**Pin**	**Eff.**
	Vout [V]	Iout [A]	Vout [V]	Iout [A]	Vout [V]	Iout [A]	[W]	[W]	**[%]**
90	5.009	0.9981	11.95	0.9998	24.01	2.9962	88.88585	101.26	**87.78%**
115	5.009	0.9981	11.95	0.9998	24.02	2.9962	88.91582	100.51	**88.46%**
230	5.009	0.9981	11.95	0.9998	24.01	2.9962	88.88585	99.82	**89.05%**
264	5.009	0.9981	11.95	0.9998	24.01	2.9962	88.88585	99.72	**89.14%**
	Load = 25%								
Vin [Vrms]	**5 Volt**		**12 Volt**		**24 Volt**		**Pout**	**Pin**	**Eff.**
	Vout [V]	Iout [A]	Vout [V]	Iout [A]	Vout [V]	Iout [A]	[W]	[W]	**[%]**
90	5.01	0.4937	11.96	0.4997	24.03	1.4981	44.44919	53.02	**83.83%**
115	5.01	0.4937	11.96	0.4997	24.03	1.4981	44.44919	52.94	**83.96%**
230	5.01	0.4937	11.96	0.4997	24.03	1.4981	44.44919	52.85	**84.10%**
264	5.01	0.4937	11.96	0.4997	24.03	1.4981	44.44919	52.47	**84.71%**

3 PFC performance

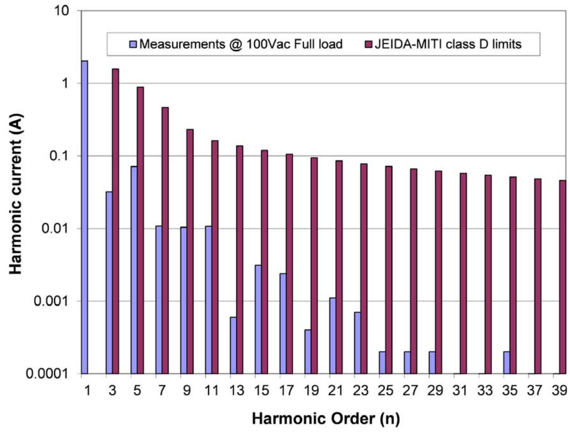
This evaluation board has been tested according to the European standard EN61000-3-2 Class-D and Japanese standard JEITA-MITI Class-D, at the full load and 75 W input power, at both the nominal input voltage mains. The test results are shown from *Figure 7* to *Figure 10*.

Figure 7. EN61000-3-2 compliance at 230 V ac - 50 Hz, full load



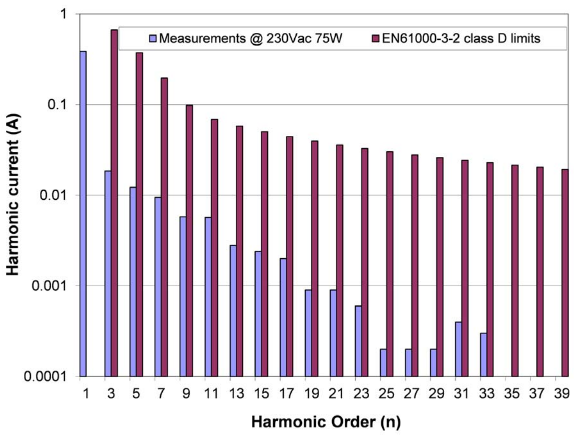
Vin = 230 V ac - 50 Hz, Pin = 196 W

Figure 8. JEITA-MITI compliance at 100 V ac - 50 Hz, full load



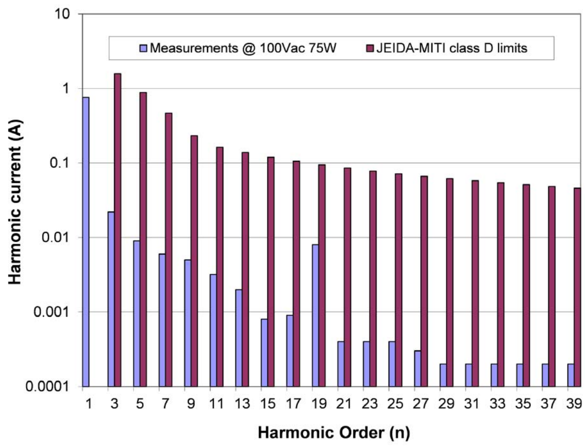
Vin = 100 V ac - 50 Hz, Pin = 202 W

Figure 9. EN61000-3-2 compliance at 230 V ac - 50 Hz, 75 W



Vin = 230 V ac - 50 Hz, Pin = 75 W

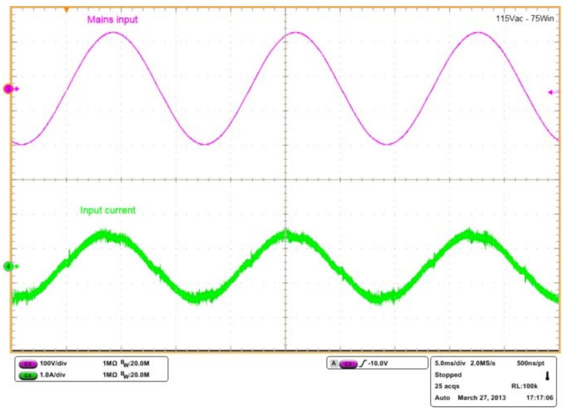
Figure 10. JEITA-MITI compliance at 100 V ac - 50 Hz, 75 W



Vin = 100 V ac - 50 Hz, Pin = 75 W

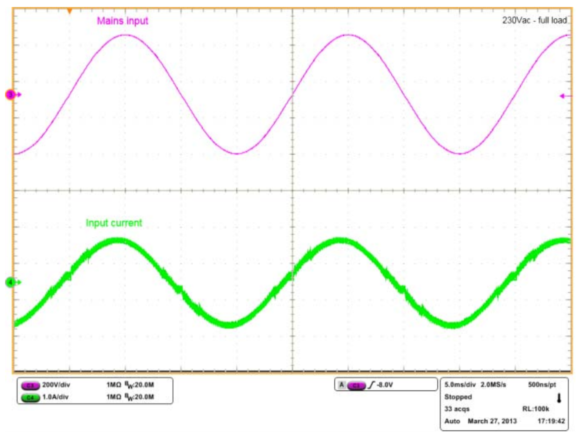
In *Figure 11* and *Figure 12* the AC input voltage and current waveforms at the nominal input mains and full load are shown.

Figure 11. Input voltage and current at 115 V ac - full load



CH3: AC input voltage CH4: AC input current

Figure 12. Input voltage and current at 230 V ac - full load



CH3: AC input voltage CH4: AC input current

In *Table 4* power factor (PF) and total harmonic distortion (THD) are shown for nominal input voltages.

Table 4. PFC PF and THD

115 V ac	PF	THD [%]
100%	0.995	2.4
75%	0.994	2.6
50%	0.987	3.3
25%	0.959	5.5
230 V ac	**PF**	**THD [%]**
100%	0.972	3.2
75%	0.952	3.6
50%	0.906	5.3
25%	0.754	11.3

4 Functional checks

4.1 Power factor corrector stage

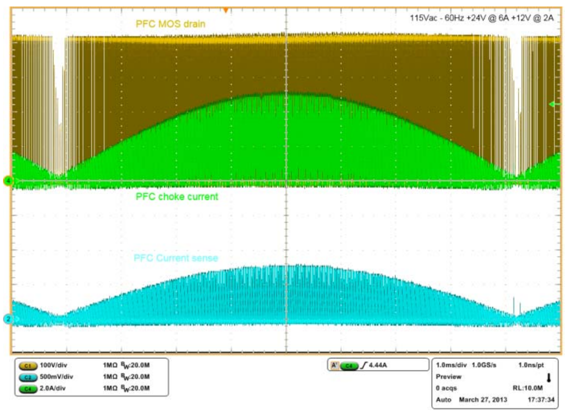
Figure 13 shows the PFC MOSFET's drain voltage, choke current and voltages on the current sense pin along a line half period at 115 V ac. Low current distortion and high power factor are achieved thanks to the enhanced constant on-time technique. Moreover, this control methodology guarantees a considerable reduction of THD (total harmonic distortion).

In *Figure 14* the same signals are captured at the top of the input sine wave. Transition mode control makes the inductor work on the boundary between the continuous and discontinuous conduction mode. ZCD transition (*Figure 17*) is detected by SMED1 and used as a start signal for a new switching cycle.

Figure 15 and *Figure 16* show the same waveforms at 230 V ac.

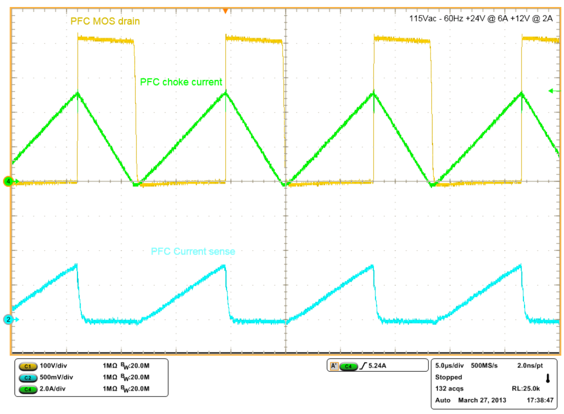
A significant plus of TM operation is the possibility to work in ZVS: if the converter instantaneous input voltage is lower than Vout/2, the ZVS (zero voltage switching) condition is achieved, decreasing MOSFET switching losses. As displayed in *Figure 16*, if the instantaneous input voltage is higher than Vout/2, the MOSFET is turned on just on the valley of the drain voltage. In other words, valley switching guarantees transition losses minimization.

Figure 13. PFC Vds and inductor current at 115 V ac - 60 Hz - full load



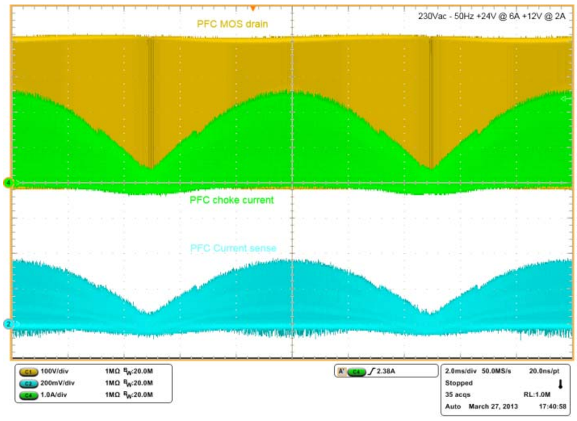
CH1: Q1 drain voltage
CH2: current sense
CH4: choke current

Figure 14. PFC Vds and inductor current at 115 V ac - 60 Hz - full load - detail



CH1: Q1 drain voltage
CH2: current sense
CH4: choke current

Figure 15. PFC Vds and inductor current at 230 V ac - 50 Hz - full load



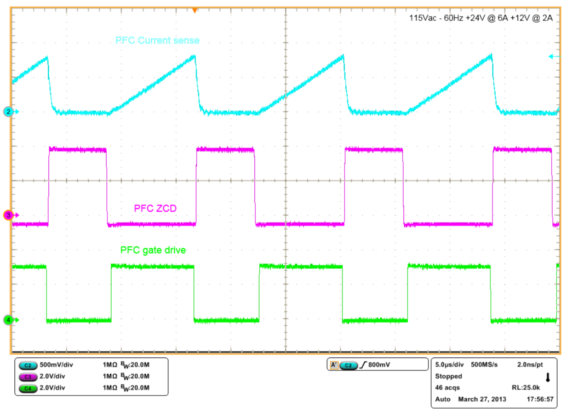
CH1: Q1 drain voltage
CH2: current sense
CH4: choke current

Figure 16. PFC Vds and inductor current at 230 V ac - 50 Hz - full load - detail

CH1: Q1 drain voltage
CH2: current sense
CH4: choke current

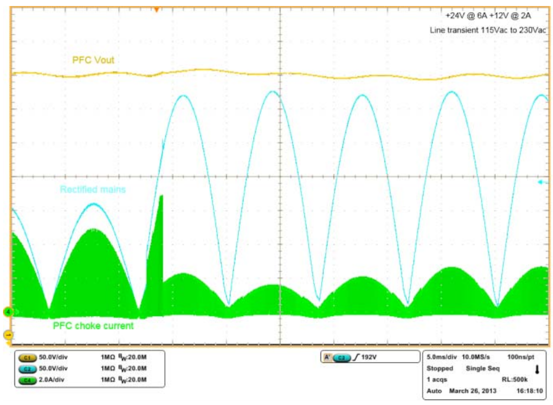
Figure 18 shows PFC reaction to a line transient from 115 V ac to 230 V ac. In this condition, a predictive algorithm detects the input voltage step and forces an immediate recalculation of the PFC compensation algorithm. As a consequence, on-time is updated without waiting for zero crossing condition.

