

# FAN6248ADPGEVB

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## Implementing High Power Adapter Evaluation Board User's Manual

### High Power Adapter with the NCP1616, NCP13992 and FAN6248

#### Description

This evaluation board user's manual provides elementary information about a high efficiency, low light load power consumption reference design that is targeting power adapter or similar type of equipments that accepts 19.5 V.

The design utilizes NCP1616 for PFC front stage to assure unity power factor, NCP13992 for current mode LLC power stage, and FAN6248 for secondary side synchronous rectification to maximize efficiency.

The NCP1616 is a high voltage PFC controller with CrM operation. Additionally, it has an innovative Current Controlled Frequency Foldback (CCFF) method to maximizes the efficiency at both nominal and light load condition.

The NCP13992 is a current mode controller for half bridge resonant converter featuring 600 V gate drivers, high-frequency operation from 20 kHz up to 750 kHz, automatic dead-time with maximum dead-time clamp, and skip mode operation for improved light load efficiency.

The secondary side controller FAN6248 is an advanced synchronous rectifier controller that is optimized for LLC resonant converter topology with minimum external components. It has two driver stages for driving the SR MOSFETs which are rectifying the output current of the secondary transformer. These two gate driver stages have dedicated sense inputs and operate independently each other.

#### Key Features

- High Voltage Start-Up Circuit with Integrated Brownout Detection
- Wide Input Voltage Range
- High Efficiency
- Fast Line / Load Transient Compensation
- Light Load Operation Mode for Improved Efficiency
- Overvoltage Protection
- Auto Recovery Overload Protection
- Auto Recovery Output Short Circuit Protection
- Open Feedback Loop Protection
- Highly Integrated Self-Contained Control of Synchronous Rectification with a Minimum External Components
- Anti Shoot-Through Control for Reliable SR Operation
- Light Load Dection for Preventing Inversion Current of SR



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### EVAL BOARD USER'S MANUAL

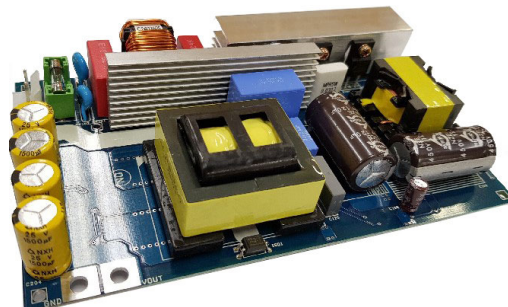


Figure 1. Evaluation Board

# FAN6248ADPGEVB

**Table 1. GENERAL INFORMATIONS**

| Parameter                  | Test Conditions                  | Min | Typ        | Max  | Unit            |
|----------------------------|----------------------------------|-----|------------|------|-----------------|
| Input Voltage              | V <sub>AC</sub>                  | 90  | –          | 264  | V <sub>AC</sub> |
| Input Voltage Brown Ouput  |                                  | –   | 70         | –    | V <sub>AC</sub> |
| Output Voltage             | No Load Condition                | –   | 19.3       | –    | V <sub>DC</sub> |
|                            | Full Load Condition              | –   | 19.3       | –    | V <sub>DC</sub> |
| Maximum Output Current     |                                  | –   | 12.4       | –    | A               |
| Output Power               |                                  | –   | 240        | –    | W               |
| Operating Frequency of LLC | Full Load Condition              | 100 | 105        | 110  | kHz             |
| System Efficiency          | 110V <sub>AC</sub> @ Full Load   | –   | 93.2       | –    | %               |
|                            | 220V <sub>AC</sub> @ Full Load   | –   | 95.1       | –    | %               |
| Power Factor               | 90 VAC ~ 264 VAC @ Over 50% Load |     | 0.95       | 0.99 | η               |
| Board Dimension            |                                  | –   | 170x100x30 | –    | mm              |

## Circuit Description

For the PFC front stage, utilizes the NCP1616 to optimize the efficiency and Power Factor throughout the load range. NCP1616 has an intergrated high voltage start up circuit accessible by the HV pin. The rectified input voltage supplies to HV pin at start up. After then Supply to VCC directly from the auxiliry winding of LLC transformer. In operation mode, the NCP1616 achieves power factor correction using the Current Controlled Frequency Foldback (CCFF) topology. In CCFF the circuit operates in the classical Critical Conduction Mode (CrM) when the inductor current exceeds a programmable value. Once the current falls below this preset level, the frequency is linearly reduced, reaching about 26 kHz when the current is zero. Also NCP1616 enter to skip mode at the Input current near the line zero crossing where the current is very low. Both CCFF and Skip mode optimize PFC stage efficiency. To protect the application system under abnormal condition, the NCP1616 has OVP, OCP, Brown Out and FB pin open protection.

In the primary side, the NCP13992 LLC controller provides a high efficiency and high power density by zero voltage switching (ZVS) of half-bridge MOSFETs. The power stage operates in above resonance area at around the resonant frequency caused by a resonant capacitor Cr and a resonance inductor Lr. Therefore, it can provide higher

efficiency with less frequency variation for light load condition.

For fast start up and extremely low standby power, NCP13992 has Dynamic Self Supply (DSS). After start up operation, Auxiliry winding maintains the voltage bias for the controller during normal operation mode. At the light load condition, the NCP13992 operates in skip mode and light load mode operation that improve light load efficiency, reduce no-load power consumption. To protect the application system under abnormal condition, the NCP13992 has OLP, OVP, OSP and FB pin open protection.

The Secondary output rectification is utilized with SR controller FAN6248. It controls the SR MOSFET based on the instantaneous drain to source voltage sensed across Drain and Source pins. Before SR gate is turned on, SR body diode conducts as the conventional diode rectifier. Once the body diode starts conducting, the drain-to-source voltage drops below the turn-on threshold voltage V<sub>TH\_ON</sub> which triggers the turn-on of the SR gate. When the drain-to-source voltage reaches the turn-off threshold voltage V<sub>TH\_OFF</sub> as SR MOSFET current decreases to near zero, FAN6248 turns off the gate. To optimize SR turn off time, the FAN6248 has Adaptive Dead Time Control function. For stable operation under light load condition, FAN6248 increase SR turn on delay using Light Load Detection (LLD).

