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# AND9240/D

# Upgrading NCP1236-Based Converters with NCP1239

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## APPLICATION NOTE

The NCP1239 is a fixed-frequency current-mode controller featuring a high-voltage start-up current source to provide a quick and lossless power-on sequence. This controller is pin-to-pin compatible with the former NCP1236. Only few components need to be changed in order to plug this new controller generation in an existing board. This application note will compare the performance of a typical 65-W application evaluation board originally equipped with the NCP1236 controller and upgraded with a NCP1239.

A NCP1236 demonstration board has been selected for this test. The specifications of this board are listed in Table 1.

**Table 1. EVALUATION BOARD SPECIFICATION**

| Parameter | Value |
|---|---|
| Minimum Input Voltage | 85 V rms |
| Maximum Input Voltage | 265 V rms |
| Output Voltage | 19 V |
| Nominal Output Power | 65 W |


**Figure 1. Evaluation Board Picture**

**Table 2. MAIN PARAMETERS COMPARISON BETWEEN NCP1236 AND NCP1239**

| Functions | NCP1236 | NCP1239 |
|---|---|---|
| Fault Pin | Upper Level: 2.5 V<br>(Usually used for OVP Detection) | Upper Level: 3.0 V<br>(Usually used for OVP Detection) |
| | Lower Level: 0.8 V with $I_{NTC}$ = 95 μA<br>(Usually used for OTP Detection)<br>The needed NTC Resistor Value for OTP Detection => $R_{NTC}$ = 8.4 kΩ | Lower level: 0.4 V with $I_{NTC}$ = 45 μA<br>(Usually used for OTP Detection)<br>The needed NTC Resistor Value for Similar OTP Level Trip Point => $R_{NTC}$ = 8.9 kΩ |
| $V_{CC}$ OVP | OVP Threshold on $V_{CC}$ Pin => 26.5 V | OVP Threshold on $V_{CC}$ pin => 25.5 V<br>Option Available upon Request |
| Frequency Jittering | 125 Hz – 6% of $F_{SW}$ | 240 Hz – 5% of $F_{SW}$ |
| Frequency Foldback Mode (FF) | Start of FF Mode when $V_{FB}$ < 2 V<br>End of FF Mode when $V_{FB}$ < 1.35 V | Start of FF Mode when $V_{FB}$ < 1.9 V<br>End of FF Mode when $V_{FB}$ < 1.5 V |
| Skip Mode | Enter in Skip Mode when $V_{FB}$ < 0.7 V with 100-mV Hysteresis | Enter in Skip Mode when $V_{FB}$ < 0.8 V with 30-mV Hysteresis |
| FB Pull Up Resistor | $R_{UP}$ = 20 kΩ | $R_{UP}$ = 30 kΩ |
| $V_{FB}$ to CS Pin Ratio | 5 | 4 |
| CS Limitation | 0.7-V Maximum Current Setpoint | 0.8-V Maximum Current Setpoint |
| | If $V_{CS}$ > 1.05 V (50% Higher), Controller Immediately Stops | If $V_{CS}$ > 1.20 V (50% Higher), Controller Stops after 4 Consecutive Pulses |
| Over Power Protection (OPP) | $V_{HV}$ = 125 V => $I_{OPP}$ = 0<br>$V_{HV}$ = 162 V => $I_{OPP}$ = 20 μA<br>$V_{HV}$ = 325 V => $I_{OPP}$ = 110 μA<br>$V_{HV}$ = 365 V => $I_{OPP}$ = 130 μA | $V_{HV}$ = 125 V => $I_{OPP}$ = 0<br>$V_{HV}$ = 162 V => $I_{OPP}$ = 20 μA<br>$V_{HV}$ = 325 V => $I_{OPP}$ = 110 μA<br>$V_{HV}$ = 365 V => $I_{OPP}$ = 130 μA |
| Over Current Protection (OCP) | 128-ms OCP Timer<br>1-s Auto-Recovery Timer | 64-ms OCP Timer<br>1-s Auto-Recovery Timer |
| | Option with 32-ms OCP Timer and 1.5-s Auto-Recovery Timer | Timer Options Available upon Request |
| Soft Start Duration | 4-ms Duration | 8-ms Duration<br>Timer Option Available upon Request |
| DRV Capability | 500-mA Source Current<br>500-mA Sink Current<br>13.5-V Clamp Voltage | 500-mA Source Current<br>500-mA Sink Current<br>13.5-V Clamp Voltage |
| IC Consumption in Skip Mode | $I_{CC(stb)}$ = 0.9 mA | $I_{CC(stb)}$ = 0.5 mA |
| UVLO Levels | $V_{CC(on)}$ = 12 V<br>$V_{CC(off)}$ = 9.5 V<br>$V_{CC(min)}$ = 10.5 V | $V_{CC(on)}$ = 12 V<br>$V_{CC(off)}$ = 8.8 V<br>$V_{CC(min)}$ = 10 V |
| High Voltage Current Source | $I_{START1}$ = 0.5 mA<br>$I_{START2}$ = 6 mA<br>HV Leakage Current, $I_{LEAK}$ = 25 μA Typ. | $I_{START1}$ = 0.5 mA<br>$I_{START2}$ = 3 mA<br>HV Leakage Current, $I_{LEAK}$ = 8 μA Typ. |
| Dynamic Self Supply (DSS) | Enable by Default | Disable by Default<br>“Enable” Option Available upon Request |
| Brown-Out | Brown-In when $V_{HV}$ > 107 V<br>Brown−Out when $V_{HV}$ < 92 V<br>68-ms BO Timer | Brown-In when $V_{HV}$ > 110 V<br>Brown-Out when $V_{HV}$ < 101 V<br>68-ms BO Timer<br>Options Available upon Request |

As shown in Table 2, both controllers are very similar. There are few differences regarding some thresholds but the impact in the application will be negligible. There are also several improvements on the NCP1239 like a lower leakage current on the HV pin that will bring a better stand-by performance for instance. Let’s go through each section to see the impact in a 19-V application.

### Over Voltage Event on the Fault Pin (OVP)

Let's take the example of an OVP event on the Fault pin. The upper level is 2.5 V for the NCP1236. For a typical 19-V output voltage in the adapter application, the transformer specifications are:

- Primary to Secondary Turns Ratio: $N_{PS}$ = 1:0.188
- Primary to Auxiliary Turns Ratio: $N_{AUX}$ = 1:0.156

Assume we detect an OVP on the fault pin when the output voltage reaches 21 V with the NCP1236 controller. Due to the turns ratio between the secondary and auxiliary windings, the auxiliary voltage will be:

$$V_{AUX\_OVP} = \frac{N_{PS}}{N_{AUX}} \cdot V_{OUT\_OVP} = \qquad \text{(eq. 1)}$$

$$= \frac{1:0.188}{1:0.156} \cdot 21 = 17.4\ \text{V}$$

Thus, with a 15-V Zener diode connected between the $V_{CC}$ pin and the Fault pin, the power supply (PSU) will latch when the output voltage increases above 21 V.

Now, with the NCP1239 controller, the fault pin upper level is 3 V. What will be the new output voltage to detect an OVP event on the primary side with the same 15-V Zener diode?

$$V_{OUT\_OVP} = \frac{N_{AUX}}{N_{PS}} \cdot \left(V_{Zener} + V_{Fault\_OVP}\right) = \qquad \text{(eq. 2)}$$

$$= \frac{1:0.156}{1:0.188} \cdot (15 + 3) = 21.7\ \text{V}$$

So the needed output voltage to detect an OVP event with the NCP1239 controller will be 21.7 V instead of 21.0 V for the NCP1236. The difference is only 3% for this application.

Figure 2 and Figure 3 illustrate the output voltage deviation during an OVP event detected through the dedicated Fault pin depending on the controller. The board behavior in both cases is identical.

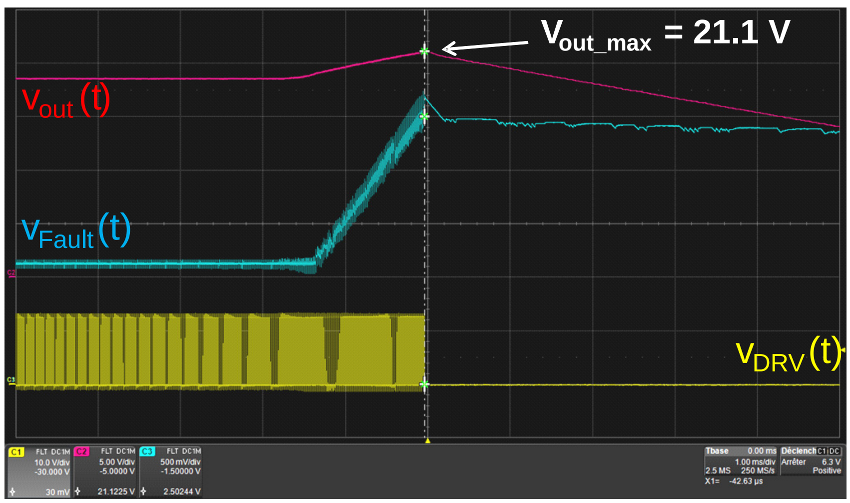


**Figure 2. OVP Event on the Fault Pin with NCP1236**

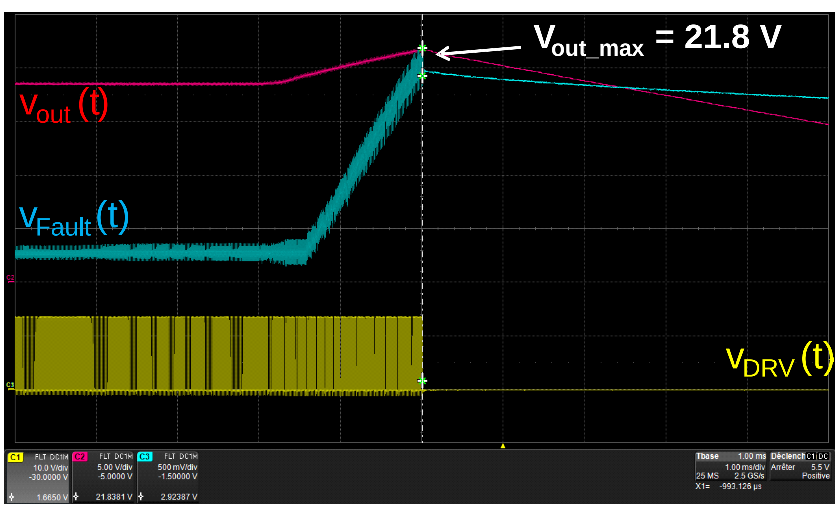


**Figure 3. OVP Event on the Fault Pin with NCP1239**

### Over Voltage Event on the $V_{CC}$ Pin

In some applications, the OVP detection can be implemented through the $V_{CC}$ pin. In this case, the impact on the output voltage will be slightly different.