Figure 17. PFC signals at 115 V ac - 60 Hz - full load



CH2: current sense
CH3: ZCD
CH4: gate drive

Figure 18. PFC signals - line transient 115 V ac to 230 V ac - 60 Hz - full load



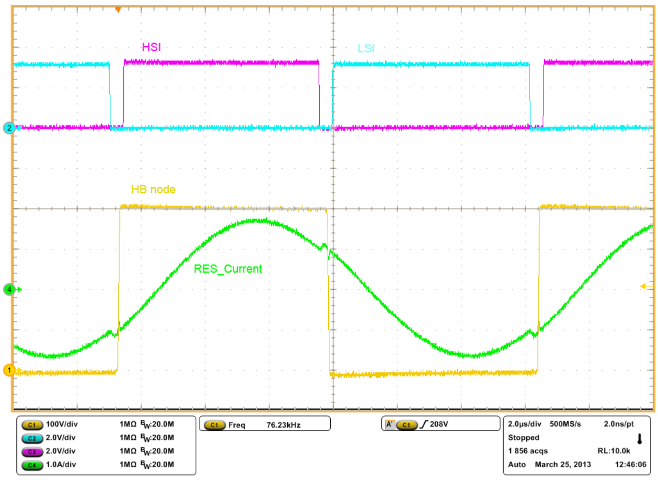
CH1: output voltage
CH2: input voltage
CH4: choke current

4.2 Resonant stage

Hereafter are shown some waveforms related to the resonant stage during steady-state operation. The switching frequency at the full load and nominal input voltage is around 75 KHz, in order to achieve a good trade-off between transformer losses and size.

Figure 19 shows the resonant ZVS operation. Since the converter operates slightly below resonance, the resonant current lags behind the voltage applied, as the input impedance of the resonant network is inductive. The current is negative during the rising edge of half bridge voltage and positive during the falling edge, providing, in both cases, the energy to allow the node HB to swing.

Figure 19. Resonant stage waveforms, full load

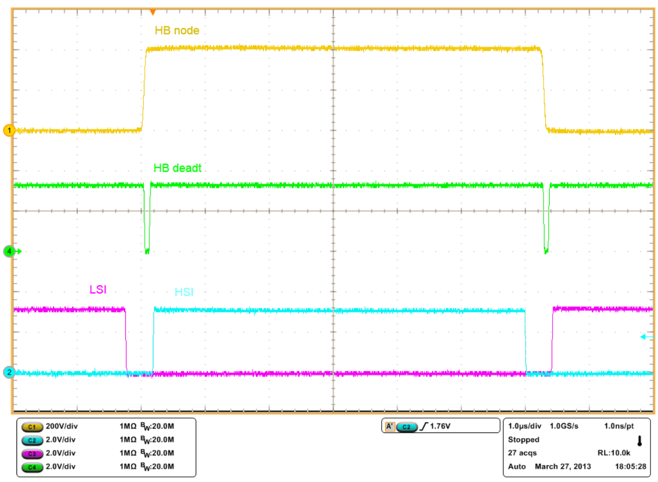


CH1: HB voltage CH2: LS gate

CH3: HS gate CH4: resonant current

In *Figure 20* the adaptive dead time feature is represented.

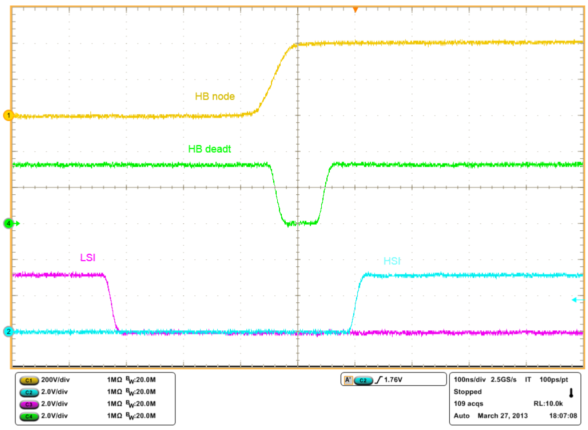
Figure 20. Adaptive dead time



CH1: HB voltage CH2: HS gate

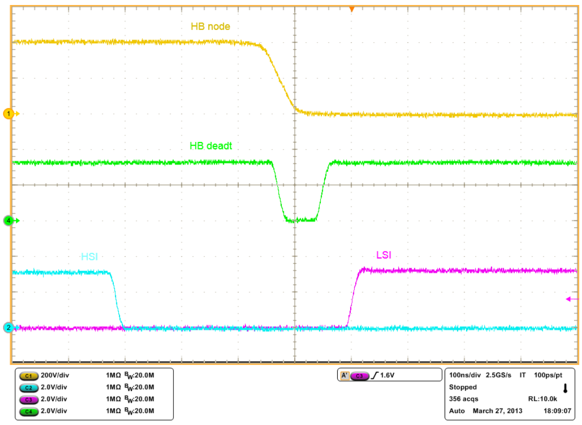
CH3: LS gate CH4: HB dead time

Figure 21. Adaptive dead time - HB rising edge



CH1: HB voltage CH2: HS gate
CH3: LS gate CH4: HB dead time

Figure 22. Adaptive dead time - HB falling edge



CH1: HB voltage CH2: HS gate
CH3: LS gate CH4: HB dead time

Adaptive dead time is implemented through a dedicated external sensing circuitry. As shown in *Figure 21* and *Figure 21*, the MOSFETs are turned on after the rising edge of HB_deadt signal.

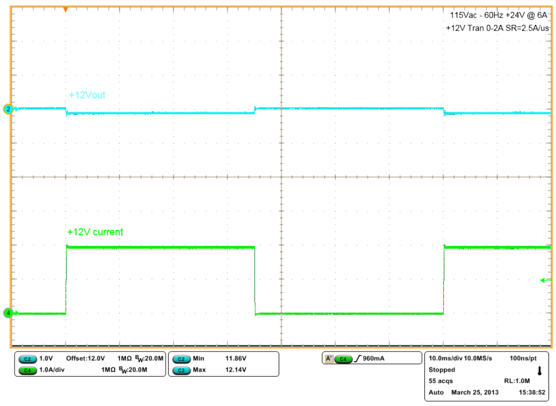
4.3 Dynamic load operation and output voltage regulation

Figure 23 and *Figure 25* show the output voltage regulation in case of load transients on both the resonant stage outputs. The waveforms have been captured applying to one output a load transient from 0 to the full load, while the other is delivering the full load.

Time-shift control allows a dramatic improvement in resonant stage transient response. The output voltage reaches the steady-state condition in less than 1 ms. It can also be noted that 12 V output has a very tight variation (within ± 3%) even considering the spikes at the current edges (see *Figure 24*).

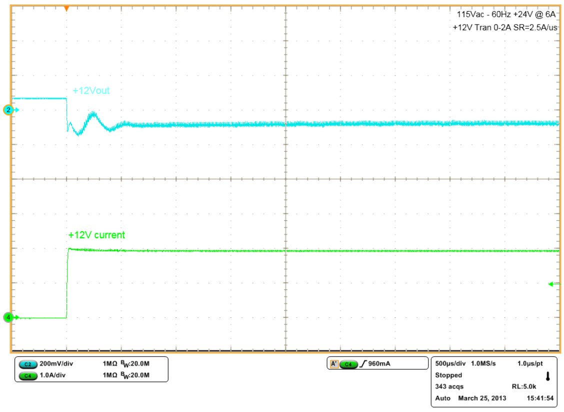
Likewise, in *Figure 26*, it is possible to see that the 24 V output has a tight variation (within ± 4%).

Figure 23. 12 V load transition at 115 V ac - 60 Hz



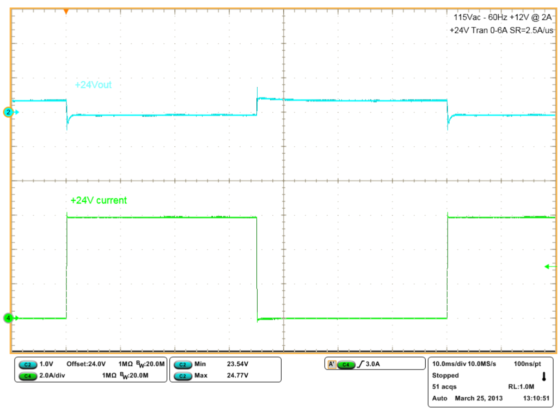
CH2: 12 V output voltage
CH4: 12 V output current

Figure 24. 12 V transition no-load to full load at 115 V ac - 60 Hz



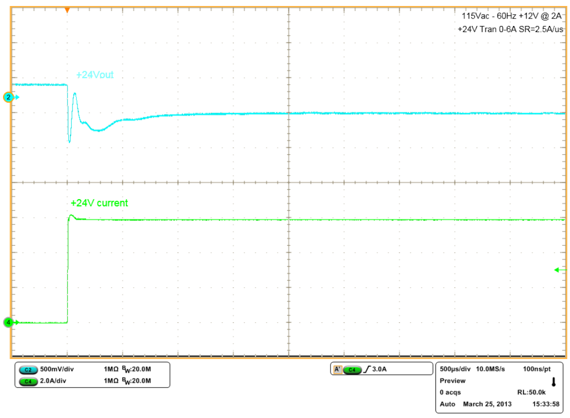
CH2: 12 V output voltage
CH4: 12 V output current

Figure 25. 24 V load transition at 115 V ac - 60 Hz



CH2: 24 V output voltage
CH4: 24 V output current

Figure 26. 24 V transition no-load to full load at 115 V ac - 60 Hz

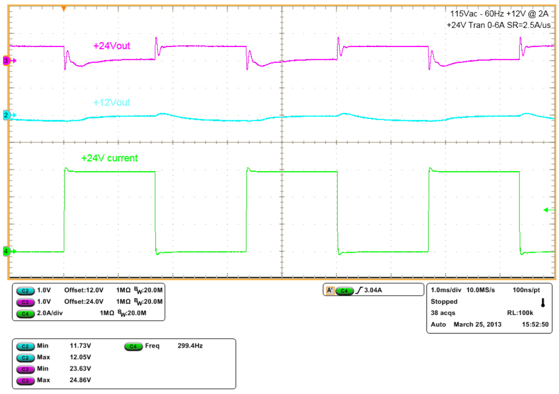


CH2: 24 V output voltage
CH4: 24 V output current

4.4 Cross regulation

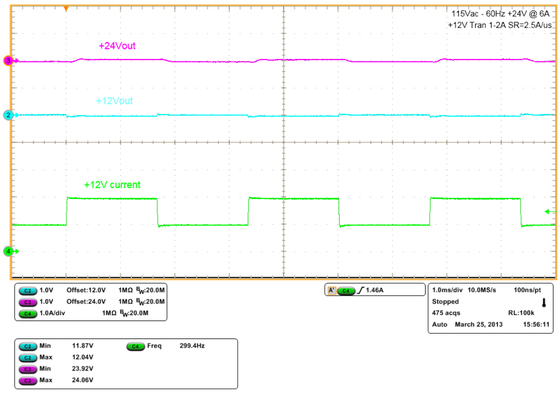
Figure 27 and *Figure 28* show the output voltage cross regulation with transient conditions similar to those of the test described above apart from the load step frequency, which is 300 Hz on one output, with the other one delivering the rated load. The transient response is so good that both outputs are able to reach the steady-state condition well before another load transition takes place.

Figure 27. 24 V load transition at 115 V ac - 60 Hz - cross regulation on 12 V



CH2: 12 V output voltage
CH3: 24 V output voltage
CH4: output current

Figure 28. 12 V load transition at 115 V ac - 60 Hz - cross regulation on 24 V



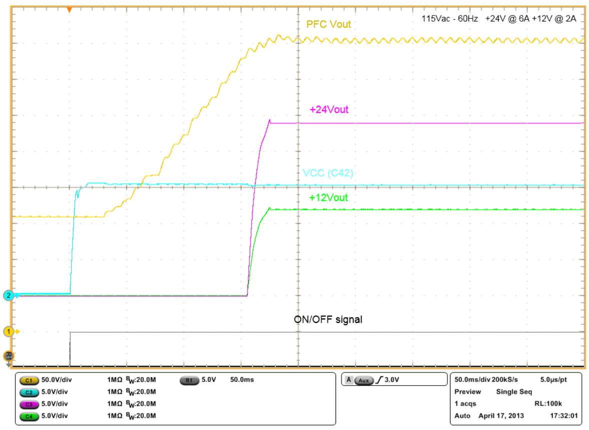
CH2: 12 V output voltage
CH3: 24 V output voltage
CH4: output current

4.5 Startup

Figure 29 and *Figure 30* show waveforms during the startup at nominal voltages and the full load of the PFC and resonant stages. It is possible to note the sequence of the two stages; once the ON/OFF signal is asserted high, the voltage on C42 increases up to the Vcc turn-on threshold of the L6382D.

