AN3089
Application note

19 V - 65 W quasi-resonant flyback adapter using L6566B and TSM1014

19 V - 65 W准谐振反激式适配器，采用L6566B和TSM101

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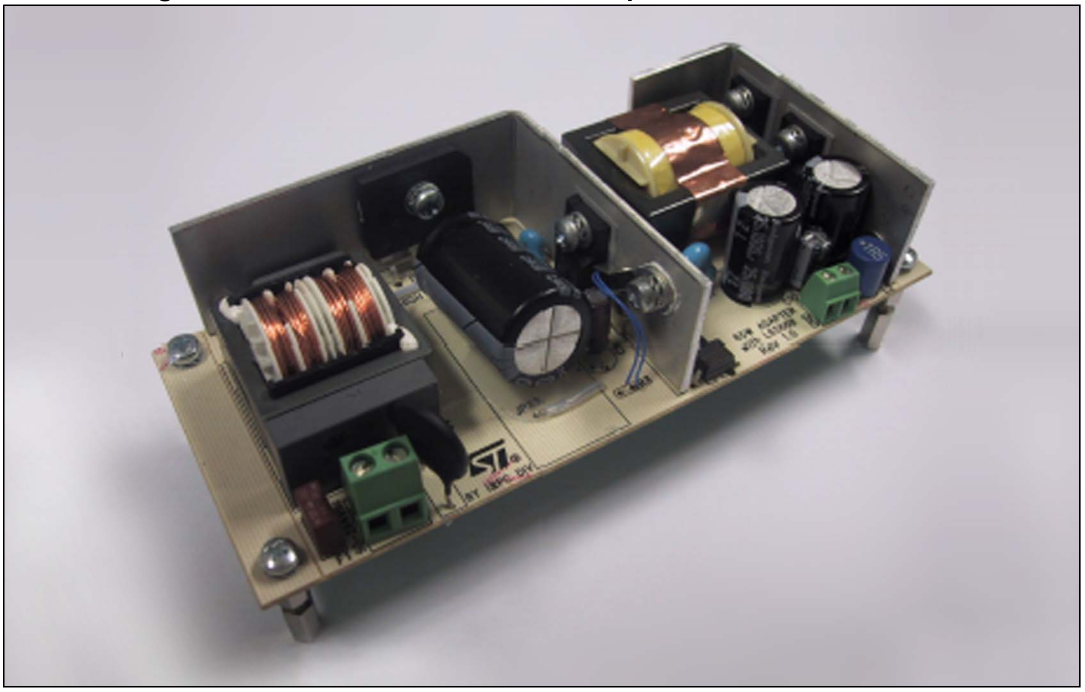
Introduction

介绍
本应用笔记介绍了65 W演示板（EVL6566B-65W-QR）的特性和特性，适用于典型的高端便携式计算机电源的规格。 这种设计的特点是非常高的平均效率约为90%，没有同步整流，而在230 Vac时的非常低的空载功耗为100 mW。 结果是该转换器符合EnergyStar?资格标准（EPA rev。2.0 EPS）。

of about 90%, without synchronous rectification, and very low no load consumption of 100 mW at 230 Vac. The result is that this converter is more than compliant with Energy Star® eligibility criteria (EPA rev. 2.0 EPS).

Figure 1. EVL6566B-65W-QR: 65 W adapter demonstration board



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主要特点及电路描述

1 Main characteristics and circuit description

SMPS的主要功能如下

The main features of the SMPS are listed below:

- Universal input mains range: 90 ÷ 264 Vac - frequency 45 ÷ 65 Hz
- Output voltage: 19 V at 3.42 A continuous operation
- Mains harmonics: acc. to EN61000-3-2 Class-D or JEITA-MITI Class-D
- Standby mains consumption: < 100 mW at 230 Vac
- Average efficiency: better than 89% without synchronous rectification
- EMI: according to EN55022-Class-B
- Safety: according to EN60950
- Dimensions: 58 x 121 mm, 25 mm maximum component height
- PCB: single side, 35 µm, CEM-1, mixed PTH/SMT.

1.1 Power stage

The flyback converter implements the new ST dedicated current mode L6566B (U2)

反激转换器实现了以准谐振模式工作的新型ST专用电流模式L6566B（U2）控制器，并通过ZCD（#11）引脚检测变压器退磁。
OSC（#13）引脚上的R23将最大开关频率设置在165 kHz左右。由于施加了最大开关频率，转换器在轻负载运行时工作在不连续导通模式。即使在DCM中，L6566B谷跳跃功能也能够在谷底开关中导通MOSFET，从而降低开关损耗。
MOSFET是标准的800 V STF7NM80，采用TO-220FP封装，只需要一个小型散热片。变压器是一种层型，使用标准铁氧体尺寸EER28L，根据EN60950设计，由MAGNETICA制造。
反激反射电压为?150V，为漏感电感尖峰提供了足够的空间，MOSFET的可靠性仍然有余量。 D5整流器和D4 Transil?钳位MOSFET关断时漏感电感尖峰峰值。与D4并联的小电容平滑漏电感尖峰，降低了EMI和Transil耗散。
输出整流器是并联的两个STPS20H100CFP双中心抽头肖特基二极管（D2和D3），容纳在TO-220FP中。它们是根据最大反向电压，正向压降和功耗来选择的。由R5，R7和C12组成的缓冲器可抑制由二极管电容产生的振荡和泄漏
电感。
在输出端增加了一个小的LC滤波器，对高频纹波和尖峰进行滤波。
D6，R4，R5，R8，R9，Q2和Q3实现输出电压“快速放电”电路，当转换器关闭时，快速放电输出电容器。已经实现了在空载关闭转换器之后快速降低剩余输出电压。

The flyback reflected voltage is ~150 V, providing enough room for the leakage inductance voltage spike with a still margin for reliability of the MOSFET. The D5 rectifier and the D4 Transil™ clamp the peak of the leakage inductance voltage spike at MOSFET turn-off. A small capacitance in parallel with D4 smooth leakage inductance spikes, reducing EMI and Transil dissipation.

The output rectifiers are two STPS20H100CFP dual center tap Schottky diodes (D2 and D3) in parallel, housed in the TO-220FP. They have been selected according to the maximum reverse voltage, forward voltage drop, and power dissipation. The snubber, made up of R5, R7 and C12, dampens the oscillation produced by the diode capacitance and the leakage inductance.

A small LC filter has been added on the output, filtering the high frequency ripple and spikes.

D6, R4, R5, R8, R9, Q2 and Q3 implement an output voltage “fast discharge” circuit, quickly discharging the output capacitors when the converter is turned off. It has been implemented to quickly decrease the residual output voltage after the converter is turned off at no load.

1.2 Startup

The L6566B flyback controller pin #1 (HV) is directly connected to the bulk capacitor, and at startup an internal high voltage current source charges C9 until the L6566B turn-on voltage threshold is reached, then the high voltage current source is automatically switched off. As the IC starts switching it is initially supplied by the C9, then the transformer auxiliary winding (pins 5 - 6) provides the voltage to power the IC.

Because the L6566B integrated HV startup circuit is turned off, and therefore not dissipative during normal operation, it gives a significant contribution to power consumption reduction when the power supply operates at light-load.

1.3 Brownout protection

Brownout protection prevents the circuit from working with abnormal mains levels. It can be easily achieved using the AC_OK controller pin (#16).

This feature is typically implemented sensing the bulk voltage through a resistor divider, however on this board a different solution has been applied. The mains voltage is sensed before the bridge rectifier. This has two main achievements: it is less dissipative and it allows faster restart in case of latching, because there is no need to wait for the bulk capacitor discharge.

If the input voltage is below 90 Vac, the startup of the circuit is inhibited, while the turn-off voltage has been set at 80 Vac. The internal comparator has in fact a current hysteresis allowing to set the converter turn-on and turn-off voltage independently. R19 sets the relation between the comparator hysteresis and the actual voltage hysteresis.

