ON Semiconductor®

# Reference design for

# FAN604HMX+FAN6390

# PD3.0 Evaluation Board 27W

## APG TA Team

## Featured ON-Semi Product:

## FAN604HMX &_FAN6390M6X

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# 1. Introduction

This user guide supports the PD and PPS protocol evaluation board of the FAN604HMX, FAN6390M6X for adaptive charger application which is only applied to PPS/QC4.0 3V~5.9V/3A, 3V~9V/3A,12V/2.25A 20mV per step change, PD 5V/3A, 9V/3A, Maximum power fixed 27W. It should be used in conjunction with the FAN604HMX and FAN6390M6X datasheets as well as ON-Semi's application notes.

- **FAN604H**

The FAN604H is an advanced PWM controller aimed at achieving power density of ≥10W/in3 in universal input range AC/DC Flyback isolated power supplies. It incorporates Quasi-Resonant (QR) control with proprietary Valley Switching with a limited frequency variation. QR switching provides high efficiency by reducing switching losses while Valley Switching with a limited frequency variation bounds the frequency band to overcome the inherent limitation of QR switching.

FAN604H features mWSaver® burst mode operation with extremely low operating current (300 μA) and significantly reduces standby power consumption to meet the most stringent efficiency regulations such as Energy Star's 5- Star Level and CoC Tier II specifications.

FAN604H includes several user configurable features aimed at optimizing efficiency, EMI and protections. FAN604H has a programmable blanking frequency range that provides flexibility in choosing noise rejection in targeted frequency zones. It incorporates user-configurable minimum peak current, which allows controlling the burst mode entry/exit power level, thereby enhancing light load efficiency and eliminating audible noise. It also includes several rich programmable protection features such as over-voltage protection (OVP), precise constant output current regulation (CC)

- **FAN6390**

FAN6390 is highly integrated, secondary-side power adaptor controllers. It implements state machines of Power Delivery 3.0 and Type-C. This PD3.0 state machine is designed for Source only and it supports PPS as well. In order to meet PPS specification, FAN6390 supports minimum 3 V output voltage control and maximum 20V output voltage control. FAN6390 internally adopts synchronous rectifier control for less BOM counts as well as easy design. It includes Constant Voltage (CV) and Constant Current (CC) control blocks, and they consist of two operational amplifiers for voltage-loop and current-loop regulation with adjustable references. The references are supported from DAC. The outputs of the CV and CC amplifiers are tied together in open-drain configuration.

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# 2. Evaluation Board Specifications

All data for this table was measured at an ambient temperature of 25°C.

**Table 1. Summary of Features and Performance**

| Description | Protocol Type | Mode | Specification | Test result | Comments |
|---|---|---|---|---|---|
| Output Voltage (CV) | PD | 5V (0A~3A) | - | 4.97V~5.39V | Measured at PCB end Include cable compensation |
| | | 9V (0A~3A) | - | 8.97V~9.39V | |
| | | 12V (2A~2.25A) | - | 11.97V~12.30V | |
| Output Constant Current (CC) | PD | 5V/3A | - | CC is 3.18A | Measured at PCB end |
| | | 9V/3A | - | OCP is 3.66A | |
| | | 12V/2.25A | - | OCP is 2.75A | |
| Input Power | PD | 5V | < 30mW | 30mW@264$V_{AC}$ | Detachment |
| Ripple Noise | PD | 5V (0A~3A) | < 150 mVp-p | 103mV@264$V_{AC}$ | Measured at PCB end |
| | PD | 9V (0A~ 3A) | | 146mV@90$V_{AC}$ | |
| | PD | 12V (0A~ 2.25A) | | 130mV@90$V_{AC}$ | |
| Dynamic | PD | 5V/3A | - | 5.317~4.938@90$V_{AC}$ 5.217~4.825@264$V_{AC}$ | Measure at PCB end Load change:10%~90% <5% tolerance |
| | | 9V/3A | - | 9.362~8.911@90$V_{AC}$ 9.250~8.831@264$V_{AC}$ | |
| | | 12V/2.25A | - | 12.33~11.87@90$V_{AC}$ 12.30~11.83@264$V_{AC}$ | |
| Voltage stress | PD | 12V/2.25A | 600V | 559V | 264$V_{AC}$ |
| | | | 100V | 97.2V | 264$V_{AC}$ |
| Efficiency | PD | 5V (0A~3A) | - | Avg. 88.68%@115$V_{AC}$ Avg. 88.28%@230$V_{AC}$ | Meets CoC V5 Tier 2 standard |
| | | 9V (0A~3A) | - | Avg. 89.28%@115$V_{AC}$ Avg. 89.37%@230$V_{AC}$ | |
| | | 12V (0A~2.25A) | - | Avg. 88.93%@115$V_{AC}$ Avg. 88.86%@230$V_{AC}$ | |
| OVP | PD | 5V (0A~3A) | ≤ 130% Vo | OVP is 6.5V at 0A OVP is 6.7V at 3A | Measured at PCB end |
| | | 12V (0A~2.25A) | | OVP is 14.67V at 0A OVP is 14.87V at 2.25A | |