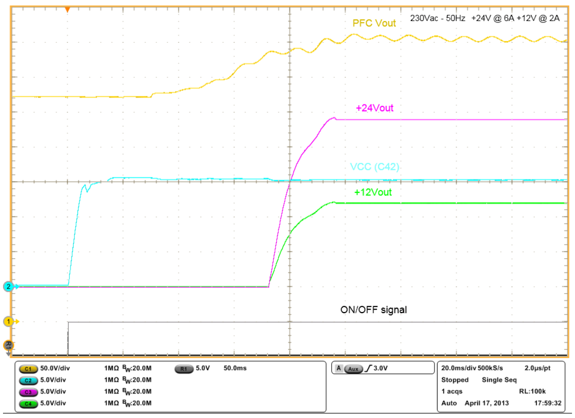
The driver, then, generates the supply voltage for the STNRG388A. At first the PFC is enabled, hereafter its output voltage starts increasing from the mains rectified peak voltage to its nominal value. Meanwhile the resonant stage is kept disabled. As soon as the PFC voltage reaches 380 V, the resonant starts to operate. Hence both the output voltages rise according to the soft-start and reach their nominal levels.

Figure 29. Startup at full load and 115 V ac - 60 Hz by ON/OFF signal



CH1: PFC output voltage CH2: ON/OFF signal
CH3: 24 V output voltage CH4: 12 V output voltage

Figure 30. Startup at full load and 230 V ac - 50 Hz by ON/OFF signal - detail

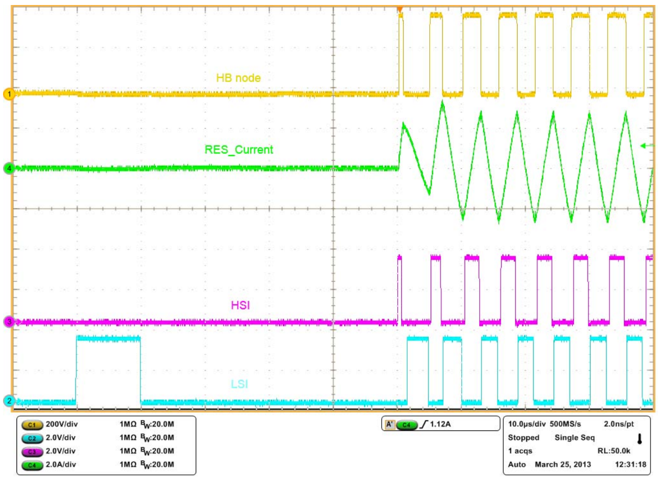


CH1: PFC output voltage CH2: ON/OFF signal
CH3: 24 V output voltage CH4: 12 V output voltage

Figure 31 shows the details of the half bridge startup. It can be noted that the low-side gate drive starts first with a pulse of about 10 µs, used to pre-charge the bootstrap capacitor. After a fixed delay of 40 µs (used to let any possible oscillations to be completely damped), the half bridge starts its switching activity. The initial HB pulse is asymmetric as the duration of the high-side pulse is half that of the low-side one. The purpose of this operation is to prevent hard switching operation and flux imbalance. This startup sequence is implemented by means of a proper configuration of resonant SMEDs' timings that can be dynamically adjusted depending on the operating conditions of the resonant stage. As soon as the startup sequence is completed, SMEDs are immediately reconfigured to manage normal operation.

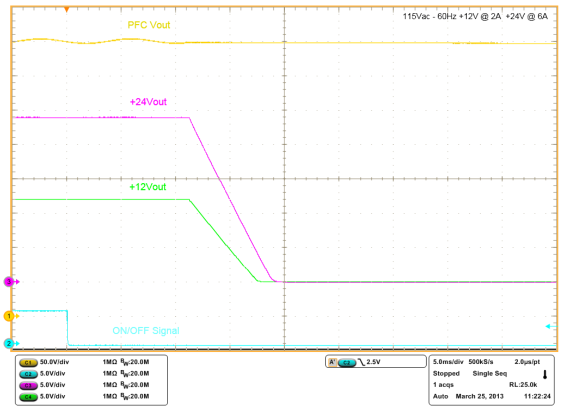
Figure 32 and *Figure 33* show the PFC and resonant converter turn-off.

Figure 31. Resonant stage safe startup at full load



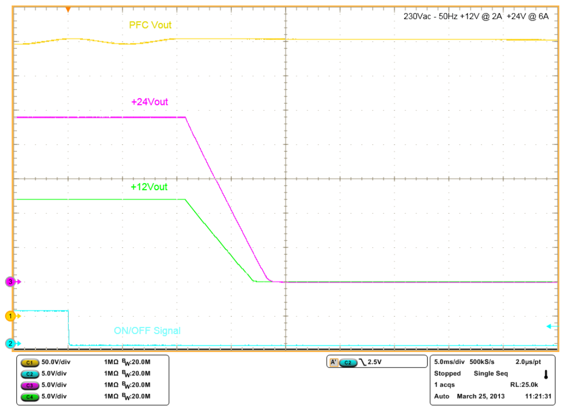
CH1: HB voltage CH2: LS gate
CH3: HS gate CH4: resonant current

Figure 32. Turn-off at full load and 115 V ac - 60 Hz by ON/OFF signal



CH1: PFC output voltage CH2: ON/OFF signal
CH3: 24 V output voltage CH4: 12 V output voltage

Figure 33. Turn-off at full load and 230 V ac - 50 Hz by ON/OFF signal - detail

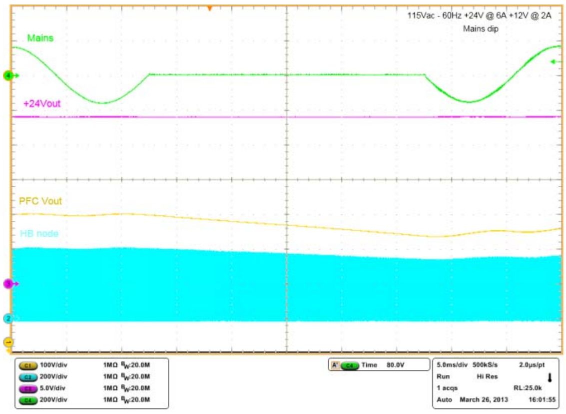


CH1: PFC output voltage CH2: ON/OFF signal
CH3: 24 V output voltage CH4:12 V output voltage

4.6 Mains dips

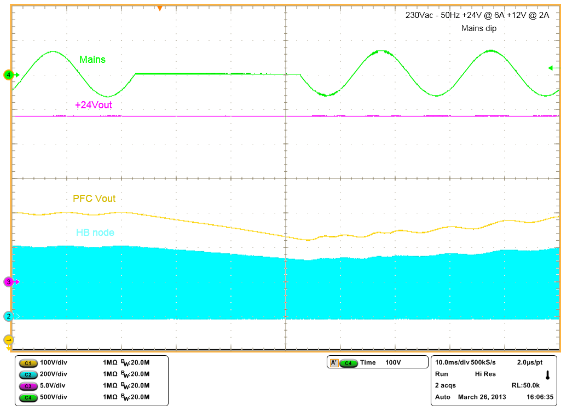
Figure 34 and *Figure 35* show the converter behavior in the case of one cycle and a half (25 ms at 60 Hz or 30 ms at 50 Hz) mains dip at 115 V ac and 230 V ac. Even if the PFC output voltage slightly drops, the output voltage is kept regulated without any disturbance, therefore demonstrating a good immunity of the circuit against mains dips.

Figure 34. One and half cycle (25 ms) mains dip at full load and 115 V ac - 60Hz



CH1: PFC output voltage CH2: HB voltage
CH3: 24 V output voltage CH4: PFC input voltage

Figure 35. One and half cycle (30 ms) mains dip at full load and 230 V ac - 50 Hz

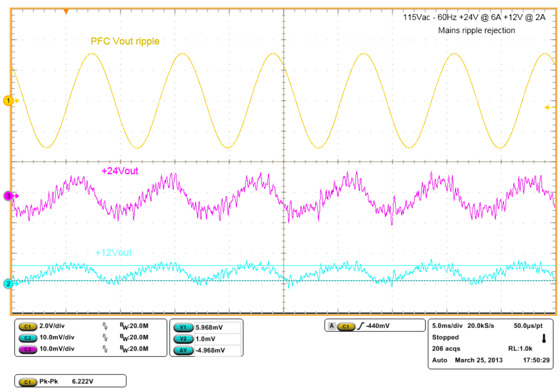


CH1: PFC output voltage CH2: HB voltage
CH3: 24 V output voltage CH4: PFC input voltage

4.7 Mains ripple rejection

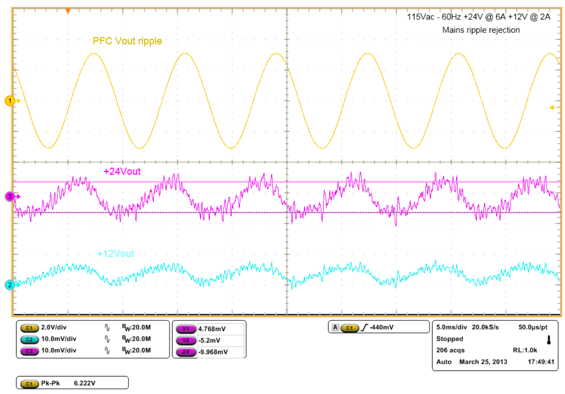
Another of the benefits introduced by the time-shift control method is the high rejection against input voltage variations of the LLC stage. This is obtained thanks to a high gain in the Gloop at mains frequency. During normal operation, the PFC output voltage has a ripple at twice of the mains frequency. On the two LLC output voltages the amount of the remaining ripple is very small.

Figure 36. LLC input voltage ripple rejection at full load - +12 Vout measurement(1)



CH1: PFC output voltage CH2: 12 V output voltage
CH3: 24 V output voltage

Figure 37. LLC input voltage ripple rejection at full load - +24 Vout measurement(1)



CH1: PFC output voltage CH2: 12 V output voltage
CH3 : 24 V output voltage

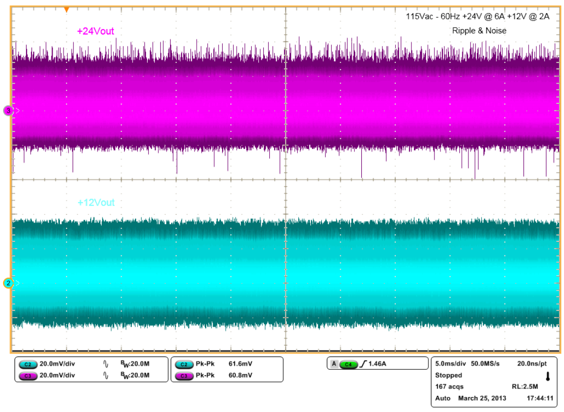
1. All signals are ac coupled.

Looking at *Figure 36* and *Figure 37* it is possible to calculate the rejection ratio for the two outputs. The PFC output ripple is 6.22 V while the remaining ripple is 4.97 mV on the +12 Vout and 9.97 mV on the +24 Vout.

This means the two rejection ratios are -61.9 dB and -55.9 dB respectively for +12 Vout and +24 Vout.

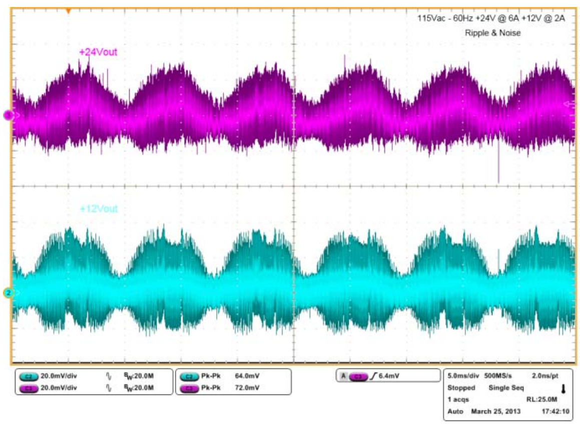
Figure 38 and *Figure 39* show the two LLC output voltages ripple and noise. In *Figure 38* the image is taken with infinite persistence and no synchronization while in *Figure 39* the signal are synchronized with input voltage mains and taken with the maximum resolution allowed by the scope (2 ns/pt). In both cases the channels bandwidth is set to 20 MHz. The ripple and noise measured is about 65 mV on the +12 V output and about 70 mV on the +24 V output. The second figure is useful to check which is the contribution of the residual mains ripple.