C13, R20 and R21 set the discharging time constant of the AC_OK voltage. This value must be dimensioned properly, taking two main points into account:

- The voltage must keep up during the mains missing cycle to avoid the converter shutting down during mains dip
- In the case of converter switch-off, the voltage must go down promptly to avoid an operation with improper input voltage.

Basically, the ideal dimensioning would allow C13 to discharge slightly faster than the bulk capacitor in the case of switch-off at nominal load.

1.4 Output regulation feedback loop

Output regulation is done by means of two control loops, voltage and current, working alternatively. A dedicated control IC, the TSM1014 (U3), has been used. It integrates two operational amplifiers (used as error amplifiers) and a precise voltage reference. The output signal of the error amplifiers drives an SFH617A-4 (U1) optocoupler to achieve the required insulation of the secondary side and modulate the COMP pin (#9) voltage of the L6566B.

1.5 L6566B current mode control and voltage feed forward function

L6566B电流模式控制和电压前馈功能

R16检测回扫MOSFET电流，并将信号馈入连接到PWM比较器的CS引脚（＃7）。该信号与来自光耦合器的COMP引脚（＃9）信号进行比较。
转换器可以传递的最大功率由限制主电流峰值的比较器设置，比较CS和内部阈值（VCSX）。如果当前信号超过阈值，则比较器限制MOSFET占空比，因此输出功率也受到限制。
由于最大可传输功率取决于初级峰值电流和输入电压，为了保持过载设定点几乎恒定，这些变化根据反激输入电压而变化，L6566B通过专用引脚实现电压前馈功能。因此，VCSX由VFF引脚（＃15）上的电压调制，通过电阻分压器感测电源电压。较高的电压导致较小的VCS，MAX，以便在任何输入电压下，最大功率可保持几乎恒定。
在该板上，VFF通过相同的掉电电路实现，节省了组件并降低了轻负载时的消耗

As the maximum transferable power depends on both the primary peak current and the input voltage, in order to keep the overload set point almost constant, which changes according to the flyback input voltage, the L6566B implements a voltage feed forward function via a dedicated pin. Therefore, V_{CSX} is modulated by the voltage on the VFF pin (#15) sensing the mains voltage through a resistor divider. A higher voltage causes a smaller $V_{CS,MAX}$ so that the maximum power can be kept almost constant at any input voltage.

On this board, VFF is implemented via the same circuit of brownout, saving components and reducing consumption at light-load.

1.6 L6566B short-circuit protection

An internal comparator senses the COMP pin after the soft-start time: in case of a short, the COMP pin goes high, and the said comparator activates a current source that restarts charging the soft-start capacitor from the initial 2 V level. If the voltage on this pin reaches 5 V, the L6566B stops the operation and enters into the so-called “hiccup mode”. The L6566B restarts with a startup sequence when the Vcc voltage drops below the Vcc restart level (5 V). Because of the long time needed by the Vcc capacitor to drop to 5 V, it results in an increase of the duration of the no load operation, therefore decreasing the power dissipation and the stress of the power components. This sequence is repeated until the short is removed, after that normal operation of the converter is automatically resumed.

A second protection, dedicated to protecting the circuit in the case of MOSFETs or output diode short or transformer saturation, is implemented by another comparator on the CS pin (#7). If the voltage on this pin exceeds the 1.5 V threshold, the IC immediately shuts down. In this way a hiccup mode operation is still obtained, avoiding consequent failures due to the power components overheating. To prevent spurious activation of the protection in the case of temporary disturbances, for example during immunity tests, the comparator must be triggered two consecutive times.

1.7 Overvoltage protection

The ZCD pin (#11) is connected to the auxiliary winding by a resistor divider. It implements the OVP against feedback network failures. When the ZCD pin voltage exceeds 5 V four consecutive times, the IC is shut down. This protection can be set as a latch or an autorestart by the user with no additional components. On the board it is set as latched. Therefore the operations can be resumed after a mains recycling.

1.8 Overtemperature protection 过热保护

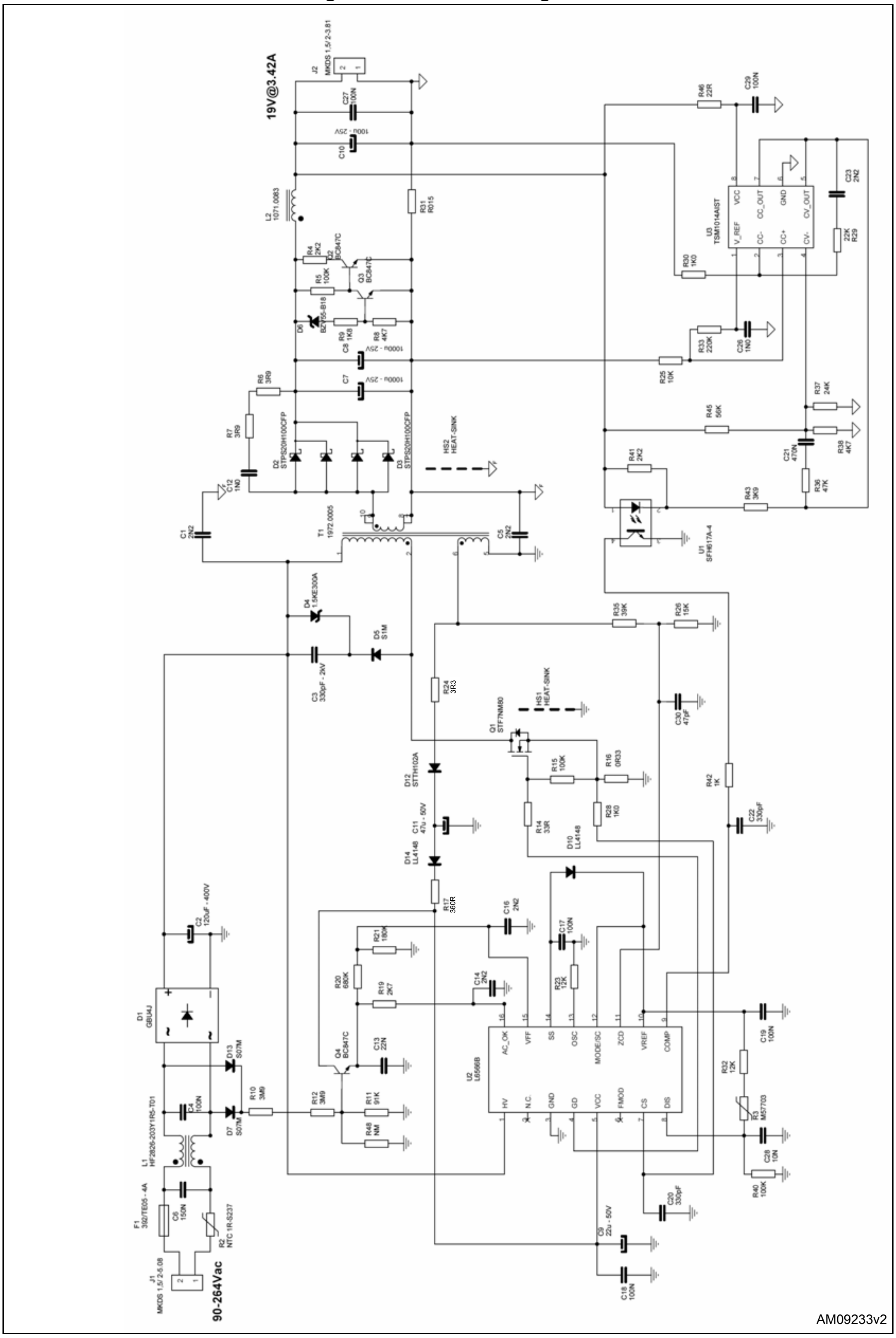
T 连接到L6566B DIS引脚（#8）的R3热敏电阻提供回扫MOSFET（Q1）的热保护。 因此，在过热的情况下 of
tl ，反激式转换器的动作被锁存。 为了保持这种状态，L6566B的内部电路监控Vcc，并周期性地重新激活HV ity
is 电流源来提供IC。 and
periodically reactivates the HV current source to supply the IC.