| | | | | | |
|---|---|---|---|---|---|
| OCP | PD | 9V<br>12V | - | OCP = 3.66A@9V<br>OCP = 2.75A@12V | - |
| UVP | PD/PPS | 5V<br>(0A~3A) | - | 3.65V | Vo*70% |
| | | 9V &<br>12V | | CC limited by OCP | |
| Conduction EMI | PPS | 9V/3.0A<br>12V/2.25A | Quasi-peak spec< EN55022Q<br>Average spec< EN55022A | QP has -6dB margin | Measured at PCB end |
| Temperature measurement | PPS | 9V/3A | Hot spot < 90°C | 87 degree at primary side MOSFET | - |

# 3. Photographs

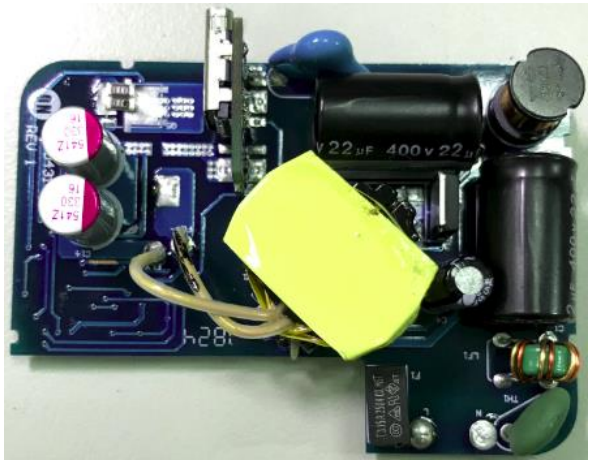


**Figure 1. Photograph ( W x L : 63mm x 44.4mm ) Top View**

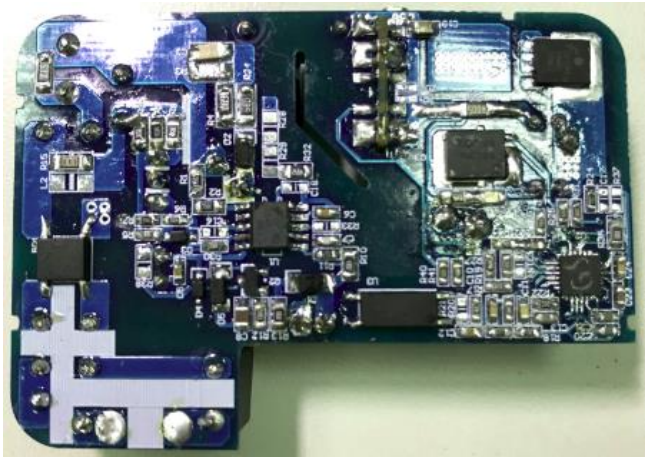