With the 26.5-V $V_{CC}$ OVP threshold for the NCP1236 controller, the maximum output voltage will be:

$$V_{OUT\_OVP} = \frac{N_{AUX}}{N_{PS}} \cdot V_{CC\_OVP} = \quad \text{(eq. 3)}$$

$$= \frac{1:0.156}{1:0.1188} \cdot 26.5 = 31.9\ \text{V}$$

With the 25.5-V $V_{CC}$ OVP threshold for the NCP1239 controller, the maximum output voltage will be:

$$V_{OUT\_OVP} = \frac{N_{AUX}}{N_{PS}} \cdot V_{CC\_OVP} = \quad \text{(eq. 4)}$$

$$= \frac{1:0.156}{1:0.1188} \cdot 25.5 = 30.7\ \text{V}$$

So, for an OVP event detected on the $V_{CC}$ pin, the difference output voltage between both controllers will be less than 4%. Also the over voltage will be lower with the NCP1239 that is better for the following structure connected to the adapter.

The OVP event has been captured with the NCP1236 (Figure 4) and with the NCP1239 (Figure 5) in the same application.

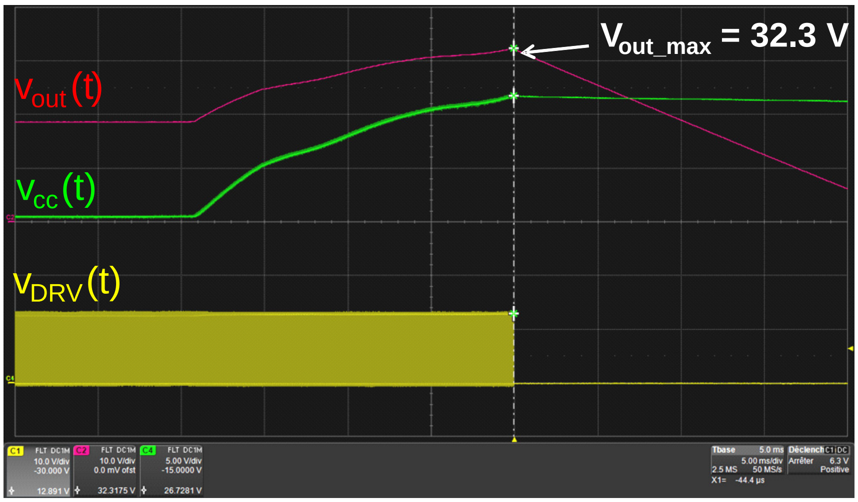


**Figure 4. OVP Event on the $V_{CC}$ Pin with NCP1236**

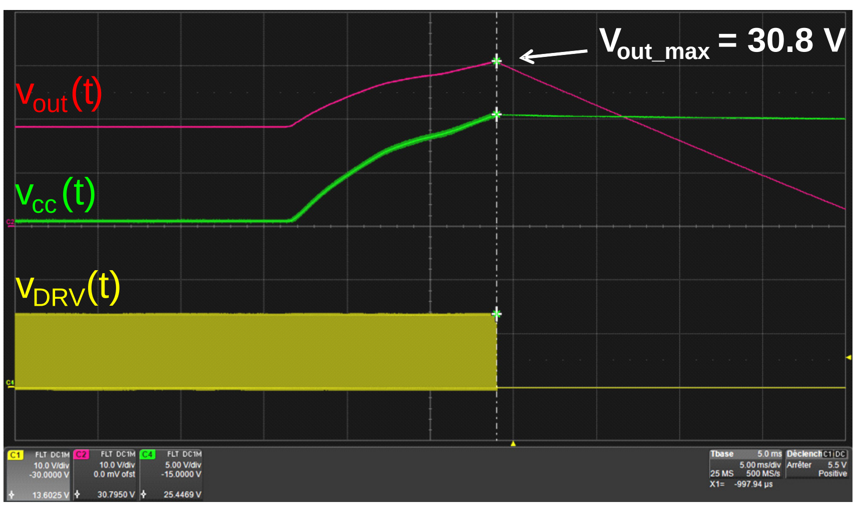


**Figure 5. OVP Event on the $V_{CC}$ Pin with NCP1239**

### Over Temperature Event (OTP)

For safety purposes, the controller offers the possibility to detect an over temperature event owing to the fault pin. Instead of using the upper threshold for the OVP detection, by connecting a NTC resistor between pin 1 and ground, the lower level is dedicated for this typical arrangement.

The NCP1236 and NCP1239 have similar level detections. The NCP1236's lower threshold is 0.8 V compared to 0.4 V for the NCP1239 but the bias current ($I_{OTP}$) has been reduced in the case of NCP1239 for the benefit of standby consumption. Thanks to this arrangement, the needed pull-down resistance to cross the $V_{Fault(OTP)}$ level is roughly equal. Equations 5 and 6 compute the value respectively for the NCP1236 and NCP1239 controller.

- For NCP1236:

$$R_{NTC} = \frac{V_{Fault(OTP)}}{I_{OTP}} = \frac{0.8}{95u} = 8.4\ k\Omega \qquad \text{(eq. 5)}$$

- For NCP1239:

$$R_{NTC} = \frac{V_{Fault(OTP)}}{I_{OTP}} = \frac{0.4}{45u} = 8.9\ k\Omega \qquad \text{(eq. 6)}$$

In the application board, a Vishay's NTC has been used (NTCLE100E3334JB0) to detect the OTP event. The entire board has been placed in an oven. The NCP1236 controller was latched off when the ambient temperature is around 105°C. The trip for the NCP1239 part was 104°C in similar conditions. Both temperatures are very close.

### Current Sense Limit

The current sense threshold on CS pin has been changed compared to the NCP1236. The maximum current sense voltage allowed on the CS pin in normal operation is 0.7 V for the NCP1236. This threshold has been increased to 0.8 V for the new NCP1239 controller. This difference induces two components changes. The first one involves the current sense resistor ($R_{SENSE}$) in order to ensure the same maximum power capability at low mains. The second one deals with the series resistor ($R_{CS}$) connected between $R_{SENSE}$ and the CS pin. This resistance has two functions:

1. It filters the signal (with the $C_{CS}$) applied on the CS pin.
2. It adjusts the Over Current Protection (OPP) in relationship to the input voltage.

For the NCP1236 design, the sense resistor is 300 mΩ. Considering a 0.7-V maximum threshold on the CS pin, the maximum peak current on the primary winding is:

$$I_{Peak\_Pri\_Max} = \frac{V_{CS\_Max}}{R_{SENSE}} = \frac{0.7}{300m} = 2.33\ A \qquad \text{(eq. 7)}$$

Moreover, to limit the maximum output current at high mains, the $R_{CS}$ resistor in series with the CS pin is set to 1 kΩ.

At high mains (i.e. 265 V rms), the internal OPP current source generates 130 μA which flows out of the CS pin. In this condition, the new primary peak current will be:

$$I_{Peak\_Pri@265V} = \frac{V_{CS\_Max}}{R_{SENSE}} = \frac{0.7 - (1k \cdot 130u)}{300m} = 1.9\ A \qquad \text{(eq. 8)}$$

The combination of these two previous elements brings the following Over Current Protection curve (Figure 6).