1.9 Burst mode operation

The L6566B implements a current mode control, thus it monitors the output power through the COMP pin, which has a level proportional to the load. Therefore, when the voltage on the COMP pin falls below an internal threshold, the controller is disabled and its consumption reduced; normal operation restarts as soon as the COMP voltage rises again. In this way a low consumption burst mode operation is obtained.

突发模式操作
L6566B实现电流模式控制，因此它通过COMP引脚监视与负载成比例的电平的输出功率。 因此，当COMP引脚上的电压低于内部阈值时，控制器被禁止
消费减少; 一旦COMP电压再次上升，正常操作就会重新启动。 以这种方式获得低消耗突发模式操作。

Figure 2. Electrical diagram



2 Efficiency measurement 效率测量

表1显示了在标称电源电压下测量的空载消耗和总体效率。平均效率在两个市级水平上均为90%左右。该值远远高于EPA rev2.0外部电源限制要求的87%。
得益于L6566B谷跳跃功能，可以对电力变压器参数进行定义，优化不同负载下的效率，即使没有同步整流也能取得突出成果。
同样在空载时，电路板性能优越：额定电源电压下的最大空载功耗低于100 mW;这个价值远远低于500MW的能源之星计划的限制。这得益于L6566B的嵌入式解决方案，允许在轻载时最大限度地减少消耗，并避免增加额外的离散电路，从而大大增加总体消耗和组件数量（HV启动，锁存电路）。另外，实现掉电保护的特殊解决方案的消耗量非常低约5mW

Tab ... nal ma ... n hig ... Tha ... er tran ... outstanding result even without synchronous rectification.

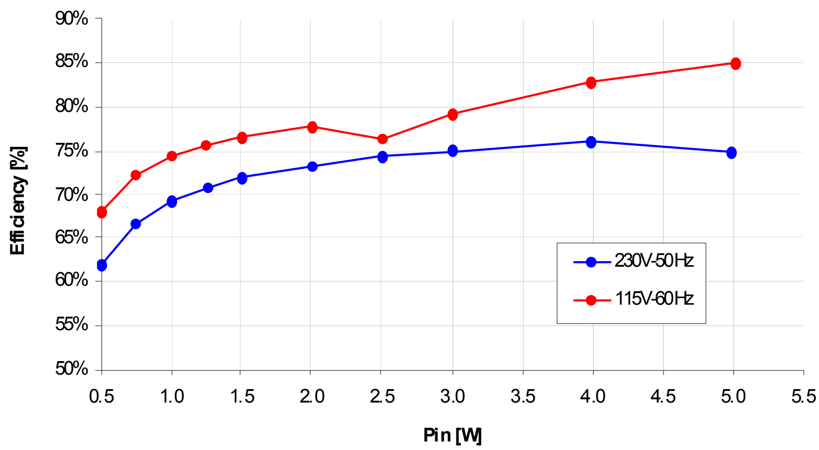
Also at no load the board performances are superior: maximum no load consumption at nominal mains voltage is below 100 mW; this value is significantly lower than the limit imposed by the Energy Star program which is 500 mW. This has been obtained thanks to the embedded solutions of the L6566B that allow the minimization of consumption at light-load and avoid adding additional discrete circuits that generally increase overall consumption and component count (HV startup, latching circuit). In addition, the peculiar solution implemented for brownout protection has a very low consumption of about 5 mW.

Table 1. Overall efficiency and no load consumption

Test	230 V - 50 Hz					115 V - 60 Hz				
	Vout [V]	Iout [mA]	Pout [W]	Pin [W]	Eff. [%]	Vout [V]	Iout [A]	Pout [W]	Pin [W]	Eff. [%]
No load	19.00	0.00	0.00	94 mW	-----	19.00	0.00	0.00	75 mW	-----
25% load eff.	18.97	0.86	16.37	18.53	88.3	18.97	0.86	16.32	18.03	90.5
50% load eff.	18.97	1.71	32.50	35.77	90.9	18.97	1.72	32.54	35.91	90.6
75% load eff.	18.98	2.57	48.74	53.44	91.2	18.97	2.57	48.82	54.39	89.8
100% load eff.	18.98	3.42	64.89	71.18	91.2	18.98	3.42	64.99	73.30	88.7
Average eff.					90.4					89.9

Light-load efficiency measurement results are plotted in *Figure 3*. As shown, efficiency is better than 60% even at half-watt input power.

Figure 3. Light-load efficiency



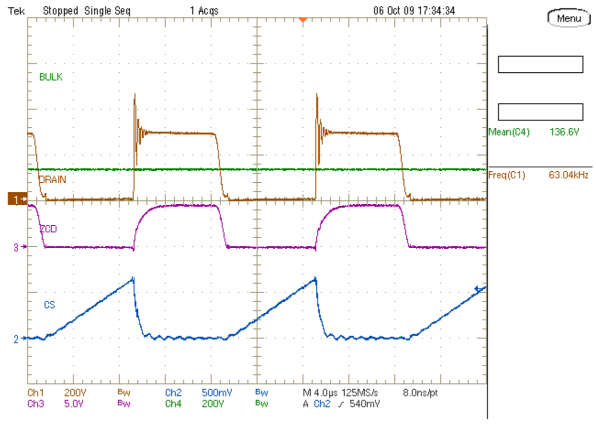
3 Functional check

这里报告稳态运行时的一些反激波形。
在额定负载条件下，在图4和图5中，可以注意到ZCD负沿触发MOSFET导通，允许准谐振操作。

Some flyback waveforms during steady state operation are reported here.

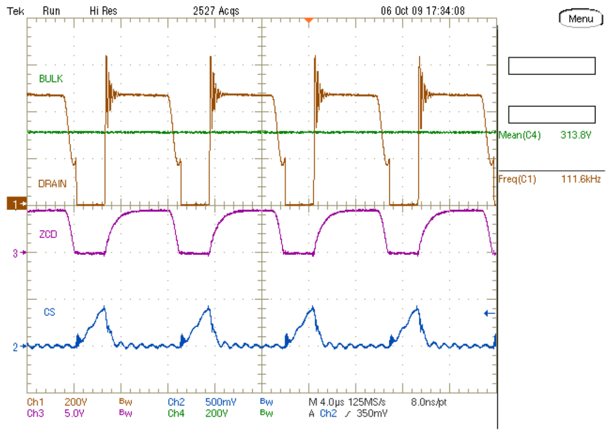
At nominal load conditions, in *Figure 4* and *Figure 5*, it is possible to note that the ZCD negative-going edge triggers MOSFET's turn-on, allowing quasi-resonant operation.

Figure 4. Flyback stage waveforms at 115 V – 60 Hz – full load



CH1: drain voltage
CH2: CS pin voltage
CH3: ZCD pin
CH4: bulk voltage

Figure 5. Flyback stage waveforms at 230 V – 50 Hz – full load

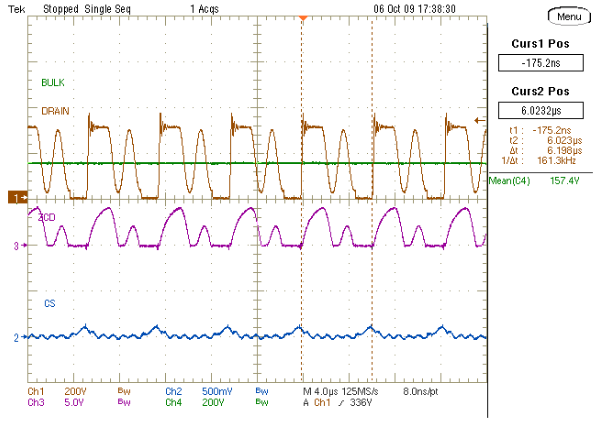


CH1: drain voltage
CH2: CS pin voltage
CH3: ZCD pin
CH4: bulk voltage

图6和图7显示了轻载操作。 如已经指出的那样，最大开关频率设定在165kHz。 因此，L6566B跳过ZCD上的第一个谷值信号，并在第二个负向边沿接通MOSFET。

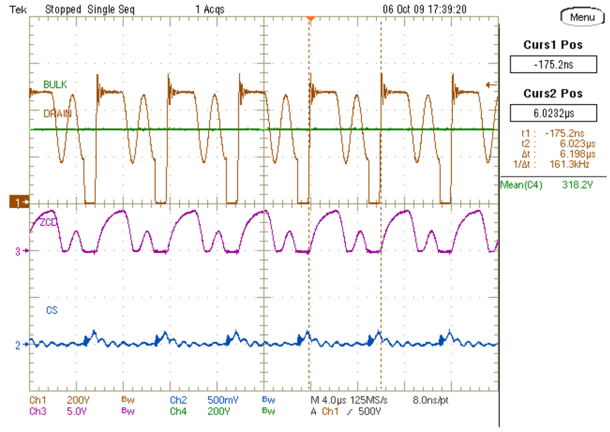
Figure 6 and *Figure 7* show operation at light-load. As already indicated, maximum switching frequency has been set at 165 kHz. For this reason, the L6566B skips the first valley signal on ZCD and switches on the MOSFET at the second negative-going edge.

