UM10379

Typical 250 W LCD TV AC-DC power supply application with the TEA1713 PFC and half-bridge resonant controller

Rev. 01 — 16 April 2010 **User manual**

Document information

Info	Content
Keywords	TEA1713, half bridge, PFC controller, LLC resonant, high efficiency, zero voltage switching, resonant frequency, leakage inductance.
Abstract	The TEA1713 includes a PFC controller as well as a controller for a half bridge resonant converter. This user manual describes a 250 W resonant switching mode power supply for a typical LCD TV design based on the TEA1713. The board provides 3 output voltages of 24 V / 8 A, 12 V / 4 A and a standby supply of 5 V / 2 A. Good cross regulation is achieved without using a compensation circuit. It is also possible to test the Burst mode of the TEA1713. This feature is normally used in single-output resonant converters but can also be tested with this demo board by making some circuit adjustments. In Burst mode, the no load input power is around 600 mW (490 mW when the 5 V STB supply is disconnected from the PFC bus voltage) at high mains voltage. Typical efficiency at high output power is above 90 % for universal mains input with Schottky rectifiers.

Revision history

Rev	Date	Description
01	20100416	First issue

Contact information

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1. Introduction

The TEA1713 integrates a Power Factor Corrector (PFC) controller and a controller for a Half-Bridge resonant Converter (HBC) in a multi-chip IC. The TEA1713 250 W resonant demo board has multiple outputs so it can be used as a typical LCD TV power supply. Other target applications include plasma TV, PC power and power adapters (only a single output would be needed for an adapter). The TEA1713 Burst mode feature makes it possible to increase efficiency in the low- to mid-power range.

The demo board contains three sub-circuits:

- A PFC control stage (integrated into the TEA1713)
- A HBC control stage (integrated into the TEA1713)
- An additional standby supply (TEA1522)

Three regulated outputs are provided:

- 24 V / 8 A
- 12 V / 4 A
- 5 V / 2 A for Normal mode or 5 V / 1.5 A for Standby mode

The demo board features a number of protection functions including OverVoltage Protection (OVP), OverCurrent Protection (OCP), Short Circuit Protection (SCP) and mains UnderVoltage Protection (UVP). See the *TEA1713 data sheet* and the *TEA1713 application note* for further details.

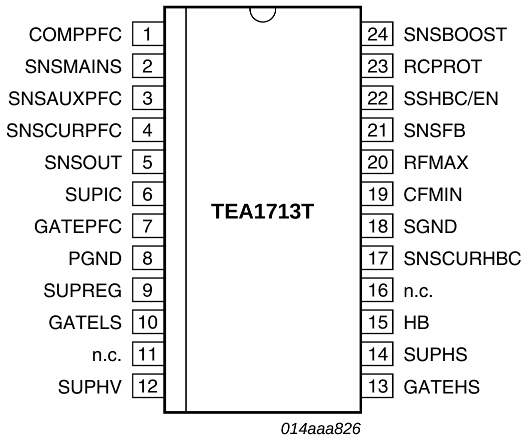


Fig 1. Pin configuration for SO24

2. Setup

2.1 Normal operation

To enable Normal mode on the demo board:

- Ensure jumper J301 is inserted to disable Burst mode; the board is designed to operate as a multiple-output board (24 V and 12 V, as well as 5 V standby); Burst mode is intended for single output solutions only (e.g. power adapters)
- Connect suitable loads at the outputs (24 V and 12 V)
- A load may also be connected at the 5 V standby output
- Connect the mains supply voltage V_{AC} (90 V to 264 V (AC))

Pressing switch S1 disables the TEA1713 while keeping the 5 V standby supply operating. S1 can also be used to reset the TEA1713 after a latched protection function has been triggered.

2.2 Burst mode operation

Burst mode helps to significantly increase the efficiency of the demo board at low output power levels. In the TEA1713, Burst mode is primarily intended to be used with single output power supplies. To enable Burst mode on the demo board:

- Remove jumper J301; this enables Burst mode operation for low loads
- Connect a suitable load at the 24 V output; leave the 12 V output open; converter operation now approximates that of a single output converter, although the 12 V rail still has some influence on the voltage feedback loop (see resistor R312)
- Resistor R361 may need to be fine-tuned in order to set the burst mode thresholds accurately.
- To measure the power consumption of the single-output resonant converter in Burst mode, the 5 V standby supply must be physically removed from the bus voltage
- Connect the mains supply voltage V_{AC} (90 V to 264 V (AC))

Switch S1 must be off (i.e. released). Otherwise the system will operate in Standby mode. With the output load decreasing, the converter starts bursting at approximately $P_O < 5$ W. When the output load is increasing with the TEA1713 in Burst mode, normal operation resumes at approximately 18 W.

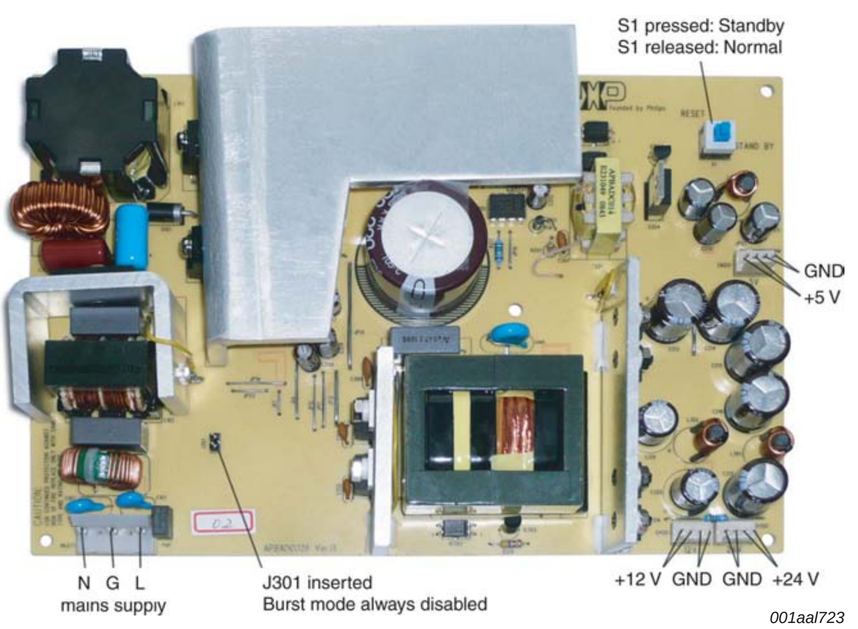


Fig 2. TEA1713 250 W demo board

3. Measurements

Remark: Unless otherwise stated, all measurements were taken with the bandwidth of the oscilloscope set to 20 MHz and with jumper J301 inserted, which disables Burst mode.

3.1 Test facilities

- Digital Oscilloscope: Yokogawa, Model DL1740EL
- Electronic load: Agilent 6063B (for 5 V and for transient response measurements)
- Electronic load: Chroma 63103 (2x), Chroma 6312 mainframe (for 12 V and 24 V)
- Digital power meter: Yokogawa, Model WT210
- Test jig: TEA1713 250 W demo board (APBADC026, version C)

3.2 Standby power/no load power consumption

The following procedure was followed to measure the input power dissipation under no-load conditions:

- Jumper J301 was removed to activate Burst mode
- To measure power consumption in Standby mode:
  - push button S1 was pressed to switch to Standby mode; pressing S1 disables the PFC and the 24 V and 12 V supplies
- To measure no-load power consumption (with 5 V + 12 V + 24 V supplies connected):
  - S1 was released to switch to Normal mode
- To measure no-load power consumption (with 12 V + 24 V supplies connected)

– the 5 V supply was physically removed by disconnecting the standby circuit from the PFC bus voltage

The measurement results are shown in Table 1.

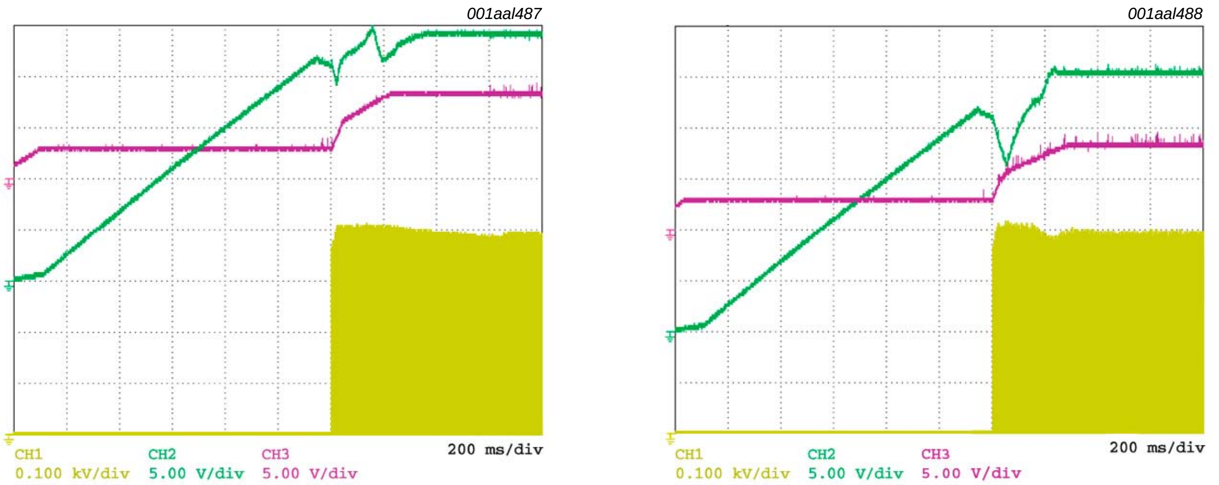
Table 1. Standby power measurements

STBY button pressed			STBY button released	
V_{AC} supply	STBY voltage	P_i	P_i (with flyback)	P_i (without flyback)
90 V / 50 Hz	5.04 V	370 mW	575 mW	475 mW
115 V / 50 Hz	5.04 V	390 mW	565 mW	465 mW
180 V / 50 Hz	5.04 V	485 mW	565 mW	460 mW
230 V / 50 Hz	5.04 V	555 mW	585 mW	480 mW
264 V / 50 Hz	5.04 V	600 mW	600 mW	490 mW