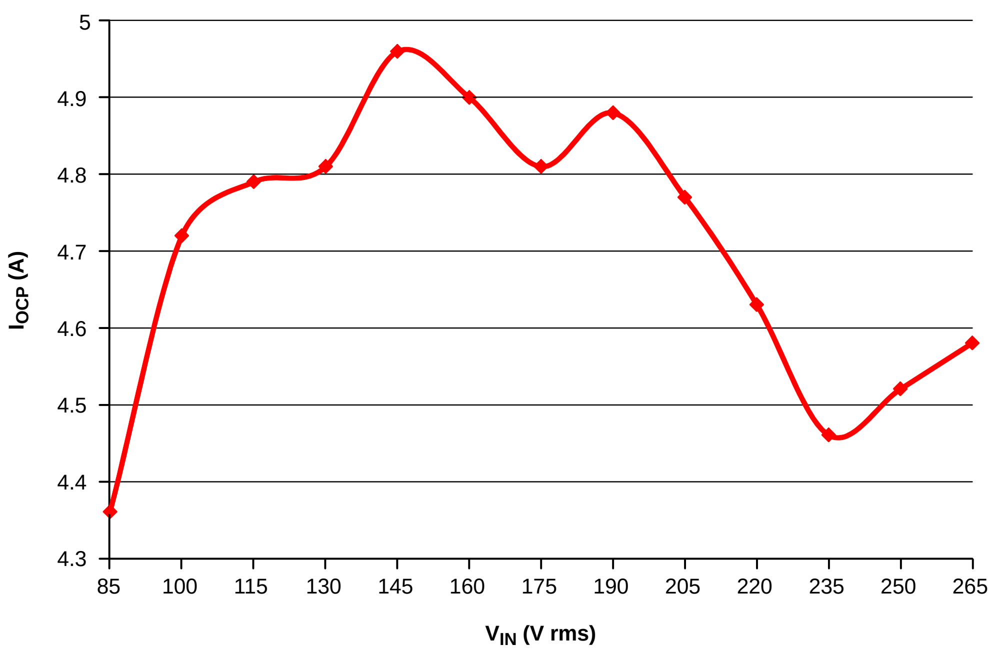


**Figure 6. Over Current Protection (OCP) vs. Input Voltage − NCP1236**

For the NCP1239, the maximum current sense level has been increased to 0.8 V. Therefore, in order to keep the same primary peak current (i.e. 2.33 A), the sense resistor has to be modified as follows:

$$R_{SENSE\_NCP1239} = \frac{V_{CS\_Max}}{I_{Peak\_Pri}} = \frac{0.8}{2.33} = 343\ \text{m}\Omega \qquad \text{(eq. 9)}$$

We will use the 330-mΩ normalized resistor (three paralleled 1-Ω resistors).

The next step now is to adjust the series resistance with the NCP1239's CS pin to obtain the equivalent maximum output current at 265 V rms. With the help of Equation 8, we know the primary peak current with the NCP1236 controller at high mains. Let's calculate the needed level on the NCP1239's CS pin to reach the same peak current.

$$V_{CS\_NCP1239@265V} = R_{SENSE\_NCP1239} \cdot I_{Peak\_Pri@265V} = \qquad \text{(eq. 10)}$$
$$= 0.33 \cdot 1.9 = 0.63\ \text{V}$$

Now, we just have to compute the $R_{CS}$ resistor to have this 0.63-V maximum threshold at high mains.

$$R_{CS\_NCP1239} = \frac{V_{CS\_Max\_NCP1239} - V_{CS\_Max\_NCP1239@265V}}{I_{OPP}\ @265\ \text{V rms}} = \qquad \text{(eq. 11)}$$
$$= \frac{0.8 - 0.63}{130u} = 1.3\ \text{k}\Omega$$

The new value is really close to that of the resistance used for the NCP1236 (i.e. 1 kΩ). We have the possibility to run the test with the same resistance considering only a sense resistor that has been increased from 0.30 Ω to 0.33 Ω. We can see that the OCP current, plotted in Figure 7, follows the same evolution compared to the NCP1236 current graph (Figure 6).

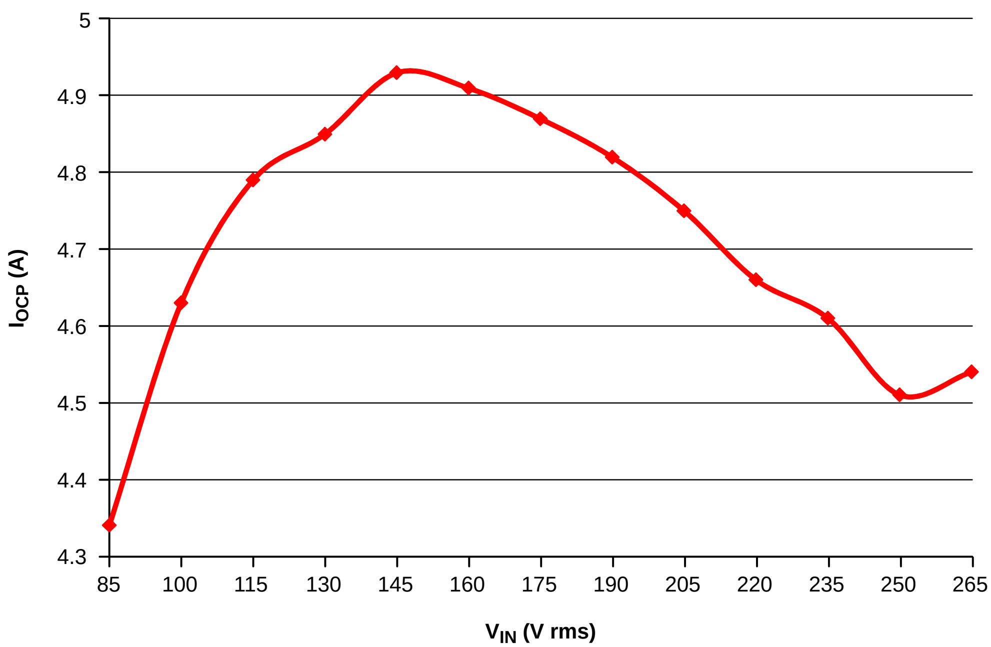


**Figure 7. Over Current Protection (OCP) vs. Input Voltage − NCP1239**

### Abnormal Over Current Protection

Both controllers include a function to protect the PSU against a severe fault. For instance, if the secondary diode is damaged and becomes shorted, the secondary winding will be shorted too. In this case, the primary current can increase very rapidly during the on-time as the inductance remaining in the mesh is the leakage term. The current sense signal significantly exceeds the maximum current sense threshold (0.7 V for the NCP1236 and 0.8 V for the NCP1239). A second comparator, 50% higher than $V_{CS\_max}$ with shorter LEB is present on CS pin. So, for the NCP1236, the level is 1.05 V compared to 1.20 V for the NCP1239. The difference is how the fault is internally handled.

Let's look at at the NCP1236. Once the CS pin is higher than the 1.05 V, the controller immediately stops switching and enters in auto-recovery or latch mode depending of the chosen option. This behavior is shown in Figure 8.

The NCP1239 offers an improved noise immunity performance compared to NC1236. To validate the fault, the controller has to detect 4 consecutive pulses with the CS pin voltage above the 1.2-V threshold. After these four periods, the controller stops operations like the NCP1236 does. This implementation will avoid an unexpected detection in case of surge tests for instance.

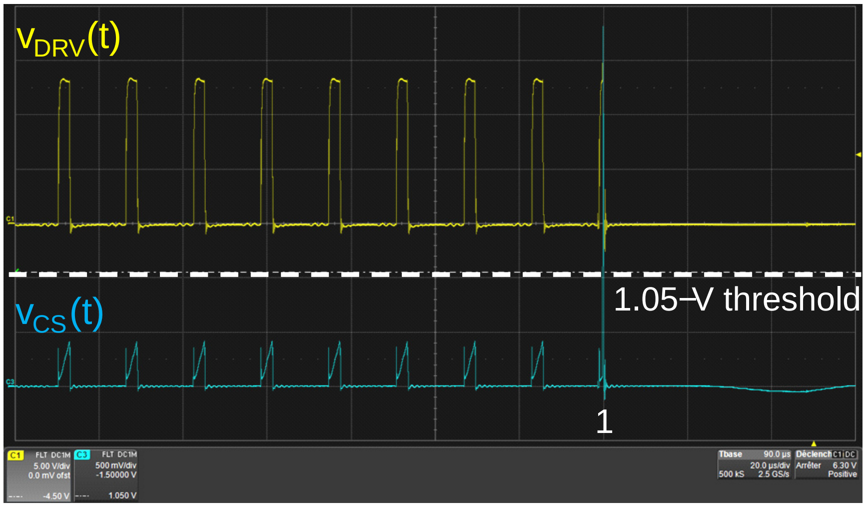


**Figure 8. Abnormal Over Current Protection − NCP1236**

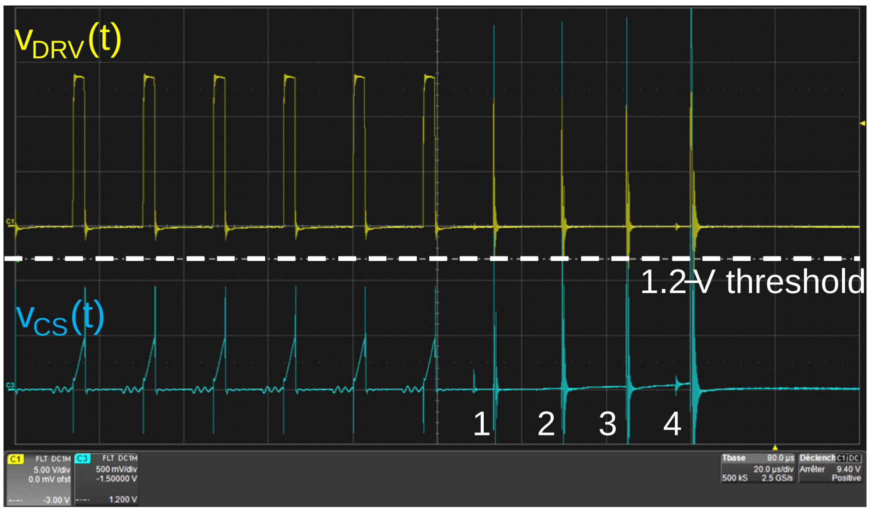


**Figure 9. Abnormal Over Current Protection − NCP1239**

### Start-Up Sequence

A high voltage (HV) current source is embedded in both controllers to ensure a quick start-up. The current capability of the NCP1236 is higher than the NCP1239 (6 mA versus 3 mA) but it will be sufficient to wake-up the controller rapidly. Also, thanks to this lower capability, the HV pin leakage current is lower for the new NCP1239. This will have a significant impact on the stand-by performance, especially at high mains. Equation 12 gives an estimation of the power you can save with the NCP1239 when its HV pin is connected to the bulk capacitor. The standby performance comparison is exposed later in the document.

$$P_{Saved} = V_{in\_max} \cdot \left(I_{LEAK\_NCP1236} + I_{LEAK\_NCP1239}\right) = \quad \text{(eq. 12)}$$

$$= 265 \cdot \sqrt{2} \cdot (25u - 8u) = 7\ \text{mW}$$

The NCP1236 controller starts pulsing after 403 ms (Figure 10) while 523 ms are needed for the NCP1239 (Figure 11). We are still far away from the 3-s limit for classical notebook adapters.