Figure 6. Flyback stage waveforms at 115 V – 60 Hz – light-load



CH1: drain voltage CH2: CS pin voltage
CH3: ZCD pin CH4: bulk voltage

Figure 7. Flyback stage waveforms at 230 V – 50 Hz – light-load



CH1: drain voltage CH2: CS pin voltage
CH3: ZCD pin CH4: bulk voltage

待机和无负载操作

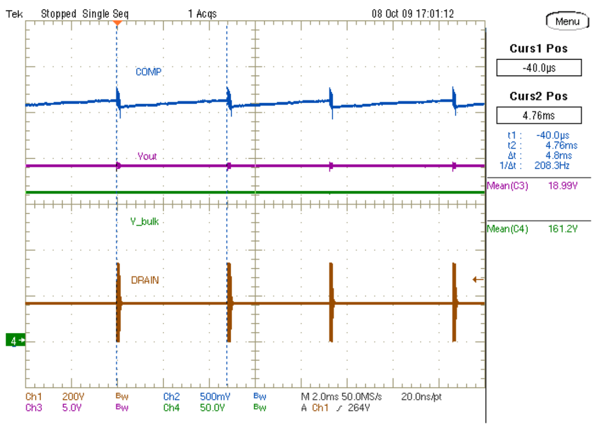
3.1 Standby and no load operation

In *Figure 8* and *Figure 9*, some no load waveforms are captured. As shown, the L6566B

在图8和图9中，捕获了一些空载波形。 如图所示，L6566B工作在突发模式。 当COMP引脚上的反馈电压降至2.65 V（典型值）以下时，IC被禁止并且其功耗降低。 当COMP引脚上的电压再次上升超过该阈值时，芯片被重新使能。 因此，PFC控制电路的剩余消耗被最小化到可忽略的水平。

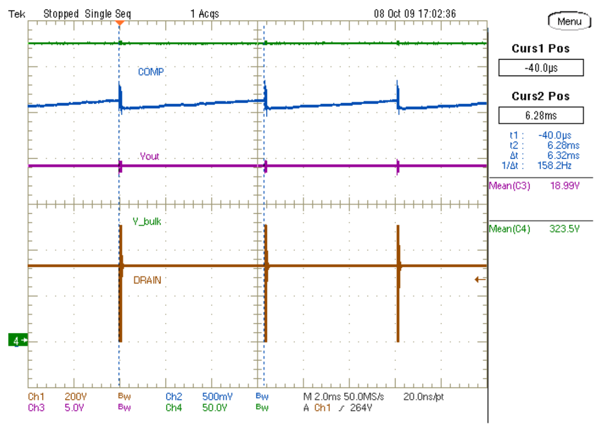
consumption of the PFC control circuitry is minimized to a negligible level.

Figure 8. No load operation at 90 V – 50 Hz



CH1: drain voltage CH2: COMP pin
CH3: Output voltage CH4: bulk voltage

Figure 9. No load operation at 265 V – 50 Hz

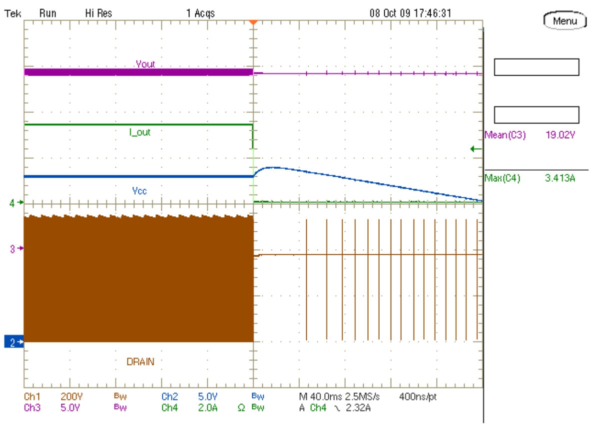


CH1: drain voltage CH2: COMP pin
CH3: Output voltage CH4: bulk voltage

在图10和图11中，已经检查了在最大输入电压下从满载到无负载的转变，反之亦然。 已经选择了最大输入电压，因为它是用于转换的最关键的输入电压：实际上，在空载时，脉冲串脉冲具有较低的重复频率，Vcc可能下降，导致控制器的重启周期。 如图所示，两个转换都是干净的，没有任何输出电压或Vcc下降。

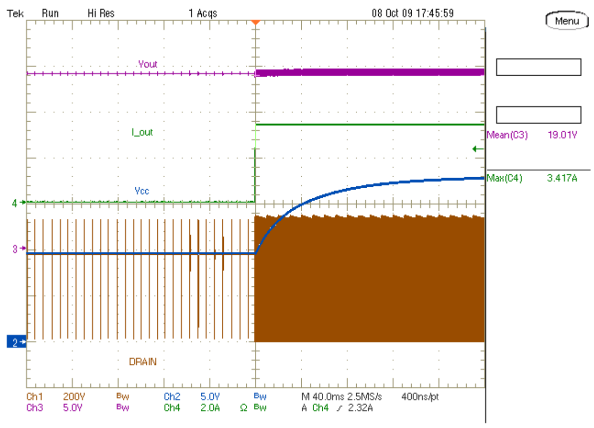
...osen because it is the most critical input voltage for transition. In fact, at no load the burst pulses have the lower repetition frequency and the Vcc may drop, causing restart cycles of the controller. As shown, both transitions are clean and there isn't any output voltage or Vcc dip.

Figure 10. Transition full load to no load at 265 Vac – 50 Hz



CH1: drain voltage CH2: Vcc
CH3: output voltage CH4: output current

Figure 11. Transition no load to full load at 265 Vac – 50 Hz



CH1: drain voltage CH2: Vcc
CH3: output voltage CH4: output current

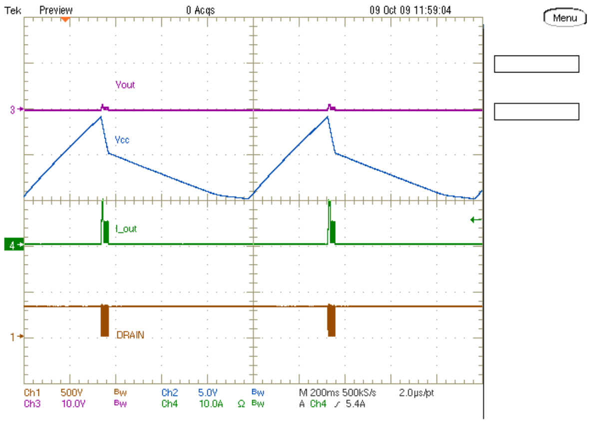
3.2 Overcurrent and short-circuit protection