Figure 38. Output voltages ripple and noise with infinite persistence(1)



CH2: 12 V output voltage
CH3: 24 V output voltage

Figure 39. Output voltages ripple and noise with maximum resolution (2 ns/pt - sync. with mains)(1)



CH2: 12 V output voltage
CH3: 24 V output voltage

1. All signals are ac coupled.

5 Conducted emission pre-compliance test

Figure 40 and *Figure 41* show the peak and average measurements of the conducted emission noise at the full load and nominal mains voltages. The limits shown in the diagrams are EN55022 Class-B, which is the most popular norm for domestic equipment and has more severe limits compared to Class-A, dedicated to IT technology equipment. As visible in the diagrams, in all test conditions the measurements are far below the limits.

Figure 40. CE peak and average measurement 230 V - phase wire

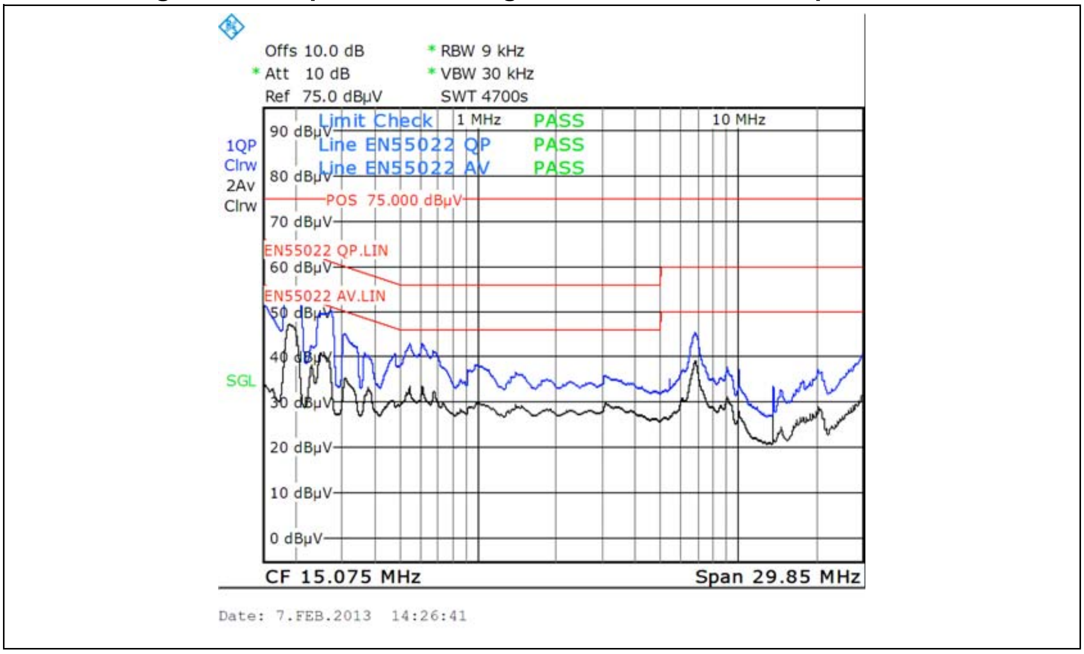
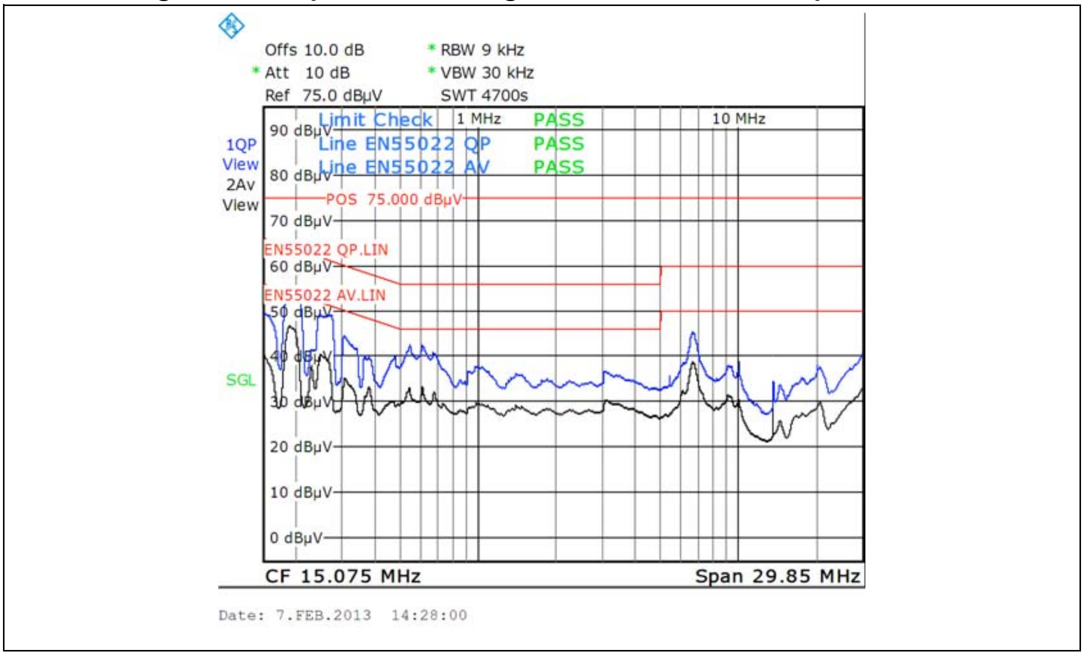