## EVALUATION BOARD SCHEMATIC

# FAN6248ADPGEVB

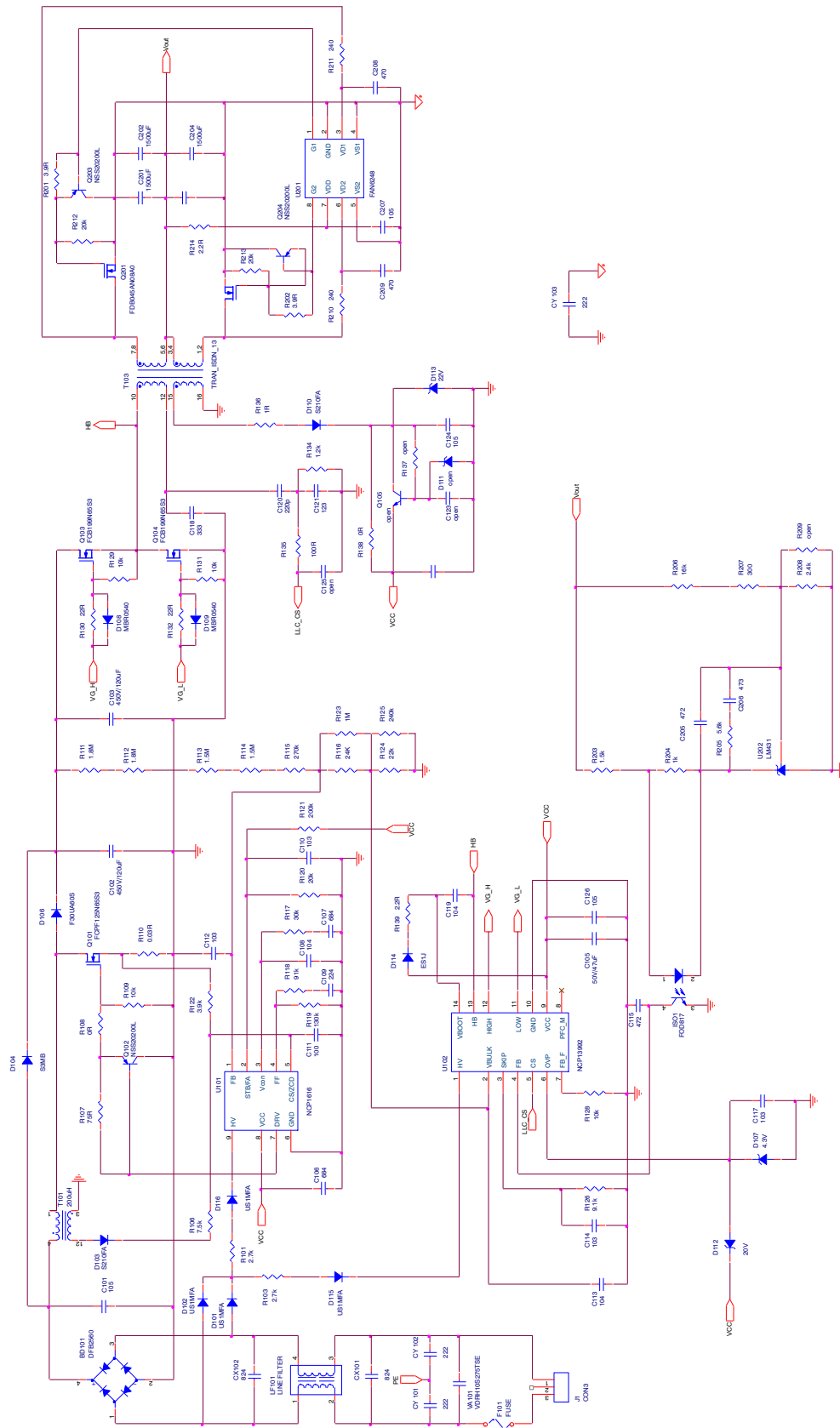


Figure 2. Evaluation Board Schematic



# FAN6248ADPGEVB

## BOARD PICTURES

Board Dimension : 170 mm x 100 mm  
PCB material : FR4  
Copper Thickness : 2 oz

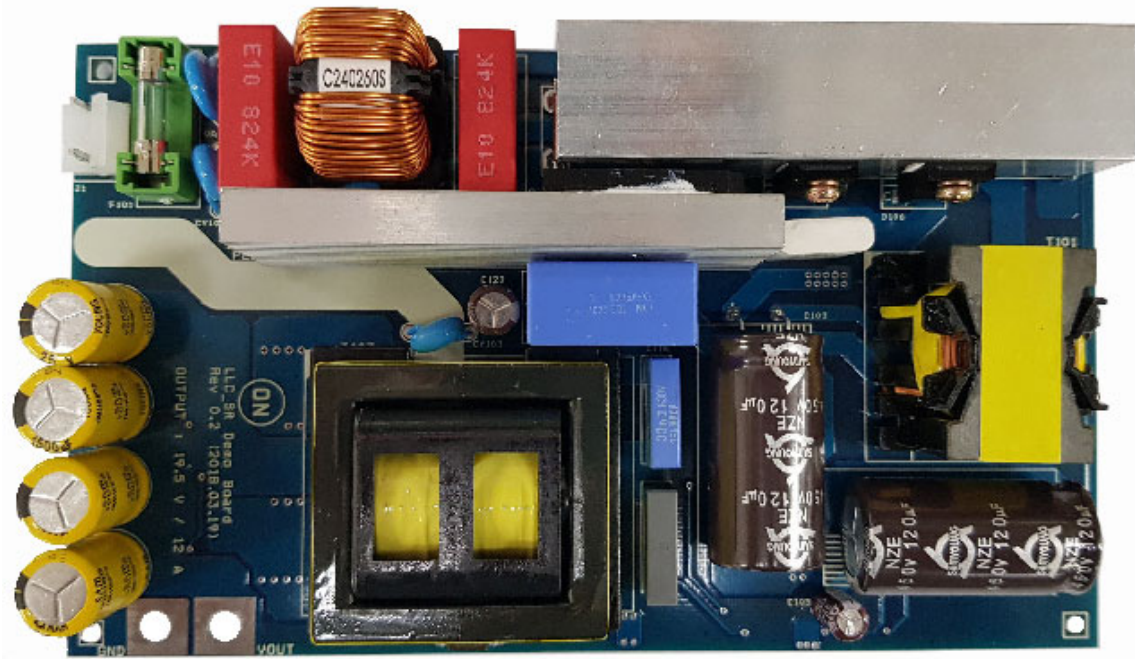


Figure 5. TOP Side View

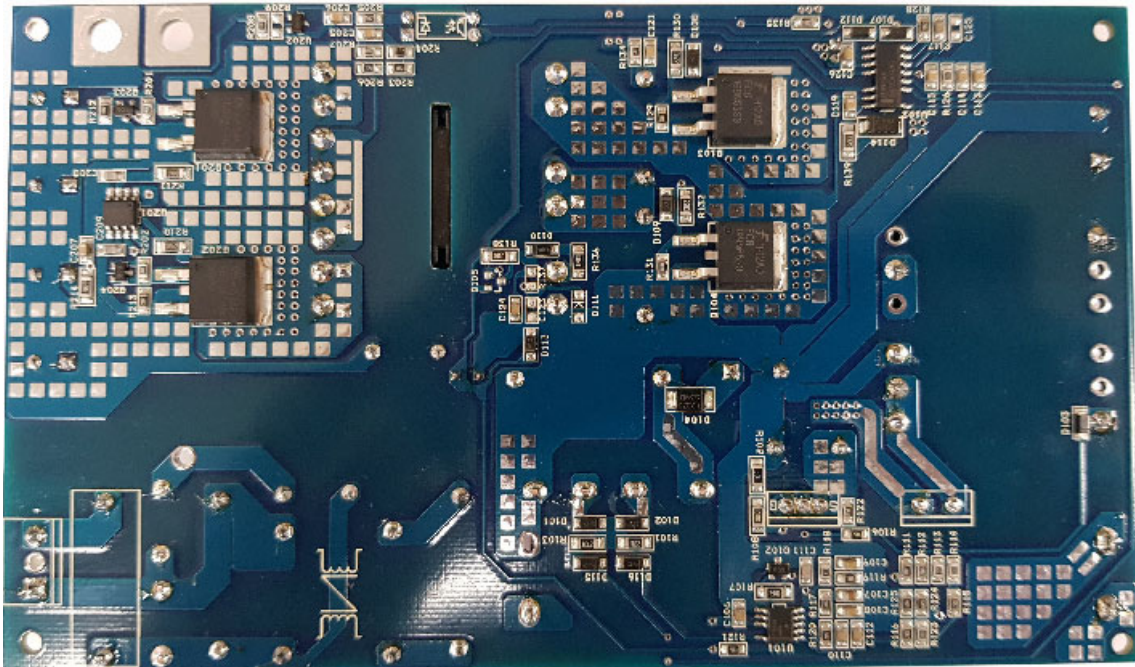


Figure 6. BOTTOM Side View

# FAN6248ADPGEVB

## Transformer Specifications

There are two kinds of transformer used in this EVB. One is PFC circuit and otherthings is LLC circuit.

### PQ3220

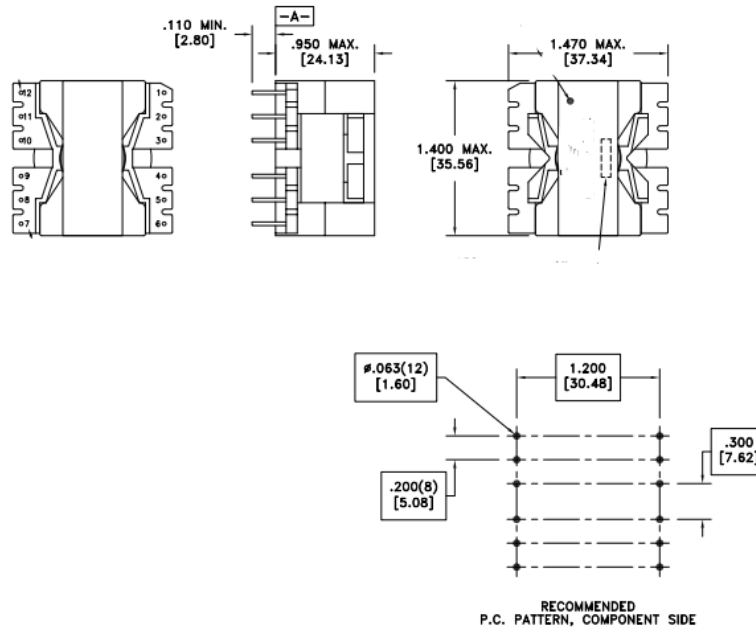


Figure 7. Transformer Dimension and Shapes (PFC)