过电流和短路保护
在这个演示板上，过电流由CC / CV控制器TSM1014（U3）管理。 IC内部有一个电压基准和两个Or-ed运算放大器，一个专门用作电压环路的误差放大器，另一个专门用作电流环路的误差放大器。在正常工作期间，电压反馈环路正在工作，而在输出电流超过编程值的情况下，电流环路误差放大器接管，因此保持输出电流恒定。
在无故障的情况下，由于输出电压下降，U5无法有效地限制电流，因此无电源，因此主控制器必须管理故障状态。
在输出短路的情况下，控制器必须处理两种不同的可能情况：如果次级绕组和辅助绕组之间的耦合良好，一旦输出电压下降，辅助电压也会下降，而IC电源电压低于欠压锁定阈值，导致L6566B停止切换。直到Vcc引脚上的电压降至低于Vccrestart阈值（5V）为止，它保持在截止状态，然后HV启动导通并对Vcc电容充电;一旦达到开启阈值，电路将重新启动。如果短路仍然存在，电路只是尝试重新启动，但在几毫秒后停止。重新启动尝试无限期重复，直到短路被移除。这提供了非常低频的打嗝工作模式（对于该板1 Hz），限制了在次级侧流动的电流（小于1 Arms），从而防止电源过热，从而可能会损坏电源。在这种情况下，辅助和次级绕组不良，辅助电压上的某些尖峰可能使Vcc高于UVLO阈值一段足以损坏转换器的时间。在这种情况下，L6566B通过监视控制引脚来检测短路：在短路情况下，COMP引脚变为高电平，内部比较器激活电流源，从初始2 V开始重新起动软启动电容器水平。如果该引脚上的电压达到5 V，则当Vcc电压降至VCCrestart电平（5V）以下时，L6566B停止运行，并以启动顺序重新启动，进入所谓的"打嗝模式"

soon as the output voltage drops, the auxiliary voltage drops as well and the IC supply voltage falls below the undervoltage lockout threshold, causing the L6566B to stop switching. It remains in the off-state until the voltage on the Vcc pin decreases below the $Vcc_{restart}$ threshold (5 V), then, the HV startup turns on and charges the Vcc capacitor; as soon as the turn-on threshold is reached, the circuit restarts. If the short is still there, the circuit just attempts to restart but it stops after a few milliseconds. Restart attempts are repeated indefinitely until the short is removed. This provides a very low frequency hiccup working mode (for this board 1 Hz), limiting the current flowing at the secondary side (less than 1 Arms) preventing the power supply from overheating, which could destroy it.
In the case where the coupling between the auxiliary and secondary winding is poor, some spikes on the auxiliary voltage may keep Vcc above the UVLO threshold for a period long enough to damage the converter. In this case the L6566B detects a short-circuit by monitoring the control pins: in the case of a short, the COMP pin goes high, and an internal

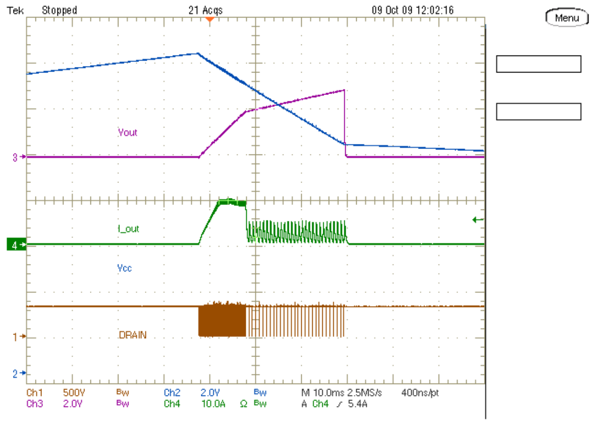
comparator activates a current source that restarts charging the soft-start capacitor from the initial 2 V level. If the voltage on this pin reaches 5 V, the L6566B stops the operation and it restarts with a startup sequence when the Vcc voltage drops below the $V_{CCrestart}$ level (5 V), entering into the so-called “hiccup mode”.

Figure 12. Short-circuit at full load and 230 Vac – 50 Hz



CH1: gate voltage CH2: Vcc
CH3: SS pin voltage CH4: output current

Figure 13. Short-circuit detail at full load and 230 Vac – 50 Hz



CH1: drain voltage CH2: Vcc
CH3: SS pin voltage CH4: output current

In *Figure 12* we can see that, in this case, the IC supply voltage drops to the UVLO

图12中，我们可以看到，在这种情况下，IC电源电压下降到UVLO阈值（10 V），导致SS引脚信号达到禁止阈值（5 V）之前关闭控制器。 这是因为变压器漏感非常低，一旦输出电压下降，辅助电压也会立即下降。 此外，在图像中，我们可以看到，在SS电压升高期间，传输功率受到限制。

e ... and ... , in the image we can note that during the SS voltage ramping-up the transferred power is limited.

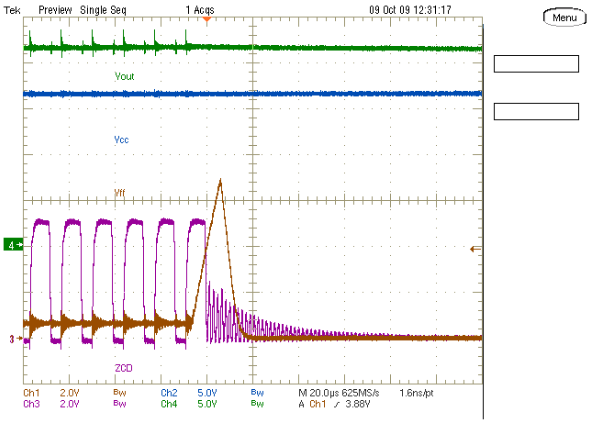
3.3 Overvoltage and open loop protection 过电压和开环保护

The L6566B OVP function monitors the voltage on the ZCD pin (#11) during the MOSFET’s OFF-time, when the voltage generated by the auxiliary winding tracks the converter’s output voltage. If the voltage on the pin exceeds an internal 5 V reference, an overvoltage condition is assumed and the device is shut down. An internal current generator is activated which sources 1 mA out of the VFF pin (#15). If the VFF voltage is allowed to reach 2 VBE over 5 V, the L6566B is latched off (*Figure 14*). As soon as the IC is latched, Vcc starts decreasing until it reaches a value 0.5 V below the turn-on threshold. Then the HV startup circuit turns on and begins to operate periodically in order to keep Vcc between VCCON and VCCON-0.5V (*Figure 15*), maintaining the IC latched.

Additionally, to improve immunity against temporary disturbances (needed for example in case of immunity tests), an internal logic activates the protection after the OVP has been detected for 4 consecutive switching cycles.

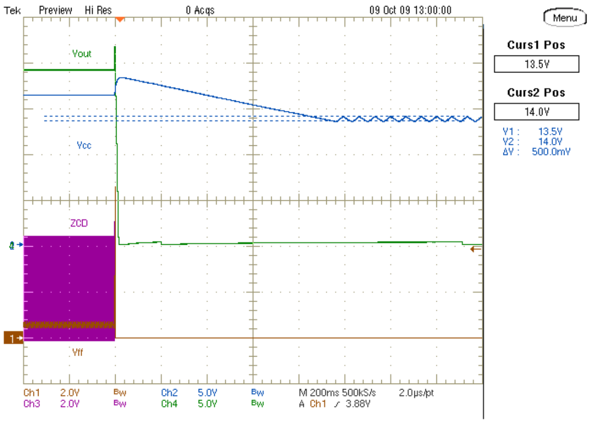
在MOSFET关断期间，当辅助绕组产生的电压跟踪转换器的输出电压时，L6566B OVP功能可监视ZCD引脚（＃11）上的电压。 如果引脚上的电压超过内部5V参考电压，则假定过压状态，并且器件关闭。 内部电流发生器被激活，从VFF引脚（＃15）输出1 mA电流。 如果VFF电压在5 V以上达到2 VBE，则L6566B被锁存（图14）。 一旦IC被锁存，Vcc开始下降，直到其达到比开启阈值低0.5V的值。 然后，HV启动电路接通并开始周期性的工作，以保持Vcc在VCCON和VCCON-0.5V之间（图15），保持IC锁存。
另外，为了提高抗临时干扰的抗扰性（例如在免疫测试的情况下需要），内部逻辑在检测到OVP已连续4个开关周期后激活保护

Figure 14. Flyback open loop – detail at 230 V – 50 Hz – half load



CH1: V_{FF} voltage CH2: Vcc
CH3: ZCD voltage CH4: output voltage

Figure 15. Flyback open loop at 230 V – 50 Hz –half load



CH1: V_{FF} voltage CH2: Vcc
CH3: ZCD voltage CH4: output voltage

4 Thermal map

热图
为了检查设计的可靠性，通过红外摄像机进行了热映射。 在图16和17中，显示了在标称输入电压下的板，元件侧的热测量。 图像中可见的一些指针已经放置在显示高温的关键组件或组件上。 两次测量时的环境温度为27°C

In order to check the design reliability, a thermal mapping by means of an IR camera was done. In *Figure 16* and *17* the thermal measurements of the board, component side, at nominal input voltage are shown. Some pointers visible in the images have been placed across key components or components showing high temperature. The ambient temperature during both measurements was 27 °C.