3.3 Measuring the start-up behavior

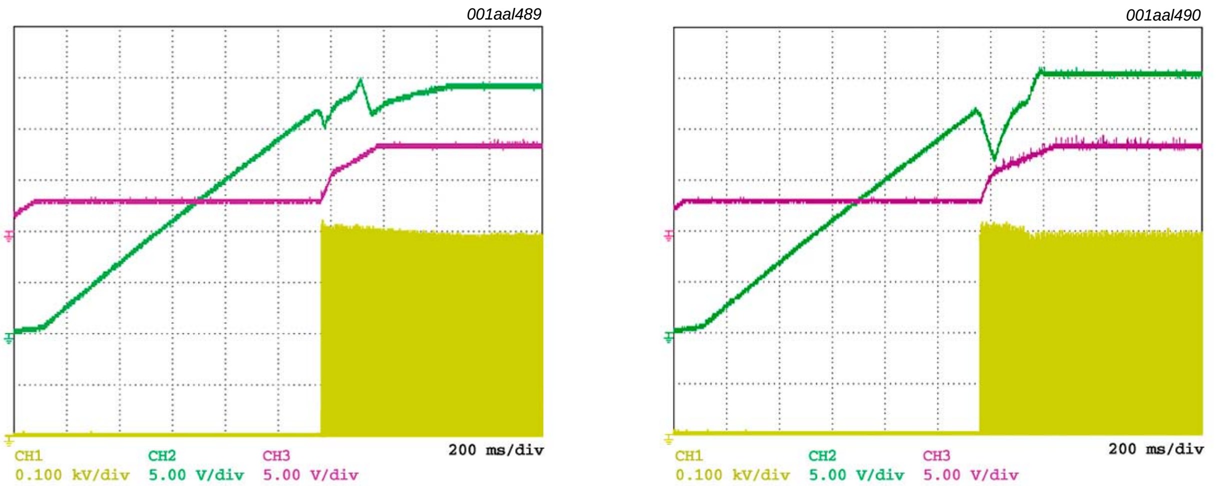
3.3.1 Supply voltage (SUPIC) and soft start voltage (SSHBC/EN) during start-up

The voltage on pin SUPIC of the TEA1713 (pin 6) was measured. V_{SUPIC} must reach the start level before the IC will start up. The SSHBC/EN pin indicates the soft start of the half bridge converter.



a. No load b. Full load

Fig 3. V_{AC} = 90 V; CH1: HB voltage, CH2: SUPIC, CH3: SSHB/EN

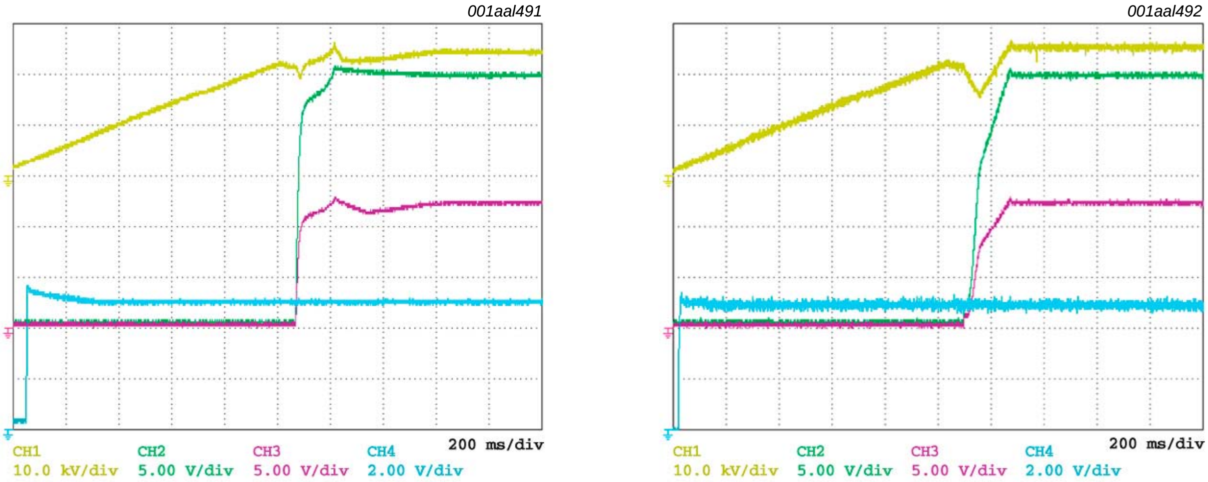


a. No load b. Full load

Fig 4. V_{AC} = 264 V; CH1: HB voltage, CH2: SUPIC, CH3: SSHB/EN

3.3.2 Output voltage during start-up

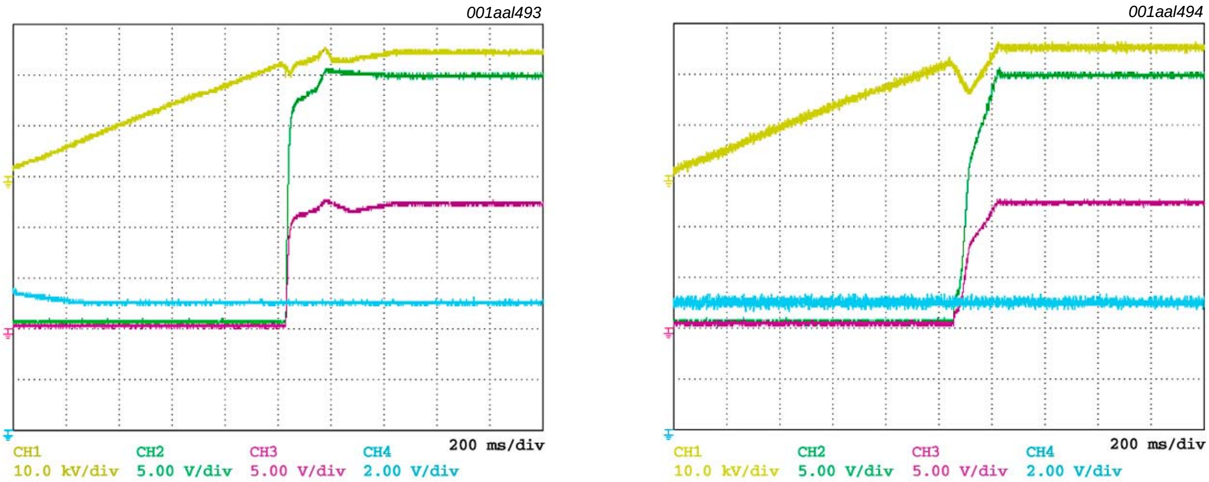
A second set of measurements shows the output voltage levels (24 V, 12 V and 5 V) during start-up.



a. No load

b. Full load

Fig 5. V_{AC} = 90 V; CH1: SUPIC, CH2: 24 V out, CH3: 12 V out, CH4: 5 V out



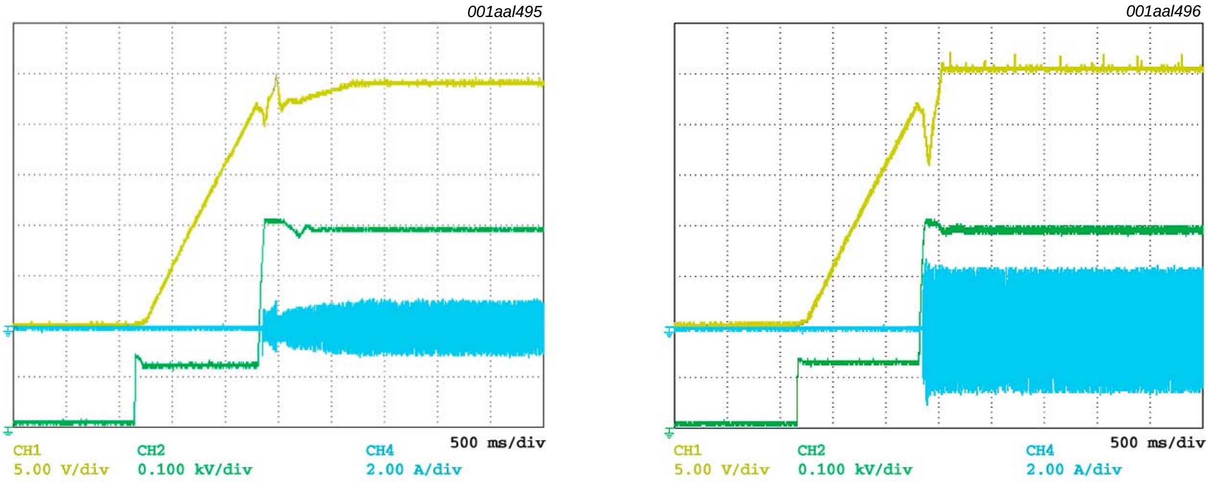
a. No load

b. Full load

Fig 6. V_{AC} = 264 V; CH1: SUPIC, CH2: 24 V out, CH3: 12 V out, CH4: 5 V out

3.3.3 Resonant current I_{RES} at start-up

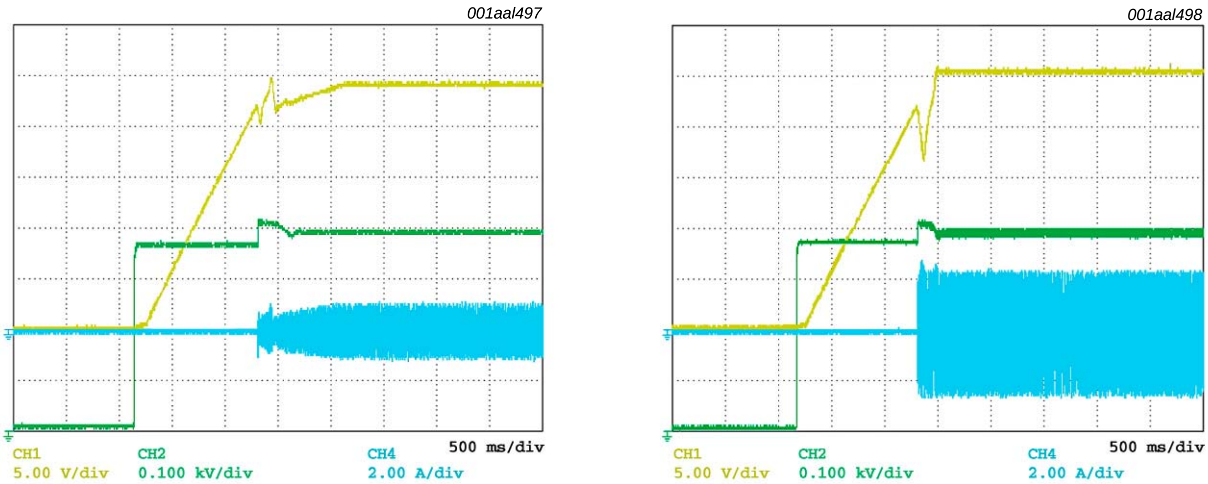
As soon as V_{SUPIC} reaches the start-level, a short inrush current peak flows followed by a stabilized and controlled resonant current waveform.