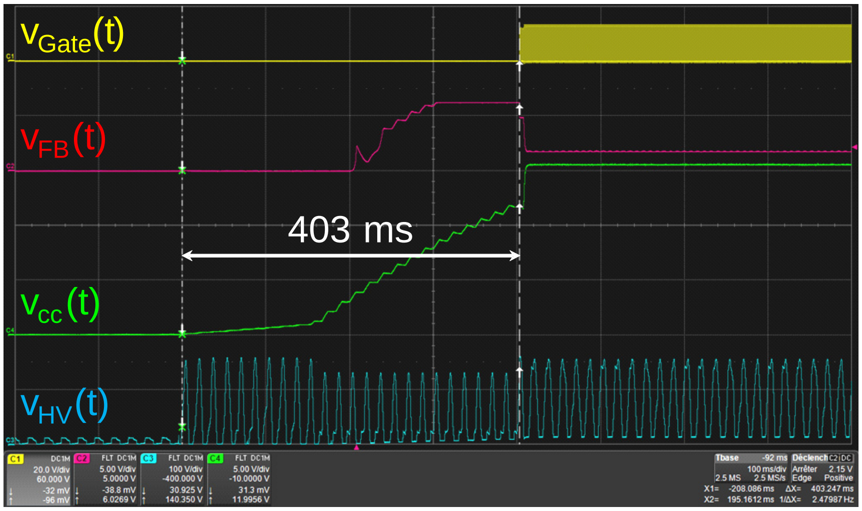


**Figure 10. Start-Up Sequence − NCP1236**

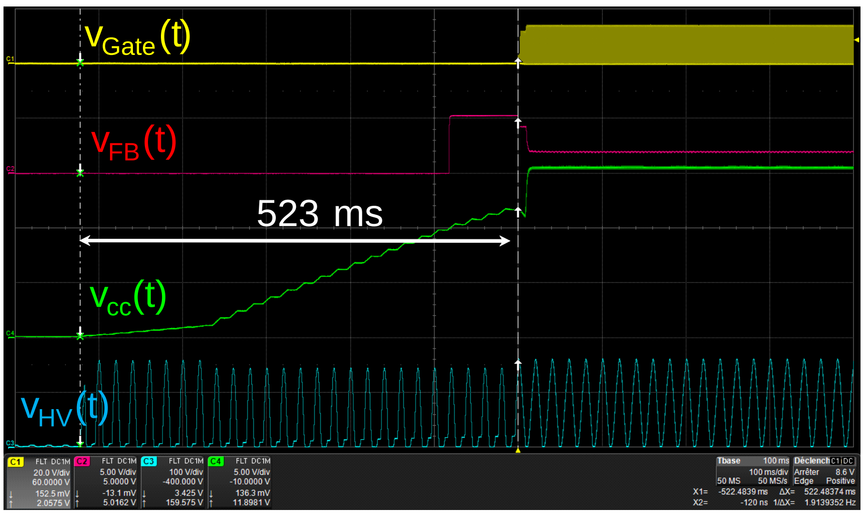


**Figure 11. Start-Up Sequence − NCP1239**

The start-up sequence also involves the internal soft-start. During this time, the peak current setpoint is linearly increased from a very low value up to the allowable maximum. To reduce the stress on the power supply, the NCP1239 soft-start duration has been increased from 4 ms to 8 ms.

**Jittering Function**

The jittering function helps spreading out energy in conducted noise analysis and it improves the EMI signature. Both controllers have this function but the levels are different. As shown on the Table 3, the frequency swing has been doubled for the NCP1239 like the famous NCP125x series. The frequency jittering is quite the same.

**Table 3. JITTERING FUNCTION PARAMETERS**

| | NCP1236 Controller | NCP1239 Controller |
|---|---|---|
| Frequency Swing | 125 Hz | 240 Hz |
| Frequency Jittering | 6% of $F_{SW}$ | 5% of $F_{SW}$ |

The EMI signature for both controllers is below the limit regardless of the input voltage.