Table 2. TRANSFORMER SPECIFICATION (PFC)

|                                                   | Pin<br>(Start → Finish) | Wire               | Turns | Winding Method   | Barrier Tape |      |    |
|---------------------------------------------------|-------------------------|--------------------|-------|------------------|--------------|------|----|
|                                                   |                         |                    |       |                  | TOP          | BOT  | Ts |
| N <sub>p</sub>                                    | 2 → 5                   | 0.1 φ × 60<br>USTC | 34    | Solenoid Winding | –            | –    | –  |
| Insulation: Polyester Tape t = 0.025 mm, 2 Layers |                         |                    |       |                  |              |      |    |
| N <sub>s</sub>                                    | 12 → 3                  | 0.2 φ              | 4.5   |                  | 3 mm         | 3 mm | –  |
| Insulation: Polyester Tape t = 0.025 mm, 2 Layers |                         |                    |       |                  |              |      |    |

|            | Pin   | Spec.  | Remark       |
|------------|-------|--------|--------------|
| Inductance | 2 → 5 | 200 μH | 100 kHz, 1 V |

# FAN6248ADPGEVB

SRX40ER

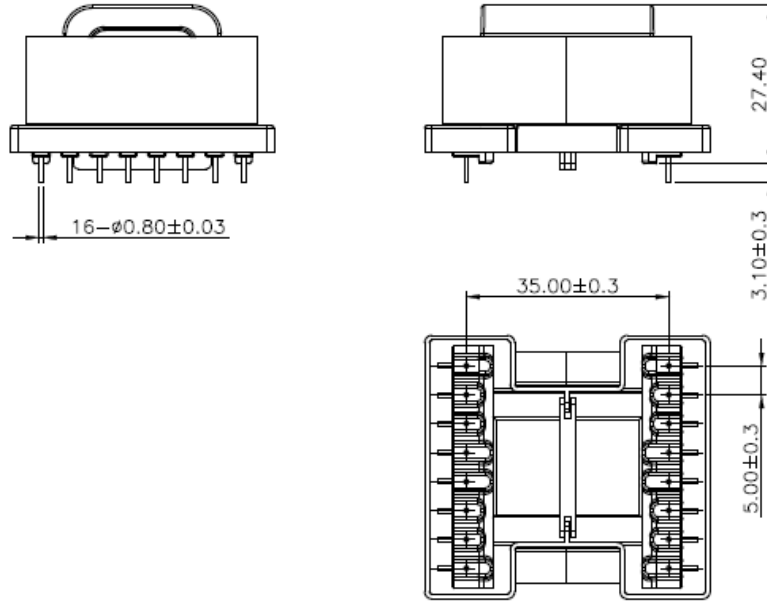


Figure 8. Transformer Dimension and Shapes (LLC)

Table 3. TRANSFORMER SPECIFICATION (LLC)

|                                                    | Pin<br>(Start → Finish) | Wire                 | Turns | Winding Method   | Barrier Tape |     |    |
|----------------------------------------------------|-------------------------|----------------------|-------|------------------|--------------|-----|----|
|                                                    |                         |                      |       |                  | TOP          | BOT | Ts |
| N <sub>p</sub>                                     | 12 → 10                 | 0.1 φ x 50<br>USTC   | 31    | Solenoid Winding | -            | -   | -  |
| Insulation: Polyester Tape, t = 0.025 mm, 2 Layers |                         |                      |       |                  |              |     |    |
| N <sub>s</sub>                                     | 5 → 1<br>7 → 3          | 0.10 φ x 120<br>USTC | 3     | Bifilar          | -            | -   | -  |
| Insulation: Polyester Tape, t = 0.025 mm, 1 Layers |                         |                      |       |                  |              |     |    |
| N <sub>s</sub>                                     | 6 → 2<br>8 → 4          | 0.10 φ x 150<br>USTC | 3     | Bifilar          | -            | -   | -  |
| Insulation: Polyester Tape, t = 0.025 mm, 2 Layers |                         |                      |       |                  |              |     |    |
| N <sub>aux</sub>                                   | 15 → 16                 | 0.2 φ                | 2     | Solenoid Winding | -            | -   | -  |
| Insulation: Polyester Tape, t = 0.025 mm, 2 Layers |                         |                      |       |                  |              |     |    |

|                            | Pin                                       | Spec.  | Remark       |
|----------------------------|-------------------------------------------|--------|--------------|
| Inductance L <sub>m</sub>  | 12 10, Other Pin Open                     | 650 μH | 100 kHz, 1 V |
| Inductance L <sub>lk</sub> | 12 10<br>1, 2, 3, 4, 5, 6, 7, 8 Pin Short | 80 μH  | 100 kHz, 1 V |

## Start Up PFC Stage

Figure 9 show that the NCP1616 start up waveforms by high voltage start up circuit. The output voltage reflects rectified voltage around 115 V by bridge diodes until the  $V_{CC}$  voltage reaches start up threshold 17 V. Once  $V_{CC}$  is

charged to the start up threshold voltage, the HV start up regulator is disabled and the controller is enabled. After LLC start up operation,  $V_{CC}$  bias comes from the auxiliary winding of LLC transformer. After then PFC stage start up and the PFC output voltage regulated target voltage.

(CH1 : HV, CH2 :  $V_{CC}$ , CH3 :  $V_{DRV}$ , CH4 : PFC output)

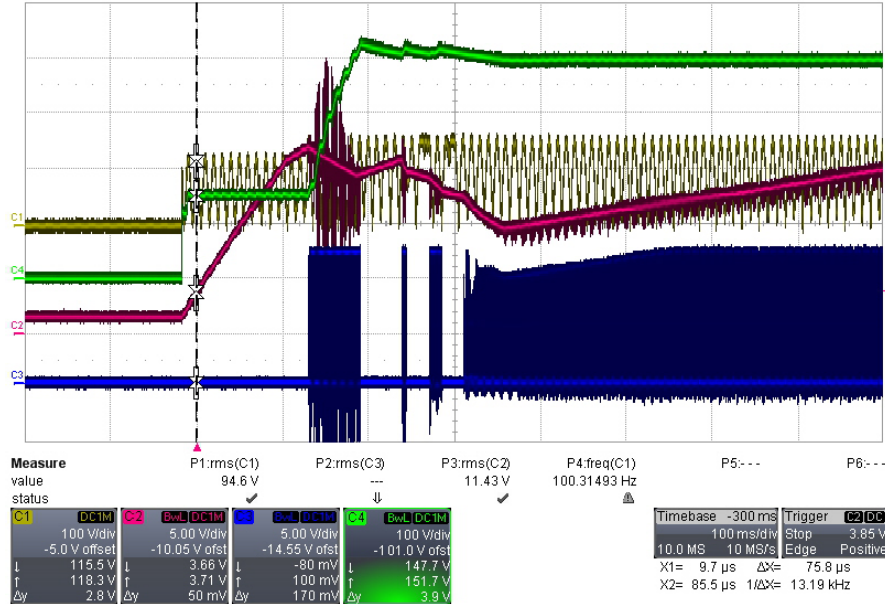


Figure 9. PFC Stage Start Up Waveforms

## Start Up LLC Stage

The NCP13992 supply voltage is charged by the HV start up circuit and controller disables the HV start up current source after the  $V_{CC}$  pin voltage level reaches threshold voltage. After start up operation, the auxiliary winding

maintains the voltage bias for the controller during normal operating modes. Figure 10 shows that the NCP13992 start up waveforms. After reaches  $V_{CC}$  on threshold voltage, NCP13992 start up after PFC stage steady state operation. NCP13992 detect PFC operation by  $V_{bulk}$  / PFC-FB pin.