a. No load

b. Full load

Fig 7. V_{AC} = 90 V; CH1: SUPIC, CH2: VBUS, CH4: I_{RES}



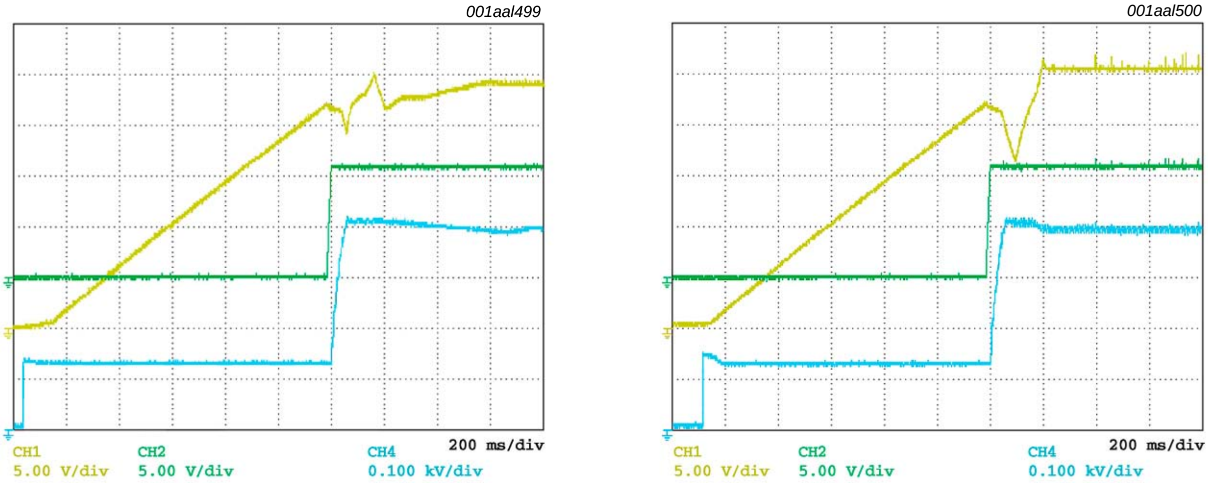
a. No load

b. Full load

Fig 8. V_{AC} = 264 V; CH1: SUPIC, CH2: VBUS, CH4: I_{RES}

3.3.4 IC supply voltages on pins SUPIC, SUPREG and SUPHV

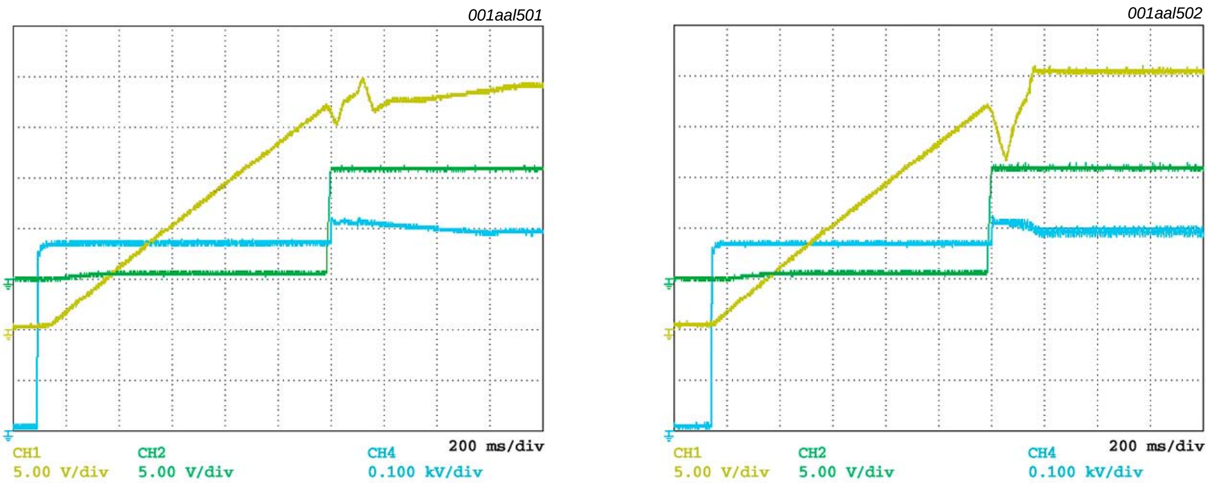
A high voltage must be present on pin SUPHV before the demo board can start up. SUPREG becomes operational as soon as SUPIC reaches the start-up voltage (typically 22 V). HBC and PFC operations are enabled when V_{SUPREG} reaches 10.7 V.



a. No load

b. Full load

Fig 9. V_{AC} = 90 V; CH1: SUPIC, CH2: SUPREG, CH4: SUPHV



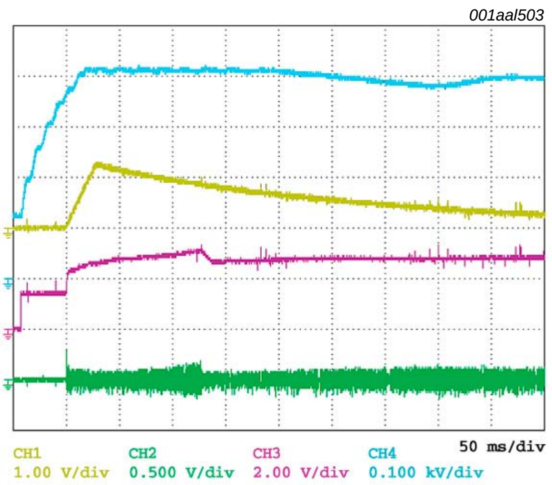
a. No load

b. Full load

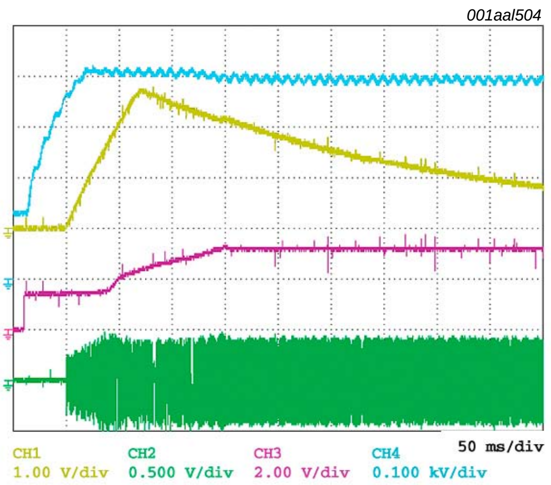
Fig 10. V_{AC} = 264 V; CH1: SUPIC, CH2: SUPREG, CH4: SUPHV

3.3.5 Protection levels on pins SNSCURHB and SNSOUT during start-up

The voltage levels on protection pins SNSCURHB and SNSOUT were measured during start-up. Safe start-up will follow provided a protection function has not been triggered (the TEA1713 will not start up if a protection function is active). The protection function is activated when V_{RCPROT} reaches 4 V.

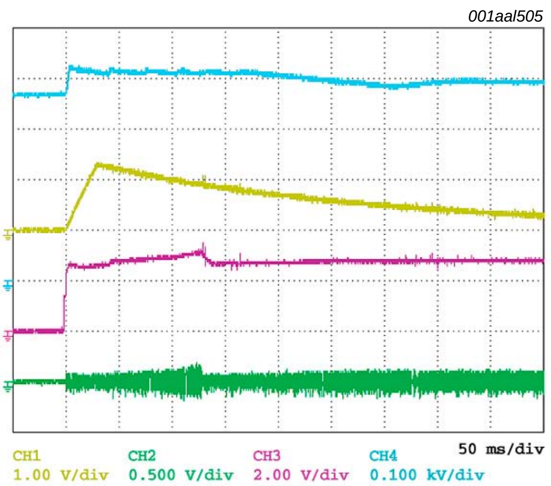


a. No load

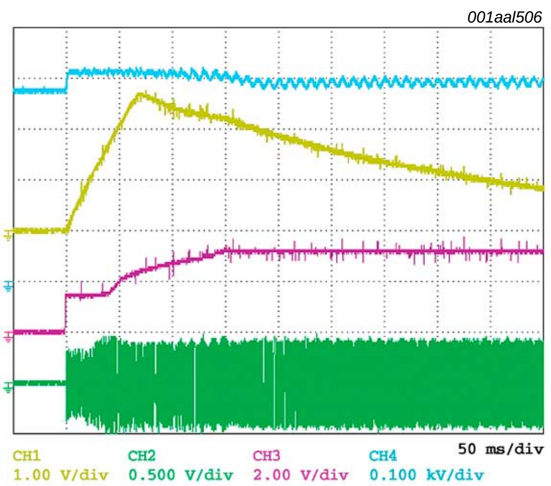


b. Full load

Fig 11. V_{AC} = 90 V; CH1: RCPROT, CH2: SNSCURHB, CH3: SNSOUT, CH4: VBUS



a. No load



b. Full load

Fig 12. V_{AC} = 264 V; CH1: RCPROT, CH2: SNSCURHB, CH3: SNSOUT, CH4: VBUS

3.4 Efficiency

Input and output power were measured at full load from low to high mains voltages. The efficiency was calculated after a 30 minute burn-in at 25 °C room temperature without a fan.

Table 2. Efficiency results

V_{AC} supply	P_i	P_o	Efficiency
90 V / 50 Hz	292.88 W	254.38 W	86.9 %
115 V / 50 Hz	285.23 W	254.2 W	89.1 %
180 V / 50 Hz	280.0 W	254.18 W	90.8 %
230 V / 50 Hz	278.4 W	254.26 W	91.3 %
264 V / 50 Hz	277.6 W	254.34 W	91.6 %

With Burst mode enabled, the efficiency for low/medium loads can be increased significantly. The following measurements were taken at 230 V (AC) with all outputs, except the 24 V output, unloaded.

Jumper J301 was removed to enable Burst mode.

In this example, the system enters Burst mode at approximately 3.5 W output power with the load decreasing. With the load increasing again, the system exits Burst mode at approximately 18 W output power. The burst comparator thresholds can be set individually.