Figure 16. Thermal map at 115 Vac – 60 Hz – full load

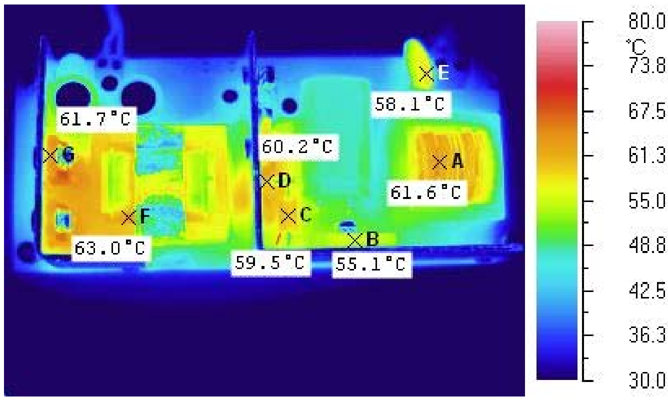


Figure 17. Thermal map at 230 Vac – 50 Hz – full load

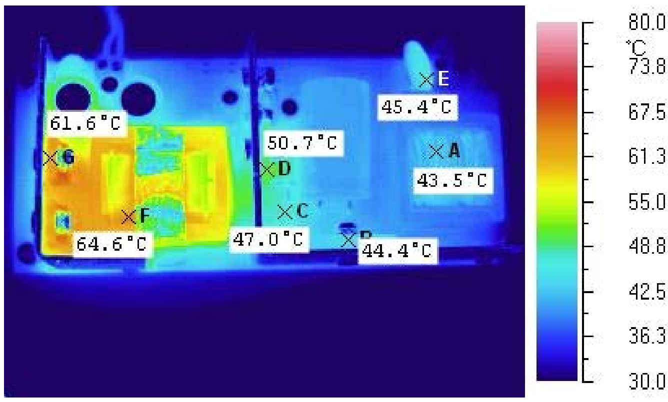


Table 2. Thermal map reference points

Point	Reference	Description
A	L1	EMI filtering common mode choke
B	D1	Bridge rectifier
C	D4	Clamping Transil
D	Q1	Flyback power MOSFET
E	R2	Input NTC
F	T1	Flyback power transformer
G	D2	Output diode

5 Conducted emission pre-compliance test

Figure 18 and *19* show the average measurement of the conducted noise at full load and nominal mains voltages. The limits shown on the diagrams are EN55022 Class-Bs, which is the most popular rule for domestic equipment and has more severe limits compared to Class-A, dedicated to IT technology equipment. As shown in the diagrams, in all test conditions the measurements are far below the limits.

Figure 18. CE average measurement at 115 Vac and full load

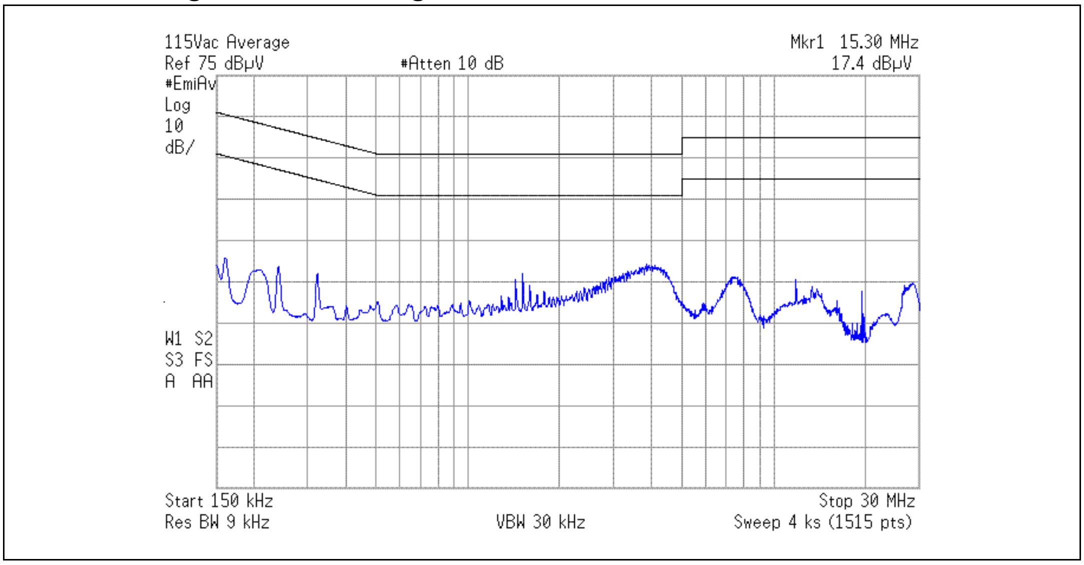
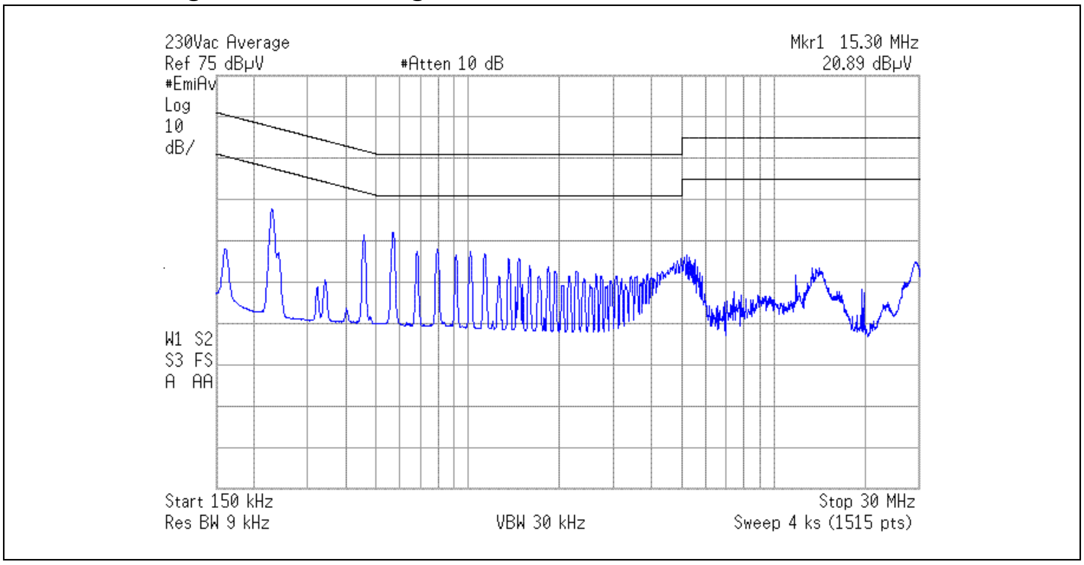


