

NCP1622GEVB

160-W, Wide Mains, PFC Stage Driven by the NCP1622 Evaluation Board User's Manual.

Rev1.0 February 20th 2017

Introduction

Housed in a TSOP6 package, the NCP1622 is designed to drive PFC boost stages in so-called Valley Synchronized Frequency Fold-back (VSFF). In this mode, the circuit classically operates in Critical conduction Mode (CrM) when VCTRL pin voltage exceeds a product version programmable voltage level.

When VCTRL pin voltage is below this programmable level, the NCP1622 linearly decays the frequency down to about 20 kHz, when the load current is nearly zero. VSFF maximizes the efficiency throughout the load range. Incorporating protection features for rugged operation, it is furthermore ideal in systems where cost-effectiveness, reliability, low stand-by power and high-efficiency are the key requirements. Extremely slim, the NCP1622 evaluation board is designed to be less than 13 mm high. This low-profile PFC Stage is intended to deliver 160 W under a 390-V output voltage from a wide mains input. This is a PFC boost converter as used in flat TVs, high power LED street light power supplies, and all-in-one computer supplies. The evaluation board embeds the NCP1622 AEA-version which is powered by an external V_{CC}. With the help of an external dc source, apply a V_{CC} voltage that exceeds the NCP1622-AEA start-up level (18.2 V max) to ensure the circuit starts operating. The V_{CC} operating range is from 9.5 V up to 30 V.

Table 1 ELECTRICAL SPECIFICATIONS

| Description | Value | Units |
|--|----------|-------|
| Input Voltage Range | 90-265 | V rms |
| Line Frequency Range | 45 to 66 | Hz |
| Maximum Output Power | 160 | W |
| Minimum Output Load Current(s) | 0 | A |
| Number of Outputs | 1 | |
| Nominal Output Voltage | 390 | V |
| Maximum Startup Time | < 3 | s |
| No-Load Power (115 V rms) | < 250 | mW |
| Target Efficiency at Full Load (115 V rms) | 95 | % |
| Load conditions for efficiency measurements (10%, 20%,...) | 10-100 | % |
| Minimum efficiency at 20% load, 115 V rms | 93 | % |
| Minimum PF over the line range at full load | 95 | % |
| Hold-up time (the output voltage remaining above 300 V) | > 10 | ms |
| Peak to peak low frequency output ripple | < 8 | % |



ON Semiconductor

<http://www.onsemi.com>

EVAL BOARD USER'S MANUAL

NCP1622 GEVB - rev1.2 june 2nd 2017

Differences between the NCP1622 and NCP1602

The NCP1622 is a spin-off of the NCP1602 and the attached table summarizes all the differences between the two products. The evaluation board of the two products is the same, except for the name printed on it and from the fact that NCP1602 evaluation board has by default the power MOSFET drain voltage used for the ZCD detection as the NCP1622 has by default the auxiliary voltage used for ZCD detection.

| | NCP1602 | | | NCP1622 | | |
|------------------------------|--|--------|--------|---------------|--------|--------|
| 2-Level Boost Follower | YES | | | NOT AVAILABLE | | |
| LLINE flag stuck at zero | YES (only when aux winding is used for ZCD) | | | FIXED | | |
| | min | typ | max | min | typ | max |
| ICC,start Over consumption | - | - | 480µA | - | - | 70µA |
| [*J*] option $t_{ON,max,LL}$ | NA | NA | NA | 26µs | 30µs | 34µs |
| [*K*] option $t_{ON,max,LL}$ | NA | NA | NA | 26µs | 30µs | 34µs |
| [*L*] option $t_{ON,max,LL}$ | NA | NA | NA | 26µs | 30µs | 34µs |
| V_{UVPH} | 555mV | 612mV | 670mV | 477mV | 530mV | 583mV |
| V_{HL} | 1718mV | 1801mV | 1882mV | 1605mV | 1690mV | 1774mV |
| V_{LL} | 1310mV | 1392mV | 1474mV | 1406mV | 1480mV | 1554mV |

Table 2: Differences between the NCP1622 and NCP1602

NCP1622 GEVB - rev1.2 june 2nd 2017

THE BOARD

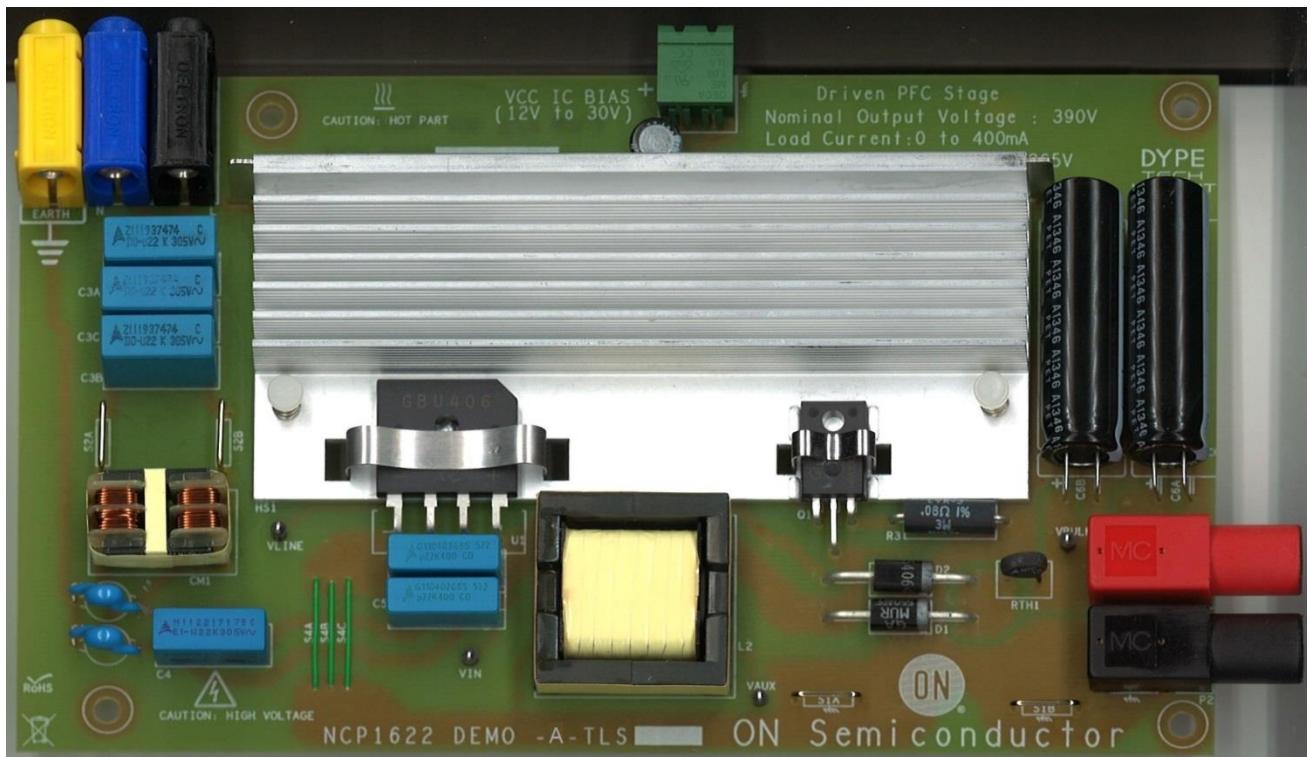


Figure 1. NCP1622 slim board (height < 13mm)