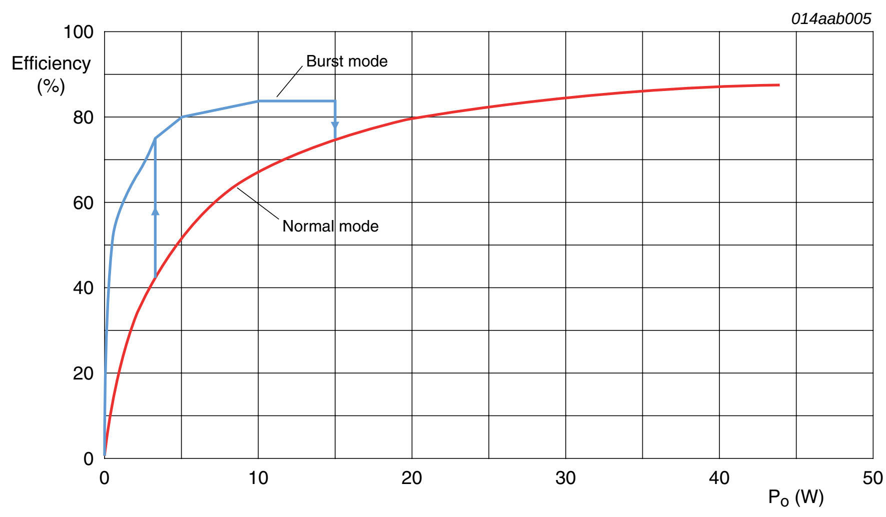


Fig 13. Efficiency measurement for low/medium loads at 230 V (AC) supply

3.5 Transient response

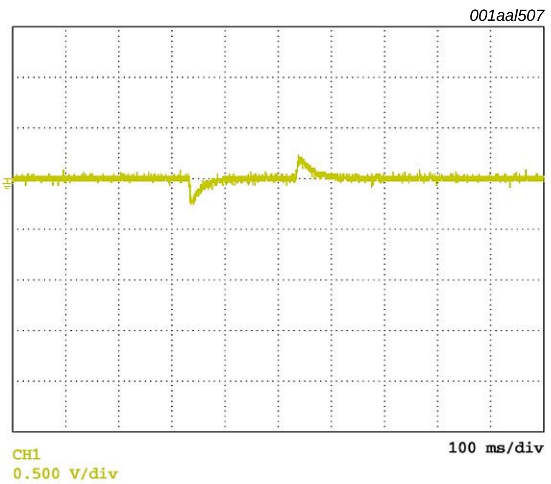
The dynamic load response of the 12 V and 24 V outputs was measured. The transient voltage should not show any ringing or oscillation.

Test results are given in Table 3.

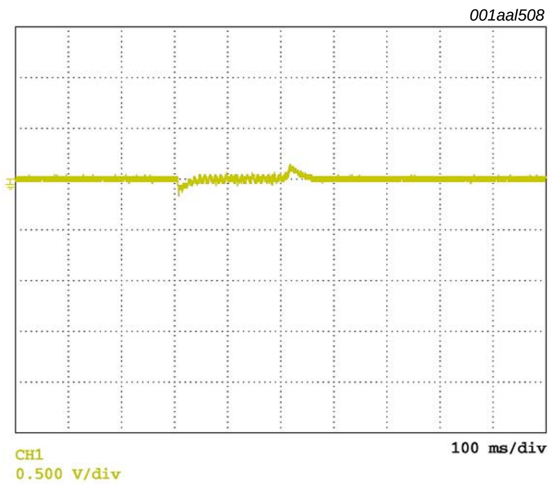
Table 3. Transient response test results

Measurement conditions: 0 % to 100 % of full load; 200 ms duty cycle; 1 mA/μs rise/fall time

Output voltage	Overshoot	Undershoot	Ringing
12 V	230 mV	250 mV	free
24 V	145 mV	165 mV	free



a. 12 V (0 A to 4 A); 24 V loaded with 8 A



b. 24 V (0 A to 8 A); 12 V loaded with 4 A

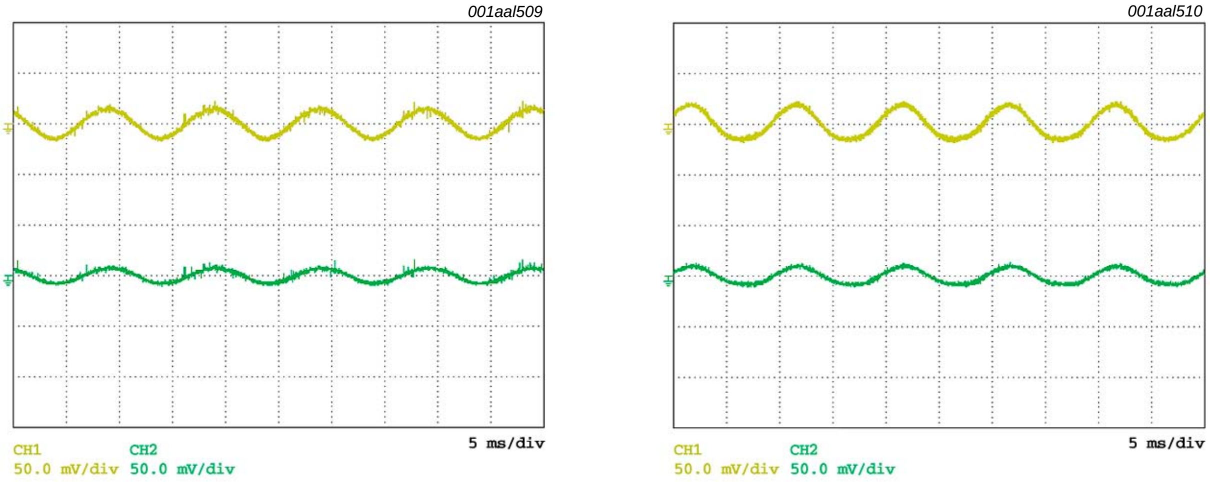
Fig 14. Transient response

3.6 Output ripple and noise

Ripple and noise were measured at full output load, buffered with a 10 μF capacitor in parallel with a high-frequency 0.1 μF capacitor.

Table 4. Ripple and noise test results

V_{AC} supply	V_O	Load	Ripple and noise
90 V to 264 V / 50 Hz	24 V	8 A	40 mV (p-p)
	12 V	4 A	25 mV (p-p)



a. V_{AC} = 90 V

b. V_{AC} = 264 V

Fig 15. Ripple and noise; CH1: 24 V out, CH2: 12 V out

3.7 OverPower Protection (OPP)

These measurements were taken to determine the output power level at which the system initiates a soft start.

Setup: constant load currents at output 2 (12 V / 4 A) and output 3 (5 V / 2 A); the load current at output 1 (24 V output) is gradually increased to determine the OPP trip point.

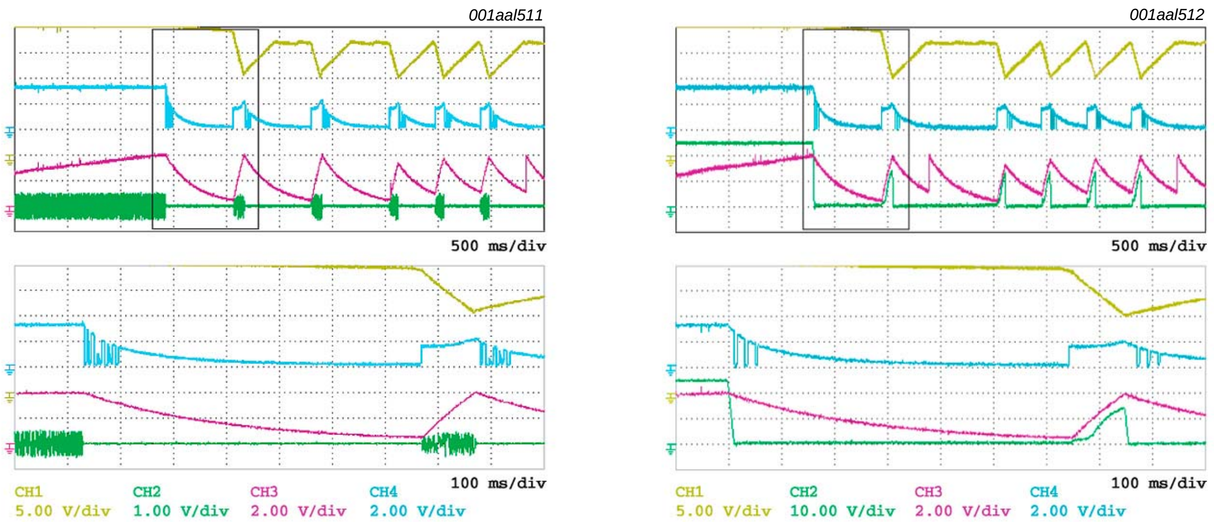
The protection timer starts (and the TEA1713 increases the switching frequency) once the voltage on pin SNSCURHBC rises above +0.5 V and/or falls below –0.5 V. As soon as $V_{SNSCURHBC}$ falls below +0.5 V again and/or rises above –0.5 V, the protection timer stops. Thus the maximum primary current remains constant (at the OPP level) whereas the output voltage decreases with frequency.

Table 5. Test results for V_{AC} = 90 V and nominal output power of 254 W

I (output 1)	V (output 1)	I (output 2)	V (output 2)	Power output (total)	Rating
9.25 A	24 V	4 A	12 V	280 W	110.2 %
9.52 A	23.7 V	4 A	11.7 V	282.4 W	111.2 %
10 A	22.4 V	4 A	11.4 V	279.6 W	110.1 %
10.5 A	21.5 V	4 A	10.6 V	278.15 W	109.5 %

If increasing the frequency fails to restrict $V_{SNSCURHBC}$ to between +0.5 V and –0.5 V, the protection timer will continue counting until eventually triggering a safe system restart.

The measurements show that, when the load increases to around 315 W, the system tries continuously to restart (for V_{AC} = 115 V, 180 V, 230 V and 264 V). This corresponds to a power rating of 126 %. See Figure 16



a. CH1: SUPIC, CH2: SNSCURHB, CH3: RCPROT, CH4: SNSOUT

b. CH1: SUPIC, CH2: 24 V out, CH3: RCPROT, CH4: SNSOUT

Fig 16. Overpower protection

From Figure 16 a, we can see that OPP is triggered initially when V_{RCPROT} reaches 4 V for the first time (because $V_{SNSCURHB}$ fails to fall below +0.5 V and/or rise above –0.5 V even though the controller increased the switching frequency in an attempt to limit the voltage swing to between +0.5 V and –0.5 V).

As soon as V_{RCPROT} reaches the protection threshold of 4 V, the IC initiates a soft start. The second and third times RCPROT is activated is caused by heavy load condition (see CH2 in Figure 16 b). The voltage at the SNSOUT pin was unable to rise above its UVLO range. The fourth time, RCPROT is triggered by UVLO on the SUPIC pin. Due to the low output voltage, the auxiliary winding could not deliver sufficient energy to the SUPIC pin. The UVLO on SUPIC forces the converter to restart even though RCPROT has not reached 4 V.

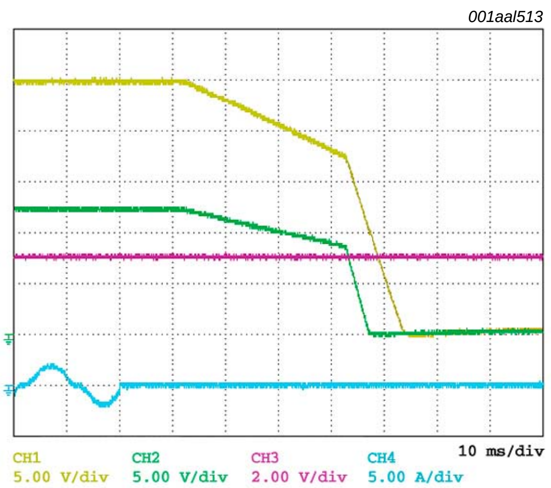
Figure 16 a and b illustrate clearly how OPP can be triggered by a number of protection mechanisms. In this example it is triggered by SNSCURHB and SNSOUT, as well as by SUPIC.