Figure 19. CE average measurement at 230 Vac and full load



6 Bill of material

Table 3. EVL6566B-65W-QR demonstration board: bill of material

Des.	Part type/ part value	Description	Supplier	Case
C1	2.2 nF	Y1 - safety cap. DE1E3KX222M	Murata	12 x 4 mm p.10 mm
C2	120 uF - 400 V	400 V - aluminium ELCAP - KXW series	Rubycon	Dia. 18 mm
C3	330 pF - 2 kV	2 kV - disc CERCAP	Murata	p. 8 mm
C4	100 nF	X2 - FLM cap. - R46-I 3100--M1-	Arcotronics	18 x 5 mm p.15 mm
C5	2.2 nF	Y1 - safety cap. DE1E3KX222M	Murata	12 x 4 mm p. 10 mm
C6	150 nF	X2 - FLM cap. - R46 KN 3150 - 01 -	Arcotronics	26 x 6 mm p. 22.5 mm
C7	1000 µF - 25 V	25 V - aluminium ELCAP - ZL SERIES	Rubycon	Dia. 13 mm
C8	1000 µF - 25 V	25 V - aluminium ELCAP - ZL SERIES	Rubycon	Dia. 13 mm
C9	22 µF - 50 V	50 V - aluminium ELCAP - YXF SERIES	Rubycon	Dia. 6 mm
C10	100 µF - 25 V	25 V - aluminium ELCAP - YXF SERIES	Rubycon	Dia. 6 mm
C11	47 µF - 50 V	50 V - aluminium ELCAP - YXF SERIES	Rubycon	Dia. 6 mm
C12	1 nF	200 V CERCAP - general purpose	AVX	1206
C13	22 nF	50 V CERCAP - general purpose	AVX	0805
C14	2.2 nF	50 V CERCAP - general purpose	AVX	0805
C16	2.2 nF	50 V CERCAP - general purpose	AVX	0805
C17	100 nF	50 V CERCAP - general purpose	AVX	0805
C18	100 nF	50 V CERCAP - general purpose	AVX	1206
C19	100 nF	50 V CERCAP - general purpose	AVX	1206
C20	330 pF	50 V CERCAP - general purpose	AVX	1206
C21	470 nF	50 V CERCAP - general purpose	AVX	0805
C22	330 pF	50 V CERCAP - general purpose	AVX	1206
C23	2.2 nF	50 V CERCAP - general purpose	AVX	1206
C26	1 nF	50 V CERCAP - general purpose	AVX	1206
C27	100 nF	50 V CERCAP - general purpose	AVX	0805
C28	10 nF	50 V CERCAP - general purpose	AVX	1206
C29	100 nF	50 V CERCAP - general purpose	AVX	0805
C30	47 pF	50 V CERCAP - general purpose	AVX	1206
D1	GBU4J	SIngle-phase bridge rectifier	VISHAY	GBU STYLE
D2	STPS20H100CFP	HV power Schottky rectifier	STMicroelectronics	TO - 220 FP
D3	STPS20H100CFP	HV power Schottky rectifier	STMicroelectronics	TO - 220 FP
D4	1.5 KE300A	Transil	STMicroelectronics	DO-201
D5	S1M	High voltage rectifier	Vishay	SMA

Table 3. EVL6566B-65W-QR demonstration board: bill of material (continued)

Des.	Part type/ part value	Description	Supplier	Case
D6	BZV55-B18	Zener diode	Philips	SOD-80
D7	S07M	High voltage diode	Vishay	SMF DO-219AB
D10	LL4148	Fast switching diode	Vishay	SOD-80
D12	STTH102A	Fast switching diode	STMicroelectronics	SMA
D13	S07M	High voltage diode	Vishay	SMF D0-219AB
D14	LL4148	Fast switching diode	Vishay	SOD-80
F1	392/TE05 - 4 A	Fuse T4A - time delay	Littelfuse	DWG
HS1	Heatsink	Bridge rect. and MOSFET heatsink	-	DWG
HS2	Heatsink	Output rectifiers heatsink	-	DWG
J1	MKDS 1,5/ 2-5.08	Screw conn., pitch 5.08 mm - 2 w.	Phoenix contact	DWG
J2	MKDS 1,5/ 2-3.81	Screw conn., pitch 3.81 mm - 2 w.	Phoenix contact	DWG
L1	HF2826-203Y1R5-T01	Input EMI filter	TDK	DWG
L2	1071.0083	1.1 µH - 5 A - radial inductor	MAGNETICA	Dia. 9 mm p. 5 mm
Q1	STF7NM80	N-channel power MOSFET	STMicroelectronics	TO-220FP
Q2	BC847C	NPN small signal BJT	ZETEX	SOT-23
Q3	BC847C	NPN small signal BJT	ZETEX	SOT-23
Q4	BC847C	NPN small signal BJT	ZETEX	SOT-23
R2	NTC 1R-S237	NTC resistor P/N B57237S0100M000	EPCOS	12 x 4 mm p. 10 mm
R3	M57703	Thermistor - B57703M103G	EPCOS	DWG
R4	2.2 KΩ	SMD film res. - 1/4 W - 5% - 250 ppm/°C	Vishay	1206
R5	100 KΩ	SMD film res. - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
R6	3.9 Ω	SMD film res. - 1/4 W - 5% - 250 ppm/°C	Vishay	1206
R7	3.9 Ω	SMD film res. - 1/4 W - 5% - 250 ppm/°C	Vishay	1206
R8	4.7 KΩ	SMD film res. - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
R9	1.8 KΩ	SMD film res. - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
R10	3.9 MΩ	SMD film res. - 1/4 W - 5% - 100 ppm/°C	Vishay	1206
R11	91 KΩ	SMD film res. - 1/4 W - 1% - 100 ppm/°C	Vishay	0805
R12	3.9 MΩ	SMD film res. - 1/4 W - 1% - 100 ppm/°C	Vishay	1206
R14	33 Ω	SMD film res - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
R15	100 KΩ	SMD film res - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
R16	0.33 Ω	MSR1 SMD film res. - 1 W - 5% - 250 ppm/°C	MEGGIT	2512
R17	360 Ω	SMD film res. - 1/4 W - 5% - 250 ppm/°C	Vishay	1206
R19	2.7 KΩ	SMD film res. - 1/4 W - 1% - 100 ppm/°C	Vishay	1206

Table 3. EVL6566B-65W-QR demonstration board: bill of material (continued)

Des.	Part type/ part value	Description	Supplier	Case
R20	680 KΩ	SMD film res. - 1/4W - 1% - 100 ppm/°C	Vishay	1206
R21	180 KΩ	SMD film res. - 1/8W - 1% - 100 ppm/°C	Vishay	0805
R23	12 KΩ	SMD film res. - 1/8 W - 1% - 100 ppm/°C	Vishay	0805
R24	3.3 Ω	SMD film res. - 1/4 W - 5% - 250 ppm/°C	Vishay	1206
R25	10 KΩ	SMD film res. - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
R26	15 KΩ	SMD film res. - 1/4 W - 5% - 250 ppm/°C	Vishay	1206
R28	1 KΩ	SMD film res. - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
R29	22 KΩ	SMD film res. - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
R30	1 KΩ	SMD film res. - 1/4 W - 5% - 250 ppm/°C	Vishay	1206
R31	0.15 Ω	MSR1 SMD film res. - 1 W - 5% - 250 ppm/°C	MEGGIT	2512
R32	12 KΩ	SMD film res. - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
R33	220 KΩ	SMD film res. - 1/4 W - 5% - 250 ppm/°C	Vishay	1206
R35	39 KΩ	SMD film res. - 1/4 W - 5% - 250 ppm/°C	Vishay	1206
R36	47 KΩ	SMD film res. - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
R37	24 KΩ	SMD film res. - 1/8 W - 1% - 100 ppm/°C	Vishay	0805
R38	4.7 KΩ	SMD film res. - 1/8 W - 1% - 100 ppm/°C	Vishay	0805
R40	100 KΩ	SMD film res. - 1/4 W - 5% - 250 ppm/°C	Vishay	1206
R41	2.2 KΩ	SMD film res. - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
R42	1 KΩ	SMD film res. - 1/4 W - 5% - 250 ppm/°C	Vishay	1206
R43	3.9 KΩ	SMD film res. - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
R45	56 KΩ	SMD film res. - 1/4 W - 1% - 100 ppm/°C	Vishay	1206
R46	22 Ω	SMD film res. - 1/8 W - 5% - 250 ppm/°C	Vishay	0805
T1	1972.0005	Power transformer	MAGNETICA	DWG
U1	SFH617A-4	Optocoupler	Infineon	DIP-4
U2	L6566B	Multimode PWM controller	STMicroelectronics	SO-16
U3	TSM1014AIST	Low consumption CC/CV controller	STMicroelectronics	MiniSO-8