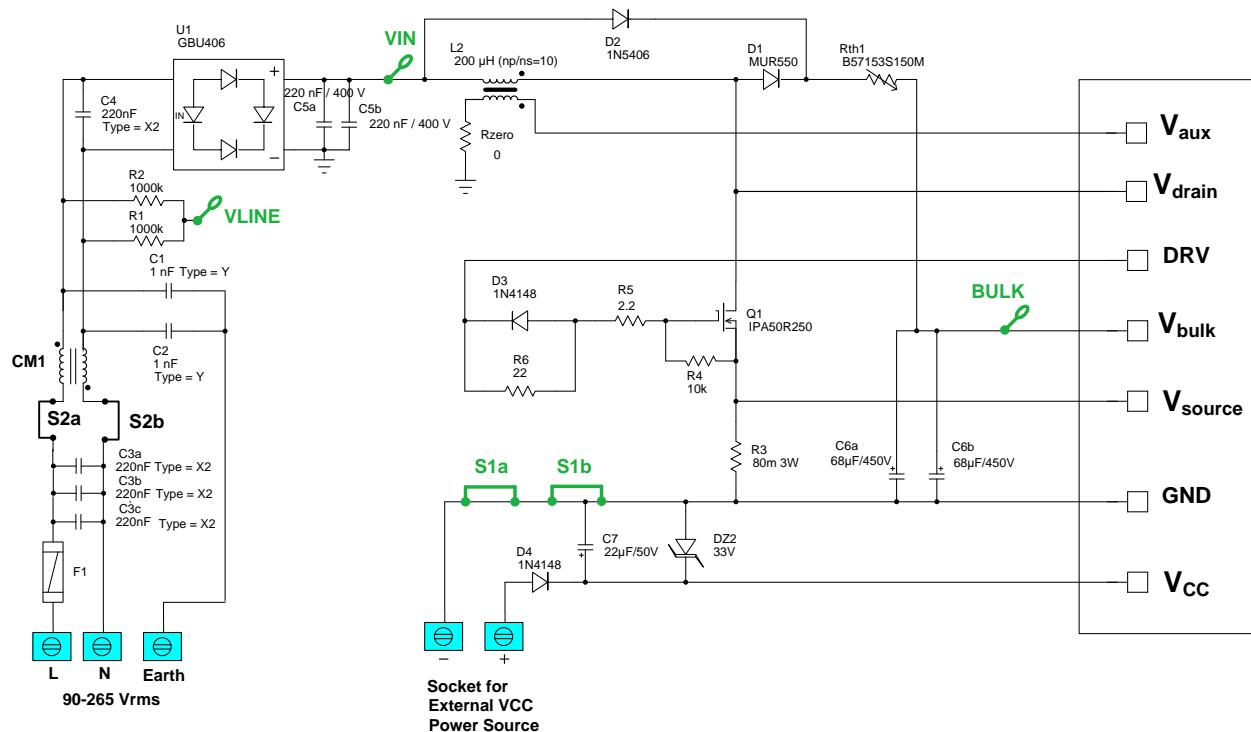


Figure 2 – NCP1622 application schematic – Power section

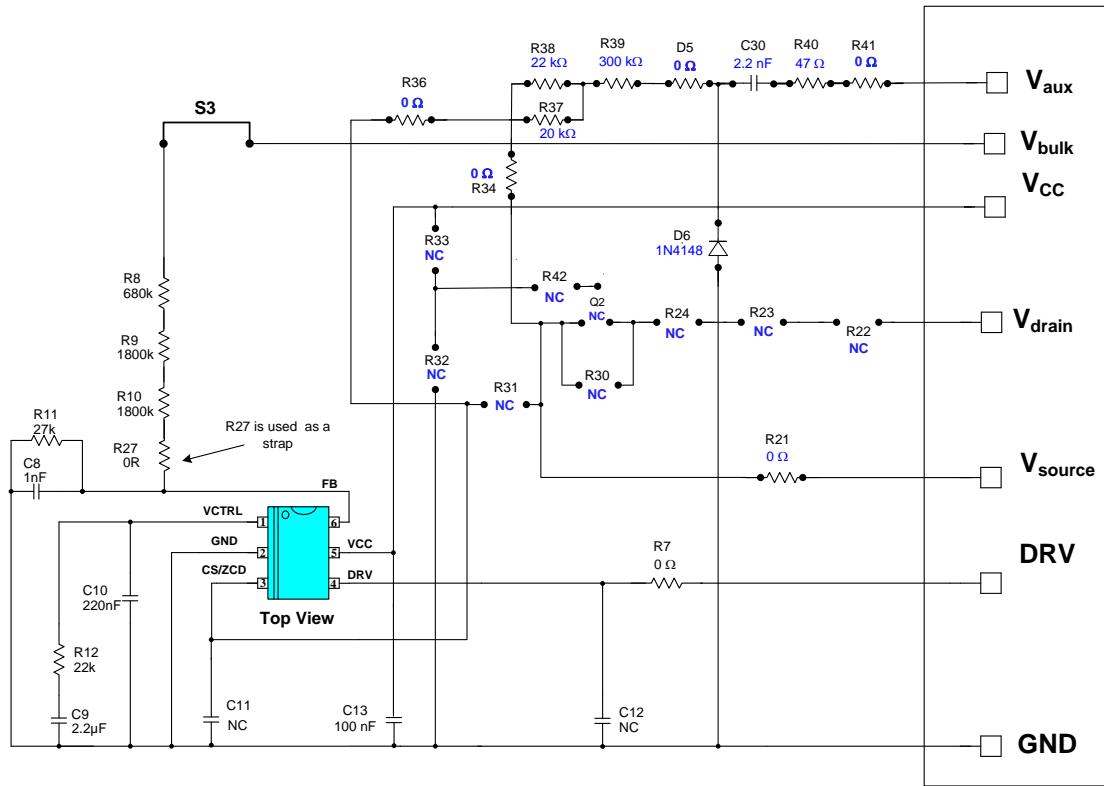


Figure 3 – NCP1622 application schematic: control section (NC means Not Connected)

VSFF Operation

The NCP1622 operates in so called Valley Synchronized Frequency Fold-back (VSFF) where the circuit works in Critical conduction Mode (CrM) when the load current is medium to high (V_{CTRL} pin voltage medium or high). The load current is correlated with the V_{CTRL} pin voltage (see Figure 8). $V_{CTRL} = 4.5$ V corresponds to the maximum current capability which in our case is not reached because we limit the application to 160 W and $V_{CTRL} = 0.5$ V corresponds to zero load current. When V_{CTRL} pin voltage (V_{CTRL}) is lower than a preset level, the switching frequency linearly decays to about 20 kHz. VSFF maximizes the efficiency at both nominal and light loads. In particular, stand-by losses are minimized. When V_{CTRL} pin voltage (V_{CTRL}) exceeds $V_{CTRL,DT}$ voltage ($V_{CTRL,DT} = 1.553$ V for the AEA option), the circuit operates in CrM (typical CrM waveforms are depicted in Figure 4). If V_{CTRL} is below $V_{CTRL,DT}$, the circuit forces a delay (or dead-time) before re-starting a DRV cycle which is proportional to the difference between $V_{CTRL,DT}$ reference and V_{CTRL} voltage. This mode is called discontinuous conduction mode (DCM) or Frequency Foldback and the main waveforms are depicted in Figure 5. This delay is maximum when V_{CTRL} reached is 0.5-V minimum value. When the 0.5-V V_{CTRL} minimum value is reached, the circuit works in a so-called Static OVP mode (for no SKIP mode options like AEA option used on this board), by skipping cycles based on the difference voltage between V_{CTRL} and 0.5-V. This static OVP mode offers a very low output ripple voltage, unlike the classical SKIP mode of other options. The added dead time starts at the end of the boost inductor demagnetization cycle and ends at the on-time start which is synchronized with the boost inductor zero crossing (valley turn on) event.

In all cases, the circuit turns on in a drain-source voltage valley:

- Classical valley turn on in CrM operation
- At the first valley following the completion of the dead-time generated by the VSFF function to reduce the frequency.

One can also note that the switching frequency being less when the load current is low, the frequency is particularly low at light load, high line. On the other hand, CrM operation being more likely to occur at heavy load, low line.

Refer to the data sheet for a detailed explanation of the VSFF operation and of its implementation in the NCP1622 [2].