3.8 Hold-up time

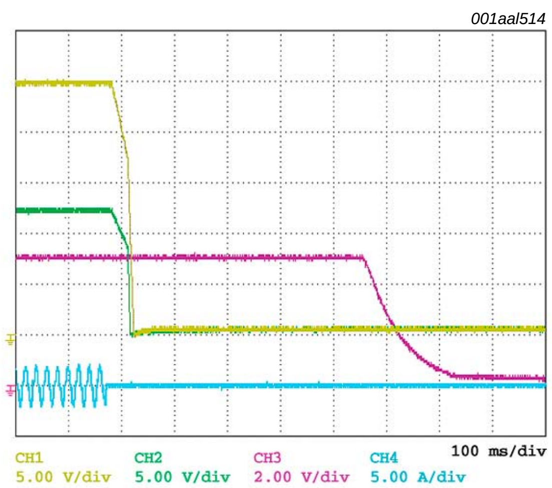
The output was set to full load and the AC supply voltage disconnected. The hold-up time that passes before the output voltage falls below 90 % of its initial value was then measured.

Table 6. Hold-up time test results

V_{AC} supply	Hold-up time 24 V to 21.6 V	Hold-up time 12 V to 10.8 V	Hold-up time 5 V to 4.5 V
90 V / 50 Hz	20 ms	22 ms	500 ms
115 V / 50 Hz	22 ms	23 ms	500 ms
230 V / 50 Hz	23 ms	24 ms	500 ms
264 V / 50 Hz	23 ms	24 ms	500 ms



a. 10 ms/div

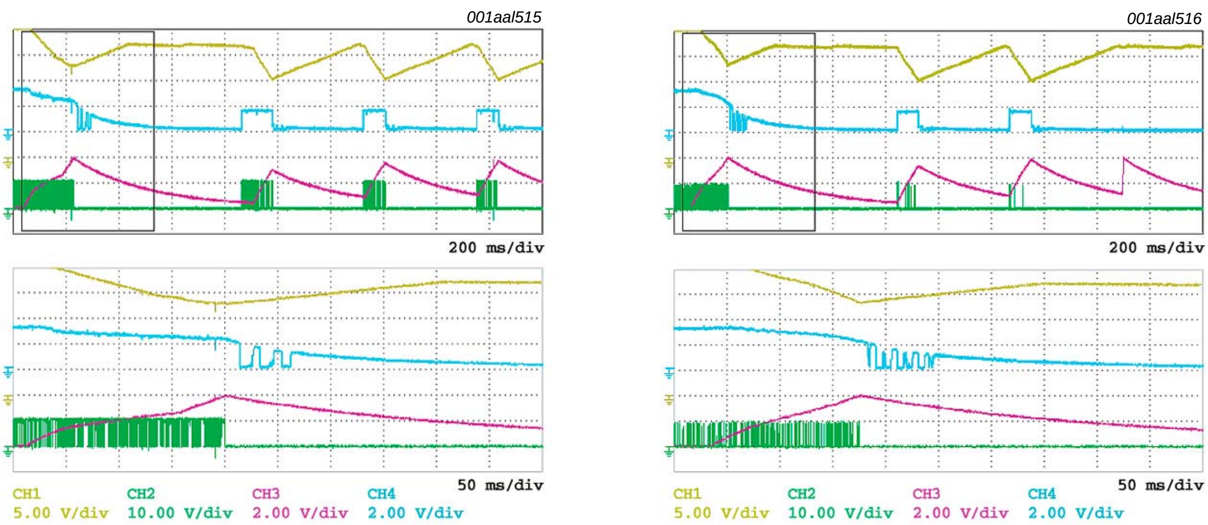


b. 100 ms/div

Fig 17. Hold-up time; V_{AC} = 230 V, CH1: 24 V out, CH2: 12 V out, CH3: 5 V out, CH4: I_{mains}

3.9 Short Circuit Protection (SCP)

If the power supply outputs are shorted under no load or full load conditions, a safe system restart will be initiated.



a. V_{AC} = 90 V

b. V_{AC} = 264 V

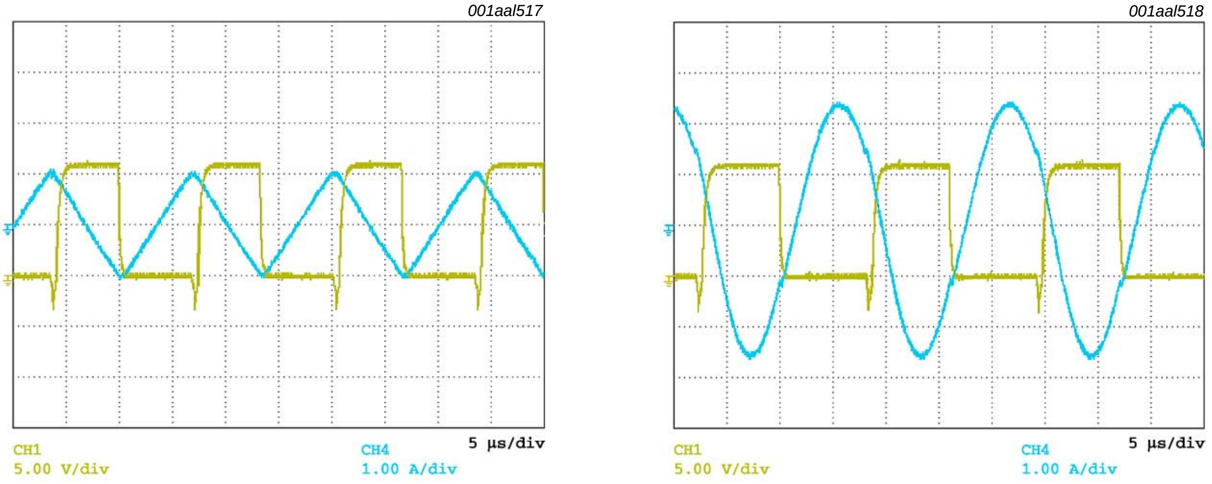
Fig 18. CH1: SUPIC, CH2: GATEPFC, CH3: RCPROT, CH4: SNSOUT

From Figure 18 a, we can see that SCP is triggered initially when V_{RCPROT} reaches 4 V for the first time because $V_{SNSCURHB}$ fails to fall below ± 0.5 V, even though the controller increased the switching frequency in an attempt to lower this voltage.

Subsequently, SCP is triggered by heavy load condition. Since the 24 V rail is shorted, the voltage across the auxiliary winding also falls. The second peak of V_{RCPROT} is below 4 V (it initiates a soft restart at 4 V) when SUPIC reaches its UVLO threshold. The third and fourth peaks of $V_{SNSCURHB}$ reach 4 V due to UVLO on pin SNSOUT or on pin SUPIC. SCP mechanisms are basically the same as OPP mechanisms.

3.10 Resonant current measurement

The gate drive signals and resonant current at no load and at full load were measured. The converter operates in Zero Voltage Switching (ZVS) mode.



a. No load

b. Full load

Fig 19. Resonant current test results; CH1: GATELS, CH4: I_{RES}

3.11 Cross regulation

Voltage regulation can be measured at 24 V / 8 A and 12 V / 0 A or at 24 V / 0 A and 12 V / 4 A, with J301 inserted to inhibit possible Burst mode intervention.

Table 7. Cross regulation test results

Load conditions	24 V		12 V	
	Measure	Regulation	Measure	Regulation
24 V / 8 A 12 V / 0 A	24.31 V	1.3 %	12.61 V	5.1 %
24 V / 0 A 12 V / 4 A	25.0 V	4.2 %	11.63 V	3.1 %