Figure 41. CE peak and average measurement 115 V - phase wire



Appendix A Electrical diagrams

Figure 42. Main board electrical diagram

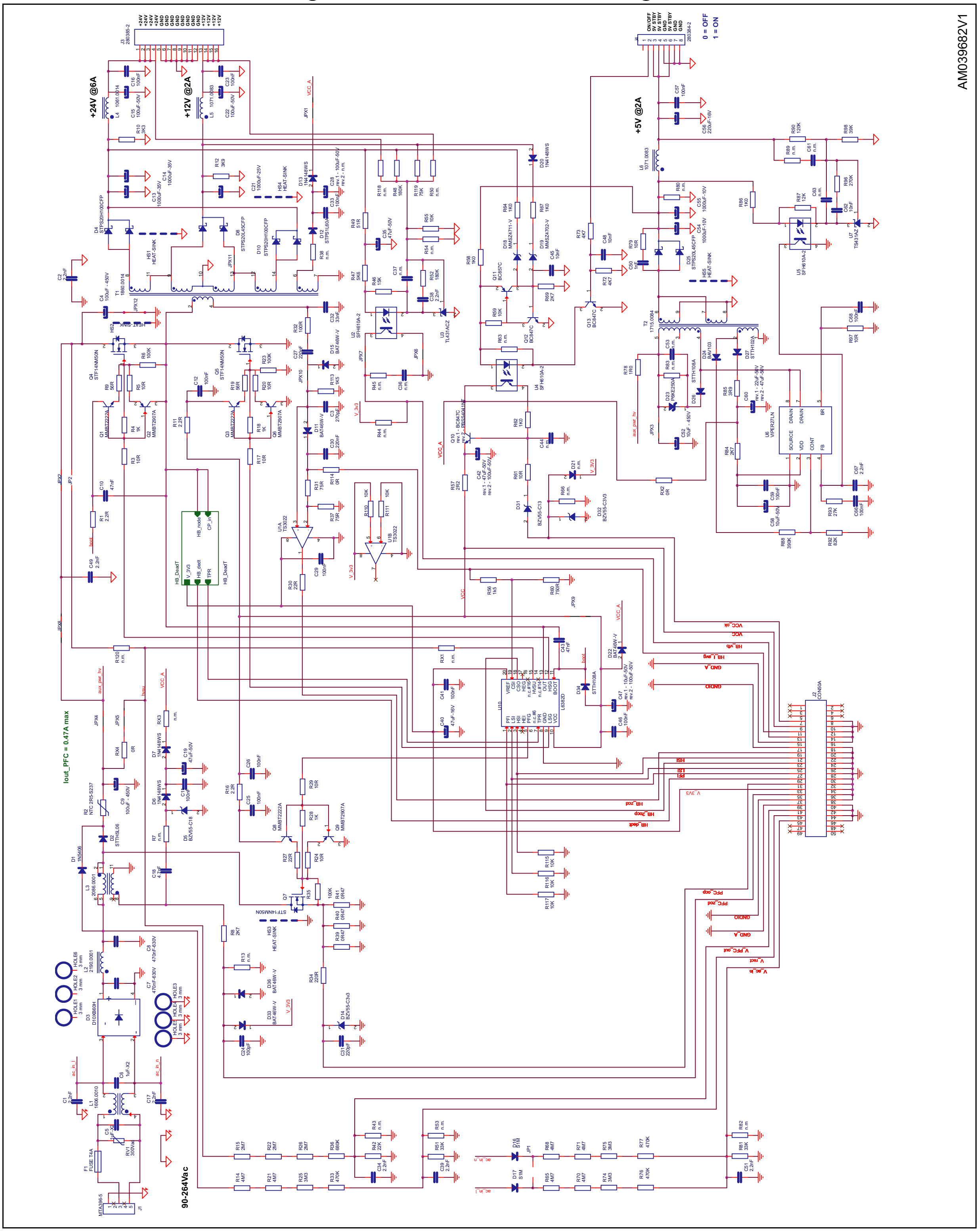


Figure 43. Electrical diagram of dead time block

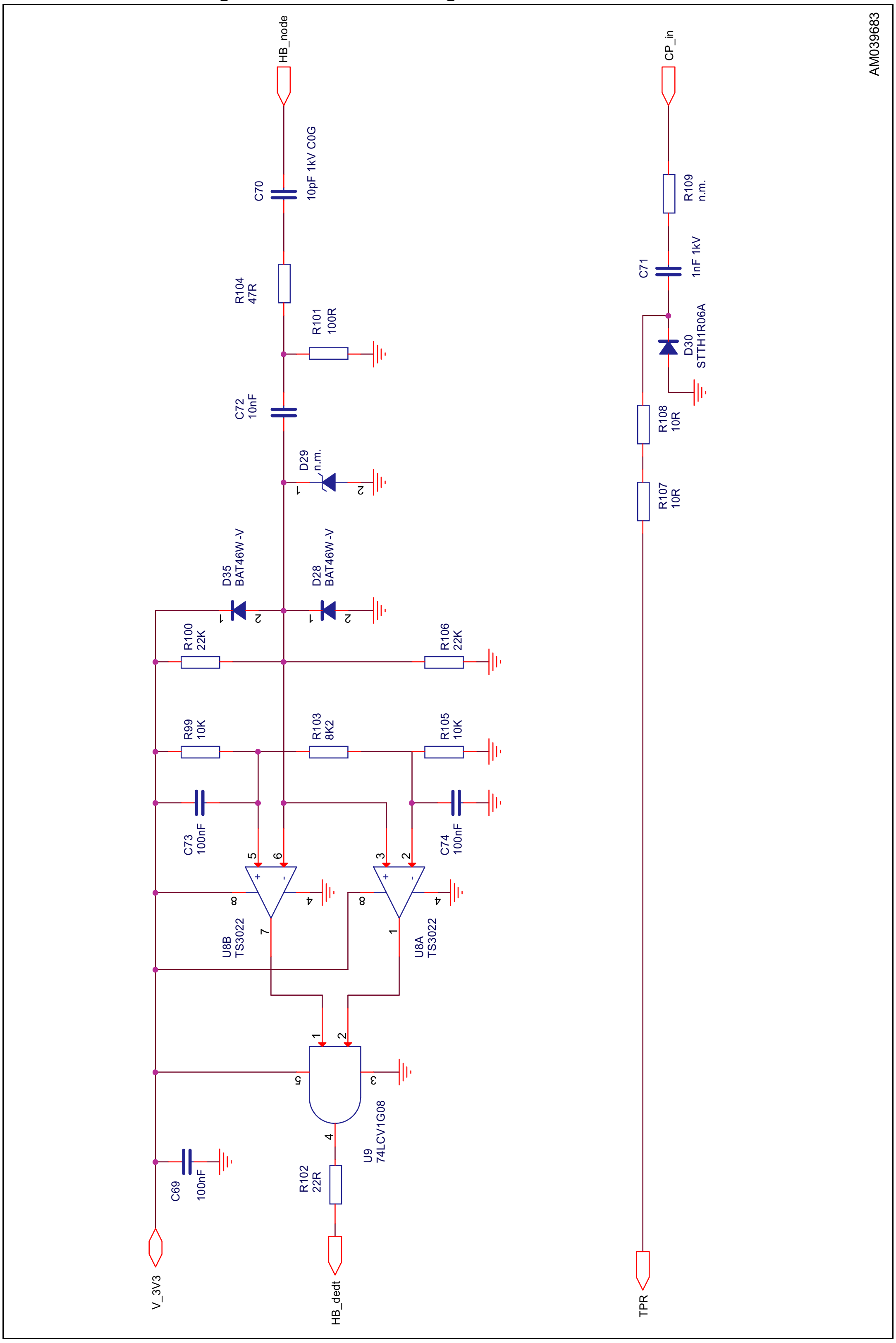


Figure 44. Electrical diagram of debug control board - controller

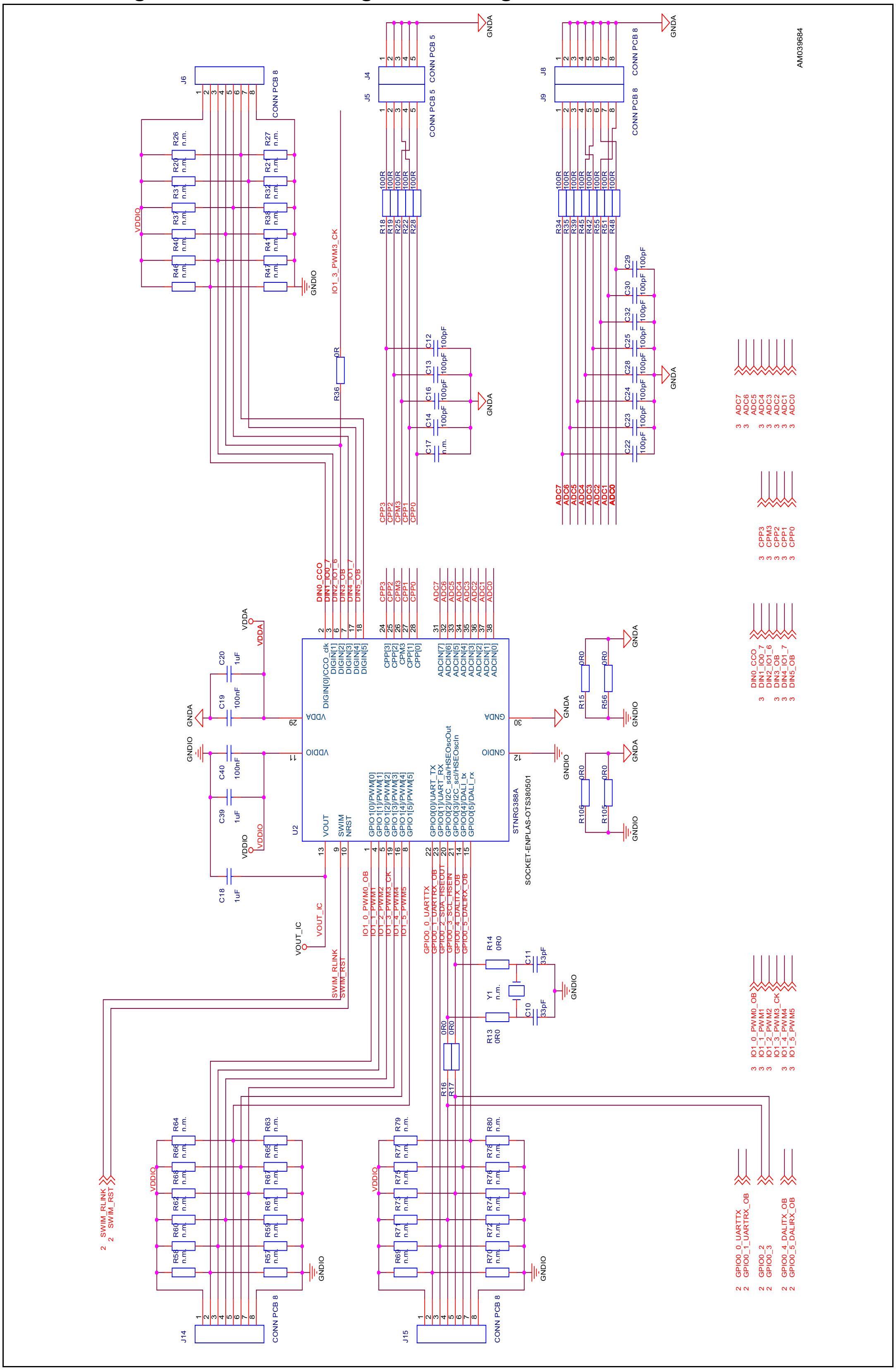


Figure 45. Electrical diagram of debug control board - connections

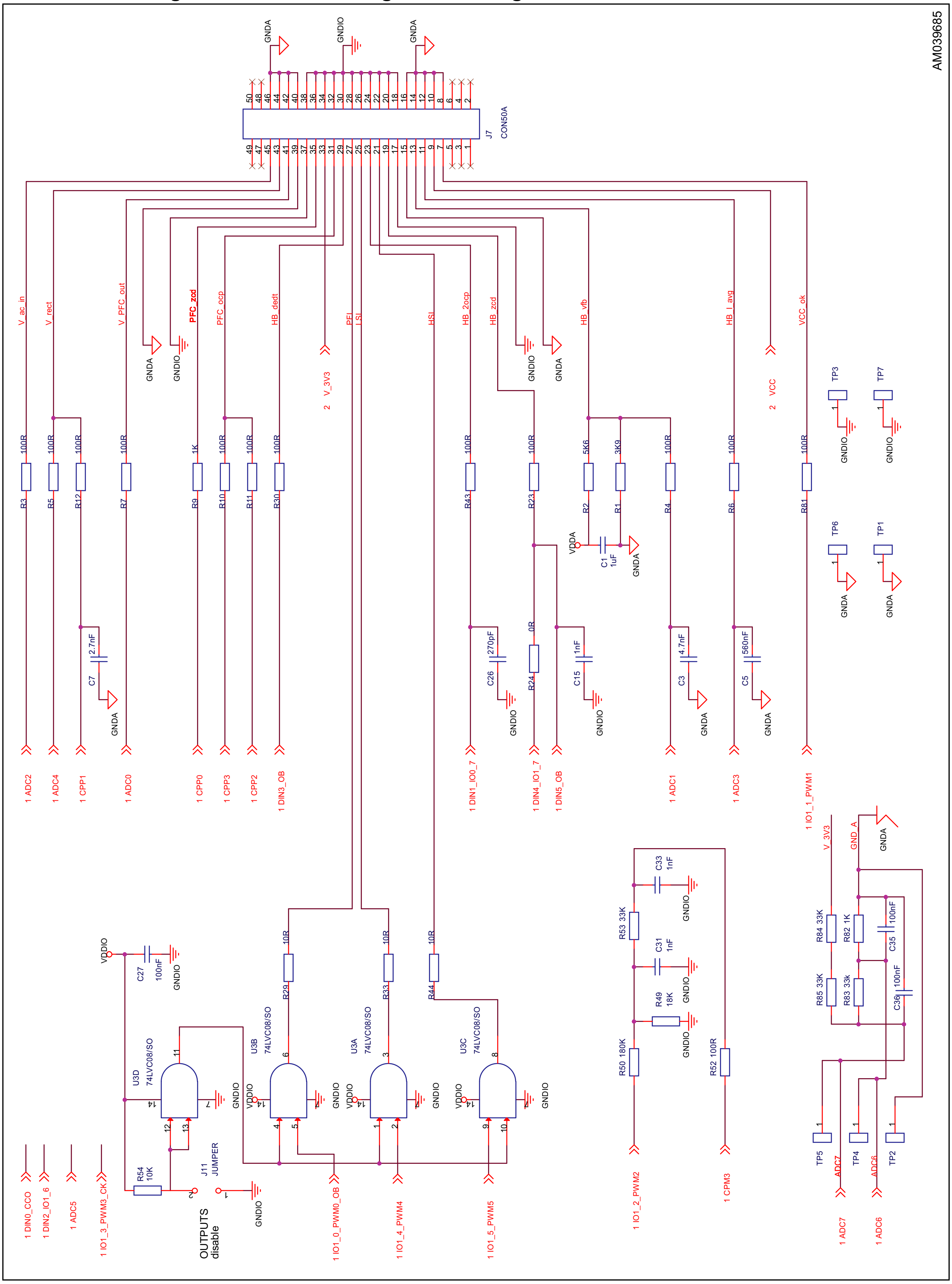


Figure 46. Electrical diagram of debug control board - power and interfaces

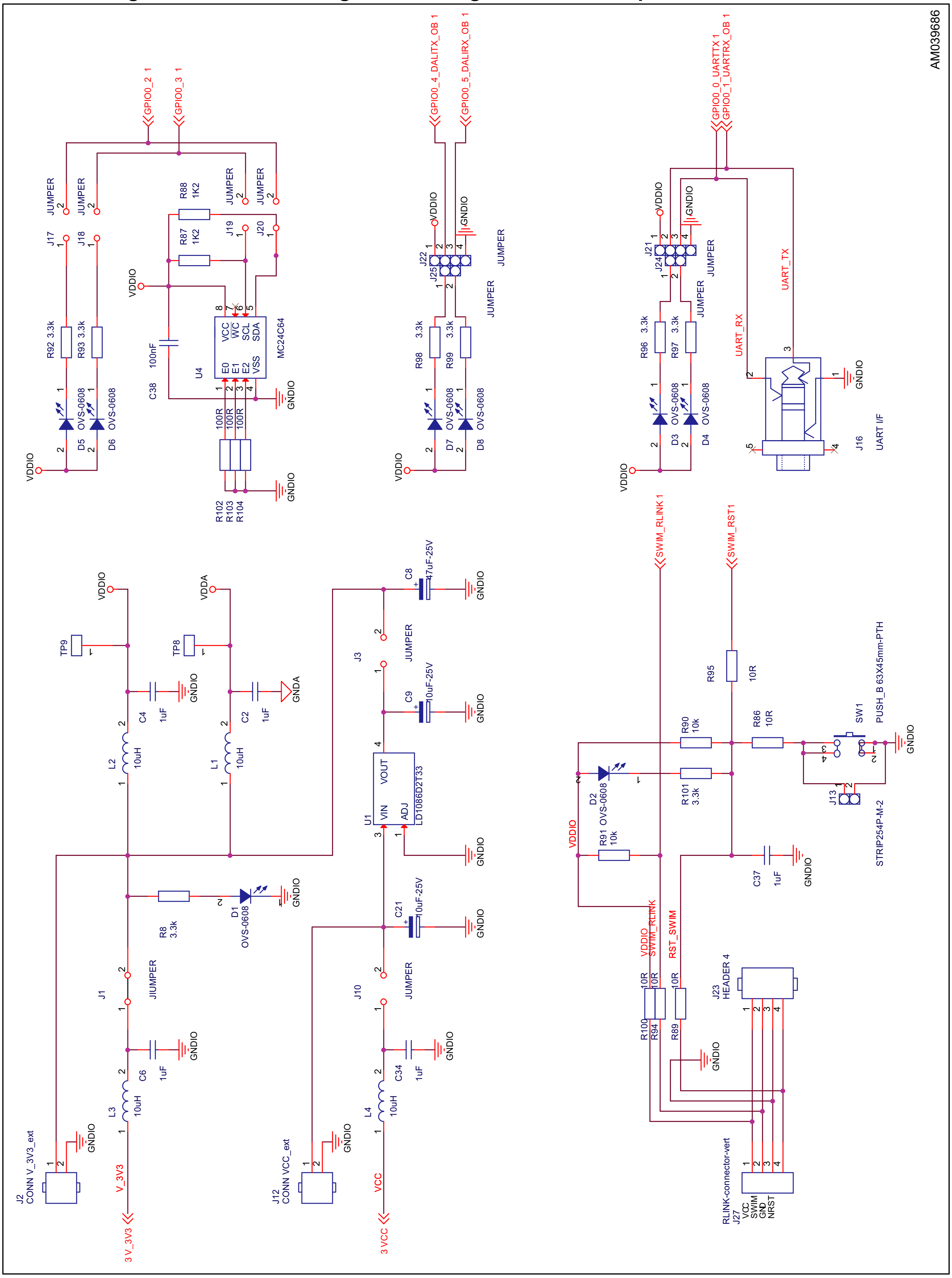


Figure 47. Electrical diagram of slim control board - controller

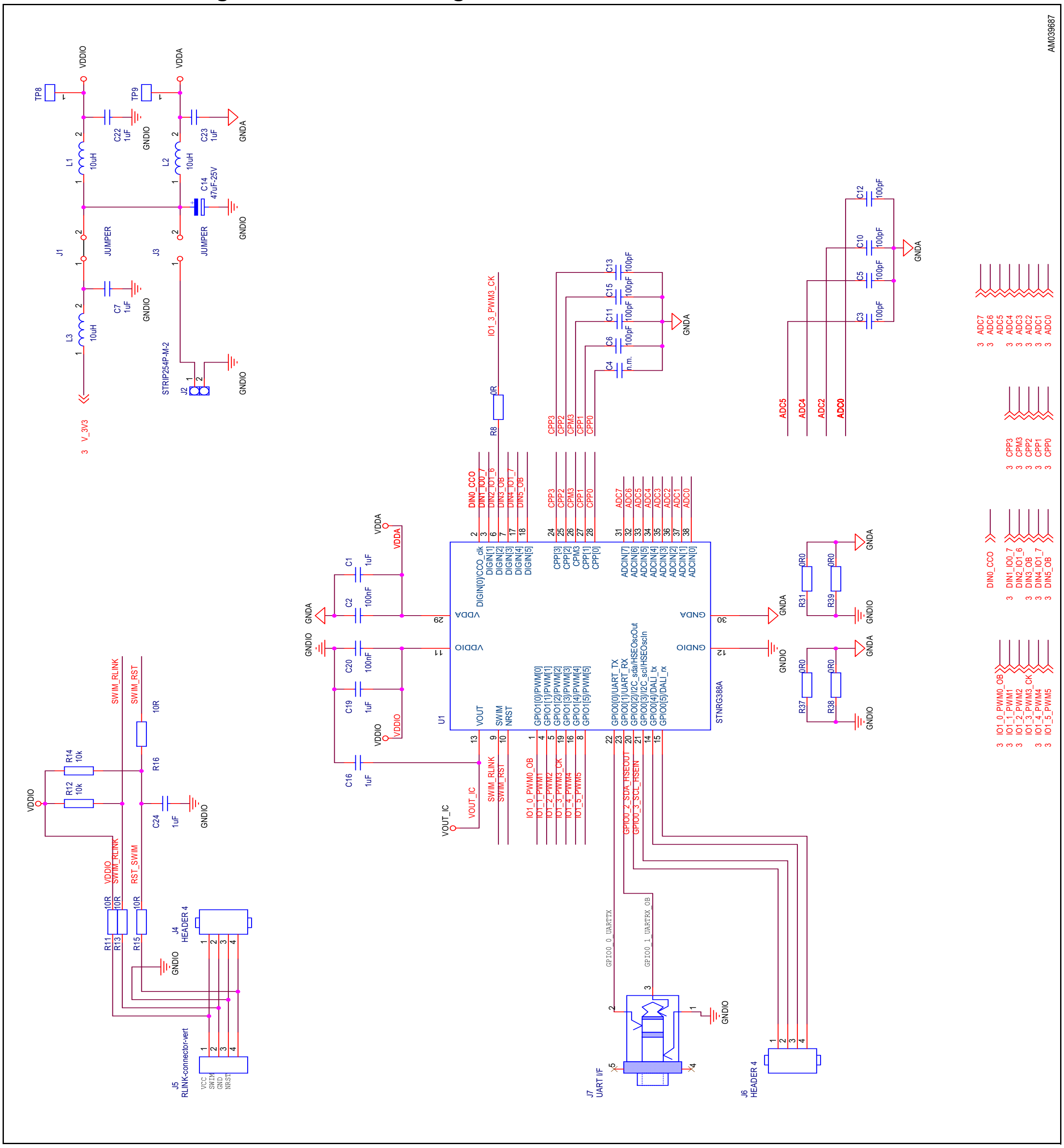
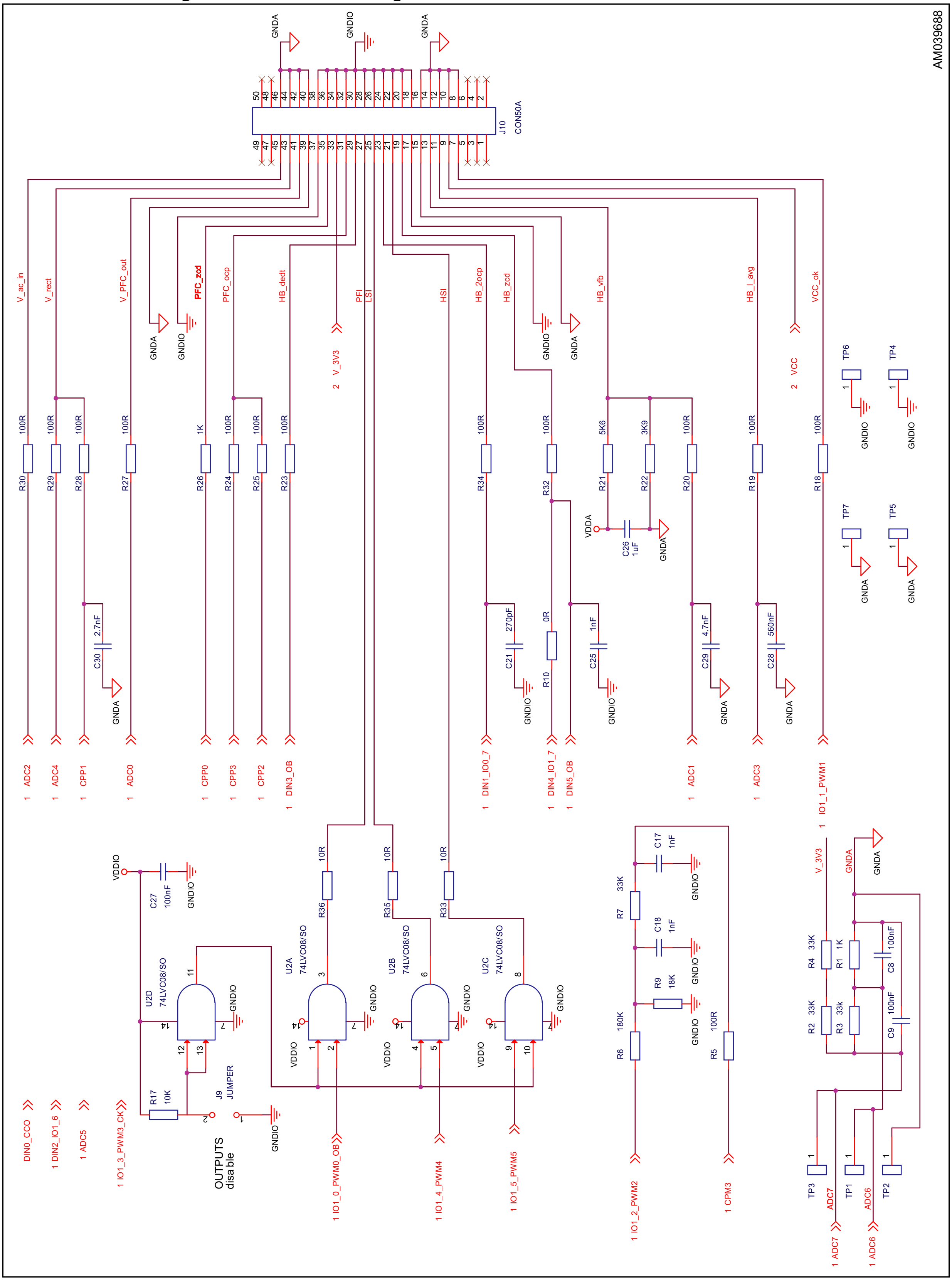


Figure 48. Electrical diagram of slim control board - connections



It is worth highlighting that the aim of this evaluation board is to make the user acquainted the application and to provide a system for learning the use of the STNRG388A IC in power supply applications. As a consequence, this evaluation module is absolutely not optimized and contains many circuits that are disabled or are not actually used.

Appendix B Bill of materials

The detailed specifications of the PFC coil, resonant power transformer and auxiliary flyback transformer are available in the application note AN3329 of the EVL170W-FTV evaluation board. The bill of materials of the power board is shown in *Table 5*, while for the debug and slim control boards these are listed in *Table 6 on page 48* and in *Table 7 on page 54* respectively.

Table 5. Bill of materials EVLSTNRG-170W "power board"

Ref.	Part	Case	Description	Supplier
C1	2.2 nF	Dia. 12 p.10 mm	Y1 - safety cap. CD12-E2GA222MYGS	TDK
C2	2.2 nF	Dia. 12 p.10 mm	Y1 - safety cap. CD12-E2GA222MYGS	TDK
C3	270 pF	0805	16 V cercap. - general purpose - X7R - 10%	KEMET
C4	100 µF - 450 V	Dia. 18 x 35 p.10 mm	450 V - aluminium elcap. - KXG series - 105 °C	NIPPON CHEMICON
C5	1 µF - X2	11 x 26.5 p. 22.5 mm	X2 - FLM CAP - B32923C3105K	EPCOS
C6	1µF - X2	11 x 26.5 p. 22.5 mm	X2 - FLM CAP - B32923C3105K	EPCOS
C7	470 nF-630 V	11 x 26.5 p. 22.5 mm	630 V - FLM CAP - B32613A6474K	EPCOS
C8	470 nF-630 V	11 x 26.5 p. 22.5 mm	630 V - FLM CAP - B32613A6474K	EPCOS
C9	100 µF - 450 V	Dia. 18 x 35 p.10 mm	450 V - aluminium elcap. - KXG series - 105 °C	NIPPON CHEMICON
C10	47 nF	1206	50 V cercap. - general purpose - X7R - 10%	KEMET
C11	100 nF	1206	50 V cercap. - general purpose - X7R - 10%	KEMET
C12	100 nF	1206	50 V cercap. - general purpose - X7R - 10%	KEMET
C13	1000 µF - 35 V	Dia. 12 x 25 p. 5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C14	1000 µF - 35 V	Dia. 12 x 25 p. 5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C15	100 µF - 50 V	Dia. 8 x 11 p. 3.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C16	100 nF	0603	50 V cercap. - general purpose - X7R - 10%	KEMET