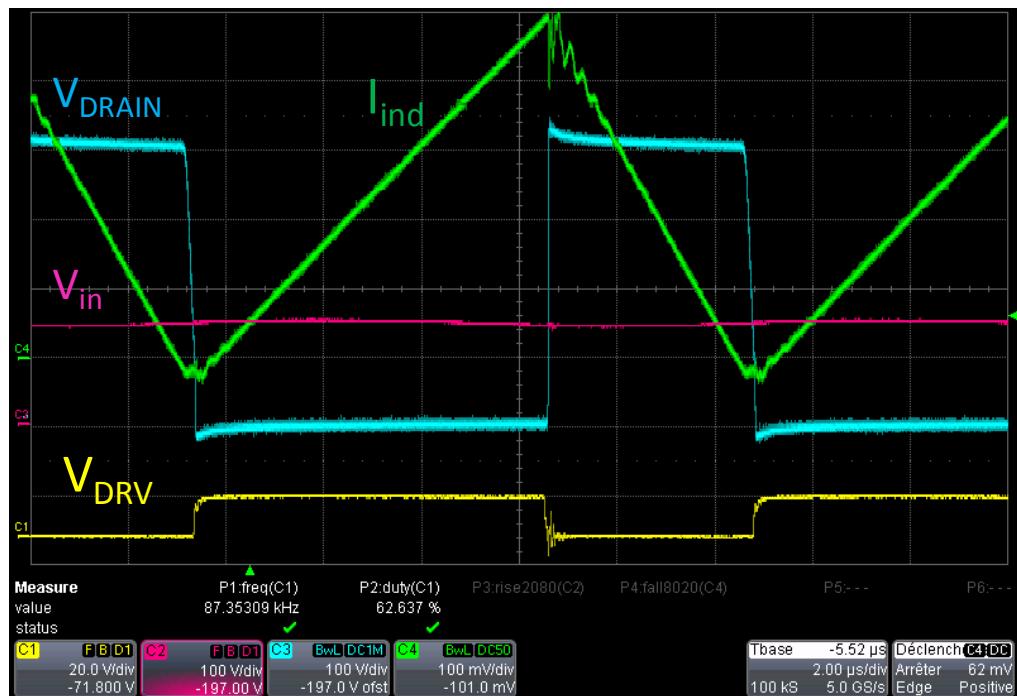


Figure 4. Typical waveforms in CrM @ $V_{\text{mains}} = 110 \text{ V rms}$, $F_{\text{mains}} = 60 \text{ Hz}$, $I_{\text{load}} = 400 \text{ mA}$

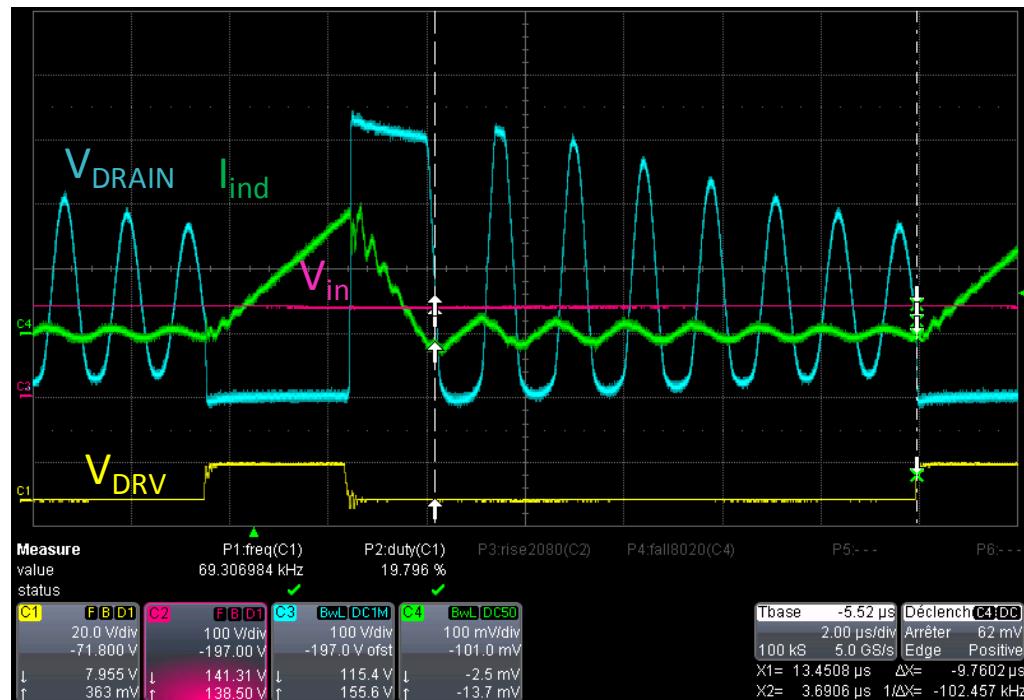


Figure 5. Typical waveforms in DCM @ $V_{\text{mains}} = 110 \text{ V rms}$, $F_{\text{mains}} = 60 \text{ Hz}$, $I_{\text{load}} = 50 \text{ mA}$

NCP1622 GEVB - rev1.2 june 2nd 2017

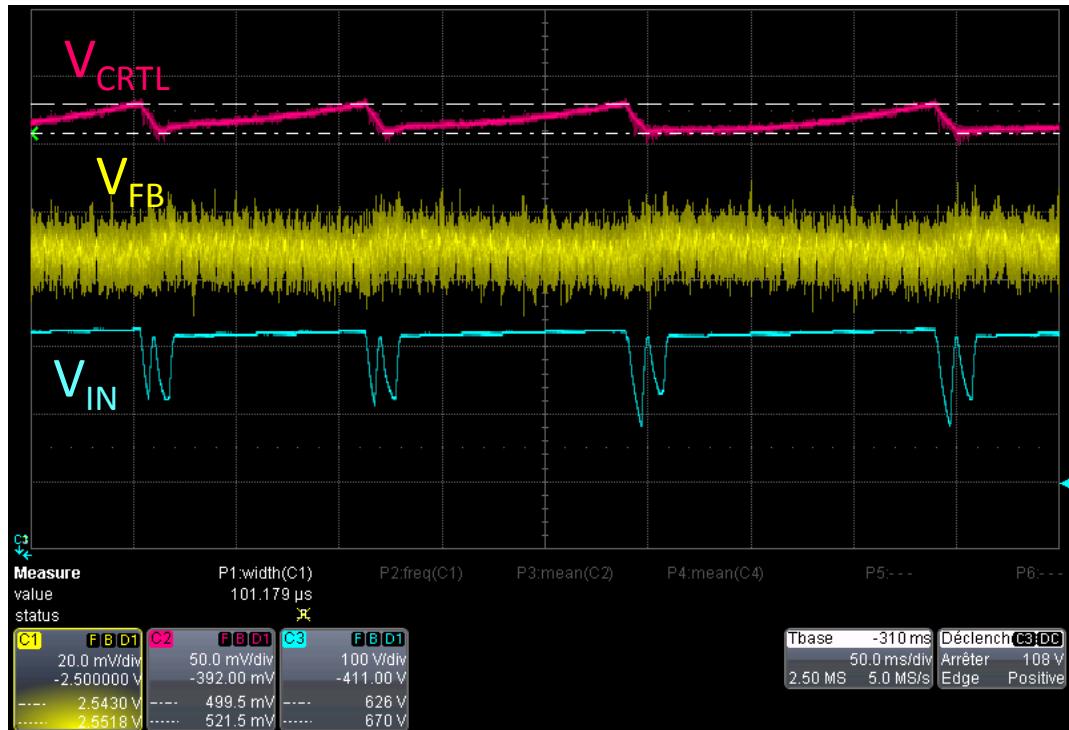


Figure 6. No-load waveforms for option AEA (skip mode disabled) featuring static OVP @ $V_{mains}=230$ V rms