4. Board properties

4.1 Circuit diagram

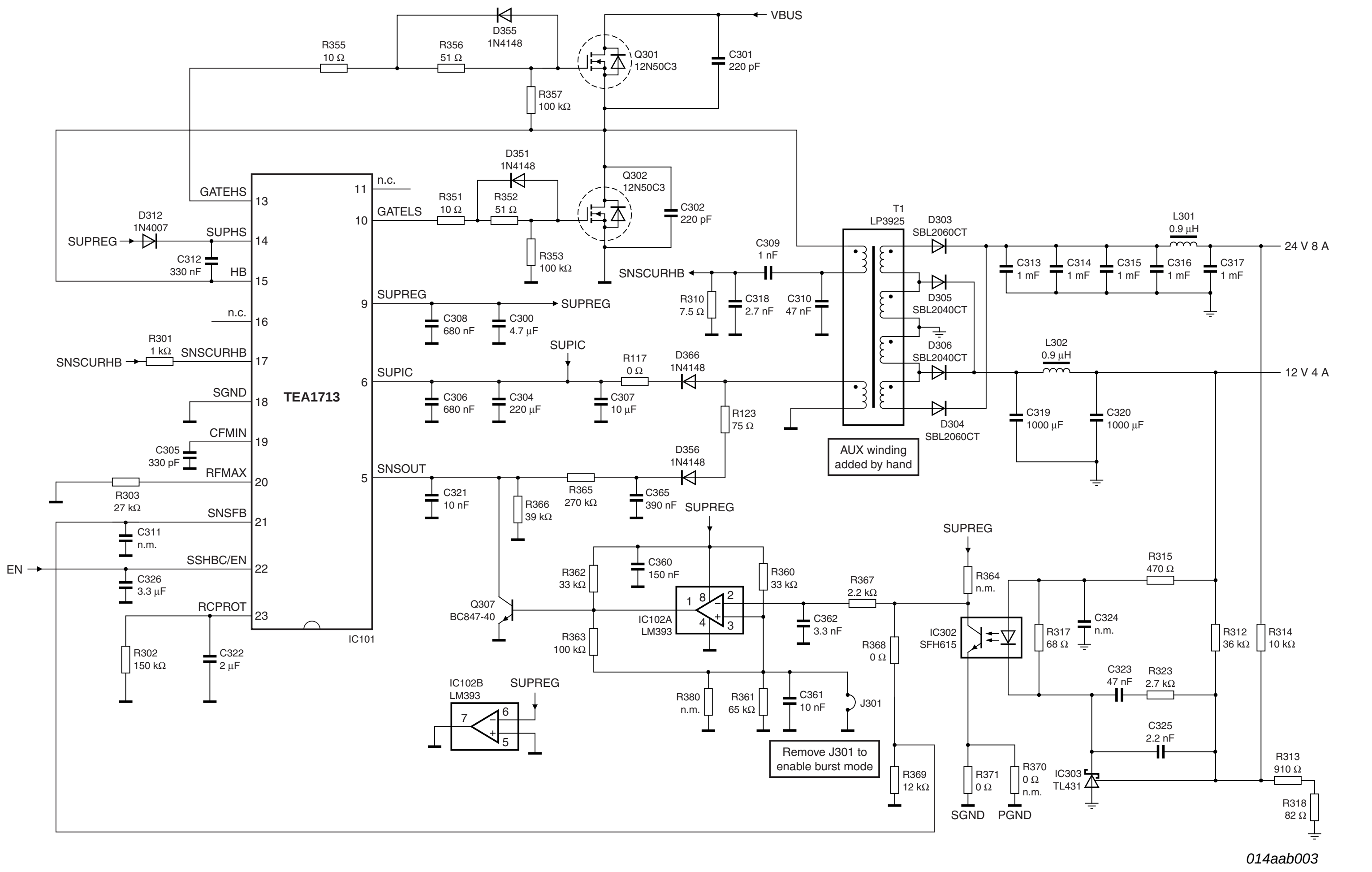


Fig 20. Half bridge resonant converter stage

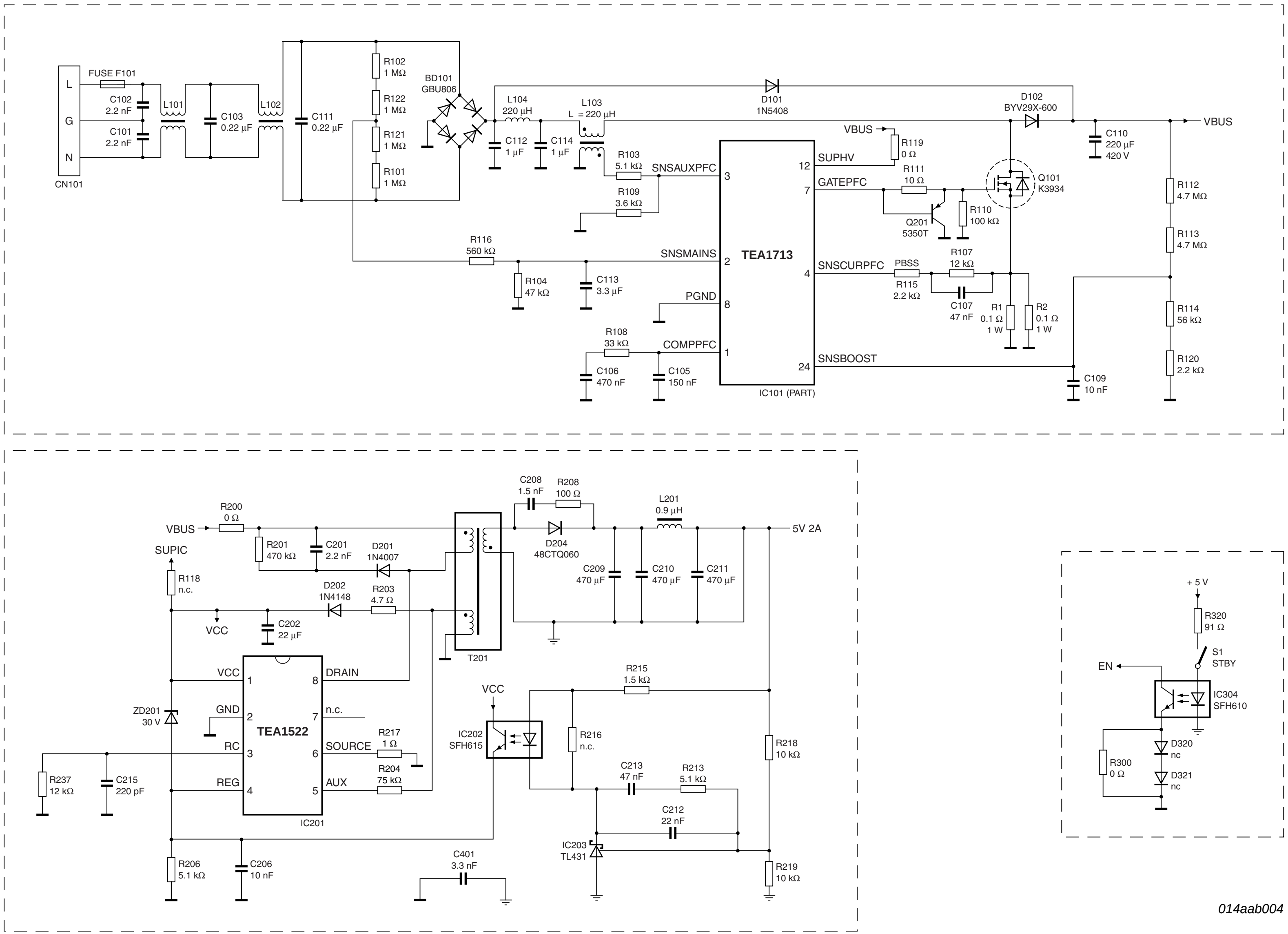


Fig 21. PFC stage (top circuit) and stand-by supply (bottom circuit)

4.2 PCB layout

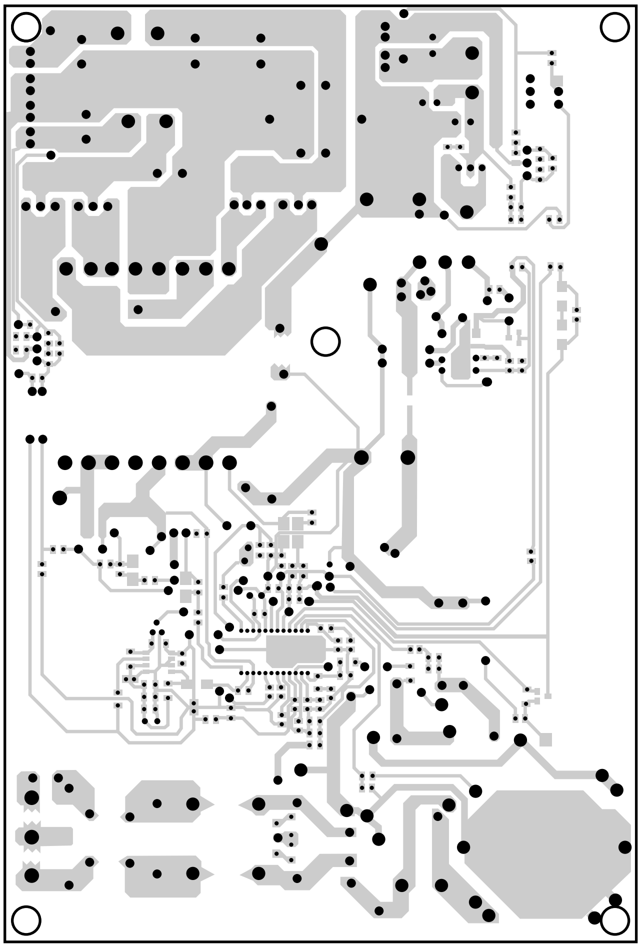


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Fig 22. PCB layout of TEA1713 250 W demo board

4.3 Bill of Materials

Table 8. Bill of material

	Part
PFC	
BD101	Bridge diode, flat/mini, GBU806 8 A, 600 V (Lite-On)
C101	Ceramic disc capacitor, Y2-type, 9 φ, KX 2200 pF, 250 V (AC) (Murata):
C102	Ceramic disc capacitor, Y2-type, 9 φ, KX 2200 pF, 250 V (AC) (Murata):
C103	MPX, X-Cap 0.22 μF, 275 V (AC)
C105	MLCC, SMD 0805, X7R 150 nF, 50 V
C106	MLCC, SMD 0805, X7R 470 nF, 50 V
C107	MLCC, SMD 0805, X7R 47 nF, 50 V
C109	MLCC, SMD 0805, X7R 10 nF, 50 V
C110	E/C, Radial Lead, 85°C, 220 μF, 420 V

Table 8. Bill of material *...continued*

	Part
C111	MPX, X-Cap 0.22 μF, 275 V (AC)
C112	MPP Cap. Radial Lead 1 μF, 450 V
C113	MLCC, SMD 0805, 3300 nF, 25 V
C114	MPP Cap. Radial lead 1 μF, 450 V
D101	General purpose diode, 1N5408 3 A, 1 KV
D102	BYV29X-600 TO220 F-pack
F101	Fuse, / PTU 6.3 A, 250 V
IC101	TEA1713 SO24 (NXP)
L101	EMI Choke, Ring core, 18 mm, / 2.0 mH (Sendpower)
L102	EMI Choke, FOTC2508000900A, 9.0 mH (Yu Jing International)
L103	PFC Choke, QP-3325 220 μH with auxiliary winding (Yu Jing International)
L104	Power Choke 220 μH (Yu Jing International)
Q101	MOSFET K3934 TO220 F-pack
Q201	PNP PBSS5350T
R1	Resistor, axial lead, 1 W, small size 0.1 Ω, 5 %
R2	Resistor, axial lead, 1 W, small size 0.1 Ω, 5 %
R101	Resistor, SMD 1206 thin film chip 1 MΩ, 5 %
R102	Resistor, SMD 1206 thin film chip 1 MΩ, 5 %
R103	Resistor, SMD 0805 thin film chip 5.1 kΩ, 5 %
R104	Resistor, SMD 0805 thin film chip 47 kΩ, 5 %
R107	Resistor, SMD 0805 thin film chip 12 kΩ, 5 %
R108	Resistor, SMD 0805 thin film chip 33 kΩ, 5 %
R109	Resistor, SMD 0805 thin film chip 3.6 kΩ, 5 %
R110	Resistor, SMD 0805 thin film chip 100 kΩ, 5 %
R111	Resistor, SMD 1206 thin film chip 10 Ω, 5 %
R112	Resistor, SMD 1206 thin film chip 4.7 MΩ, 5 %
R113	Resistor, SMD 1206 thin film chip 4.7 MΩ, 5 %
R114	Resistor, SMD 0805 thin film chip 56 kΩ, 1 %
R115	Resistor, SMD 0805 thin film chip 2.2 kΩ, 5 %
R116	Resistor, SMD 0805 thin film chip 560 kΩ, 5 %
R119	Resistor, SMD 0805 thin film chip 0 Ω, 5 %
R120	Resistor, SMD 0805 thin film chip 2.2 kΩ, 5 %
R121	Resistor, SMD 1206 thin film chip 1 MΩ, 5 %
R122	Resistor, SMD 1206 thin film chip 1 MΩ, 5 %
Resonant LLC converter stage	
C300	E/C, Radial Lead, 4.7 μF / 16 V
C301	Ceramic capacitor, Disc, 5φ 220 pF, 1 kV
C302	Ceramic capacitor, Disc, 5φ 220 pF, 1 kV
C304	E/C, Radial Lead, 7.5 mm × 12 mm, 220 μF / 35 V
C305	MLCC, SMD 0805, X7R 330 pF, 50 V
C306	MLCC, SMD 0805, X7R 680 nF, 50 V