(CH1 : HV, CH2 :  $V_{CC}$ , CH3 :  $M_{LOWER}$ , CH4 : PFC Output)

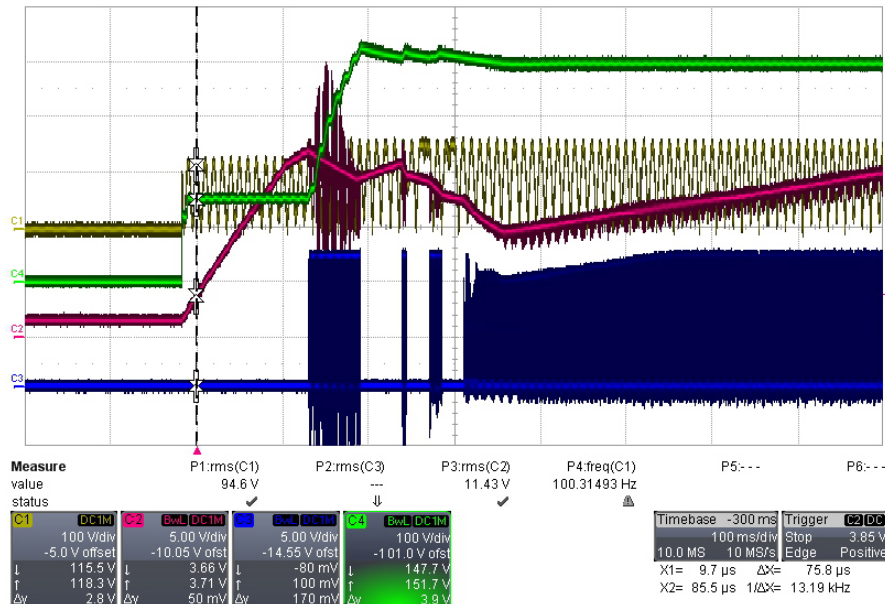


Figure 10. LLC Stage Start Up Waveforms

## FAN6248ADPGEVB

### Start Up SR Stage

When  $V_{DD}$  is higher than  $V_{DD\_GATE\_ON}$  of FAN6248, SR gate signals are generated. If the sensed drain voltage cannot

meet turn-on condition, SR operation may be delayed after  $V_{DD\_GATE\_ON}$ .

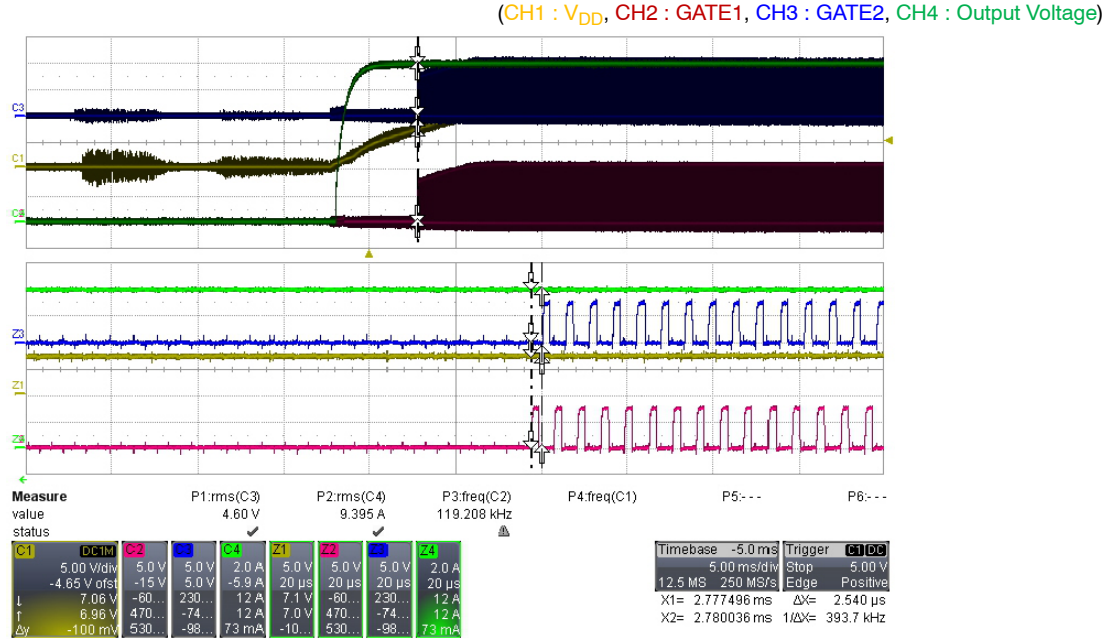


Figure 11. SR Stage Start Up Waveforms

### Current Controlled Frequency Foldback

The NCP1616 PFC controller achieves power factor correction using the novel Current Controlled Frequency Foldback (CCFF) topology. In this mode, the circuit operates in classical Critical Conduction Mode (CrM) with

ZCD when the inductor current exceeds a programmable value. When the current falls below this preset level, the NCP1616 linearly reduces the operating frequency down to a minimum of about 26 kHz when input current reaches zero.

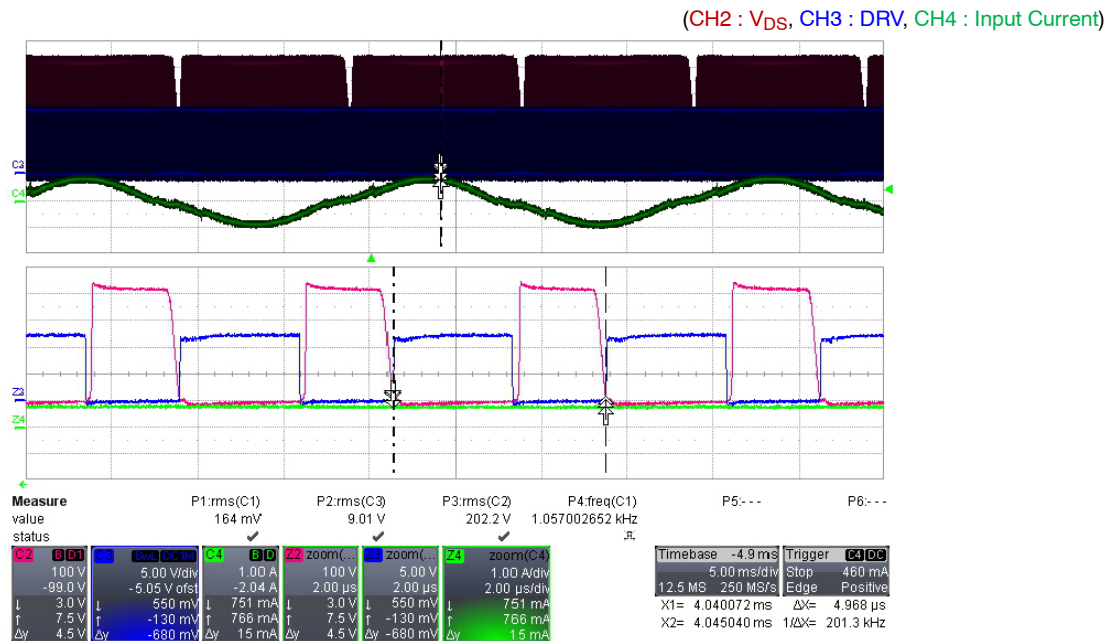


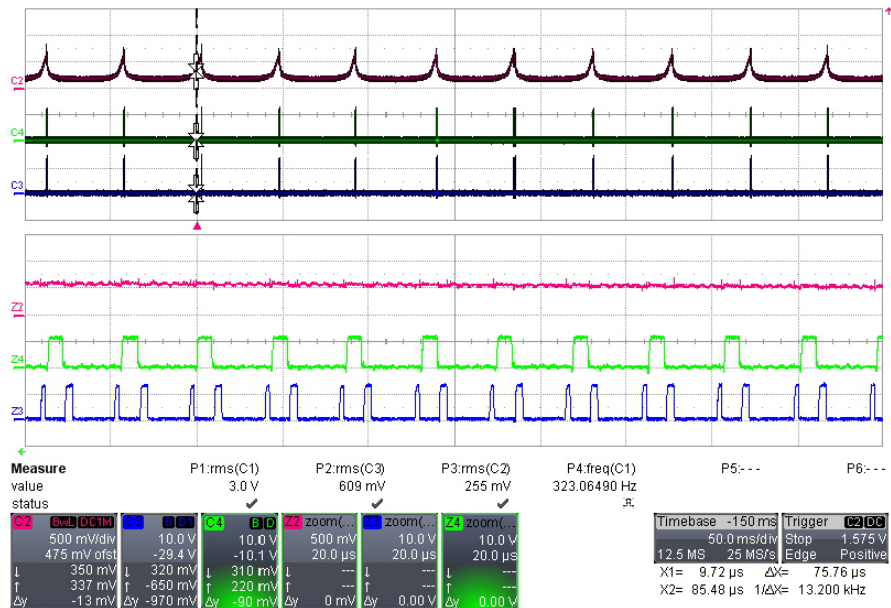
Figure 12. Critical Conduction Mode Operation

**Measure value status**

| Channel | Measurement | Value         | Unit |
|---------|-------------|---------------|------|
| P1      | rms(C1)     | 165 mV        |      |
| P2      | rms(C3)     | 6.74 V        |      |
| P3      | rms(C2)     | 187.4 V       |      |
| P4      | freq(C1)    | 584.775018 Hz |      |
| P5      | --          | --            |      |
| P6      | --          | --            |      |

**Settings:**

| Channel | Setting  | Value             |
|---------|----------|-------------------|
| B1      | Timebase | -4.9 ms           |
| B2      | Trigger  | Stop              |
| B3      | Stop     | 460 mA            |
| B4      | Edge     | Positive          |
| B5      | Timebase | 12.5 MS           |
| B6      | Timebase | 250 MS/s          |
| B7      | Timebase | 75.748 μs         |
| B8      | Timebase | ΔX= 85.484 μs     |
| B9      | Timebase | 1/ΔX= 13.2017 kHz |



## LLC Operation

Below waveform is normal operation mode of LLC in heavy load condition. The LLC operated in above resonance area.