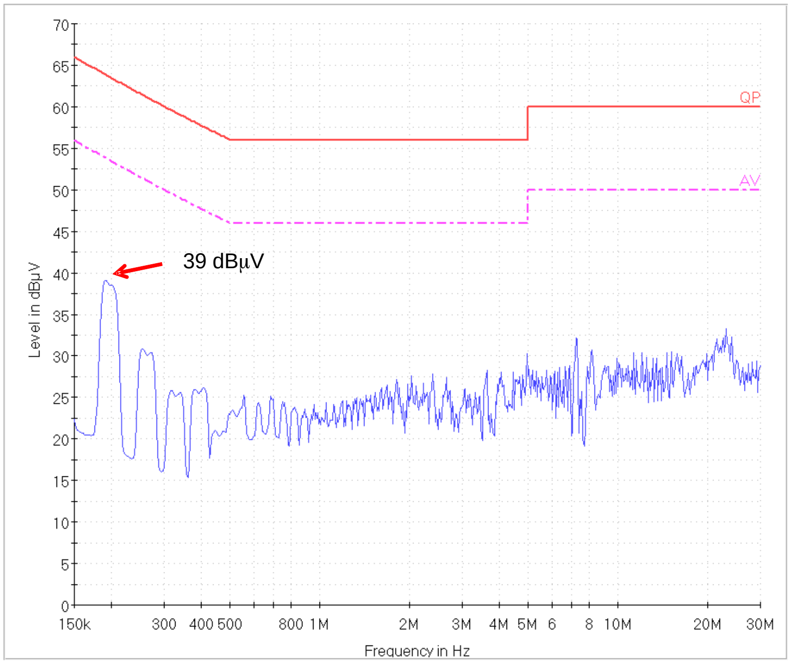


Figure 12. Average EMI Signature @115 V rms/Full Load − NCP1236

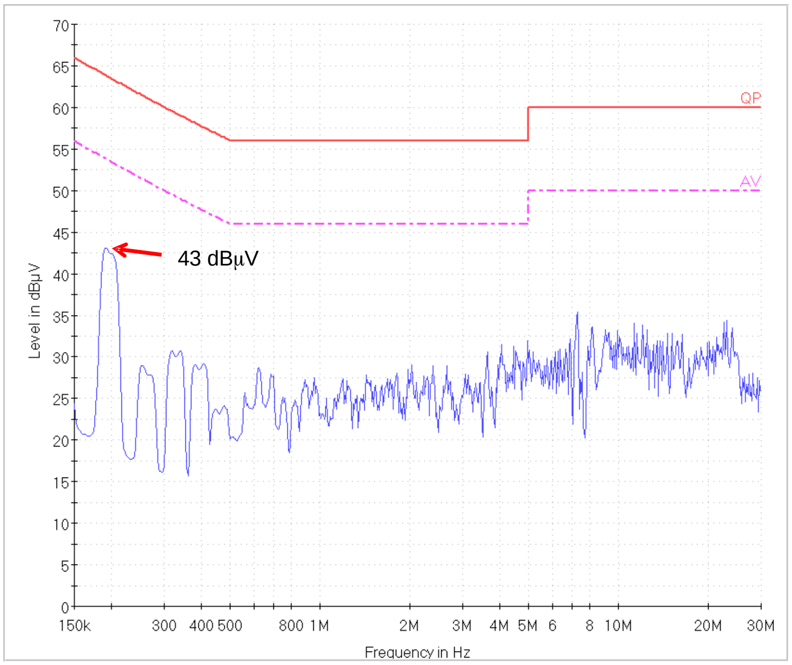


Figure 13. Average EMI Signature @230 V rms/Full Load − NCP1236

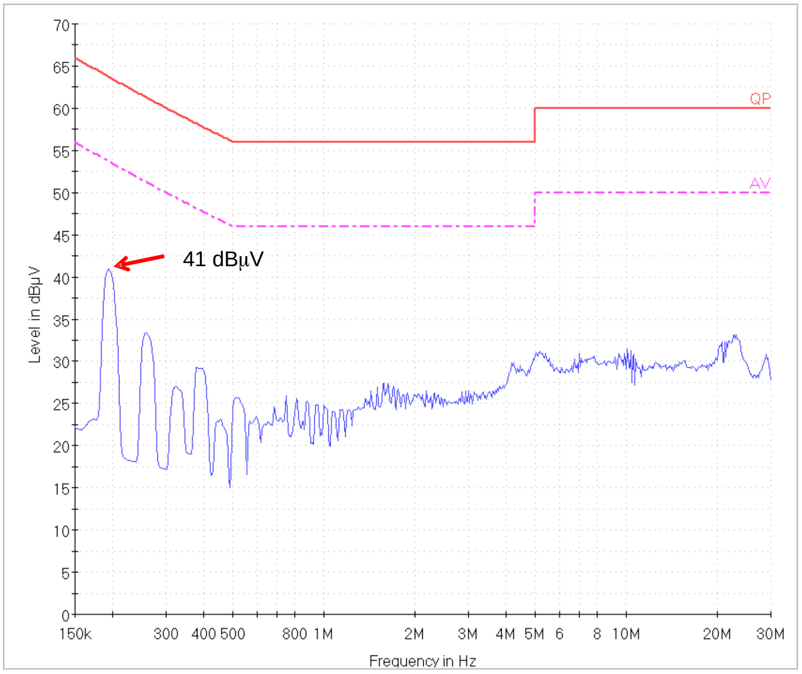


**Figure 14. Average EMI Signature @115 V rms/Full Load − NCP1239**

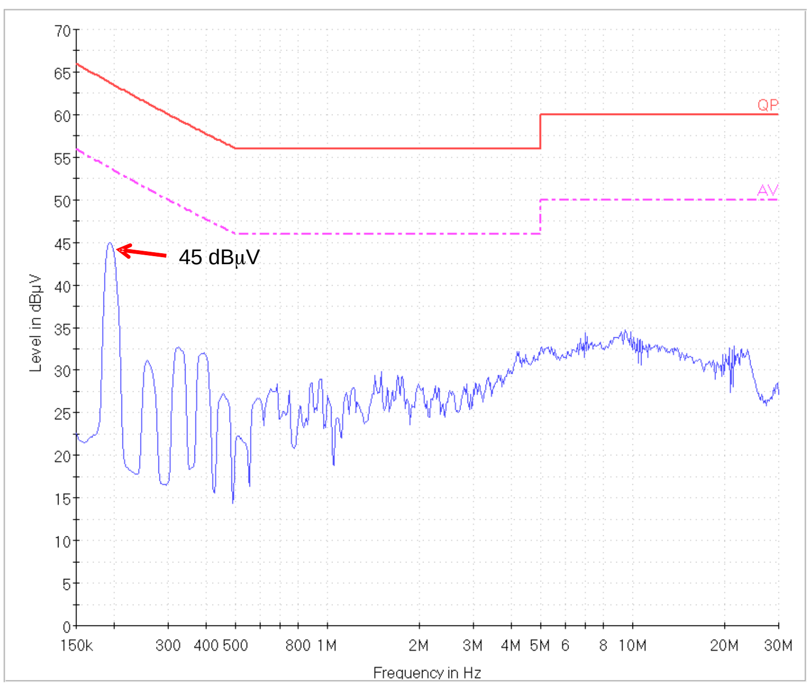


**Figure 15. Average EMI Signature @230 V rms/Full Load − NCP1239**

### Transient Load

Figure 16 and Figure 17 show an output transient load step from 10% to 100% of the maximum output power at low line and high line. The slew rate is 1 A/µs and the frequency is 5 Hz.

- For the NCP1236 controller, the step load response is ±16 mV or ±0.9% of the output voltage
- For the NCP1239 controller, the step load response is ±29 mV or ±1.8% of the output voltage

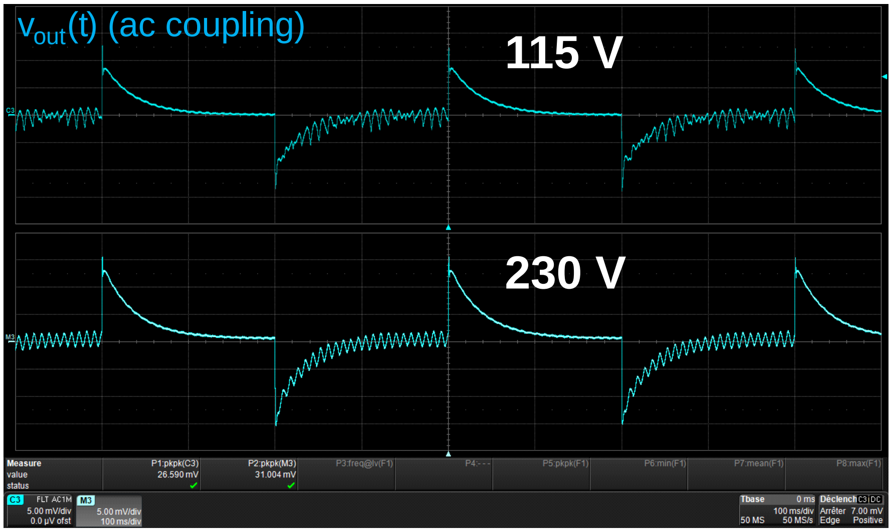


**Figure 16. Step Load Response between 10% to 100% − NCP1236**

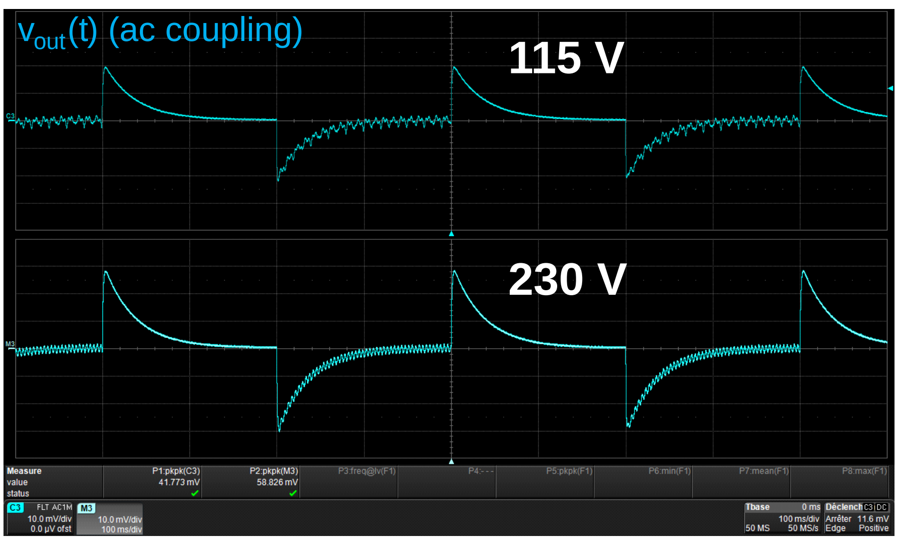


**Figure 17. Step Load Response between 10% to 100% − NCP1239**

Both responses are good. The NCP1236 offers a better response and it can be explained by the NCP1239 higher internal FB pull-up resistance. Indeed, the internal resistor connected to the FB pin has been increased from 20 kΩ to 30 kΩ in the NCP1239 controller in order to reduce the circuit consumption and improve the standby performance. This resistor has an impact on the compensation. Please refer the AND8334 application note to have more information about the compensation with the TL431.

To confirm this analysis, several open-loop measurements have been performed. One typical result at 162 V dc (115 V rms) is given in Figure 18 for the NCP1236 and in Figure 19 for the NCP1239. A crossover frequency of 624 Hz is observed, together with a comfortable phase margin (89°) for the NCP1236. With the NCP1239, the converter is also well compensated. The crossover frequency is 412 Hz with a ≈100° phase margin. Both values explain the slow response during the transient test.