Table 8. Bill of material *...continued*

	Part
C307	E/C, radial lead, 7.5 mm × 12 mm, 10 μF / 35 V
C308	MLCC, SMD 0805, X7R 680 nF, 50 V
C309	Ceramic disc capacitor, 5φ 1000 pF, 1 KV
C310	MPP radial lead capacitor, high current 47 nF, 800 V or 1000 V
C311	n.m. (not mounted)
C312	MLCC, SMD 0805, X7R 330 nF, 50 V
C313	E/C radial lead capacitor, 12.5 mm × 20 mm, 1000 μF / 35 V
C314	E/C radial lead capacitor, 12.5 mm × 20 mm, 1000 μF / 35 V
C315	E/C radial lead capacitor, 12.5 mm × 20 mm, 1000 μF / 35 V
C316	E/C radial lead capacitor, 12.5 mm × 20 mm, 1000 μF / 35 V
C317	E/C radial lead capacitor, 12.5 mm × 20 mm, 1000 μF / 35 V
C318	MLCC, SMD 0805, X7R 2.7 nF, 50 V
C319	E/C radial lead capacitor, 10 mm × 15 mm, 1000 μF / 16 V
C320	E/C radial lead capacitor, 10 mm × 15 mm, 1000 μF / 16 V
C321	MLCC, SMD 0805, X7R 10 nF, 50 V
C322	MLCC, SMD 0805, 2.2 μF, 16 V
C323	MLCC, SMD 0805, X7R 47 nF, 50 V
C324	n.m. (not mounted)
C325	MLCC, SMD 0805, X7R 2.2 nF, 50 V
C326	MLCC, SMD 0805, 3.3 μF, 16 V
C360	MLCC, SMD 0805, X7R 150 nF, 50 V
C361	MLCC, SMD 0805, X7R 10 nF, 50 V
C362	MLCC, SMD 0805, X7R 3.3 nF, 50 V
C365	MLCC, SMD 0805, X7R 390 nF, 50 V
D303	Schottky diode, TO220AB, SBL2060CT, 20 A, 60 V (Lite-On)
D304	Schottky diode, TO220AB, SBL2060CT, 20 A, 60 V (Lite-On)
D305	Schottky diode, TO220AB, SBL2040CT, 20 A, 40 V (Lite-On)
D306	Schottky diode, TO220AB, SBL2040CT, 20 A, 40 V (Lite-On)
D312	General purpose diode, 1N4007 1 A, 1 KV or alternatively fast recovery diode UF4007
D351	Switching diode, SMD SOD-80, LL4148, 0.2 A, 75 V (NXP)
D355	Switching diode, SMD SOD-80, LL4148, 0.2 A, 75 V(NXP)
D356	Switching diode, SMD SOD-80, LL4148, 0.2 A, 75 V (NXP)
D366	Switching diode, SMD SOD-80, LL4148, 0.2 A, 75 V (NXP)
IC102	LM393 SO8
IC302	Optocoupler, SFH615A-1
IC303	Voltage regulator, TO92, TL431
J301	Jumper
L301	Power choke; 0.9 μH (Sendpower) core: R4 × 15; wiring: 1.2 mm (diameter) × 6.5 turns
L302	Power choke; 0.9 μH (Sendpower) core: R4 × 15; 1.2 mm (diameter) × 6.5 turns

Table 8. Bill of material *…continued*

	Part
Q301	NMOS SPA12N50C3 TO220
Q302	NMOS SPA12N50C3 TO220
Q307	BC847
R117	Resistor, SMD 0805 thin film chip 0 Ω
R123	Resistor, SMD 0805 thin film chip 75 Ω, 5 %
R301	Resistor, SMD 0805 thin film chip 1 kΩ, 5 %
R302	Resistor, SMD 0805 thin film chip 150 kΩ, 5 %
R303	Resistor, SMD 0805 thin film chip 27 kΩ, 5 %
R310	Resistor, SMD 0805 thin film chip 7.5 Ω, 5 %
R312	Resistor, SMD 0805 thin film chip 36 kΩ, 1 %
R313	Resistor, SMD 0805 thin film chip 910 Ω, 1 %
R314	Resistor, axial lead 1/4 W 10 kΩ, 1 %
R315	Resistor, axial lead 1/4 W 470 Ω, 1 %
R317	Resistor, SMD 0805 thin film chip 68 Ω, 5 %
R318	Resistor, SMD 0805 thin film chip 82 Ω, 5 %
R323	Resistor, SMD 0805 thin film chip 2.7 kΩ, 5 %
R351	Resistor, SMD 0805 thin film chip 10 Ω, 5 %
R352	Resistor, SMD 0805 thin film chip 51 Ω, 5 %
R353	Resistor, SMD 0805 thin film chip 100 kΩ, 5 %
R355	Resistor, SMD 0805 thin film chip 10 Ω, 5 %
R356	Resistor, SMD 0805 thin film chip 51 Ω, 5 %
R357	Resistor, SMD 0805 thin film chip 100 k Ω, 5 %
R360	Resistor, SMD 1206 thin film chip 33 kΩ, 1 %
R361	Resistor, SMD 0805 thin film chip 65 kΩ, 1 %; if burst problems: check similar values (e.g. values between 56 kΩ and 68 kΩ)
R362	Resistor, SMD 1206 thin film chip 33 kΩ, 5 %
R363	Resistor, SMD 1206 thin film chip 100 kΩ, 5 %
R364	n.m. (not mounted)
R365	Resistor, SMD 0805 thin film chip 270 kΩ, 5 %
R366	Resistor, SMD 0805 thin film chip 39 kΩ, 5 %
R367	Resistor, SMD 0805 thin film chip 2.2 kΩ, 5 %
R368	Resistor, SMD 0805 thin film chip 0 Ω, 5 %
R369	Resistor, SMD 0805 thin film chip 12 kΩ, 5 %
R370	n.m. (not mounted)
R371	Resistor, SMD 0805 thin film chip 0 Ω, 5 %
R380	n.m. (not mounted)
T1	Transformer, LP3925, L_k = 110 μH, L = 660 μH (Yu Jing International) add 4 auxiliary windings
Flyback stage	
C201	Ceramic disc capacitor, 5φ 2200 pF, 1 kV
C202	E/C radial lead capacitor, 105 °C, 6.3 mm × 11 mm, LZP 22 μF, 50 V (LTEC)

Table 8. Bill of material *...continued*

	Part
C206	MLCC, SMD 0805, X7R 10 nF, 50 V
C208	MLCC, SMD 0805, X7R 1.5 nF, 50 V
C209	E/C radial lead capacitor,105 °C, 5 mm × 12 mm, LZP 470 μF, 16 V (LTEC)
C210	E/C radial lead capacitor, 5 mm × 12 mm, LZP 470 μF, 16 V (LTEC)
C211	E/C radial lead capacitor, 105°C, 5 mm × 12 mm, LZP 470 μF, 16 V (LTEC)
C212	MLCC, SMD 0805, X7R 22 nF, 50 V
C213	MLCC, SMD 0805, X7R 47 nF, 50 V
C215	MLCC, SMD 0805, X7R 220 pF, 50 V
C401	Ceramic, Y1-Cap, Disc 9φ, KX 3300 pF, 250 V (AC) (Murata)
D201	General purpose diode, 1N4007 1 A, 1 KV
D202	Switching diode, DIP, 1N4148, 0.2 A, 75 V (NXP)
D204	Schottky diode, TO220AB, SBL1040CT, 10 A, 40 V (Lite-On)
D320	n.m. (not mounted)
D321	n.m. (not mounted)
IC201	SMPS controller IC, SO8, TEA1522P (NXP)
IC202	Optocoupler, SFH615A-1
IC203	Voltage regulator, TO92, TL431
IC304	Optocoupler, SFH610A-1
L201	Power choke; 0.9 μH (Sendpower) core: R4 × 15; wiring: 1.2 mm (diameter) × 6.5 turns
R118	n.m. (not mounted)
R200	Resistor, SMD 1206 thin film chip 0 Ω,
R201	Resistor, axial lead, CF 1/4 W, small size 470 kΩ, 5 %
R203	Resistor, SMD 0805 thin film chip 4.7 Ω, 5 %
R204	Resistor, axial lead 1/4 W 75 kΩ, 5 %
R206	Resistor, SMD 0805 thin film chip 5.1 kΩ, 5 %
R208	Resistor, SMD 0805 thin film chip 100 Ω, 5 %
R213	Resistor, SMD 0805 thin film chip 5.1 kΩ, 5 %
R215	Resistor, SMD 0805 thin film chip 1.5 kΩ, 5 %
R216	n.m. (not mounted)
R217	Resistor, axial lead 1/4W 1 Ω, 5 %
R218	Resistor, SMD 0805 thin film chip 10 kΩ, 1 %
R219	Resistor, SMD 0805 thin film chip 10 kΩ, 1 %
R237	Resistor, SMD 0805 thin film chip 12 kΩ, 5 %
R300	Resistor, SMD 0805 thin film chip 0 Ω, 5 %
R320	Resistor, SMD 0805 thin film chip 91 Ω, 5 %
S1	Switch, small signal, 6 pin
T201	Transformer, EF20 PC40 2.1 mH (TDK)
ZD201	Zener diode, SMD BZX84-C30, 30 V (NXP)