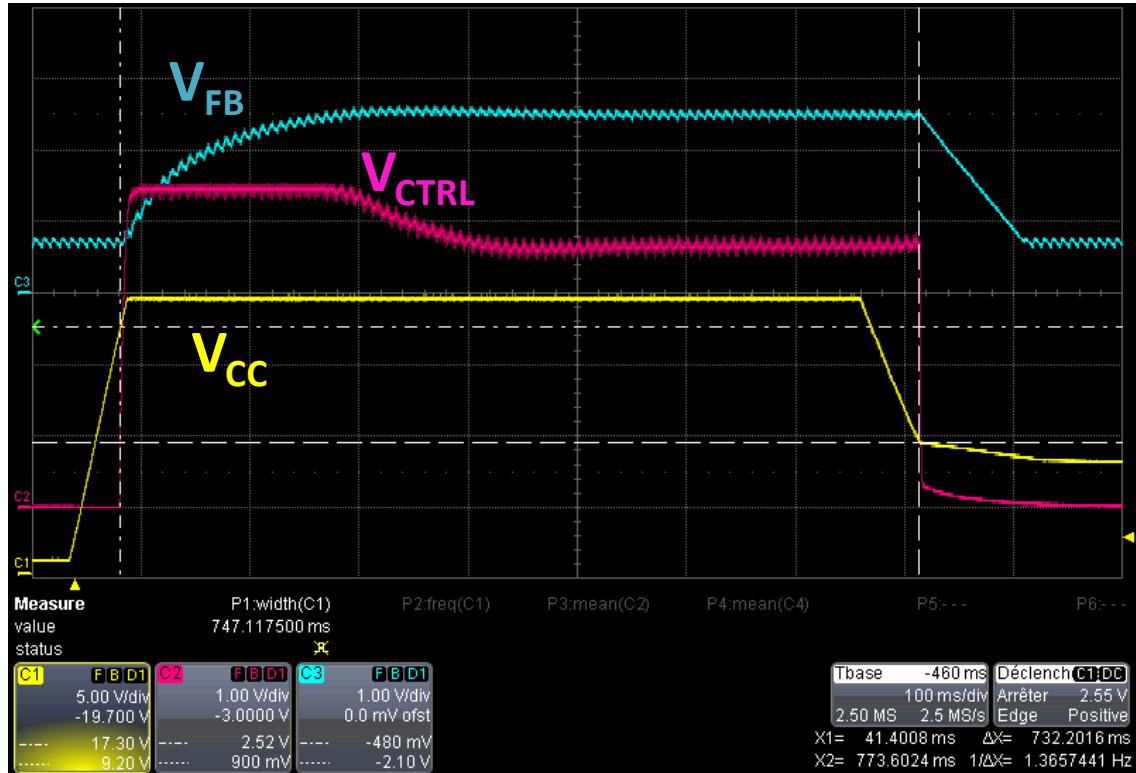


Figure 7. Startup and stop sequence @ $I_{load}=400$ mA ; $V_{mains}=90$ V rms; V_{cc} OFF=>ON=>OFF

| V_{mains} (V rms) | @ $I_{load} =$ 400 mA | @ $I_{load} =$ 300 mA | @ $I_{load} =$ 100 mA | @ $I_{load} =$ 50 mA | @ $I_{load} =$ 0 mA |
|------------------------|--------------------------|--------------------------|--------------------------|-------------------------|------------------------|
| 90 | 3.77 | 3.01 | 1.38 | 0.96 | 0.490 |
| 110 | 2.55 | 2.13 | 1.02 | 0.75 | 0.490 |
| 230 | 1.77 | 1.42 | 0.79 | 0.63 | 0.490 |
| 265 | 1.35 | 1.10 | 0.67 | 0.57 | 0.490 |

Figure 8. V_{CTRL} voltage versus I_{load} & V_{mains}

POWER FACTOR AND EFFICIENCY

The NCP1622 evaluation board embeds a NTC to limit the in-rush current that takes place when the PFC stage is plugged in. The NTC is placed in series with the boost diode. This location is rather optimum in term of efficiency since it is in the in-rush current path at a place where the rms current is less compared to the input side. However, this component still consumes some power. That is why the efficiency is given with a shorted NTC to approximately improve the power efficiency value by 1 percent.

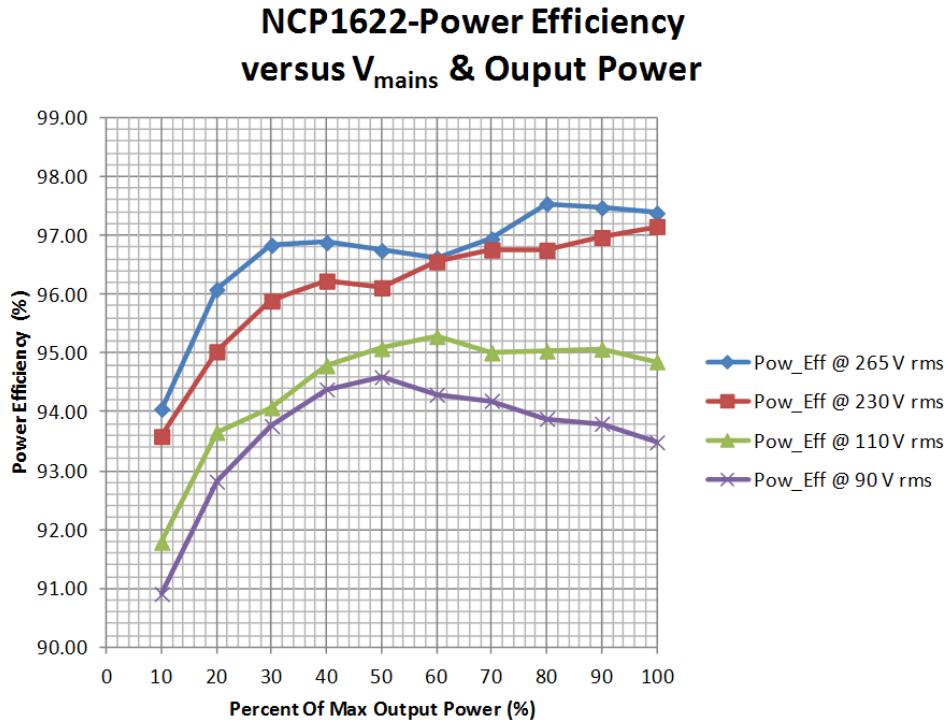


Figure 9 . Evaluation board power efficiency versus output power (NTC is shorted)
100% ouput power corresponds to 160 W

Figure 9 displays the efficiency versus load at different line levels. When considering efficiency versus load, we generally think of the traditional bell-shaped curves:

- At low line, the efficiency peaks somewhere at a medium load and declines at full load as a result of the conduction losses and at light load due to the switching losses.
- At high line, the conduction losses being less critical, efficiency is maximal at or near the maximum load point and decays when the power demand diminishes because the increasing impact of the switching losses.

Curves of Figure 9 meet this behavior in the right-hand side where our demo-board resembles a traditional CrM PFC stage. In the left-hand side, the efficiency normally drops because of the switching losses until an inflection point where it rises up again as a result of the VSFF operation. As previously stated, VSFF makes the switching frequency decay linearly as a function of V_{CTRL} voltage (load current) when it goes below a preset level.

**PF and THD performance have been measured using a
CHROMA 66202 Digital Power Meter.**

Figure 10 and Figure 11 show that VSFF exhibits very similar PF ratios compared to those obtained with CrM traditional operation. VSFF improves the THD performance at light load. We can see on Figure 11 a 5% decrease of THD value when switching from CrM mode to DCM mode. This behavior is due to the fact that in CrM, close to mains voltage zero crossing, there is a zone of zero mains current which leads to a slight mains current distortion (higher THD). When entering DCM, as a dead time is added, the inductor peak current gets higher and the zero mains current region becomes narrower, leading to a 5% decrease of the THD value.

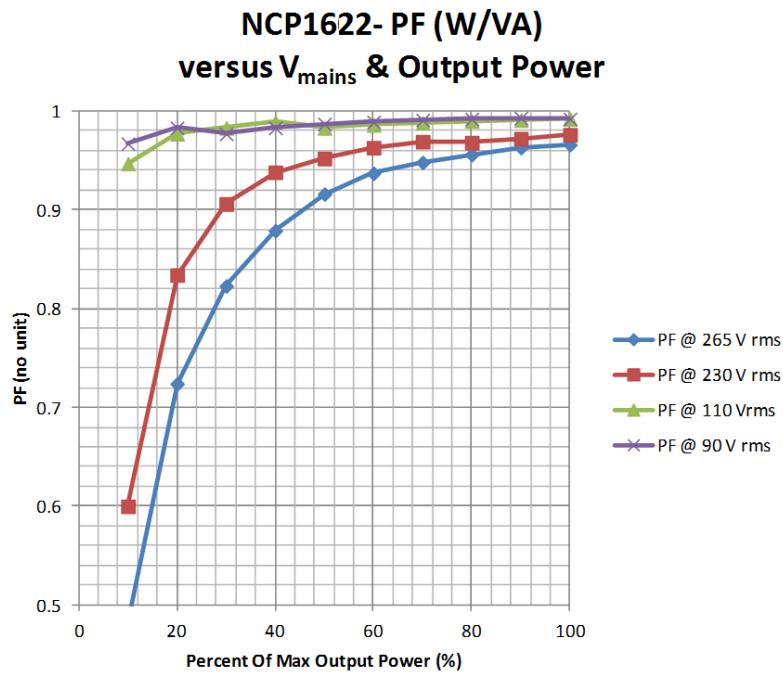


Figure 10. Evaluation board PF versus output power - 100% output power corresponds to 160 W