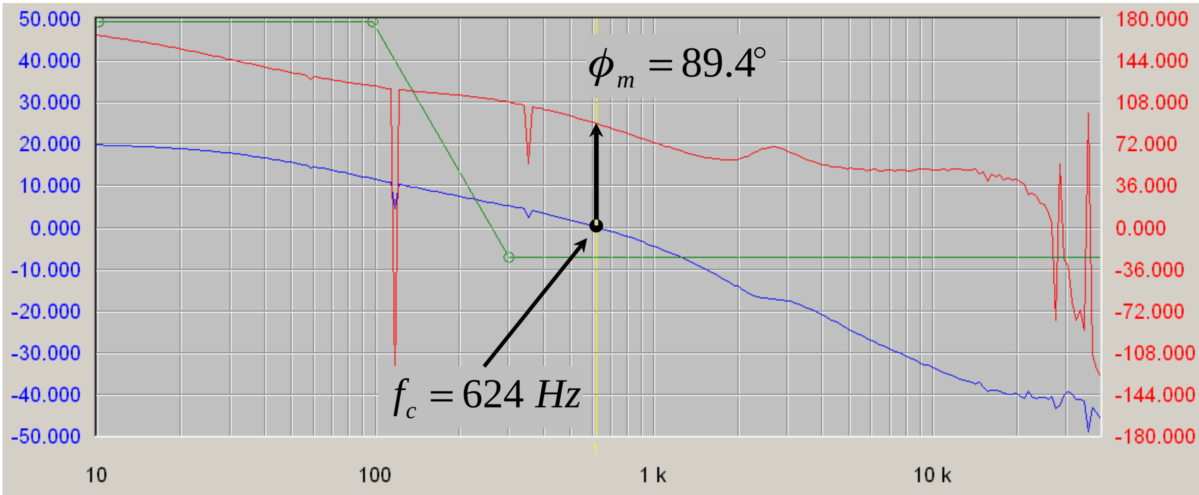


**Figure 18. Open-Loop AC Sweep at 162 V dc Input Voltage − NCP1236**

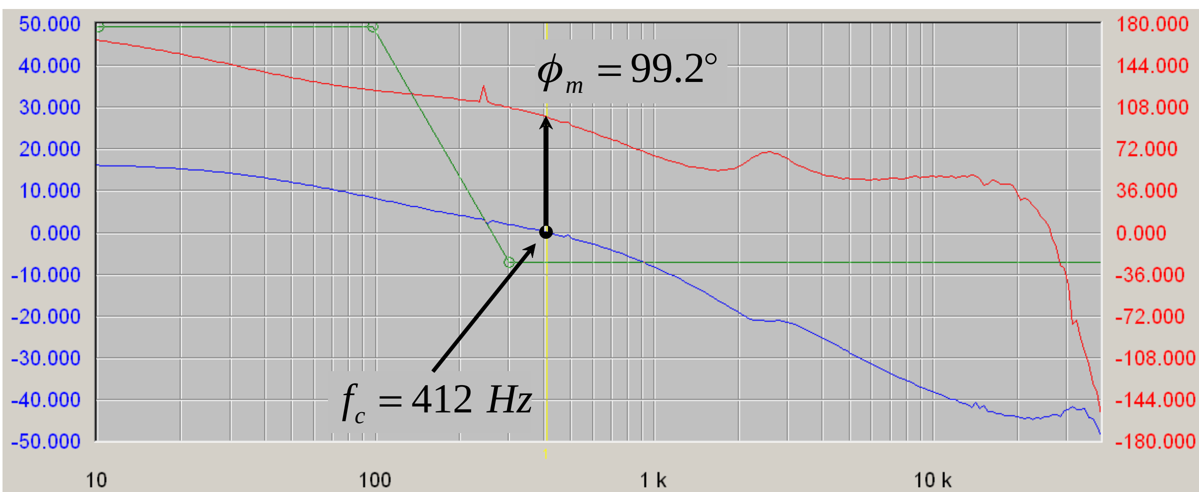


**Figure 19. Open-Loop AC Sweep at 162 V dc Input Voltage − NCP1239**

### Efficiency and Average Efficiency

Thanks to a different Frequency Foldback (FF) implementation, efficiency in middle and light load operation is better with the new NCP1239. NCP1236 features a larger FF window and does not freeze the primary peak current. On the contrary, the NCP1239 controller freezes the current in light load condition to limit the pulse number in a switching period and accordingly reduces switching losses.

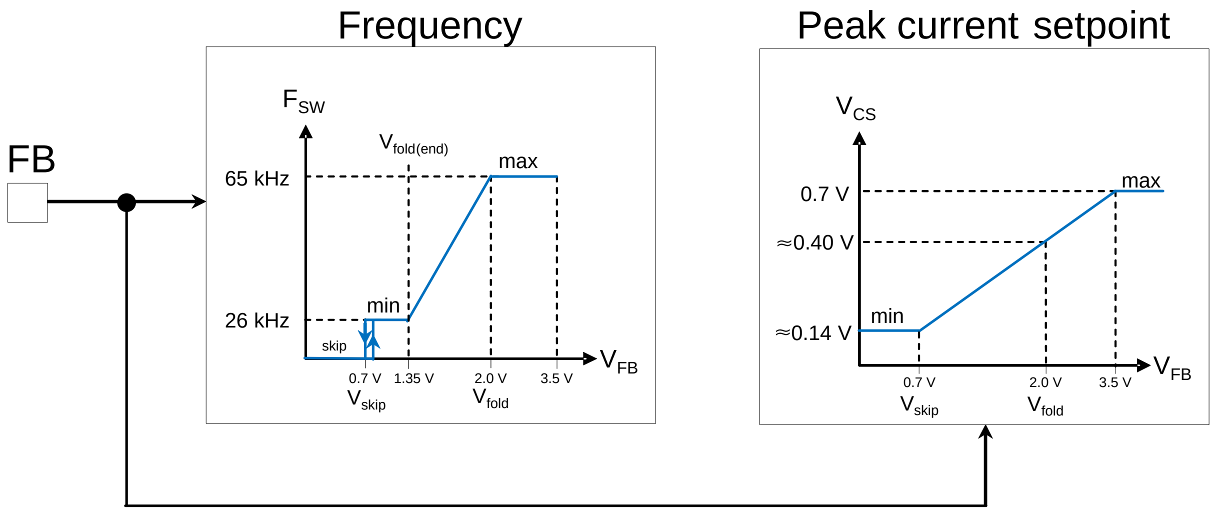


**Figure 20. Frequency Foldback Mode − NCP1236**

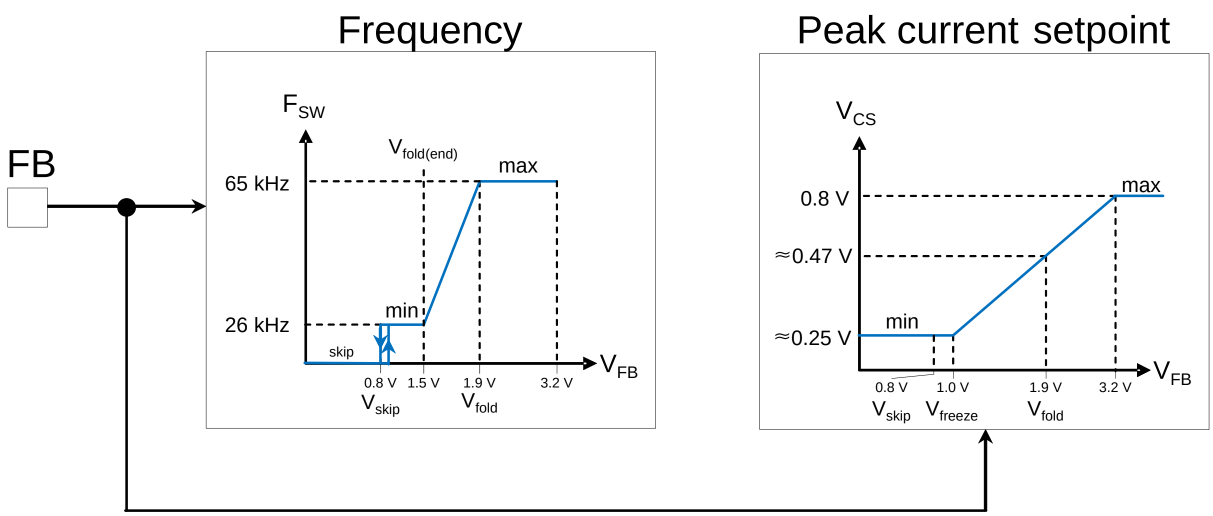


**Figure 21. Frequency Foldback Mode − NCP1239**

Efficiency measurements in Figure 22 and Figure 23 have been conducted on the same evaluation board, with the same equipment and at room temperature. All measurements have been done following the Code of Conduct specification (CoC). So following a 30 min warm-up phase at full load, all measurements have been performed further to a 5-min loading consideration.

The input power was measured with the 66202 power meter (Chroma) and the output voltage and output current were measured using digital multimeter embedded in the dc electronic load 66103, also from Chroma.