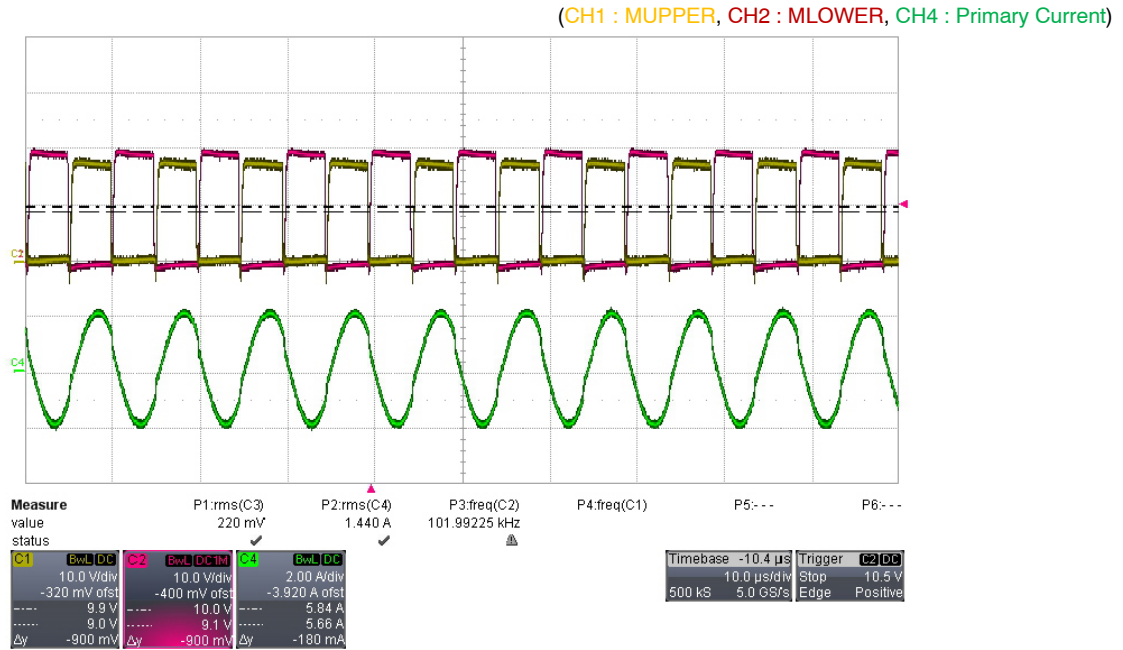


Figure 15. LLC Operation Waveforms

## Synchronous Rectification Control and Normal Operation

FAN6248 controls the SR MOSFET based on the instantaneous drain-to-source voltage sensed across DRAIN and SOURCE pins. Before SR gate is turned on, SR body diode conducts as the conventional diode rectifier. Once the body diode starts conducting, the drain-to-source voltage drops below the turn-on threshold voltage  $V_{TH\_ON}$  which triggers the turn-on of the SR gate. Then the drain-to-source voltage is determined by the product of

turn-on resistance  $R_{ds\_on}$  of SR MOSFET and instantaneous SR current. When the drain-to-source voltage reaches the turn-off threshold voltage  $V_{TH\_OFF}$  as SR MOSFET current decreases to near zero, FAN6248 turns off the gate. If a SR dead time is larger or smaller than the dead time regulation target  $t_{DEAD}$ , FAN6248 adaptively changes internal offset voltage to compensate the dead time. In addition, to prevent cross conduction SR operation, FAN6248 has 200 ns of turn-on blaking time just after alternating SR gate is turned off.

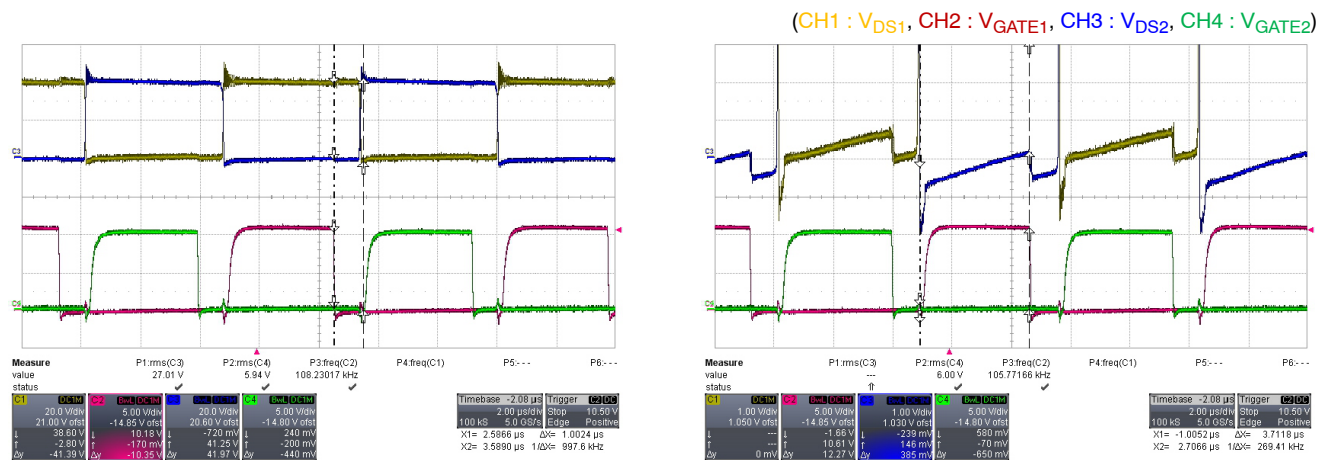


Figure 16. SR Gate and Drain Voltage Waveforms at Full Load Condition

# FAN6248ADPGEVB

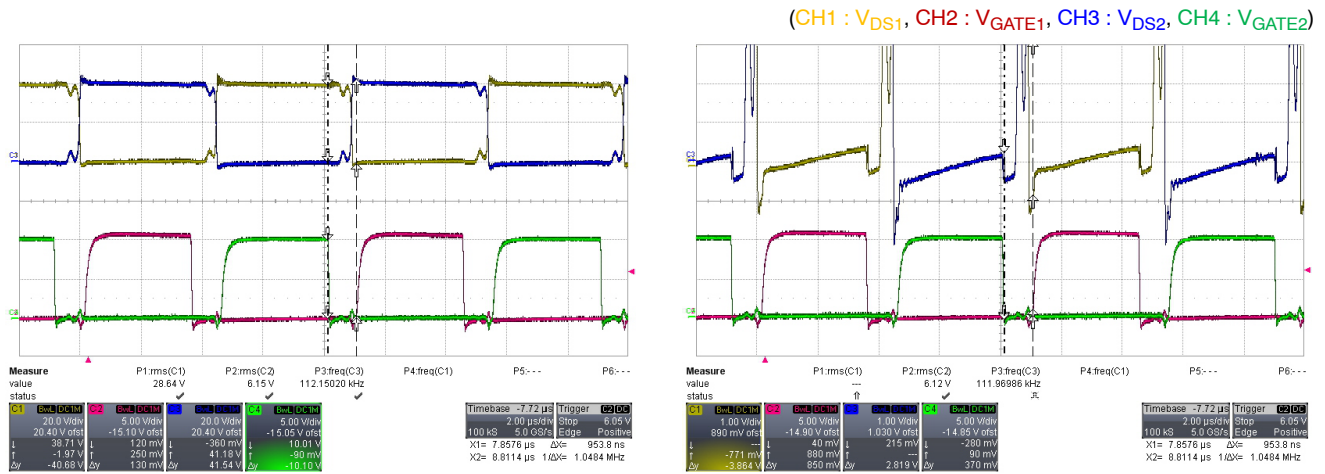


Figure 17. SR Gate and Drain Voltage Waveforms at Light Load Condition

## Output Current Transient Response

There are no output voltage drop and overshoot during load current transition.