**Figure 2. Photograph (W x L : 63mm x 44.4mm) Bottom View**

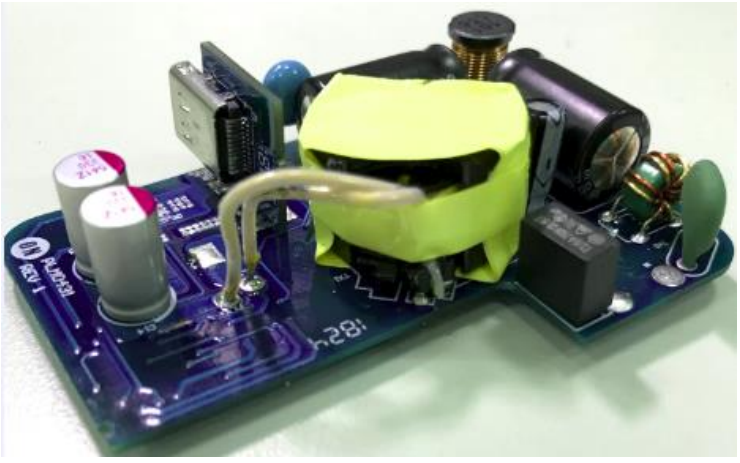


**Figure 3. Photograph ( H: 20mm ) Side View**

# 4. Printing Circuits

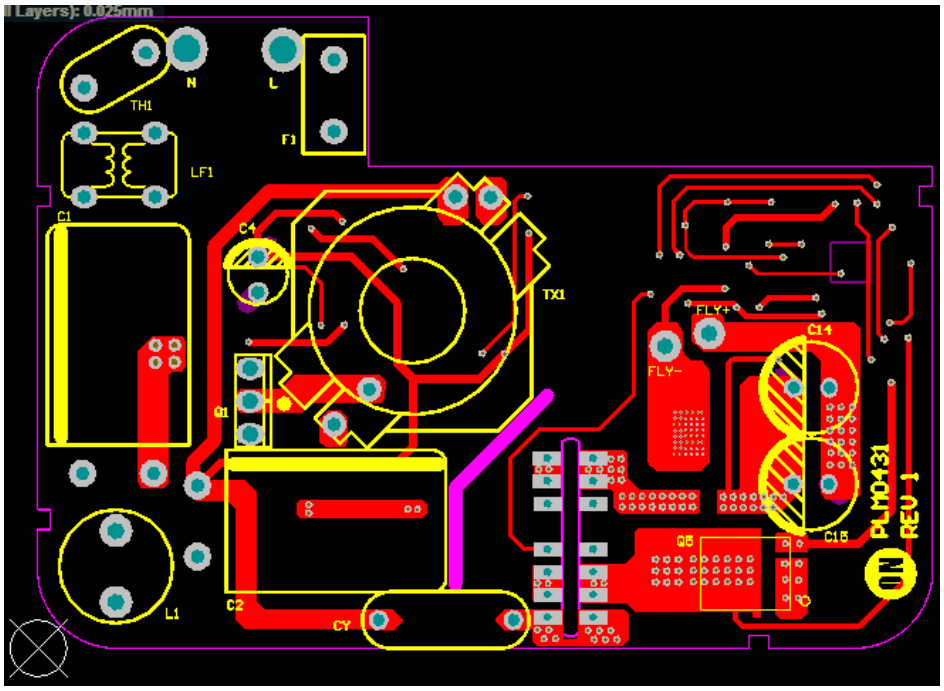



**Figure 4. PCB Top view**

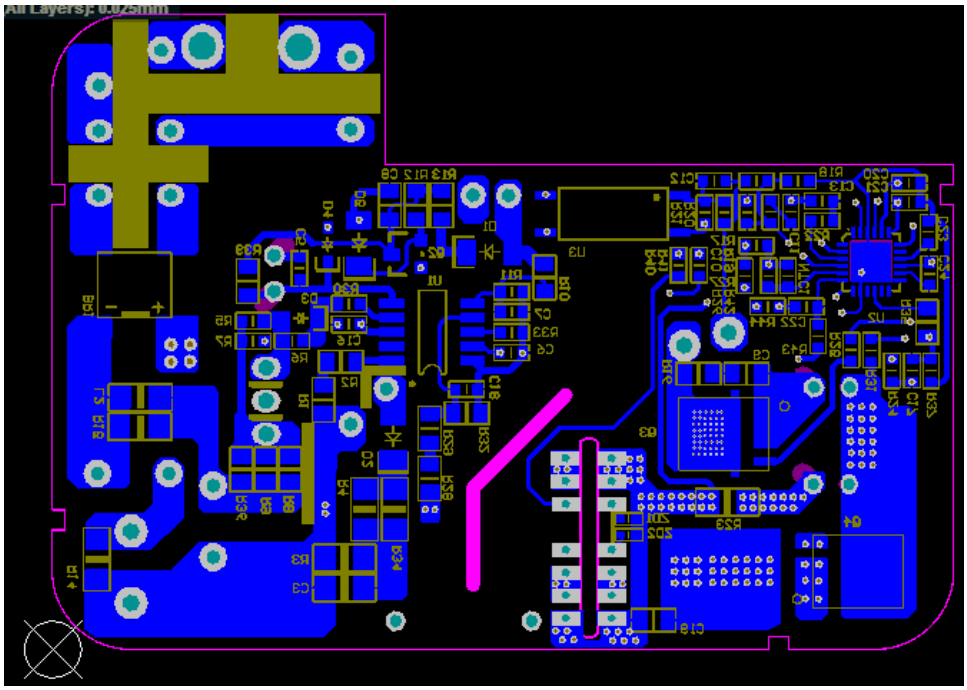
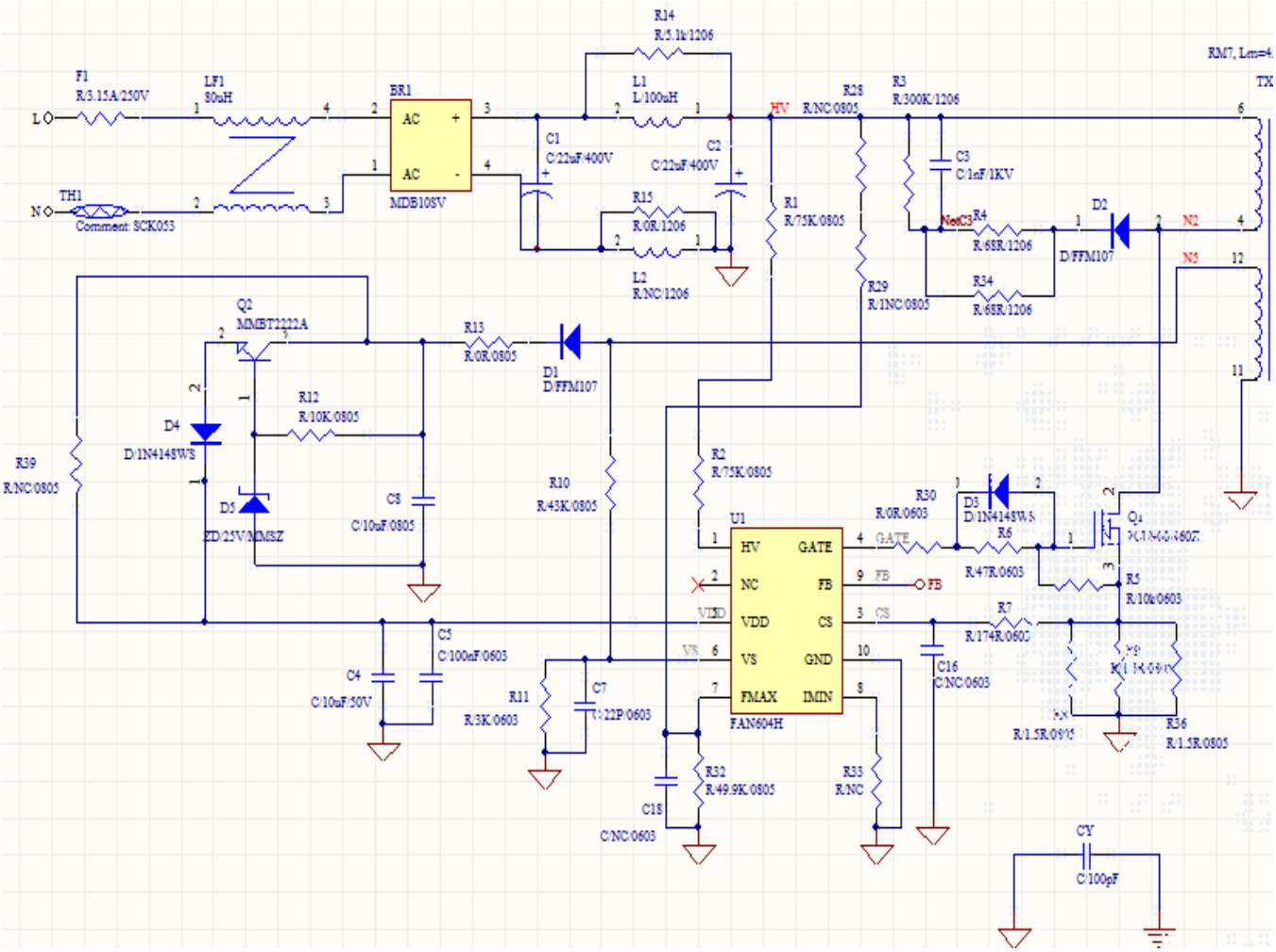