C17	2.2 nF	Dia. 12 p.10 mm	Y1 - safety cap. CD12-E2GA222MYGS	TDK
C18	4.7 nF	1206	500 V cercap. - 12067A221JAT2A - C0G - 5%	AVX
C19	47 µF - 50 V	Dia. 6.3 x 11 p. 2.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C21	1000 µF - 25 V	Dia.12 x 20 p. 5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C22	100 µF - 50 V	Dia. 8 x 11 p. 3.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C23	100 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C24	N. M.	0805		
C25	100 nF	1206	50 V cercap. - general purpose - X7R - 10%	KEMET
C26	100 nF	1206	50 V cercap. - general purpose - X7R - 10%	KEMET
C27	220 pF	1206	500 V cercap. - 12067A221JAT2A - C0G - 5%	AVX

Table 5. Bill of materials EVLSTNRG-170W “power board” (continued)

Ref.	Part	Case	Description	Supplier
C28	Rev. 1: 100 µF - 50 V Rev. 2: N. M.	Dia. 8 x 11 p. 3.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C29	100 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C30	220 nF	0805	16 V cercap. - general purpose - X7R - 10%	KEMET
C31	N. M.	1206		
C32	33 nF	5.0 x 18.0 p.15 mm	1 KV - MKP film capacitor B32652A0333J	EPCOS
C33	100 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C34	2.2 nF	0805	50 V cercap. - general purpose - X7R - 10%	AVX
C35	47 µF - 50 V	Dia. 6.3 x 11 p. 2.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C36	N. M.	0805		
C37	N. M.	0805		
C38	47 nF	0805	25 V cercap. - general purpose - X7R - 10%	KEMET
C39	2.2 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C40	47 µF - 16 V	Dia. 6.3 x 11 p. 2.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C41	100 nF	1206	50 V cercap. - general purpose - X7R - 10%	KEMET
C42	Rev.1: 47 µF - 50 V Rev.2: 100 µF - 50 V	Dia. 6.3 x 11 p. 2.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C43	47 nF	1206	50 V cercap. - general purpose - X7R - 10%	KEMET
C44	N. M.	0805		
C45	10 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C46	100 nF	1206	50 V cercap. - general purpose - X7R - 10%	KEMET
C47	Rev.1: 10 µF - 50 V Rev.2: 100 µF - 50 V	Dia. 6.3 x 11 p. 2.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C48	10 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C49	2.2 nF	Dia. 12 p.10 mm	Y1 - safety cap. CD12-E2GA222MYGS	TDK
C50	1 nF	1206	100 V cercap. - general purpose - X7R - 10%	KEMET
C51	2.2 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C52	10 µF - 450 V	Dia. 10 P. 5 mm	450 V - aluminium elcap. - TXW series - 105 °C	RUBYCON
C53	N. M.	5.0 x 13.0 p.10 mm		
C54	1000 µF - 10 V	Dia. 10 x 16 p. 5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C55	1000 µF-10 V	Dia. 10X16 p. 5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON

Table 5. Bill of materials EVLSTNRG-170W “power board” (continued)