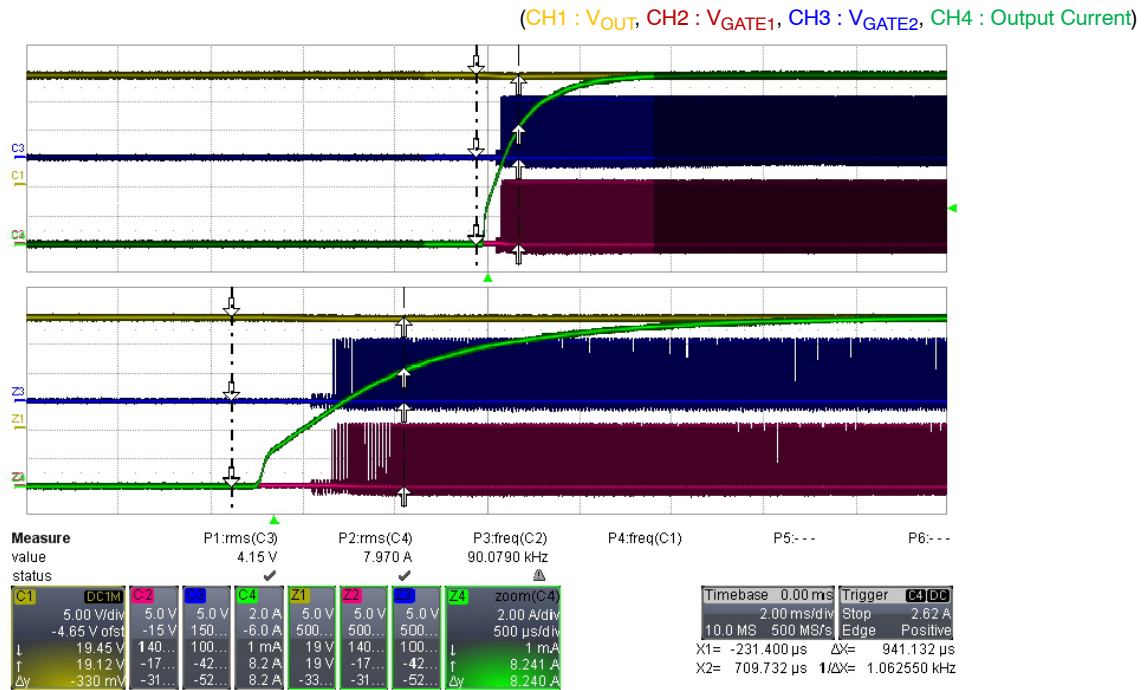


Figure 18. Output Load Transient Response at 0 to 12 A

## FAN6248ADPGEVB

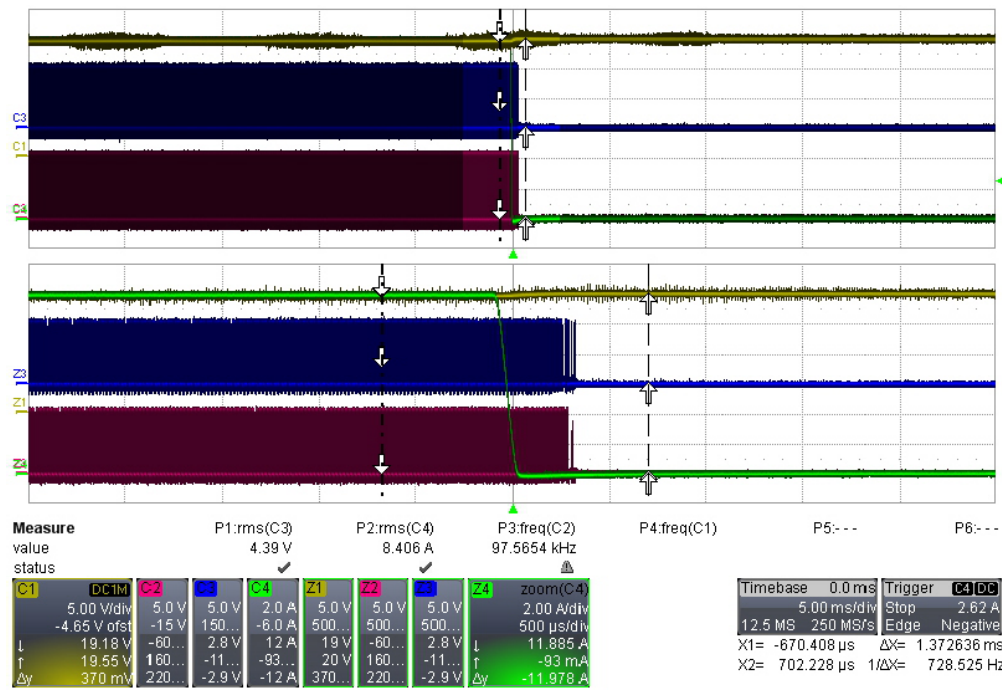


Figure 19. Output Load Transient Response at 12 to 0 A

### System Efficiency & PF

Figure 20 presents the system efficiency of the EVB with various input voltage. The EVB demonstrated that the

240 W power application can approach 95% peak system efficiency at high line. Also the PF is over 0.96 at wide input range.