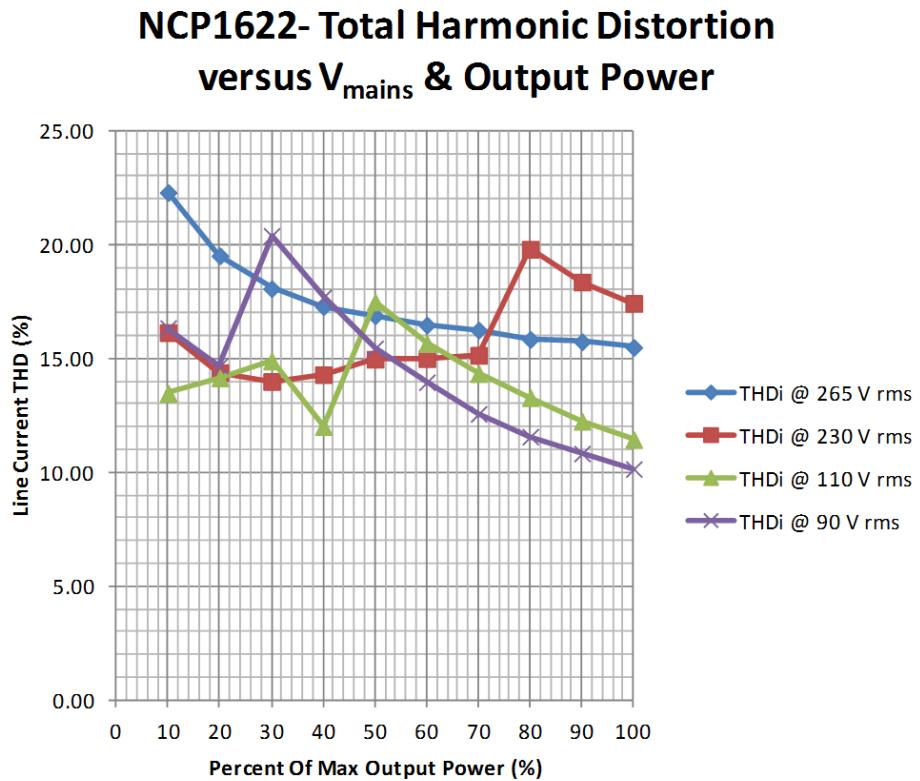


Figure 11. Evaluation board THD versus output power - 100% output power corresponds to 160 W

PROTECTION OF THE PFC STAGES

The NCP1622 protection features allows to design very rugged PFC stages

Brown-out

Brown out detection is disabled in product option AEA which is used in this Evaluation Board. If brown-is needed, check which option is needed using the product datasheet [2] and use the application note [1] for operating details .

Over-Current Protection (OCP)

The NCP1622 is designed to monitor the current flowing through the power switch. A current sense resistor (R3 of Figure 2) is inserted between the MOSFET source and ground to generate a positive voltage proportional to the MOSFET current (V_{C5ZCD}). When V_{C5ZCD} exceeds a 500-mV internal reference, the circuit forces the driver low. A 400-ns blanking time prevents the OCP comparator from tripping because of the switching spikes that occur when the MOSFET turns on. In our application, the theoretical maximal inductor current is

$$I_{ind,max} = \left(\frac{500 \text{ mV}}{80 \text{ m}\Omega} \right) \approx 6.25 \text{ A} \quad (1)$$

Figure 12 shows the inductor current when clamped. The over-current situation was obtained @ V_{mains}= 90 V rms with a 427-mA load. A 20-V VCC power source was applied to the board.

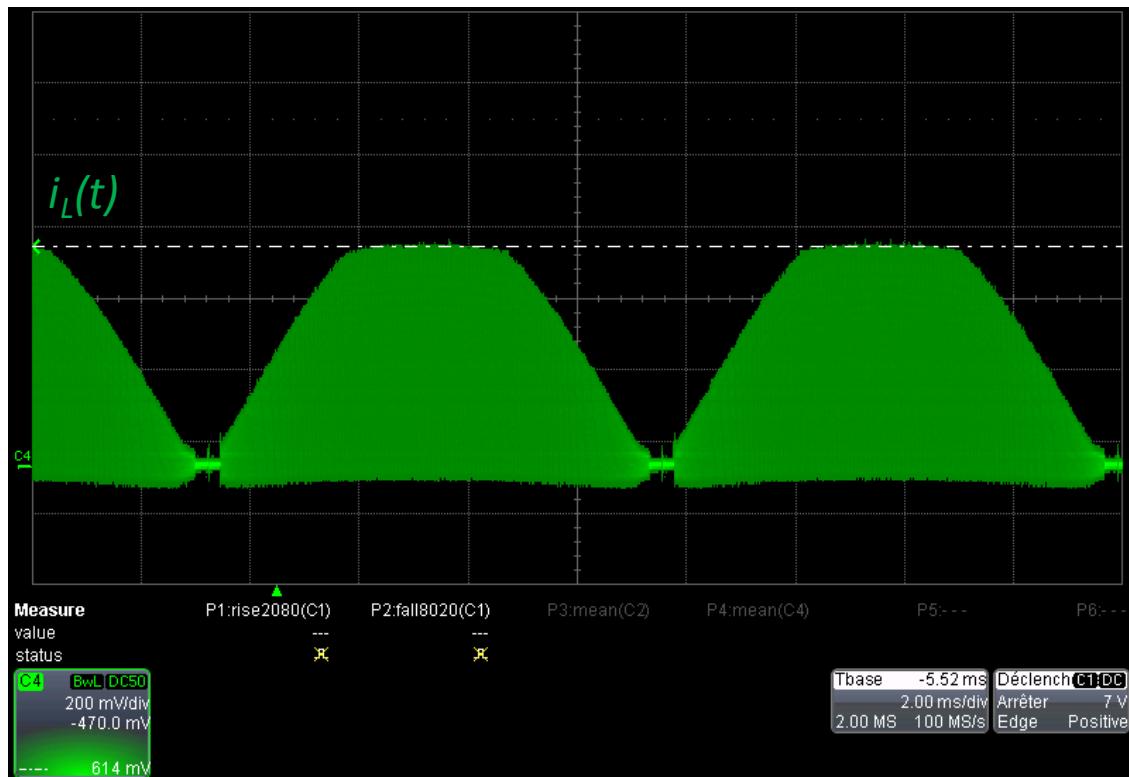


Figure 12. Inductor current showing OCP limitation @ V_{mains} = 90 V rms ; F_{mains} = 60 Hz ; I_{load} = 427 mA

DYNAMIC PERFORMANCE

The NCP1622 features the **dynamic response enhancer** (DRE) that increases the loop gain by an order of magnitude when the output voltage goes below 95.5% of its nominal level. This function dramatically reduces undershoots in case of an abrupt increase of the load demand. As an example, Figure 13 illustrates a load step from 400 mA to 0 mA and 0

mA to 400 mA (2-A/μs slope) @ 110 V rms input voltage. One can note that as a result of the DRE function, the control signal (VCTRL) steeply rises multiple times when the FB voltage goes below 0.955*2.5V = 2.487 V