7 Transformer specification

General description and characteristics

- Application type: consumer, home appliance
- Transformer type: open
- Coil former: horizontal type, 6 + 6 pins
- Max. temp. rise: 45 °C
- Max. operating ambient temperature: 60 °C
- Mains insulation: acc. with EN60950

Electrical characteristics

- Converter topology: QR flyback
- Core type: EER28L-PC44 or equivalent
- Typical operating frequency: 100 kHz
- Primary inductance: 500 µH ± 10% at 1 kHz - 0.25 V[a]
- Leakage inductance: 5 µH max. at 100 kHz - 0.25 V[b]

Figure 20. Transformer

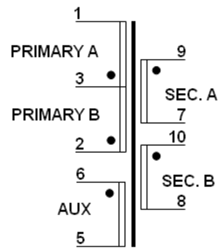


Table 4. Transformer winding data

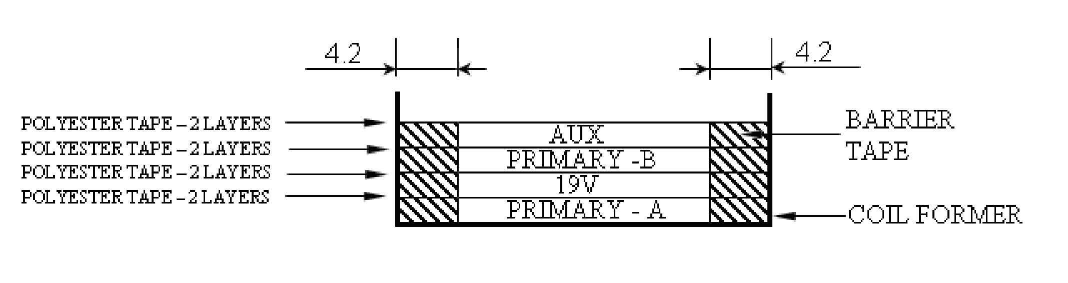
Pins	Winding	RMS current	Number of turns	Wire type
3 - 1	PRIMARY A(1)	0.84 A_{RMS}	27	G1 ϕ 30 x 0.1 mm
9 - 7	SEC - A(2)	2.9 A_{RMS}	7	G1 ϕ 90 x 0.1 mm
10 - 8	SEC - B (2)	2.9 A_{RMS}	7	G1 ϕ 90 x 0.1 mm
2 - 3	PRIMARY B(1)	0.84 A_{RMS}	27	G1 ϕ 30 x 0.1 mm
6 - 5	AUX	0.05 A_{RMS}	6 spaced	G2 ϕ 0.25 mm

1. Secondary windings are wound between primary A and primary B layers.
2. Secondary windings A and B are in parallel.

a. Measured between pins 2 - 1.

b. Measured between pins 2 - 1 with secondary windings shorted.

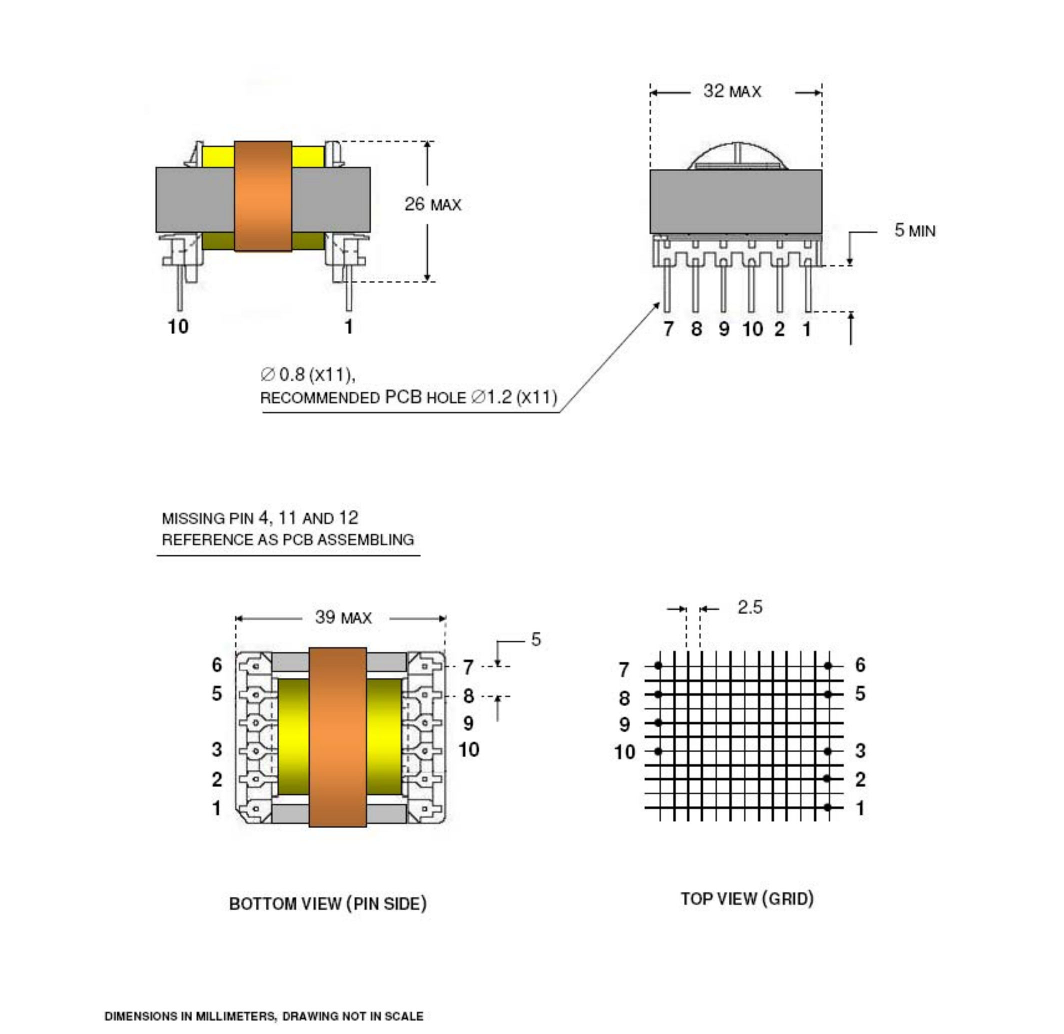
Figure 21. Transformer winding diagram



Mechanical aspect and pin numbering

- Maximum height from PCB: 26 mm
- Coil former type: horizontal, 6 + 6 pins (pins 4, 11 and 12 removed)
- Pin distance: 5.08 mm
- Row distance: 30 mm
- External copper shield: not insulated, wound around the ferrite core and including the coil former. Height is 12 mm.

Figure 22. Transformer mechanical diagrams



Manufacturer

- MAGNETICA - Italy
- Transformer P/N: 1972.0005.

8 Revision history

Table 5. Document revision history

Date	Revision	Changes
01-Jul-2010	1	Initial release.
06-Oct-2014	2	Updated *Figure 2: Electrical diagram on page 9* - improvement startup at light-load (replaced value of R17 - “470R” by “360R” and R24 - “6R8” by “3R3”). Updated *Table 3: EVL6566B-65W-QR demonstration board: bill of material on page 18* - improvement startup at light-load (replaced value of R17 - “470R” by “360 Ω” and R24 - “6R8” by “3.3 Ω”). Minor modifications throughout document.