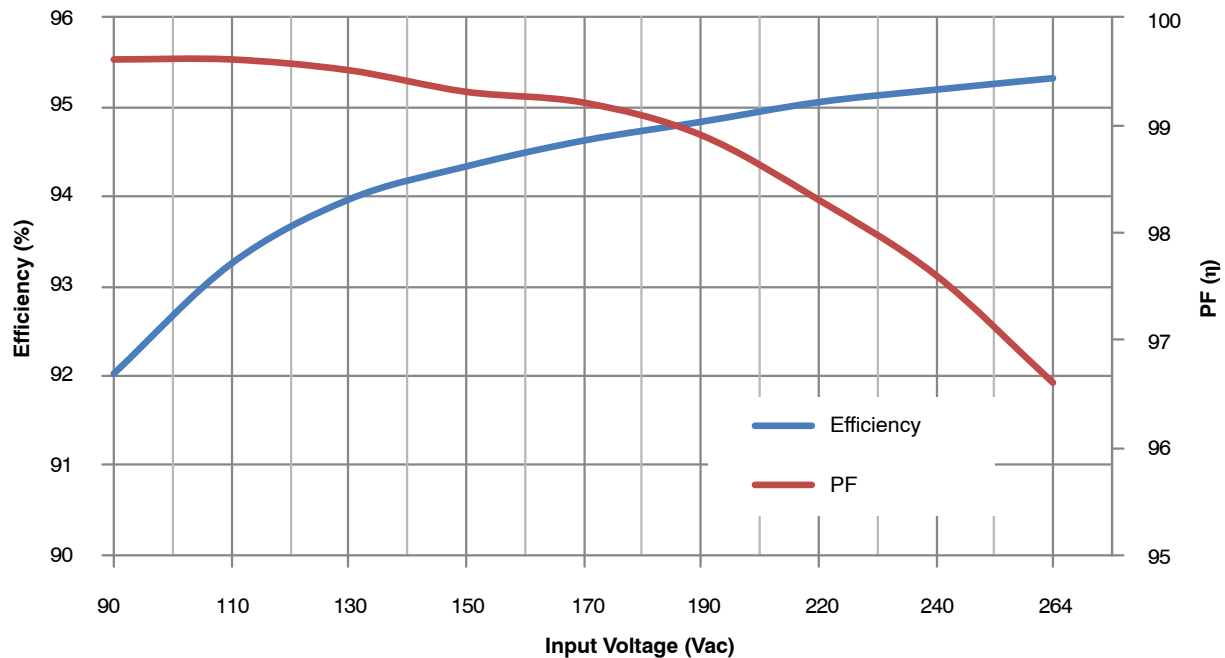


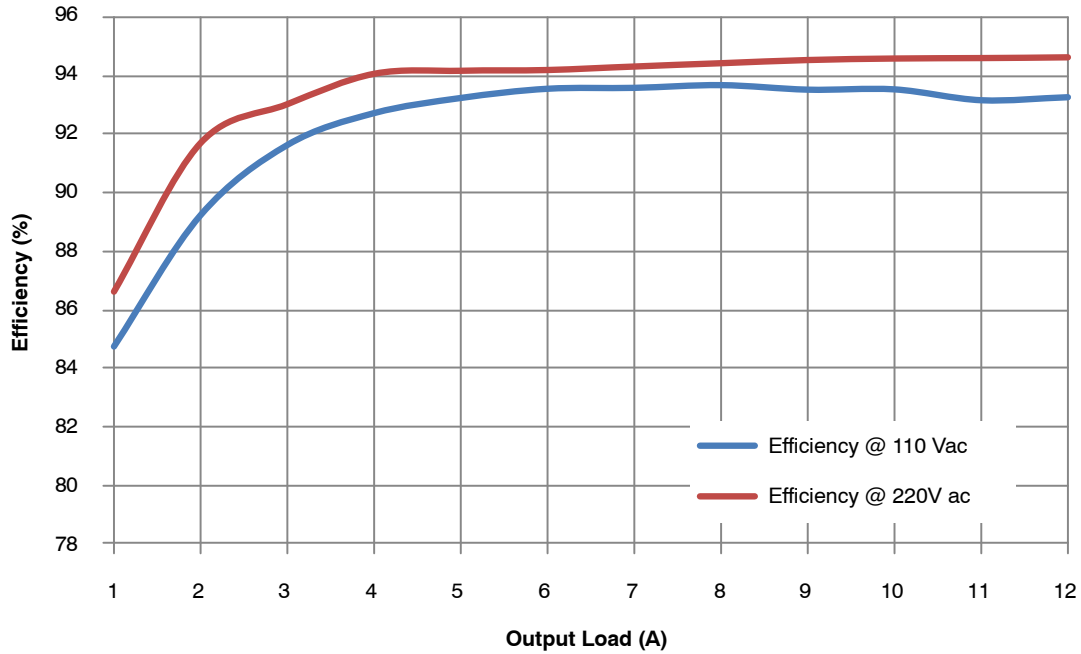
Figure 20. System Efficiency by the Input Voltage.

## FAN6248ADPGEVB

**Table 4. MEASURING RESULTS OF EFFICIENCY & PF**

| Vac        | 90     | 110    | 130    | 150    | 170    | 190    | 220    | 240    | 264    |
|------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Efficiency | 92.02% | 93.25% | 93.97% | 94.34% | 94.63% | 94.84% | 95.06% | 95.20% | 95.33% |
| PF         | 0.9961 | 0.9960 | 0.9952 | 0.9930 | 0.9920 | 0.9891 | 0.9829 | 0.9760 | 0.9661 |

Figure 21 and Figure 22 show system efficiency & PF by the output load condition, respectively.



**Figure 21. Comparison Efficiency by Low and High Line**

**Table 5. MEASURING RESULTS OF EFFICIENCY BY LOAD CONDITION**

| Output Current       | 1 A    | 2 A    | 3 A    | 4 A    | 5 A    | 6 A    |
|----------------------|--------|--------|--------|--------|--------|--------|
| Efficiency @ 110 Vac | 84.75% | 89.23% | 91.62% | 92.71% | 93.22% | 93.54% |
| Efficiency @ 220 Vac | 86.61% | 91.69% | 93.02% | 94.07% | 94.17% | 94.19% |
|                      |        |        |        |        |        |        |
| Output Current       | 7 A    | 8 A    | 9 A    | 10 A   | 11 A   | 12 A   |
| Efficiency @ 110 Vac | 93.57% | 93.67% | 93.51% | 93.52% | 93.15% | 93.25% |
| Efficiency @ 220 Vac | 94.31% | 94.43% | 94.54% | 94.59% | 94.60% | 94.63% |

## FAN6248ADPGEVB

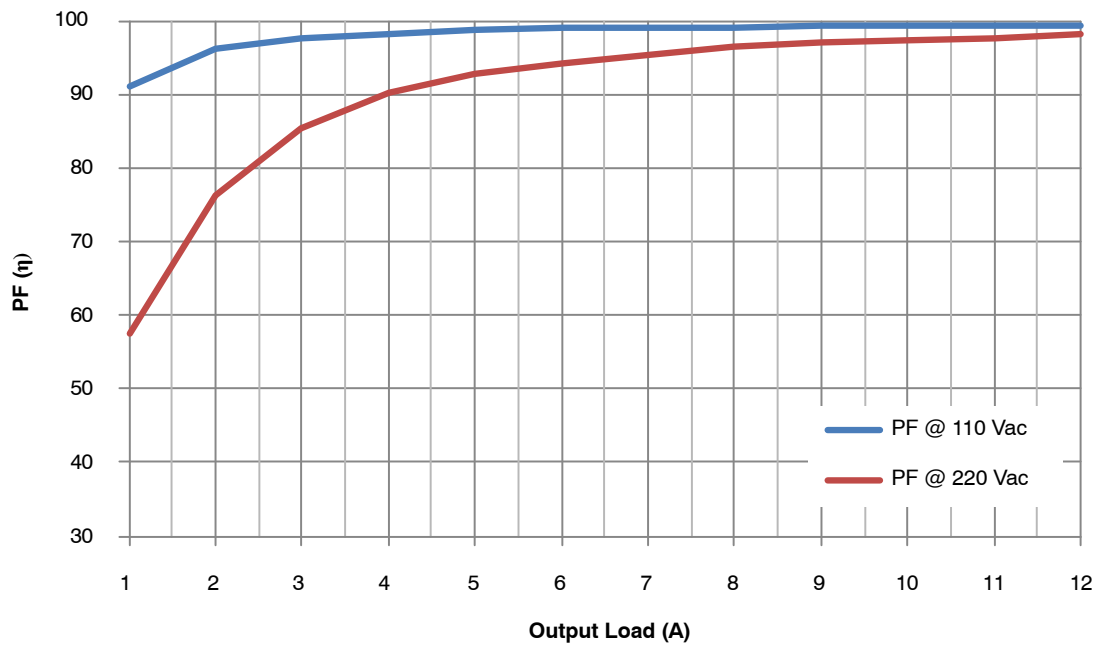


Figure 22. Comparison PF by Low and High Line

Table 6. MEASURING RESULTS OF EFFICIENCY BY LOAD CONDITION

| Output Current | 1 A    | 2 A    | 3 A    | 4 A    | 5 A    | 6 A    |
|----------------|--------|--------|--------|--------|--------|--------|
| PF @ 110 Vac   | 0.9120 | 0.9620 | 0.9780 | 0.9830 | 0.9880 | 0.9910 |
| PF @ 220 Vac   | 0.5760 | 0.7640 | 0.8560 | 0.9040 | 0.9280 | 0.9427 |
| Output Current | 7 A    | 8 A    | 9 A    | 10 A   | 11 A   | 12 A   |
| PF @ 110 Vac   | 0.9920 | 0.9930 | 0.9940 | 0.9950 | 0.9960 | 0.9960 |
| PF @ 220 Vac   | 0.9556 | 0.9660 | 0.9720 | 0.9760 | 0.9790 | 0.9830 |