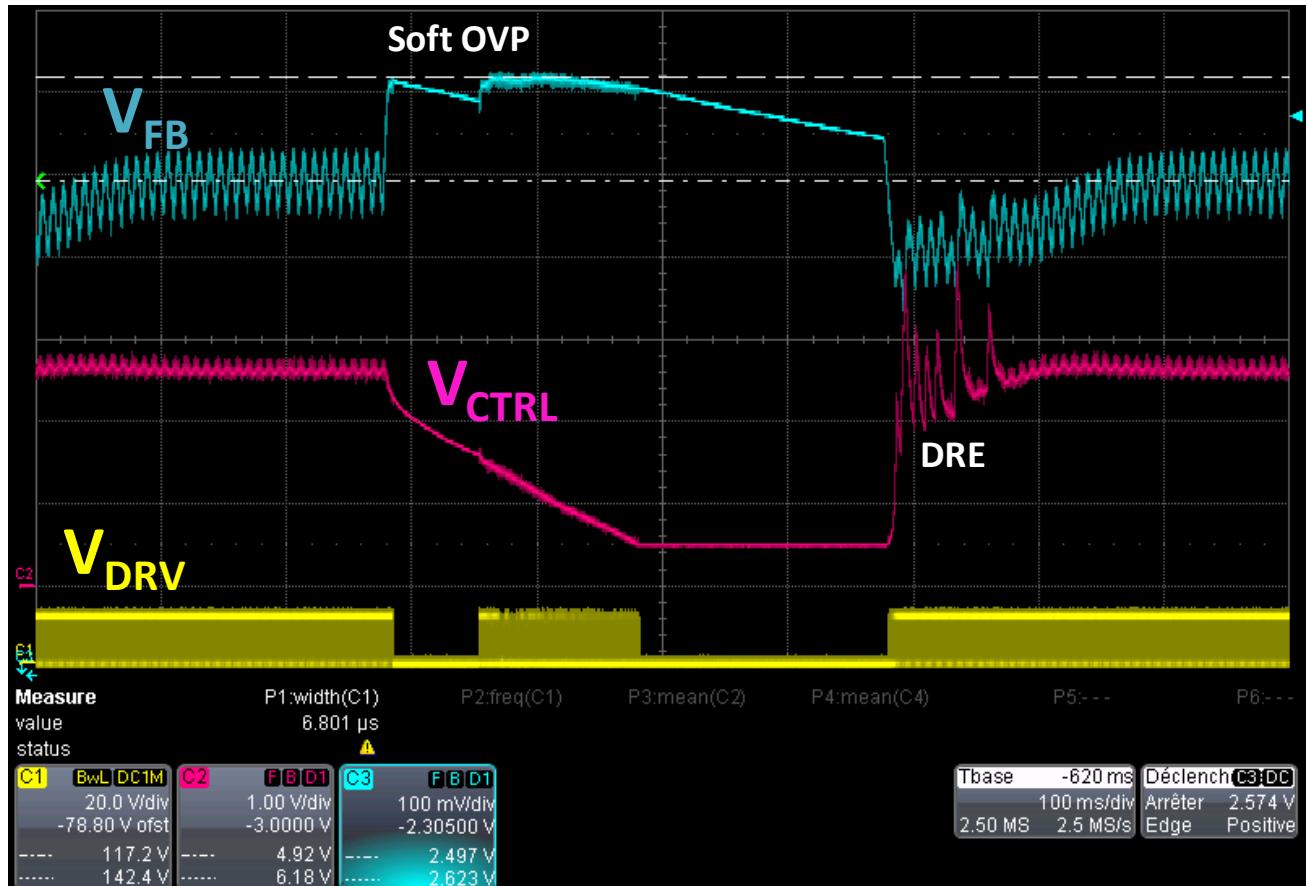


Figure 13. Load current transient featuring Soft OVP and DRE @ $I_{load}=400\text{mA}$ / zero mA ; $V_{cc}=20\text{V}$, $V_{mains}=110\text{V}_{\text{rms}}$

BEHAVIOR UNDER FAILURE SITUATIONS

Elements of the PFC stage can be accidentally shorted, badly soldered or damaged as a result of manufacturing incidents, of an excessive operating stress or of other troubles. In particular, adjacent pins of controllers can be shorted, a pin, grounded or badly connected. It is often required that such open/short situations do not cause fire, smoke nor loud noise. The NCP1622 integrates functions that help meet this requirement, for instance, in case of an improper pin connection (including GND) or of a short of the boost or bypass diode.

As an example, we will illustrate here the circuit operation when the PFC bypass diode is shorted. When the PFC stage is plugged in, a large in-rush current takes place that charges the bulk capacitor to the line peak voltage. Traditionally, a bypass diode (D₂ in the application schematic of Figure 2) is placed between the input and output high-voltage rails to divert this inrush current from the inductor and boost diode. When it is shorted, the bulk voltage being equal to the input voltage, the inductor slightly demagnetizes owing to the boost diode voltage drop. As this voltage is small, the demagnetization can be extremely long. This is generally far insufficient to prevent a cycle-by-cycle cumulative rise of the inductor current and an unsafe heating of the inductor, the MOSFET and the boost diode. As the internal NCP1622 watchdog may kick in during this long demagnetization period, continuous conduction mode (CCM) can occur for a few cycles. The NCP1622 incorporates a second over-current comparator that trips whenever the MOSFET current happens to exceed 150% of its maximum level. Such an event can happen when a) the watchdog restarts a cycle as explained before b) if the current slope is so sharp that the main over-current comparator cannot prevent the current from exceeding this second level as the result of the inductor saturation for instance. In this case, the circuit detects an “overstress” situation and disables the driver for an 800-μs delay. This long delay leads to a very low duty-ratio operation to dramatically limit the risk of overheating. Figure 14 illustrates the operation while the bypass diode and the NTC are both shorted @ $V_{mains}=110\text{V}$ with a 400-mA load current, the NCP1622 being supplied by a 20-V external power source. When the bypass diode is shorted, the demagnetization of the inductor takes too much time and the 200-μs Watchdog

timer helps to start a new on-time, during which the OCP limit is reached. Because the previous demag was not reached and OCP is triggered, a 800- μ s timer is used before allowing to start a new on-time. This helps limit the current resulting from the shorting of the bypass diode and the very low duty-ratio prevents the application from heating up.



Figure 14. From steady state the bypass diode is shorted @ $V_{\text{mains}}=110\text{V}_{\text{rms}}$, $F_{\text{mains}}=60\text{Hz}$, $I_{\text{load}}=400\text{mA}$, NTC shorted

Please note that we do not guarantee that the a NCP1622-driven PFC stage necessarily passes all the safety tests and in particular the boost diode short one since the performance can vary with respect to the application or conditions. The reported tests are intended to illustrate the typical behavior of the part in one particular application, highlighting the protections helping pass the safety tests. The reported tests were made at 25 °C ambient temperature.

NCP1622 GEVB - rev1.2 june 2nd 2017

BILL OF MATERIALS (Used by default on the EVB)