**Figure 5. PCB Bottom view**

# 5. Schematic


F1
R/3.15A/250V
LF1
90uH
BR1
AC
AC
MDB10S/V
TH1
Comment: SCK053
L
N
C1
C/22uF/400V
C2
C/22uF/400V
R14
R/5.1k/1206
L1
L/100uH
HV
R28
R/NC/0805
R3
R/300K/1206
C3
C/1nF/1KV
R1
R/75K/0805
R29
R/1NC/0805
R15
R/0R/1206
L2
R/NC/1206
R4
R/68R/1206
R34
R/68R/1206
D2
D/FFM107
N2
N5
TX
Q2
MMBT2222A
R13
R/0R/0805
D1
D/FFM107
R12
R/10K/0805
D4
D/1N4148WS
D5
ZD/25V/MMSZ
C8
C/10uF/0805
R39
R/NC/0805
R10
R/43K/0805
R2
R/75K/0805
U1
HV
NC
VDD
VS
FMAX
GATE
FB
CS
GND
IMIN
FAN604H
R30
R/0R/0603
D3
D/1N4148WS
R6
R/47R/0603
R5
R/10k/0603
R7
R/174R/0603
C16
C/NC/0603
R36
R/1.5R/0805
C5
C/100nF/0603
C4
C/10uF/50V
R11
R/3K/0603
C7
C/22P/0603
R32
R/49.9K/0805
R33
R/NC
C15
C/NC/0603
CY
C/100pF