5. Appendix 1 - Resonant transformer data

5.1 LP3925 outline

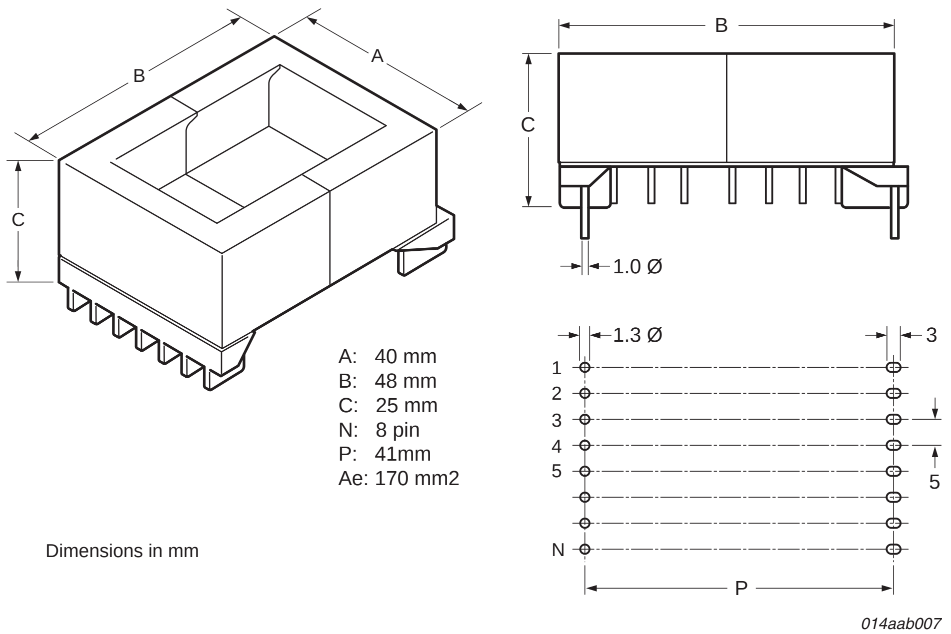

Fig 23. LP3925 dimensions

5.2 Winding order

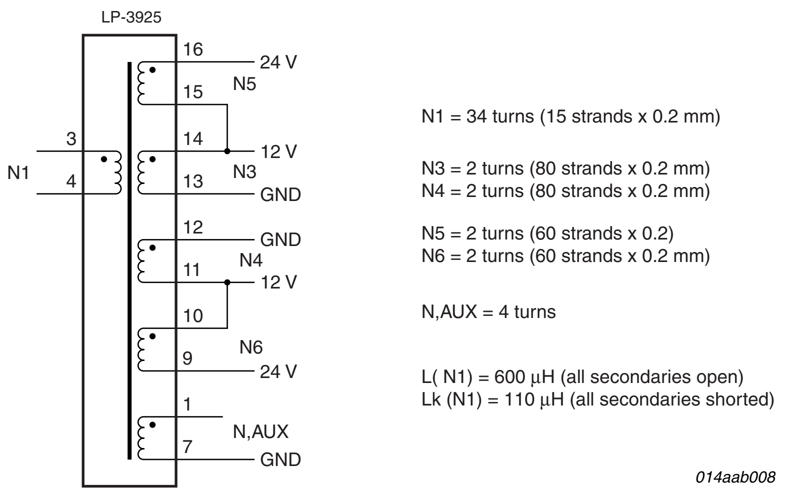

Fig 24. LP3925 winding order

6. Appendix 2 - PFC transformer data

6.1 QP-3325 outline

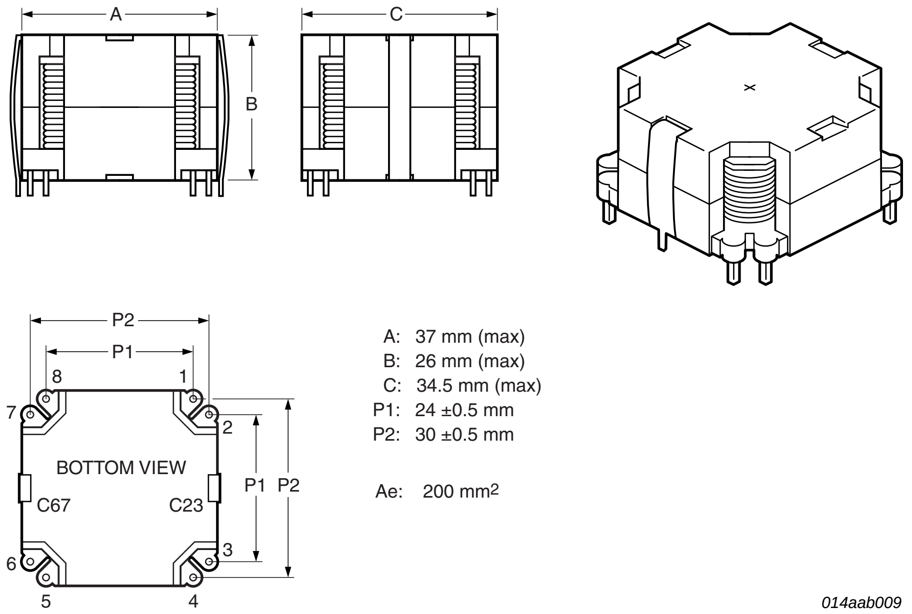

Fig 25. QP-3325 dimensions

6.2 Winding order

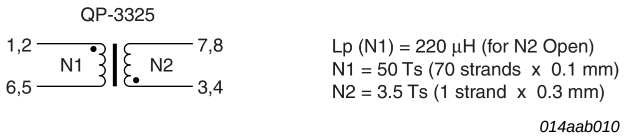

Fig 26. QP-3325 winding order

7. Appendix 3 - Coil L104 data

7.1 Core

An iron powder toroid core should be used for the inductor core. The core must meet the electrical specifications defined for the T80-52 package.

The following cores can be used:

MICROMETALS: AL = 42 ±10 % nH/N^2; Part No. T80-52

CURIE AL = 42 ±10 % nH/N^2; Part No. 80-75H

CORTEC AL = 42 ±10 % nH/N^2; Part No. CA80-52

7.2 Winding

The winding must consist of 82 turns of 1.0 Ø × 1 magnetic wire evenly distributed on three toroid layers. The inductance of the coil is 220 μH.

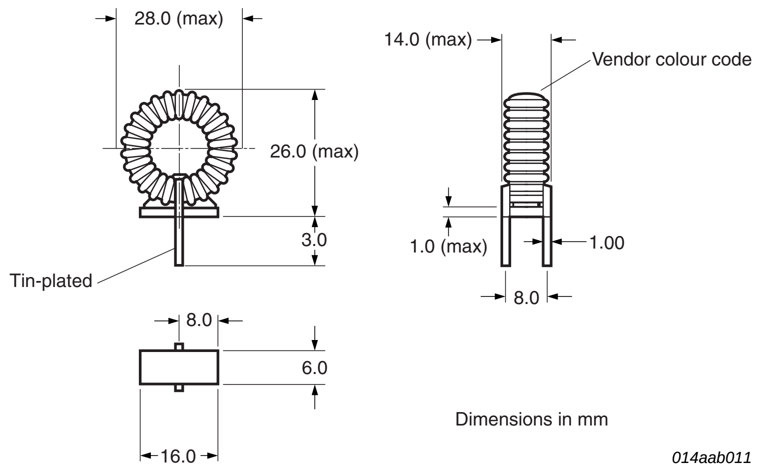

Fig 27. L104 dimensions

8. Appendix 4 - Standby transformer data

8.1 EF20 transformer with TDK PC40 core

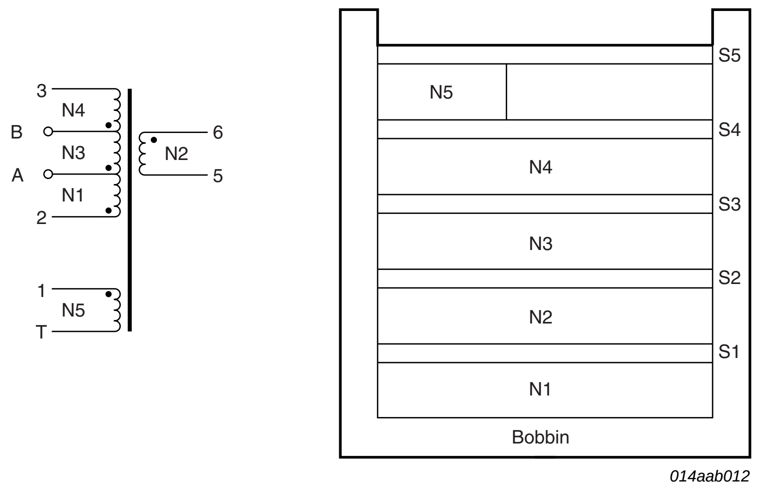

Fig 28. Winding order

8.2 Winding specifications

Table 9. Winding specifications

Layer	Winding		Wire	Turns	Winding Method	Tape insulation		
	Start	Finish				No.	Turns	Width
N1	2	A	0.25 Ø × 1	40	center	S1	2	13 mm
N2	6	5	0.35 Ø × 4 (3L)	5	center	S2	2	13 mm
N3	A	B	0.25 Ø × 1	40	center	S3	1	13 mm
N4	B	3	0.25 Ø × 1	40	center	S4	2	13 mm
N5	1	1	0.3 Ø × 1	20	side	S5	3	13 mm

8.3 Electrical characteristics

Table 10. Electrical characteristics

Item	Pin	Specification	Condition
Inductance	2 to 3	2.1 mH ±5%	80 kHz, 1 V
Leakage inductance	2 to 3	<100 μH	2nd all short

8.4 Core and bobbin

Core: EF-20 (TDK PC40 or equivalent)

Bobbin: EF-20 (6-pin vertical type, Chang Chun Plastics Co. Ltd)

Ae: 32.1 mm^2

8.5 Outline

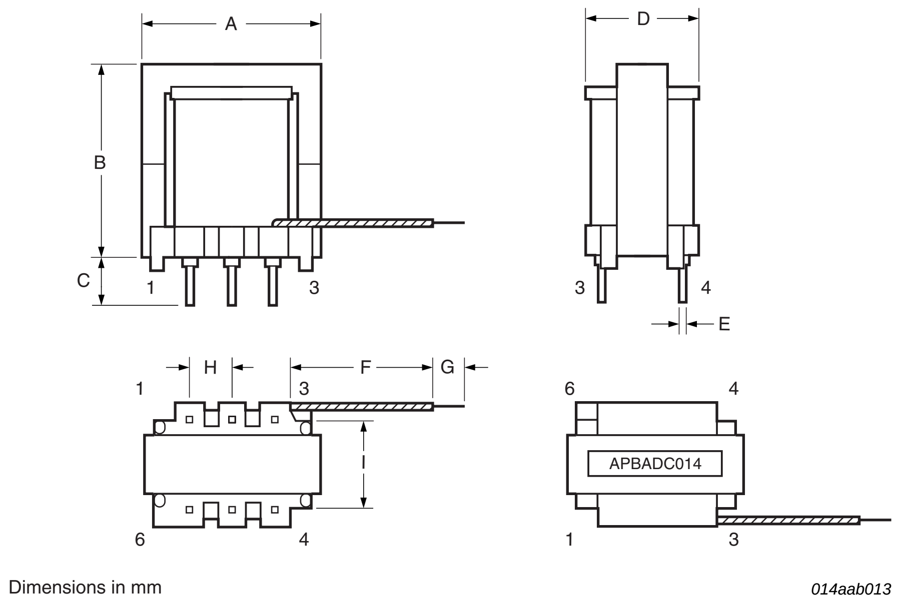

Fig 29. EF-20 dimensions

Table 11. Dimensions

	A	B	C	D	E	F	G	H	I
Spec	22.0	23.0	3.5	15.0	SQ0.64	25.0	10.0	5	10.0
Tolerance	MAX	MAX	MIN	MAX	±0.5	±2.0	±2.0	±0.5	±0.5

[1] Pin 4 is removed completely in this application.

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10. Contents

Date of release: 16 April 2010
Document identifier: UM10379_1