| Designator | Quantity | Description | Value | Tolerance | Footprint | Manufacturer | Manufacturer Part Number | Substitution allowed | Lead Free |
|----------------------------|----------|-------------------------------------|----------------------|-----------|---------------|------------------|---------------------------|----------------------|-----------|
| J4 | 1 | PC terminal block | — | — | — | Phoenix | MTBSA2.5/2-5.08 | YES | YES |
| P1 | 1 | 4-mm Red-Connector | — | — | — | Multicomp | 23.3200-22 | YES | YES |
| P2 | 1 | 4-mm Black-Connector | — | — | — | Multicomp | 23.3200-21 | YES | YES |
| EARTH | 1 | 4-mm Yellow-Connector | — | — | — | DELTRON | 571-0700 | YES | YES |
| L | 1 | 4-mm Black-Connector | — | — | — | DELTRON | 571-0100 | YES | YES |
| N | 1 | 4-mm Blue-Connector | — | — | — | DELTRON | 571-0200 | YES | YES |
| S1A;S1B;S2A;S2B | 4 | JUMPER | — | — | — | HARWIN | D3082F05 | YES | YES |
| S3;S4A;S4B;S4C | 4 | Wire Strap | stiff insulated wire | — | 0.700" length | Various | Various | YES | YES |
| VAUX;VBULK;VIN;VLINE | 4 | TEST POINT | — | — | — | Keystone | 5000 | YES | YES |
| CSZCD;DRV;FB;GND;VCC;VCTRL | 6 | TEST POINT | — | — | — | Various | Various | YES | YES |
| * | 4 | Board Supports | — | — | — | TCBS-801 | RICHCO | YES | YES |
| HS1 | 1 | Heatsink with fixation clips to PCB | — | — | — | COLUMBIA-STAVER | TP207ST,120,12.5,NA,SP,03 | NO | YES |
| | 1 | Heatsink MOSFET clip | — | — | — | COLUMBIA-STAVER | W950 | NO | YES |
| | 1 | Heatsink diodes bridge clip | — | — | — | COLUMBIA-STAVER | W936R | NO | YES |
| F1 | 1 | 4-A fuse | 4A | 250V | Through_hole | Multicomp | MCPEP 4A 250V | NO | YES |
| C1;C2 | 2 | Y Capacitors | 1nF | 400V | Through_hole | TDK | CD702U2GA102MYNKA | NO | YES |
| C4;C3A;C3B;C3C | 4 | X2 Capacitors | 220nF | 305Vac | Through_hole | EPCOS | B32922C3224K | NO | YES |
| C5a ; C5b | 2 | Filtering capacitor | 220nF | 400V | Through_hole | EPCOS | B32522-E6224-K000 | NO | YES |
| C6A;C6B | 2 | Bulk capacitor | 68uF | 450V | Through_hole | Rubycon | 450QXW68M12.5X40 | NO | YES |
| C7 | 1 | Electrolytic Capacitor | 22uF | 50V | Through_hole | Rubycon | 50ML22MEFC | YES | YES |
| U1 | 1 | DIODES BRIDGE | GBU406 | 800V/4A | Through_hole | LITE-ON | GBU406 | NO | YES |
| CM1 | 1 | Common Mode Filter | 2x3.3mH | 5A | Through_hole | Wurth Elektronik | 750341632 | NO | YES |
| L2 | 1 | Boost Inductor | 200uH | 6Apl | Through_hole | Wurth Elektronik | 750370081 (EFD30) | NO | YES |
| Q1 | 1 | Power MOSFET | IPAS0R250CP | 550V | TO220_C | Infineon | IPAS0R250CP | NO | YES |
| D1 | 1 | Boost Diode | MUR550 | 5A, 520V | Axial | ON Semiconductor | MUR550APFG | NO | YES |
| D2 | 1 | Bypass Diode | 1N5406 | 3A, 600V | Axial | ON Semiconductor | 1N5406G | NO | YES |
| D22 | 1 | 33-V ZENER DIODE | MMS233T1 | 33V, 0.5W | SOD123 | ON Semiconductor | MMSZ33T1G | NO | YES |
| RTH1 | 1 | Inrush Current Limiter | 15W | 1.8Amax | Through_hole | EPCOS | B57153S150M | NO | YES |
| D3 ,D4 | 2 | Switching Diode | D1N4148 | 100V | SOD-123 | ON Semiconductor | MMSD4148T1G | NO | YES |
| R1;R2 | 2 | Resistor | 1000kΩ | 500V | SMD, 1206 | Various | Various | YES | YES |
| R3 | 1 | Resistor | 80mΩ | 1%, 3W | Through_hole | Vishay | LVR03R0800FE12 | NO | YES |
| R4 | 1 | Resistor | 10kΩ | 5% | SMD, 1206 | Various | Various | YES | YES |
| R5 | 1 | Resistor | 2.2Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| R6 | 1 | Resistor | 22Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| C13 | 1 | Capacitor | 100nF | 50V | SMD, 1206 | Various | Various | YES | YES |
| C10 | 1 | Capacitor | 220nF | 50V | SMD, 1206 | Various | Various | YES | YES |
| C9 | 1 | Capacitor | 2.2uF | 50V | SMD, 1206 | Various | Various | YES | YES |
| C11;C12 | 2 | Capacitor | NC (**) | 50V | SMD, 1206 | Various | Various | YES | YES |
| R8 | 1 | Resistor | 680 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| R9;R10 | 2 | Resistor | 1800 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| R27 | 1 | Resistor | 0 Ω | 5% | 2512 | Various | Various | YES | YES |
| R11 | 1 | Resistor | 27kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| C8 | 1 | Capacitor | 1nF | 50V | SMD, 1206 | Various | Various | YES | YES |
| R22 | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| R23 | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| R24 | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| Q2 | 1 | Switch MOSFET | NC (**) | — | SOT23 | Infineon | BSS127 | YES | YES |
| R30 | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| R21 | 1 | Resistor | 0 Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| R31 | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| R32 | 1 | Resistor | NC (**) | 5% | SMD, 1206 | Various | Various | YES | YES |
| R33 | 1 | Resistor | NC (**) | 5% | SMD, 1206 | Various | Various | YES | YES |
| R42 | 1 | Resistor | NC (**) | 10% | SMD, 1206 | Various | Various | YES | YES |
| R41 | 1 | Resistor | 0 Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| R40 | 1 | Resistor | 47 Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| C30 | 1 | Capacitor | 2.2 nF | 50V | SMD, 1206 | Various | Various | YES | YES |
| D6 | 1 | Diode | 1N4148 | 100V | SOD-123 | ON Semiconductor | MMSD4148T1G | YES | YES |
| D5 (*) | 1 | Resistor | 0 Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| R39 | 1 | Resistor | 300 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| R37 | 1 | Resistor | 20 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| R36 | 1 | Resistor | 0 Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| R38 | 1 | Resistor | 22 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| R34 | 1 | Resistor | 0 Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| R12 | 1 | Resistor | 22 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| R7;RZ | 2 | Resistor | 0 Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| U2 | 1 | PFC Controller | NCP1622 | — | TSOP6 | ON Semiconductor | NCP1622AEA | NO | YES |

Table 3. NCP1622 GEVB Bill of Materials (ZCD detection using V_{aux})

REFERENCES

- [1] “5 Key Steps to Designing a Compact, High-Efficiency PFC Stage Using The NCP1602”, Application noteAND9218/D, http://www.onsemi.com/pub_link/Collateral/AND9218-D.PDF
- [2] NCP1622 Data Sheet, <http://www.onsemi.com/xxxxx>
- [3] NCP1622 Evaluation Board documents <http://www.onsemi.com/xxxxx>

ANNEX

Schematic & BOM for modifying the evaluation board in order to use the Power MOSFET Drain voltage instead of the Auxiliary voltage for CS/ZCD pin

NCP1622 GEVB - rev1.2 june 2nd 2017

While this evaluation board uses the auxiliary voltage for ZCD detection, it is also possible to use the power MOSFET drain voltage to do the ZCD detection. It is possible to configure this same evaluation board for using the power MOSFET drain voltage to feed the CS/ZCD pin for ZCD detection. The power section of the schematic does not change and it is only the control schematic which changes. The components on the path between the auxiliary voltage and CS/ZCD pin must be removed and new components placed between the power MOSFET drain voltage (V_{drain}) and CS/ZCD pin. The details of this modification are entirely described by the schematic of Figure 15 and, the bill of materials of Table 4. Application note AND9218/D [1] gives the design procedure and equations.

Using the schematic using power MOSFET drain voltage has pros and cons.

| Power MOSFET Drain for ZCD Detection (Alternative BOM) | Auxiliary Voltage for ZCD Detection (EVB default BOM) |
|--|--|
| Pros: <ul style="list-style-type: none"> • A simple boost inductor can be used (not necessary to use a transformer) • Brown-out detection is possible when using brown-out activated product option | Pros: <ul style="list-style-type: none"> • R₃₈ and R₃₉ value can be small and sensitivity to noise and parasitic capacitances is reduced • Consumes no power during standby even if R₃₈ and R₃₉ value are small |
| Cons: <ul style="list-style-type: none"> • R₂₂, R₂₃ and R₂₄ must not be too high because pin CSZCD is very sensitive to parasitic • Standby power (when there is no switching activity) is consumed by R₂₂, R₂₃ and R₂₄ | Cons: <ul style="list-style-type: none"> • Brown-out detection is not possible when using brown-out activated product option • The simple inductor becomes a transformer to which an auxiliary winding is added |

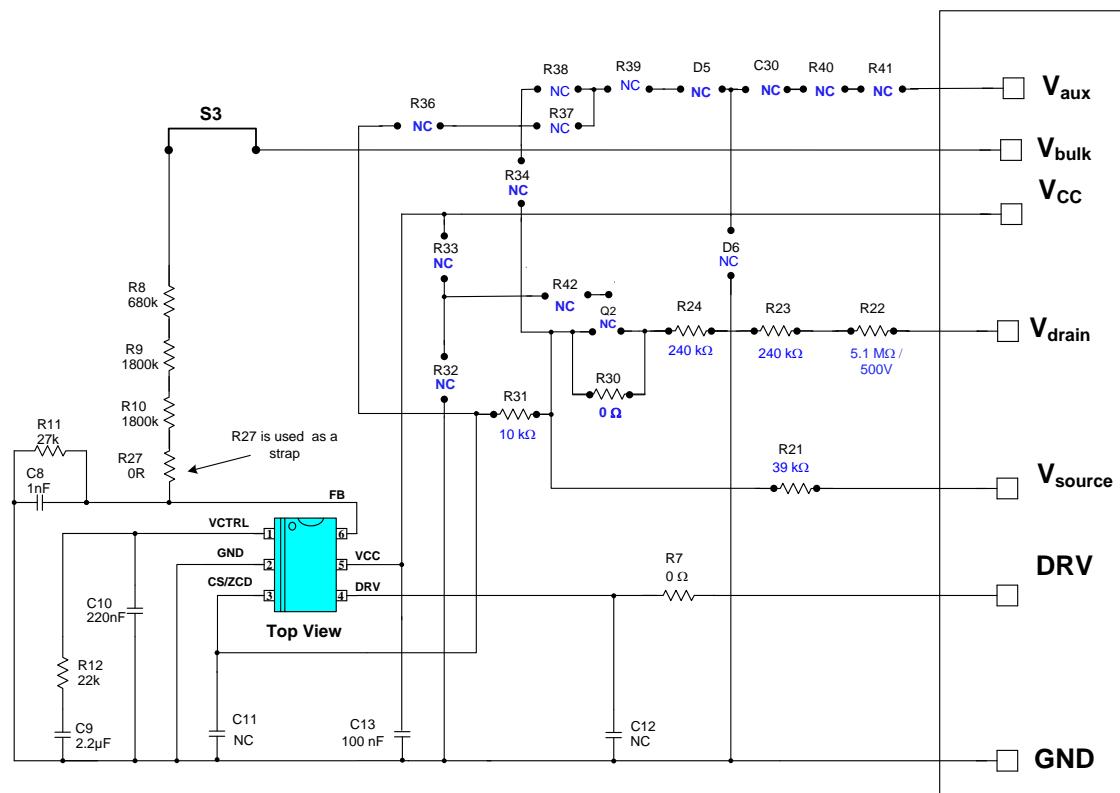


Figure 15. NCP1622 application Schematic – Control Section for ZCD Detection Using power MOSFET drain voltage (V_{drain})