Ref.	Part	Case	Description	Supplier
C56	220 µF-16 V	Dia. 8 x 11 p. 3.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C57	100 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C58	10 µF - 50 V	Dia. 6.3 x 11 p. 2.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C59	100 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C60	Rev.1: 22 µF - 50 V Rev.2: 47 µF - 50 V	Dia. 5 x 11 p. 2 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C61	N. M.	0805		
C62	10 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C63	N. M.	0805		
C66	100 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C67	2.2 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C68	100 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C69	100 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C70	10 pF 1 kV C0G	1206	1 KV cercap. - C0G - 5%	EPCOS
C71	1 nF 1 kV	1206	1 KV cercap. - X7R - 10%	EPCOS
C72	10 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C73	100 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
C74	100 nF	0805	50 V cercap. - general purpose - X7R - 10%	KEMET
D1	1N5406	DO-201	Rectifier - general purpose	VISHAY
D2	STTH5L06	DO-201	Ultrafast high voltage rectifier	STMicroelectronics
D3	D10XB60H	DWG	Single phase bridge rectifier	SHINDENGEN
D4	STPS20H100 CFP	TO-220FP	Power Schottky rectifier	STMicroelectronics
D5	BZV55-C18	MINIMELF	Zener diode	VISHAY
D6	1N4148 WS	SOD323	High speed signal diode	VISHAY
D7	1N4148 WS	SOD323	High speed signal diode	VISHAY
D8	STPS20L45C FP	TO-220FP	Power Schottky rectifier	STMicroelectronics
D10	STPS20H100 CFP	TO-220FP	Power Schottky rectifier	STMicroelectronics
D11	BAT46W-V	SOD123	Schottky diode	VISHAY
D12	STPS1L60A	DO-214	Power Schottky rectifier	STMicroelectronics
D13	1N4148 WS	SOD323	High speed signal diode	VISHAY

Table 5. Bill of materials EVLSTNRG-170W “power board” (continued)

Ref.	Part	Case	Description	Supplier
D14	BZV55-C3 V3	MINIMELF	Zener diode	VISHAY
D15	BAT46W-V	SOD123	Schottky diode	VISHAY
D16	S1M	DO-214	Rectifier - general purpose	VISHAY
D17	S1M	DO-214	Rectifier - general purpose	VISHAY
D18	MMSZ4711-V	SOD123	27 V Zener diode	VISHAY
D19	MMSZ4702-V	SOD123	15 V Zener diode	VISHAY
D20	1N4148 WS	SOD323	High speed signal diode	VISHAY
D21	N. M.	SOD123		
D22	BAT46W-V	SOD123	Schottky diode	VISHAY
D23	P6KE250A	DO-15	Transil™	STMicroelectronics
D24	BAV103	MINIMELF	High speed signal diode	VISHAY
D25	STPS20L45CFP	TO-220FP	Power Schottky rectifier	STMicroelectronics
D26	STTH108A	SMA	HV ultrafast rectifier	STMicroelectronics
D27	STTH102A	SMA	High efficiency ultrafast diode	STMicroelectronics
D28	BAT46W-V	SOD123	Schottky diode	VISHAY
D29	N. M.	MINIMELF		
D30	STTH1R06A	SMA	Ultrafast high voltage rectifier	STMicroelectronics
D31	BZV55-C13	MINIMELF	Zener diode	VISHAY
D32	BZV55-C3 V3	MINIMELF	Zener diode	VISHAY
D33	BAT46W-V	SOD123	Schottky diode	VISHAY
D34	STTH108A	SMA	HV ultrafast rectifier	STMicroelectronics
D35	BAT46W-V	SOD123	Schottky diode	VISHAY
D36	BAT46W-V	SOD123	Schottky diode	VISHAY
F1	Fuse T4A	8.5 x 4 p. 5.08 mm	Fuse 4 A - time LAG - 3921400	LITTLEFUSE
HOLE1	3 mm		Threaded stand-off	
HOLE2	3 mm		Threaded stand-off	
HOLE3	3 mm		Threaded stand-off	
HOLE4	3 mm		Threaded stand-off	
HOLE5	3 mm		Threaded stand-off	
HOLE6	3 mm		Threaded stand-off	
HS1	Heatsink	DWG	Heatsink for D4 and D10	
HS2	Heatsink	DWG	Heatsink for Q4 and Q5	
HS3	Heatsink	DWG	Heatsink for D3 and Q7	
HS4	Heatsink	DWG	Heatsink for D8	

Table 5. Bill of materials EVLSTNRG-170W “power board” (continued)

Ref.	Part	Case	Description	Supplier
HS5	Heatsink	DWG	Heatsink for D25	
J1	MTA396-5		Connector - p. 3.96 mm - 5 pins (2 removed) - KK	MOLEX
J2	CON50A		Connector-FLAT P. 2.54 mm 25 x 2 rows 90 M	
J3	280385-2		Connector - P. 2.54 mm - 8 x 2 rows - MODU-II	AMP
J4	280384-2		Connector - P. 2.54 mm - 4 x 2 rows - MODU-II	AMP
JP1	N. M.		Wire jumper	
JP2	Shorted		Wire jumper	
JPX1	Shorted		Wire jumper	
JPX2	Shorted		Wire jumper	
JPX3	Shorted		Wire jumper	
JPX4	Shorted		Wire jumper	
JPX5	Shorted		Wire jumper	
JPX6	Shorted		Wire jumper	
JPX7	Shorted		Wire jumper	
JPX8	Shorted		Wire jumper	
JPX9	Shorted		Wire jumper	
JPX10	Shorted		Wire jumper	
JPX11	Shorted		Wire jumper	
JPX12	Shorted		Wire jumper	
L1	1606.001	DWG	1606.0010 EMI filter 2 x 4 mH 3.3 A	MAGNETICA
L2	2190.0001	26 x 13 mm	2190.0001 DM inductor 100 µH 2.5 A	MAGNETICA
L3	2086.0001	DWG	2086.0001 PFC inductor 240 µH 2.65 A	MAGNETICA
L4	1061.0014	Dia.12 p. 5 mm	1061.0041 inductor 2.9 µH 11 A	MAGNETICA
L5	1071.0083	Dia. 8 p. 5 mm	1071.0083 inductor 1 µH 5 A	MAGNETICA
L6	1071.0083	Dia. 8 p. 5 mm	1071.0083 inductor 1 µH 5 A	MAGNETICA
PCB1	PCB rev. 1.0.1		Dual layer - 2 OZ. - CEM-1	
Q1	MMBT2222A	SOT-23	NPN small signal BJT	STMicroelectronics
Q2	MMBT2907A	SOT-23	PNP small signal BJT	STMicroelectronics
Q3	MMBT2222A	SOT-23	NPN small signal BJT	STMicroelectronics
Q4	STF14NM50N	TO-220FP	N-channel power MOSFET	STMicroelectronics
Q5	STF14NM50N	TO-220FP	N-channel power MOSFET	STMicroelectronics
Q6	MMBT2907A	SOT-23	PNP small signal BJT	STMicroelectronics
Q7	STF14NM50N	TO-220FP	N-channel power MOSFET	STMicroelectronics
Q8	MMBT2222A	SOT-23	NPN small signal BJT	STMicroelectronics

Table 5. Bill of materials EVLSTNRG-170W "power board" (continued)

Ref.	Part	Case	Description	Supplier
Q9	MMBT2907A	SOT-23	PNP small signal BJT	STMicroelectronics
Q10	Rev.1: BC847C Rev. 2: PBSS4041NT	SOT-23	NPN small signal BJT	Rev.1: VISHAY Rev.2: NXP
Q11	BC857C	SOT-23	PNP small signal BJT	VISHAY
Q12	BC847C	SOT-23	NPN small signal BJT	VISHAY
Q13	BC847C	SOT-23	NPN small signal BJT	VISHAY
R1	2.2 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R2	NTC 2R5-S237	DWG	NTC resistor P/N B57237S0259M000	EPCOS
R3	10 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R4	1 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R5	10 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R6	100 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R7	N. M.	0805		
R8	2.7 KΩ	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R9	56 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R10	3.3 KΩ	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	VISHAY
R11	2.2 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R12	3.9 KΩ	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	VISHAY
R13	N. M.	0805		
R14	4.7 MΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R15	2.7 MΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R16	2.2 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R17	10 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY

Table 5. Bill of materials EVLSTNRG-170W “power board” (continued)

Ref.	Part	Case	Description	Supplier
R18	1 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R19	56 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R20	10 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R21	4.7 MΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R22	2.7 MΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R23	100 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R24	10 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R25	3.3 MΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R26	2.7 MΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R27	22 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R28	1 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R29	10 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R30	22 Ω	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R31	75 Ω	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	VISHAY
R32	100 Ω	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R33	470 KΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R34	220 Ω	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	VISHAY
R35	100 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R36	680 KΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R37	75 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R38	N. M.	1206		
R39	0.47 Ω	PTH	PR01 - metal film res. - 1 W - 5% - 250 ppm/°C	VISHAY

Table 5. Bill of materials EVLSTNRG-170W “power board” (continued)

Ref.	Part	Case	Description	Supplier
R40	0.47 Ω	PTH	PR01 - metal film res. - 1 W - 5% - 250 ppm/°C	VISHAY
R41	0.47 Ω	PTH	PR01 - metal film res. - 1 W - 5% - 250 ppm/°C	VISHAY
R42	22 KΩ	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R43	N. M.	0805		
R44	N. M.	0805		
R45	N. M.	0805		
R46	1 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R47	5.6 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R48	180 KΩ	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R49	51 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R50	N. M.	0805		
R51	33 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R52	180 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R53	N. M.	0805		
R54	N. M.	0805		
R55	10 kΩ	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R56	1.5 kΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R57	2.2 RΩ	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	VISHAY
R58	1 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R59	10 kΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R60	750 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R61	10 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R62	1 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R63	N. M.	0805		

Table 5. Bill of materials EVLSTNRG-170W “power board” (continued)

Ref.	Part	Case	Description	Supplier
R64	1 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R65	4.7 MΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R66	N. M.	0805		
R67	1 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R68	4.7 MΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R69	2.7 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R70	4.7 MΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R71	4.7 MΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R72	4.7 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R73	4.7 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R74	3.3 MΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R75	3.3 MΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R76	470 KΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R77	470 KΩ	1206	SMD standard film res. - 1/4 W - 1% - 100 ppm/°C	VISHAY
R78	1 Ω	PTH	NFR25H - axial fusible res. - 1/2 W - 5% - 100 ppm/°C	VISHAY
R79	10 Ω	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	VISHAY
R80	N. M.	1206		
R81	33 KΩ	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R82	N. M	0805		
R83	N. M.	PTH		
R84	2.7 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R85	3.9 Ω	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	VISHAY

Table 5. Bill of materials EVLSTNRG-170W “power board” (continued)

Ref.	Part	Case	Description	Supplier
R86	1 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R87	12 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R88	390 KΩ	PTH	AXIAL STD FILM RES - 1/8 W - 5% - 100 ppm/°C	VISHAY
R89	N. M.	0805		
R90	120 KΩ	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R92	82 KΩ	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R93	27 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R96	270 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R97	10 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R98	39 KΩ	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R99	10 kΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R100	22 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R101	100 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R102	22 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R103	8.2 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R104	47 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R105	10 kΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R106	22 KΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R107	10 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R108	10 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R109	N. M.	0805		
R110	10 kΩ	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	VISHAY

Table 5. Bill of materials EVLSTNRG-170W “power board” (continued)

Ref.	Part	Case	Description	Supplier
R111	10 kΩ	1206	SMD standard film res. - 1/4 W - 5% - 250 ppm/°C	VISHAY
R113	1.5 kΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R114	0 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R115	10 kΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R116	10 kΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R117	10 kΩ	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
R118	N. M.	0805		VISHAY
R119	75 KΩ	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R120	N. M.	1206		
RV1	300 V ac	Dia. 15 x 5 p. 7.5 mm	300 V metal oxide varistor - B72214S0301K101	EPCOS
RX1	1.5 kΩ	1206	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
RX2	1.5 kΩ	1206	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
RX3	0 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
RX4	0 Ω	0805	SMD standard film res. - 1/8 W - 5% - 250 ppm/°C	VISHAY
T1	1860.0014	DWG	1860.0014 resonant transformer 520 µH	MAGNETICA
T2	1715.0084	DWG	1715.0084 ST-BY flyback trafo. 2.38 mH	MAGNETICA
U1	TS3022	SO-8	High speed dual comparator	STMicroelectronics
U2	SFH610A-2	DIP-4 - 10.16 mm	Optocoupler	INFINEON
U4	SFH610A-2	DIP-4 - 10.16 mm	Optocoupler	INFINEON
U5	SFH610A-2	DIP-4 - 10.16 mm	Optocoupler	INFINEON
U3	TL431ACZ	TO-92	Programmable shunt voltage reference	STMicroelectronics
U6	VIPER27LN	DIP-8	Off-line HV converter	STMicroelectronics
U7	TS431AZ	TO-92	Programmable shunt voltage reference	STMicroelectronics
U8	TS3022	SO-8	High speed dual comparator	STMicroelectronics
U9	74LCV1G08	SOT353-1	Single 2-input and gate	
U10	L6382D	SO-20	Power management unit	STMicroelectronics