# FAN6248ADPGEVB

**Table 7. BILL OF MATERIALS**

| Reference              | Vendor           | Part Number                                | Type        | Value               | PC / Board |
|------------------------|------------------|--------------------------------------------|-------------|---------------------|------------|
| BD101                  | ON Semiconductor | DFB2560                                    | TS-6P-4L    | 600 V / 25 A        | 1          |
| CX101, CX102           | PILKO            | PCMP 327 / 820 nF<br>(Pitch: 22.5 mm)      | MKP RADIAL  | 275 Vac / 820 nF    | 2          |
| CY101, CY102, CY103    | TDK              | CD45B2GA222K                               | Y-Cap       | 400 V / 2.2 nF      | 2          |
| C101                   | PILKOR           | PCMP 327 / 1 $\mu$ F<br>(Pitch: 22.5 mm)   | MKP RADIAL  | 275 Vac / 1 $\mu$ F | 1          |
| C102, C103             | SAMYOUNG         | KMF-series: 18 x 40                        | KMF         | 450 V / 120 $\mu$ F | 2          |
| C124, C126, C207       | TDK              | C2012X7R1E105K085AB                        | MLCC_2012   | 25 V / 1 $\mu$ F    | 3          |
| C105                   | SAMYOUNG         | KMF-series: 5 x 11                         | KMF         | 50 V / 47 $\mu$ F   | 1          |
| C106, C107             | TDK              | C2012X7R1H684K125AE                        | MLCC_2012   | 50 V / 680 nF       | 2          |
| C108, C113, C119       | TDK              | C2012X8R1E104K125AA                        | MLCC_2012   | 25 V / 100 nF       | 3          |
| C109                   | TDK              | C2012X7R1H224K125AE                        | MLCC_2012   | 50 V / 220 nF       | 1          |
| C110, C112, C114, C117 | TDK              | C2012C0G1H103J060AA                        | MLCC_2012   | 50 V / 10 nF        | 4          |
| C111                   | TDK              | CGJ4C2C0G2A100J060AA                       | MLCC_2012   | 50 V / 10 pF        | 2          |
| C115, C205             | TDK              | C2012CH1H472J085AA                         | MLCC_2012   | 50 V / 4.7 nF       | 2          |
| C118                   | PILKOR           | PCMP 384 / 33 nF                           | 33 nF       | -                   | 1          |
| C120                   | PILKOR           | PCMP 384 / 220 pF 630 V<br>(Pitch : 15 mm) | MMKP RADIAL | 630 V / 220 pF      | 1          |
| C121                   | TDK              | C2012C0G1H123J060AA                        | MLCC_2012   | 25 V / 12 nF        | 1          |
| C122                   | SAMYOUNG         | KMF-series: 8 x 11                         | KMF         | 50 V / 100 $\mu$ F  | 1          |
| C125                   | TDK              | C2012 C0G1E101J060AA                       | MLCC_2012   | 25 V / 100 pF       | 1          |
| C201, C202, C203, C204 | SAMYOUNG         | NXH-series: 12.5 x 20                      | NXH         | 25 V / 1500 $\mu$ F | 4          |
| C206                   | TDK              | C2012C0G1H473J060AA                        | MLCC_2012   | 25 V / 47 nF        | 1          |
| C208, C209             | TDK              | CGJ4C2C0G2A470J060AA                       | MLCC_2012   | 50 V / 47 pF        | 2          |
| D101, D102, D115, D116 | ON Semiconductor | US1MFA                                     | SOD-123FA   | 1000 V / 1 A        | 4          |
| D103, D110             | ON Semiconductor | S210FA                                     | SOD-123FA   | 100 V / 2 A         | 2          |
| D104                   | ON Semiconductor | S3MB                                       | SMB         | 1000 V / 3 A        | 1          |
| D106                   | ON Semiconductor | FFPF30UA60S                                | TO-220F-2L  | 600 V / 30 A        | 1          |
| D107                   | ON Semiconductor | MMSZ4V3T1G                                 | SOD-123     | 4.3 V / 0.5 W       | 1          |
| D108, D109             | ON Semiconductor | MBR0540                                    | SOD-123     | 40 V / 0.5 A        | 2          |
| D112                   | ON Semiconductor | MMSZ20T1G                                  | SOD-123     | 20 V / 0.5 W        | 1          |
| D113                   | ON Semiconductor | MMSZ22T1G                                  | SOD-123     | 22 V / 0.5 W        | 1          |
| D114                   | ON Semiconductor | ES1J                                       | SMA         | 600 V / 1 A         | 1          |
| F101 (Holder)          | STELVIO          | PTF78                                      | 5 x 20      | Fuse Holder         | 1          |
| F101 (Fuse)            | Little Fuse      | 021 7004.MXP Fast-acting                   | 5 x 20      | 250 Va / 4A         | 1          |
| ISO1                   | ON Semiconductor | FOD817B                                    | 4-pin DIP   | Optocoupler         | 1          |
| J1                     | MOLEX            | 5273-03A                                   | 3-pin       | Connector           | 1          |
| LF101                  | EMC parts        | CV240260SK                                 | 133T-F      | 300 Va / 4 A        | 1          |
| Q101                   | ON Semiconductor | FCPF125N65S3                               | TO-220F     | 650 V / 24 A        | 1          |
| Q102, Q203, Q204       | ON Semiconductor | NSS20200L                                  | SOT-23      | -20 A / 4 A         | 3          |
| Q103, Q104             | ON Semiconductor | FCB199N65S3                                | D2 PAK      | 650 V / 14 A        | 2          |
| Q201, Q202             | ON Semiconductor | FDB045AN08A0                               | D2 PAK      | 75 V / 235 A        | 2          |
| R101, R103             | Yageo            | RC1206JR-07272RL                           | CHIP_R_3216 | 2.7 k $\Omega$      | 2          |
| R106                   | Yageo            | RC0805JR-07752RL                           | CHIP_R_2012 | 7.5 k $\Omega$      | 1          |
| R107                   | Yageo            | RC1206JR-07750RL                           | CHIP_R_3216 | 75 $\Omega$         | 1          |
| R108, R138             | Yageo            | RC1206JR-07000RL                           | CHIP_R_3216 | 0 $\Omega$          | 2          |

# FAN6248ADPGEVB

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

| Reference        | Vendor           | Part Number      | Type          | Value  | PC / Board |
|------------------|------------------|------------------|---------------|--------|------------|
| R109             | Yageo            | RC1206JR-07103RL | CHIP_R_3216   | 10 kΩ  | 1          |
| R110             | PILKO            | MPR5W 0.03ΩJ     | Metal plate R | 0.03 Ω | 1          |
| R111, R112       | Yageo            | RC0805JR-07185RL | CHIP_R_2012   | 1.8 MΩ | 2          |
| R113, R114       | Yageo            | RC0805JR-07155RL | CHIP_R_2012   | 1.5 MΩ | 2          |
| R115             | Yageo            | RC0805JR-07274RL | CHIP_R_2012   | 270 kΩ | 1          |
| R116             | Yageo            | RC0805JR-07243RL | CHIP_R_2012   | 24 kΩ  | 1          |
| R117             | Yageo            | RC0805JR-07303RL | CHIP_R_2012   | 30 kΩ  | 1          |
| R118             | Yageo            | RC0805JR-07913RL | CHIP_R_2012   | 91 kΩ  | 1          |
| R119             | Yageo            | RC0805JR-07134RL | CHIP_R_2012   | 130 kΩ | 1          |
| R120, R212, R213 | Yageo            | RC0805JR-07203RL | CHIP_R_2012   | 20 kΩ  | 3          |
| R121             | Yageo            | RC0805JR-07204RL | CHIP_R_2012   | 200 kΩ | 1          |
| R122             | Yageo            | RC0805JR-07392RL | CHIP_R_2012   | 3.9 kΩ | 1          |
| R123             | Yageo            | RC0805JR-07105RL | CHIP_R_2012   | 1 MΩ   | 1          |
| R124             | Yageo            | RC0805JR-07223RL | CHIP_R_2012   | 22 kΩ  | 1          |
| R125             | Yageo            | RC0805JR-07244RL | CHIP_R_2012   | 240 kΩ | 1          |
| R126             | Yageo            | RC0805JR-07912RL | CHIP_R_2012   | 9.1 kΩ | 1          |
| R128             | Yageo            | RC0805JR-07104RL | CHIP_R_2012   | 100 kΩ | 1          |
| R129, R131       | Yageo            | RC0805JR-07103RL | CHIP_R_2012   | 10 kΩ  | 2          |
| R130, R132       | Yageo            | RC1206JR-07220RL | CHIP_R_3216   | 22 Ω   | 2          |
| R134             | Yageo            | RC0805JR-07122RL | CHIP_R_2012   | 1.2 kΩ | 1          |
| R135             | Yageo            | RC0805JR-07101RL | CHIP_R_2012   | 100 Ω  | 1          |
| R136             | Yageo            | RC1206JR-071R0L  | CHIP_R_3216   | 1 Ω    | 1          |
| R139, R214       | Yageo            | RC1206JR-072R2L  | CHIP_R_3216   | 2.2 Ω  | 2          |
| R201, R202       | Yageo            | RC0805JR-073R9L  | CHIP_R_2012   | 3.9 Ω  | 2          |
| R203             | Yageo            | RC0805JR-07152L  | CHIP_R_2012   | 1.5 kΩ | 1          |
| R204             | Yageo            | RC0805JR-07102L  | CHIP_R_2012   | 1 kΩ   | 1          |
| R205             | Yageo            | RC0805JR-07562L  | CHIP_R_2012   | 5.6 kΩ | 1          |
| R206             | Yageo            | RC0805JR-07163L  | CHIP_R_2012   | 16 kΩ  | 1          |
| R207             | Yageo            | RC0805JR-07301L  | CHIP_R_2012   | 300 Ω  | 1          |
| R208             | Yageo            | RC0805JR-07242RL | CHIP_R_2012   | 2.4 kΩ | 2          |
| R210, R211       | Yageo            | RC1206JR-07241L  | CHIP_R_3216   | 240 Ω  | 2          |
| T101             | TDK              | PQ3220           | -             | 200 μH | 1          |
| T103             | FEELUX           | SRX40ER          | -             | 650 μH | 1          |
| U101             | ON Semiconductor | NCP1616A1DR2G    | SOIC-9        | PFC    | 1          |
| U102             | ON Semiconductor | NCP13992AXDR2G   | SOIC-16       | LLC    | 1          |
| U201             | ON Semiconductor | FAN6248HC        | SOIC-8        | SR     | 1          |
| U202             | ON Semiconductor | LM431SBCM3X      | SOT-23        | Shunt  | 1          |
| VA101            | HIEL             | HVR431D10        | VARISTOR      | -      | 1          |

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