NCP1622 GEVB - rev1.2 june 2nd 2017

| Designator | Quantity | Description | Value | Tolerance | Footprint | Manufacturer | Manufacturer Part Number | Substitution allowed | Lead Free |
|----------------------------|----------|-------------------------------------|----------------------|-----------|---------------|------------------|---------------------------|----------------------|-----------|
| J4 | 1 | PC terminal block | — | — | — | Phoenix | MTBSA2.5/2-5.08 | YES | YES |
| P1 | 1 | 4-mm Red-Connector | — | — | — | Multicomp | 23.3200-22 | YES | YES |
| P2 | 1 | 4-mm Black-Connector | — | — | — | Multicomp | 23.3200-21 | YES | YES |
| EARTH | 1 | 4-mm Yellow-Connector | — | — | — | DELTRON | 571-0700 | YES | YES |
| L | 1 | 4-mm Black-Connector | — | — | — | DELTRON | 571-0100 | YES | YES |
| N | 1 | 4-mm Blue-Connector | — | — | — | DELTRON | 571-0200 | YES | YES |
| S1A;S1B;S2A;S2B | 4 | JUMPER | — | — | — | HARWIN | D3082F05 | YES | YES |
| S3;S4A;S4B;S4C | 4 | Wire Strap | stiff insulated wire | — | 0.700" length | Various | Various | YES | YES |
| VAUX;VBULK;VIN;VLINE | 4 | TEST POINT | — | — | — | keystone | 5000 | YES | YES |
| CSZCD;DRV;FB;GND;VCC;VCTRL | 6 | TEST POINT | — | — | — | Various | Various | YES | YES |
| * | 4 | Board Supports | — | — | — | TCBS-801 | RICHCO | YES | YES |
| HS1 | 1 | Heatsink with fixation clips to PCB | — | — | — | COLUMBIA-STAVER | TP207ST,120,12.5,NA,SP,03 | NO | YES |
| | 1 | Heatsink MOSFET clip | — | — | — | COLUMBIA-STAVER | W950 | NO | YES |
| | 1 | Heatsink diodes bridge clip | — | — | — | COLUMBIA-STAVER | W936R | NO | YES |
| F1 | 1 | 4-A fuse | 4A | 250V | Through_hole | Multicomp | MCPEP 4A 250V | NO | YES |
| C1;C2 | 2 | Y Capacitors | 1nF | 400V | Through_hole | TDK | CD70ZU2GA102MYNKA | NO | YES |
| C4;C3A;C3B;C3C | 4 | X2 Capacitors | 220nF | 305Vac | Through_hole | EPCOS | B32922C3224K | NO | YES |
| C5a ; C5b | 2 | Filtering capacitor | 220nF | 400V | Through_hole | EPCOS | B32522-E6224-K000 | NO | YES |
| C6A;C6B | 2 | Bulk capacitor | 68uF | 450V | Through_hole | Rubycon | 4500XW68M12.5X40 | NO | YES |
| C7 | 1 | Electrolytic Capacitor | 22uF | 50V | Through_hole | Rubycon | 50ML22MEFC | YES | YES |
| U1 | 1 | DIODES BRIDGE | GBU406 | 800V/4A | Through_hole | LITE-ON | GBU406 | NO | YES |
| CM1 | 1 | Common Mode Filter | 2x3.3mH | 5A | Through_hole | Wurth Elektronik | 750341632 | NO | YES |
| L2 | 1 | Boost Inductor | 200uH | 6Apk | Through_hole | Wurth Elektronik | 750370081 (EFD30) | NO | YES |
| Q1 | 1 | Power MOSFET | IPA50R250CP | 550V | TO220_C | Infineon | IPA50R250CP | NO | YES |
| D1 | 1 | Boost Diode | MUR550 | 5A, 520V | Axial | ON Semiconductor | MUR550APFG | NO | YES |
| D2 | 1 | Bypass Diode | 1N5406 | 3A, 600V | Axial | ON Semiconductor | 1N5406G | NO | YES |
| D22 | 1 | 33-V ZENER DIODE | MMSZ33T1 | 33V, 0.5W | SOD123 | ON Semiconductor | MMSZ33T1G | NO | YES |
| RTH1 | 1 | Inrush Current Limiter | — | 15W | 1.8Amax | EPkos | B571535150M | NO | YES |
| D3;D4 | 2 | Switching Diode | D1N4148 | 100V | SOD-123 | ON Semiconductor | MMSD4148T1G | NO | YES |
| R1;R2 | 2 | Resistor | 1000kΩ | 500V | SMD, 1206 | Various | Various | YES | YES |
| R3 | 1 | Resistor | 80mΩ | 1%, 3W | Through_hole | Vishay | LVR03R0800FE12 | NO | YES |
| R4 | 1 | Resistor | 10kΩ | 5% | SMD, 1206 | Various | Various | YES | YES |
| R5 | 1 | Resistor | 2.2Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| R6 | 1 | Resistor | 22Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| C13 | 1 | Capacitor | 100nF | 50V | SMD, 1206 | Various | Various | YES | YES |
| C10 | 1 | Capacitor | 220nF | 50V | SMD, 1206 | Various | Various | YES | YES |
| C9 | 1 | Capacitor | 2.2uF | 50V | SMD, 1206 | Various | Various | YES | YES |
| C11;C12 | 2 | Capacitor | NC (**) | 50V | SMD, 1206 | Various | Various | YES | YES |
| R8 | 1 | Resistor | 680 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| R9;R10 | 2 | Resistor | 1800 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| R27 | 1 | Resistor | 0 Ω | 5% | 2512 | Various | Various | YES | YES |
| R11 | 1 | Resistor | 27kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| C8 | 1 | Capacitor | 1nF | 50V | SMD, 1206 | Various | Various | YES | YES |
| R22 | 1 | Resistor | 5.1 MΩ | 1% /500V | SMD, 1206 | Various | Various | YES | YES |
| R23 | 1 | Resistor | 240 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| R24 | 1 | Resistor | 240 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| Q2 | 1 | Switch MOSFET | NC (**) | — | SOT23 | Infineon | BSS127 | YES | YES |
| R30 | 1 | Resistor | 0 Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| R21 | 1 | Resistor | 39 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| R31 | 1 | Resistor | 10 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| R32 | 1 | Resistor | NC (**) | 5% | SMD, 1206 | Various | Various | YES | YES |
| R33 | 1 | Resistor | NC (**) | 5% | SMD, 1206 | Various | Various | YES | YES |
| R42 | 1 | Resistor | NC (**) | 10% | SMD, 1206 | Various | Various | YES | YES |
| R41 | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| R40 | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| C30 | 1 | Capacitor | NC (**) | 50V | SMD, 1206 | Various | Various | YES | YES |
| D6 | 1 | Diode | NC (**) | 100V | SOD-123 | ON Semiconductor | MMSD4148T1G | YES | YES |
| D5 (*) | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| R39 | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| R37 | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| R36 | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| R38 | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| R34 | 1 | Resistor | NC (**) | 1% | SMD, 1206 | Various | Various | YES | YES |
| R12 | 1 | Resistor | 22 kΩ | 1% | SMD, 1206 | Various | Various | YES | YES |
| R7;RZ | 2 | Resistor | 0 Ω | 1% | SMD, 1206 | Various | Various | YES | YES |
| U2 | 1 | PFC Controller | NCP1622 | — | TSOP6 | ON Semiconductor | NCP1622AEA | NO | YES |

Table 4. NCP1622 GEVB Bill of Materials for ZCD Detection Using power MOSFET drain voltage (V_{drain})