Table 6. Bill of materials EVLSTNRG-170W “STNRG388A debug control board”

Ref.	Part	Case	Description	Supplier
C1	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C2	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C3	4.7 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C4	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C5	560 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C6	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C7	2.7 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C8	47 µF - 25 V	Dia. 6.3 x 11 (MM) p. 2.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C9	10 µF -25 V	Dia. 6.3 x 11 (MM) p. 2.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C10	33 pF	0603	10 V cercap. - general purpose - C0G 5%	
C11	33 pF	0603	10 V cercap. - general purpose - C0G 5%	
C12	100 pF	0603	10 V cercap. - general purpose - C0G 5%	
C13	100 pF	0603	10 V cercap. - general purpose - C0G 5%	
C14	100 pF	0603	10 V cercap. - general purpose - C0G 5%	
C15	1 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C16	100 pF	0603	10 V cercap. - general purpose - C0G 5%	
C17	N. M.	0603		
C18	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C19	100 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C20	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C21	10 µF -25 V	Dia. 6.3 x 11 (MM) p. 2.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C22	100 pF	0603	10 V cercap. - general purpose - C0G 5%	
C23	100 pF	0603	10 V cercap. - general purpose - C0G 5%	
C24	100 pF	0603	10 V cercap. - general purpose - C0G 5%	
C25	100 pF	0603	10 V cercap. - general purpose - C0G 5%	
C26	270 pF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C27	100 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C28	100 pF	0603	10 V cercap. - general purpose - C0G 5%	
C29	100 pF	0603	10 V cercap. - general purpose - C0G 5%	
C30	100 pF	0603	10 V cercap. - general purpose - C0G 5%	
C31	1 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C32	100 pF	0603	10 V cercap. - general purpose - C0G 5%	
C33	1 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET

Table 6. Bill of materials EVLSTNRG-170W “STNRG388A debug control board” (continued)

Ref.	Part	Case	Description	Supplier
C34	1 µF	0603	25 V cercap. - general purpose - X7R 10%	KEMET
C35	100 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C36	100 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C37	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C38	100 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C39	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C40	100 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
D1	OVS-0608	0603	LED red	
D2	OVS-0608	0603	LED red	
D3	OVS-0608	0603	LED red	
D4	OVS-0608	0603	LED red	
D5	OVS-0608	0603	LED red	
D6	OVS-0608	0603	LED red	
D7	OVS-0608	0603	LED red	
D8	OVS-0608	0603	LED red	
J1	Jumper		Strip P 254 mm M 2	
J2	Conn. V_3 V3_ext		MORSQC508-ADIMPEX-MK159002	
J3	Jumper		Strip P 254 mm M 2	
J4	Conn. PCB 5		Strip P 254 mm M 5	
J5	Conn. PCB 5		Strip P 254 mm M 5	
J6	Conn. PCB 8		Strip P 254 mm M 8	
J7	CON50A		CON-FLAT_CABLE P 254 mm 25 x 2 90 F	
J8	Conn. PCB 8		Strip P 254 mm M 8	
J9	Conn. PCB 8		Strip P 254 mm M 8	
J10	Jumper		Strip P 254 mm M 2	
J11	Jumper		Strip P 254 mm M 2	
J12	Conn. VCC_ext		MORSQC508-ADIMPEX-MK159002	
J13	Strip254P-M-2		Strip P 254 mm M 2	
J14	Conn. PCB 8		Strip P 254 mm M 8	
J15	Conn. PCB 8		Strip P 254 mm M 8	
J16	UART I/F		3.5 mm JACK SC-35RASMT4BHNTRX	
J17	Jumper		Strip P 254 mm M 2	
J18	Jumper		Strip P 254 mm M 2	
J19	Jumper		Strip P 254 mm M 2	
J20	Jumper		Strip P 254 mm M 2	

Table 6. Bill of materials EVLSTNRG-170W "STNRG388A debug control board" (continued)

Ref.	Part	Case	Description	Supplier
J21	Jumper		Strip P 254 mm M 4	
J22	Jumper		Strip P 254 mm M 4	
J23	Header 4		Strip P 254 mm M 4	
J24	Jumper		Strip P 254 mm M 2	
J25	Jumper		Strip P 254 mm M 2	
J27	RLink-connector-vert.		ERNI_284697	ERNI
L1	10 µH	1206	SMD inductor	
L2	10 µH	1206	SMD inductor	
L3	10 µH	1206	SMD inductor	
L4	10 µH	1206	SMD inductor	
R1	3.9 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R2	5.6 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R3	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R4	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R5	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R6	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R7	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R8	3.3 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R9	1 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R10	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R11	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R12	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R13	0 Ω	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R14	0 Ω	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R15	0 Ω	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R16	0 Ω	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R17	0 Ω	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R18	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R19	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R20	N. M.	0603		
R21	N. M.	0603		
R22	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R23	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R24	0 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY

Table 6. Bill of materials EVLSTNRG-170W “STNRG388A debug control board” (continued)

Ref.	Part	Case	Description	Supplier
R25	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R26	N. M.	0603		
R27	N. M.	0603		
R28	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R29	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R30	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R31	N. M.	0603		
R32	N. M.	0603		
R33	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R34	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R35	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R36	0 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R37	N. M.	0603		
R38	N. M.	0603		
R39	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R40	N. M.	0603		
R41	N. M.	0603		
R42	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R43	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R44	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R45	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R46	N. M.	0603		
R47	N. M.	0603		
R48	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R49	18 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R50	180 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R51	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R52	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R53	33 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R54	10 kΩ	0603	SMD standard film res. - 1/8 W - 5% - 100 ppm/°C	VISHAY
R55	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R56	0 Ω	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R57	N. M.	0603		
R58	N. M.	0603		
R59	N. M.	0603		

Table 6. Bill of materials EVLSTNRG-170W “STNRG388A debug control board” (continued)

Ref.	Part	Case	Description	Supplier
R60	N. M.	0603		
R61	N. M.	0603		
R62	N. M.	0603		
R63	N. M.	0603		
R64	N. M.	0603		
R65	N. M.	0603		
R66	N. M.	0603		
R67	N. M.	0603		
R68	N. M.	0603		
R69	N. M.	0603		
R70	N. M.	0603		
R71	N. M.	0603		
R72	N. M.	0603		
R73	N. M.	0603		
R74	N. M.	0603		
R75	N. M.	0603		
R76	N. M.	0603		
R77	N. M.	0603		
R78	N. M.	0603		
R79	N. M.	0603		
R80	N. M.	0603		
R81	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R82	1 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R83	33 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R84	33 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R85	33 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R86	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R87	1.2 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R88	1.2 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R89	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R90	10 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R91	10 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R92	3.3 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R93	3.3 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R94	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY

Table 6. Bill of materials EVLSTNRG-170W “STNRG388A debug control board” (continued)

Ref.	Part	Case	Description	Supplier
R95	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R96	3.3 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R97	3.3 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R98	3.3 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R99	3.3 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R100	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R101	3.3 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R102	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R103	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R104	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R105	0 Ω	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R106	0 Ω	0805	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
SW1	PUSH_B 63 x 45 mm - PTH		PUSH_B switch 63 x 45 mm - PTH	
TP1	Test point			
TP2	Test point			
TP3	Test point			
TP4	Test point			
TP5	Test point			
TP6	Test point			
TP7	Test point			
TP8	Test point			
TP9	Test point			
U1	LD1086D2T33	D2PAK	LDO 3.3 V 1.5 A	STMicroelectronics
U2	STNRG388A	TSSOP38	STNRG388A on TSSOP38 socket	STMicroelectronics
U3	74LVC08/SO	TSSOP-14	Quad 2-input and gate	
U4	MC24C64	SO-8	64 K 2-wire serial EEPROM	
Y1	N. M.	HC49	XTAL 4 mm PTH	

Table 7. Bill of materials EVLSTNRG-170W “STNRG388A slim control board”

Ref.	Part	Case	Description	Supplier
C1	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C2	100 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C3	100 pF	0603	10 V cercap. - general purpose - NP0 5%	KEMET
C4	N. M.	0603		
C5	100 pF	0603	10 V cercap. - general purpose - NP0 5%	KEMET
C6	100 pF	0603	10 V cercap. - general purpose - NP0 5%	KEMET
C7	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C8	100 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C9	100 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C10	100 pF	0603	10 V cercap. - general purpose - NP0 5%	KEMET
C11	100 pF	0603	10 V cercap. - general purpose - NP0 5%	KEMET
C12	100 pF	0603	10 V cercap. - general purpose - NP0 5%	KEMET
C13	100 pF	0603	10 V cercap. - general purpose - NP0 5%	KEMET
C14	47 µF - 25 V	Dia. 6.3 x 11 (MM) P. 2.5 mm	Aluminium elcap. - YXF series - 105 °C	RUBYCON
C15	100 pF	0603	10 V cercap. - general purpose - NP0 5%	KEMET
C16	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C17	1 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C18	1 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C19	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C20	100 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C21	270 pF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C22	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C23	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C24	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C25	1 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C26	1 µF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C27	100 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C28	560 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C29	4.7 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
C30	2.7 nF	0603	10 V cercap. - general purpose - X7R 10%	KEMET
J1	Jumper		Strip P 254 mm M 2	
J2	Strip254P-M-2		Strip P 254 mm M 2	
J3	Jumper		Strip P 254 mm M 2	
J4	Header 4		Strip P 254 mm M 4	

Table 7. Bill of materials EVLSTNRG-170W “STNRG388A slim control board” (continued)

Ref.	Part	Case	Description	Supplier
J5	RLink-connector-vert.		ERNI_284697	ERNI
J6	Header 4		Strip P 254 mm M4	
J7	UART I/F		3.5 mm STEREO JACK SC-35RASMT4BHNTRX	
J9	Jumper		Strip P 254 mm M 2	
J10	CON50A		Strip P254 mm F 25X2	
L1	10 µH	1206	SMD inductor	
L2	10 µH	1206	SMD inductor	
L3	10 µH	1206	SMD inductor	
R1	1 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R2	33 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R3	33 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R4	33 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R5	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R6	180 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R7	33 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R8	0 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R9	18 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R10	0 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R11	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R12	10 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R13	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R14	10 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R15	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R16	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R17	10 kΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R18	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R19	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R20	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R21	5.6 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R22	3.9 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R23	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R24	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R25	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R26	1 KΩ	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY

Table 7. Bill of materials EVLSTNRG-170W “STNRG388A slim control board” (continued)

Ref.	Part	Case	Description	Supplier
R27	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R28	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R29	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R30	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R31	0 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R32	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R33	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R34	100 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R35	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R36	10 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R37	0 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R38	0 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
R39	0 Ω	0603	SMD standard film res. - 1/8 W - 1% - 100 ppm/°C	VISHAY
TP1	Test point			
TP2	Test point			
TP3	Test point			
TP4	Test point			
TP5	Test point			
TP6	Test point			
TP7	Test point			
TP8	Test point			
TP9	Test point			
U1	STNRG388A	TSSOP38	STNRG388A on TSSOP38	STMicroelectronics
U2	74LVC08/SO	TSSOP-14	Quad 2-input and gate	

Board revision

There are 2 revisions of the EVLSTNRG-170W evaluation board. The following changes apply:

- Rev.1: all boards manufactured and tested before 2016 are marked with “STEVALDPS-170W” or with a white label attached close to the 50-pin connector labeled “EVLSTNRG-170W”
- Rev.2: all boards manufactured since 2016 are marked “EVLSTNRG-170W PWR rev.2” and feature improved board stability when a transient is applied on the 5 V output bus.

The main differences about the two revision are:

- C28: rev.1: 100 µF - 50 V; rev. 2: N. M.
- C42: rev.1: 47 µF - 50 V; rev. 2: 100 µF - 50 V
- C47: rev.1: 10 µF - 50 V; rev. 2: 100 µF - 50 V
- C60: rev.1: 22 µF - 50 V; rev. 2: 47 µF - 50 V
- Q10: rev.1: BC847C; rev. 2: PBSS4041NT.

Revision history

Table 8. Document revision history

Date	Revision	Changes
22-Jun-2015	1	Initial release.
11-Mar-2016	2	Updated *Figure 1 on page 1*, *Figure 2 on page 7*, and *Figure 42 on page 29* (replaced by new figures). Updated *Table 5 on page 37* (updated C28, C42, C47, C60, and Q10). Added *Section : Board revision on page 57* Minor modifications throughout document.