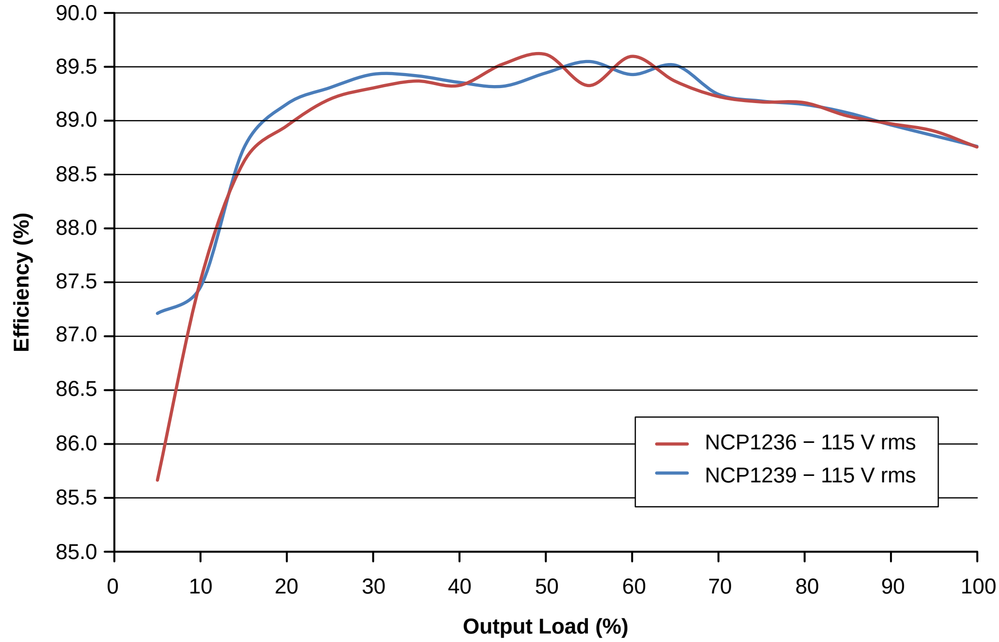


**Figure 22. Efficiency (%) vs. Output Power (% of Max) @115 V rms**

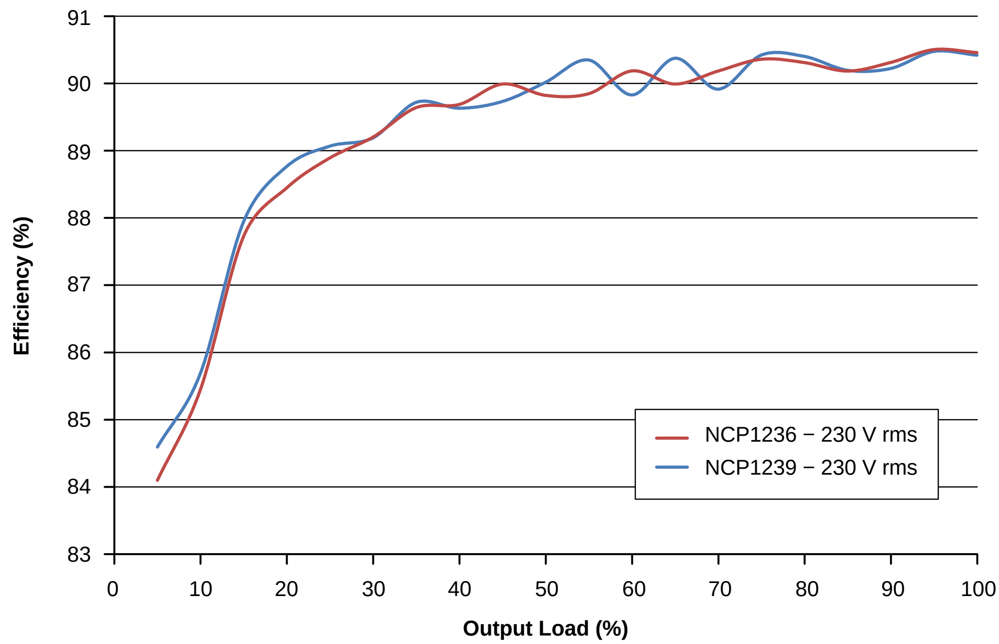


**Figure 23. Efficiency (%) vs. Output Power (% of Max) @230 V rms**

From the previous curves, we can extract the average efficiency for both controllers. This parameter is calculated from the efficiency measurements at 25%, 50%, 75% and 100% of the full rated output power.

What does the CoC say about efficiency? For a typical 19-V adapter, 65-W output power, the average efficiency has to be higher than 89% and the minimum efficiency @10% of the maximum load higher than 79%. As described in Table 4, in this application, the NCP1236 is not able to comply with the CoC requirements. On the contrary, thanks to a better efficiency at middle load, the NCP1239 can pass the standard requirements.

**Table 4. EFFICIENCY @115 V RMS AND 230 V RMS**

| Input Voltage | $P_{OUT}$ (%) | NCP1236 Efficiency (%) | NCP1239 Efficiency (%) |
|---|---|---|---|
| 115 V rms | 100 | 88.75 | 88.75 |
| | 75 | 89.17 | 89.18 |
| | 50 | 89.61 | 89.44 |
| | 25 | 89.20 | 89.30 |
| | Average | 89.18 | 89.17 |
| | 10 | 87.51 | 87.45 |
| 230 V rms | 100 | 90.48 | 90.44 |
| | 75 | 90.38 | 90.44 |
| | 50 | 89.84 | 90.04 |
| | 25 | 88.91 | 89.09 |
| | Average | 89.90 | 90.00 |
| | 10 | 85.46 | 85.71 |

If we expand our view on the light-load power consumption, in the range of 1-W output power, we can see the benefit of the NCP1239 compared to the NCP1236 in Figure 24. Again, all measurements have been performed on the same evaluation board, only the controller was changed together with the sense resistor as previously explained.

We can see that we can deliver 0.73 W and keeps the input power below 1 W @115 V rms for the NCP1236 compared to 0.77 W for the NCP1239.

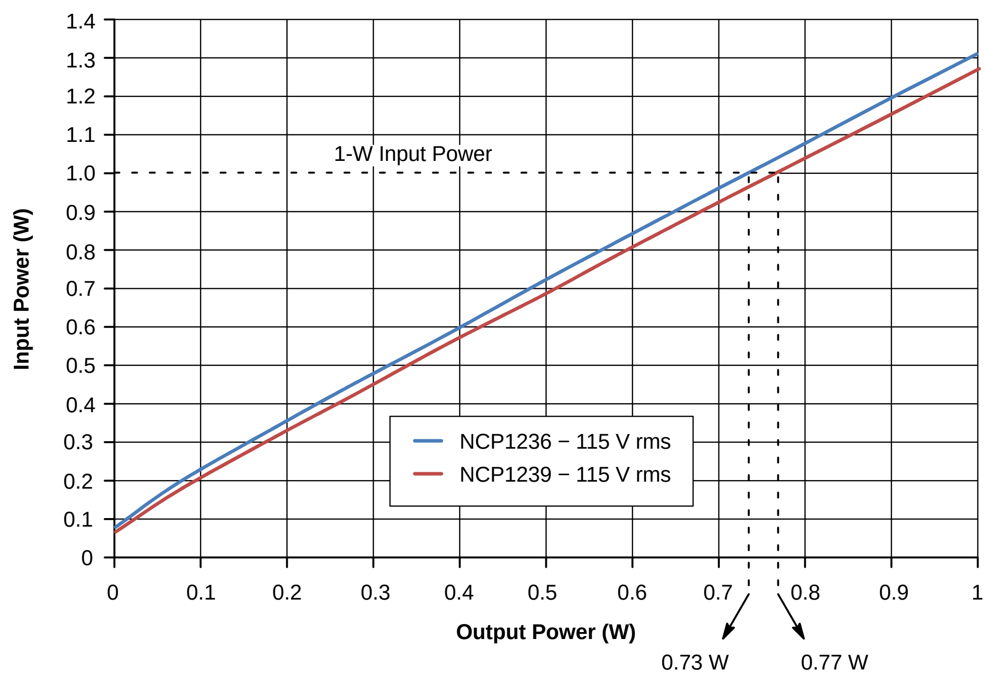


**Figure 24. Low Power Consumption**

### Stand-By Performance

The last point of comparison between both controllers is regarding the stand-by consumption. We already tackled this subject in the start-up section. The NCP1239's HV pin features a lower leakage current that will help saving a few mW. Also, the IC consumption has been optimized in this new controller to reduce the overall consumption. The NCP1239 consumption in skip mode is only 500 μA while 900 μA is absorbed by the NCP1236 in similar operating conditions. If we consider a $V_{CC}$ voltage around 12 V, the saved power will be:

$$P = V_{CC} \cdot \left( ICC(stb)_{NCP1236} - ICC(stb)_{NCP1239} \right) = \quad \text{(eq. 13)}$$
$$= 12 \cdot (900u - 500u) = 5\ mW$$

Thanks to these two points, the standby consumption has been improved with the NCP1239 like shown in the Table 5.

**Table 5. STAND-BY CONSUMPTION**

| Input Voltage (V rms) | Input Power (mW) | | Burst Period (ms) | | Pulse Number during each Burst | |
|---|---|---|---|---|---|---|
| | NCP1236 | NCP1239 | NCP1236 | NCP1239 | NCP1236 | NCP1239 |
| 85 | 68 | 54 | 12 | 10.9 | 6 | 3 |
| 115 | 74 | 58 | 13.3 | 11.3 | 6 | 3 |
| 230 | 105 | 79 | 14.6 | 8.8 | 5 | 2 |
| 265 | 121 | 88 | 13 | 9.2 | 5 | 2 |

Also in this table, we can see that there are some differences regarding the controller operations. There is no impact on the output voltage but it can lead to some improvements regarding the $V_{CC}$ capacitor for instance. Indeed, the NCP1236 controller has 100-mV hysteresis to leave from the skip mode (no pulse) and enters in the frequency foldback mode (clamped 26 kHz). Please refer to the Figure 20. The skip hysteresis level is only 30 mV for the NCP1239. So there are less cycles during each burst sequence and so the time between each burst is shorter. Thanks to that and to the lower IC consumption, the $V_{CC}$ capacitor can be reduced. Some space will be saved and the start-up duration will be even shorter.

### Summary

Considering a single element changed (sense resistor), we were able to replace the NCP1236 controller by the new NCP1239 part and significantly improve the overall performance. Efficiency and the standby consumption have clearly benefited from these improvements. The performance summary for both controllers in a typical 19-V/65-W adapters is listed in Table 6.

**Table 6. PERFORMANCE COMPARISON BETWEEN NCP1236 AND NCP1239 CONTROLLER**

| | NCP1236 | NCP1239 | NCP1239 Improvement |
|---|---|---|---|
| OVP Event on Fault Pin | 21.1 V | 21.8 V | +3.3% |
| OVP Event on $V_{CC}$ Pin | 32.3 V | 30.8 V | −6% |
| OTP Event on Fault Pin | 105°C | 104°C | −1% |
| OCP Threshold | 4.36 A < $I_{OUT\_Max}$ < 4.96 A | 4.34 A < $I_{OUT\_Max}$ < 4.93 A | ≈ |
| Start-Up Duration | 403 ms | 523 ms | +30% |
| Average Efficiency<br>115 V rms<br>230 V rms | <br>89.18%<br>89.90% | <br>89.17%<br>90.00% | <br>**−0.01%**<br>**+0.10%** |
| Efficiency @ 10% of Full Load<br>115 V rms<br>230 V rms | <br>87.51%<br>85.46% | <br>87.45%<br>85.71% | <br>**−0.06%**<br>**+0.25%** |
| Stand-By Power Consumption<br>115 V rms<br>230 V rms | <br>74 mW<br>105 mW | <br>58 mW<br>79 mW | <br>**−28%**<br>**−25%** |

### Conclusion

This application note has described and compared the performance obtained for 19-V/65-W application between the NCP1236 and the NCP1239 controller that are pin to pin compatible. The new NCP1239 IC shows several improvements and so better performance.

## BOARD SCHEMATIC − CHANGED COMPONENTS CIRCLE IN RED

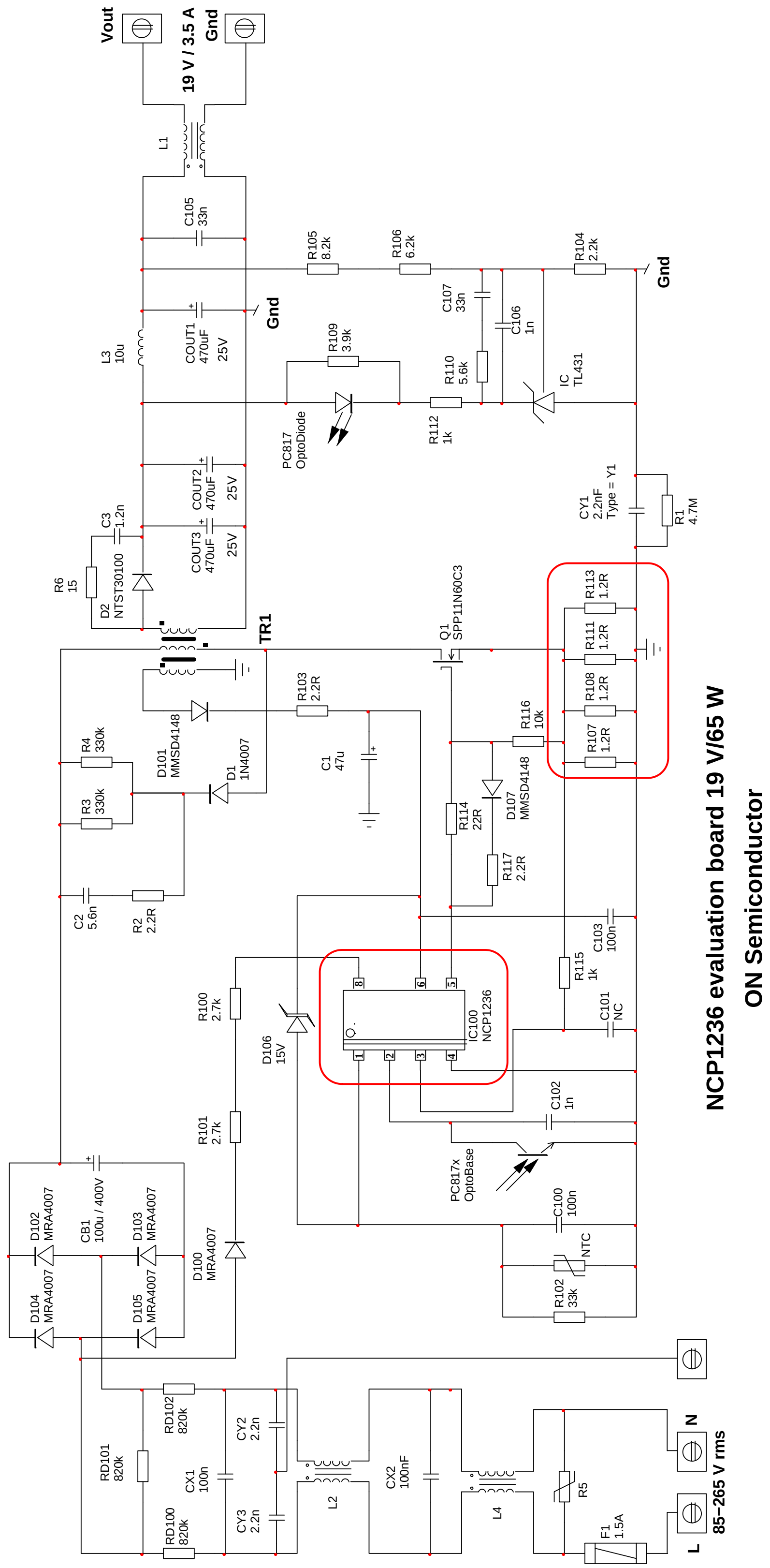


Figure 25. Evaluation Board Schematic

## BILL OF MATERIALS

**Table 7. BILL OF MATERIALS**

| Designator | Qty. | Description | Value | Manufacturer Part Number |
|---|---|---|---|---|
| C1 | 1 | Electrolytic Capacitor | 47 μF/50 V | KLH−050V470ME110 |
| C100, C103 | 2 | Ceramic Capacitor | 100 nF | C1206C104K5RAC |
| C102, C106 | 2 | Ceramic Capacitor | 1 nF | C1206C102K5RAC |
| C105, C107 | 2 | Ceramic Capacitor | 33 nF | C1206C333K5RAC |
| C2 | 1 | Ceramic Capacitor | 5.6 nF/630 V | FK20C0G2J562J |
| C3 | 1 | Ceramic Capacitor | 1.2 nF/630 V | FK26C0G2J122J |
| CB1 | 1 | Bulk Capacitor | 100 μF/400 V | EKXG401ELL101MMN3S |
| COUT1, COUT2, COUT3 | 3 | Electrolytic Capacitor | 470 μF/25 V | ECA−1EHG471 |
| CX1, CX2 | 2 | Suppression Film Capacitors | 100 nF | B32922C3104K |
| CY1, CY2, CY3 | 3 | Ceramic Capacitor | 2.2 nF/X1/Y1 | DE1E3KX222MA5B |
| D1 | 1 | Standard Recovery Rectifier | 1N4007 | 1N4007G |
| D100, D102, D103, D104, D105 | 5 | Standard Recovery Rectifier | MRA4007T3G | MRA4007T3G |
| D101, D107 | 2 | Diode | MMSD4148 | MMSD4148T3G |
| D106 | 1 | Zener Diode | MMSZ15 | MMSZ15T3G |
| D2 | 1 | Diode Schottky 150 V 15 A | NTST30100SG | NTST30100SG |
| F1 | 1 | Fuse (MST ser.) | 1.6 A | 0034.6617 |
| IC1 | 1 | Programmable Precision Reference | TL431 | TL431BCLPG |
| IC100 | 1 | SMPS Controller | NCP1236B65 | NCP1236BD65R2G |
| L1 | 1 | Inductor | 744 841 414 | 744 841 414 |
| L2 | 1 | Inductor | 2 × 20 mH/2 A | B82734W2202B030 |
| L3 | 1 | Inductor | 10 μH | DR0810−103L |
| L4 | 1 | Inductor | 744 841 330 | 744 841 330 |
| NTC | 1 | Sensing NTC Thermistor | 330 kΩ | NTCLE100E3334JB0 |
| OK1 | 1 | Optocoupler | PC817 | PC817X2J000F |
| Q1 | 1 | N MOSFET Transistor | SPP11N60C3 | SPP11N60C3 |
| R1 | 1 | Resistor Through Hole, High Voltage | 4.7 MΩ | VRW37−4M7JI |
| R100, R101 | 2 | Resistor SMD | 2.7 kΩ | MCR18EZHF2701 |
| R102 | 1 | Resistor SMD | 33 kΩ | MCR18EZHF3302 |
| R103, R117 | 2 | Resistor SMD | 2.2 Ω | MCR18EZHFL2R20 |
| R104 | 1 | Resistor SMD | 2.2 kΩ | MCR18EZHF2201 |
| R105 | 1 | Resistor SMD | 8.2 kΩ | MCR18EZHF8201 |
| R106 | 1 | Resistor SMD | 6.2 kΩ | MCR18EZHF6201 |
| R107, R108, R111, R113 (for NCP1236) | 4 | Resistor SMD | 1.2 Ω | MCR18EZHFL1R20 |
| R107, R108, R111 (for NCP1239) | 3 | Resistor SMD | 1 Ω | MCR18EZHFL1R00 |
| R109 | 1 | Resistor SMD | 3.9 kΩ | MCR18EZHF3901 |
| R110 | 2 | Resistor SMD | 5.6 kΩ | MCR18EZHF1001 |
| R112 | 2 | Resistor SMD | 1.0 kΩ | MCR18EZHF1001 |
| R114 | 1 | Resistor SMD | 22 Ω | MCR18EZHF22R0 |

**Table 7. BILL OF MATERIALS** (continued)

| Designator | Qty. | Description | Value | Manufacturer Part Number |
|---|---|---|---|---|
| R115 | 1 | Resistor SMD | 1 kΩ | MCR18EZPF1001 |
| R116 | 1 | Resistor SMD | 10 kΩ | MCR18EZHF1002 |
| R2 | 1 | Resistor | 2.2 Ω | MBB02070C2208FRP00 |
| R3, R4 | 2 | Resistor | 330 kΩ | HVR2500003303FR500 |
| R5 | 1 | Surge Protecting Varistor | B72210P2301K101 | B72210P2301K101 |
| R6 | 1 | Resistor | 15 Ω | MRS25000C1509FRP00 |
| RD100, RD101, RD102 | 3 | Resistor SMD | 820 kΩ | MCR18EZHF8203 |
| TR1 | 1 | Transformer | KA5038−BL | KA5037−BL |
| X1 | 1 | Terminal Block, 2 Way | CTB5000/2 | CTB5000/2 |
| X2 | 1 | Terminal Block, 3 Way | CTB5000/3 | CTB5000/3 |



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