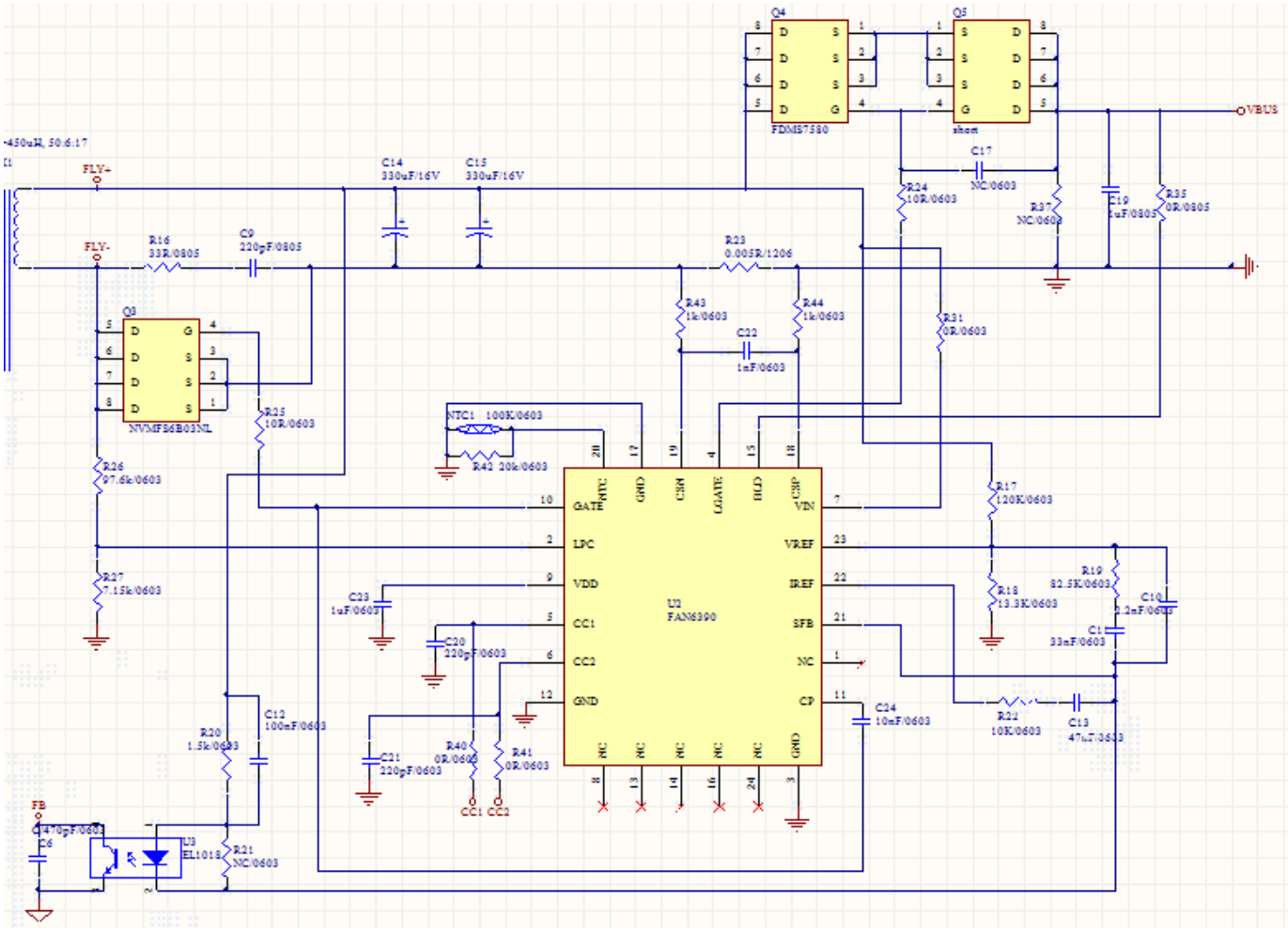



**Figure 6. Evaluation Board Schematic**

# 6. Bill of Materials

**Table 2. BOM of the EVB**

| ON-Semi Component | | | | |
|---|---|---|---|---|
| Part Name | Part No. | Specification | Manufacturing | Qty. |
| Bridge rectifier | BR1 | MDB10SV | ON-Semi | 1 |
| NMOSFET | Q1 | FCU900N60Z | ON-Semi | 1 |
| SR MOSFET | Q3 | NVMFS6B03NL | ON-Semi | 1 |
| NMOSFET | Q4,Q5 | FDMS7580 | ON-Semi | 2 |
| PWM IC controller | U1 | FAN604HMX | ON-Semi | 1 |
| SR & protocol IC controller | U2 | FAN6390 | ON-Semi | 1 |
| Photo Coupler | U3 | EL1018 | ON-Semi | 1 |
| Diode | D3,D4 | 1N4148WS 150mA/100V D-SMA | ON-Semi | 2 |
| **Others Component (A)** | | | | |
| Part Name | Part No. | Specification | Manufacturing | Qty. |
| Transformer | TX1 | RM7 | - | 1 |
| Fast Recovery Diode | D1,D2 | FFM107 | - | 2 |
| Thermistor | TH1 | SCK053 | - | 1 |
| Fuse | F1 | 3.15A 250V CQ MST, FUSE-SF8.4*5 | - | 1 |
| ESD Protection Diode | ZD1,ZD2 | VCUT05B1-DD1 | - | 2 |
| USB TYPE C | J1 | USB TYPE C | - | 1 |
| Precision resistors | R23 | 0.005R/1%/1206 | - | 1 |
| Y-Cap | CY | 220pF/250V | - | 1 |
| Solid-Cap | C14, C15 | 330uF/16V | - | 2 |
| E-Cap | C1, C2 | 22uF/400V | - | 2 |
| Axis Inductor | L1 | 100uH | - | 1 |
| Common Mode choke | LF1 | 80uH | - | 1 |
| NPN Transistor | Q2 | MMBT2222A | - | 1 |
| Zener | D5 | 25V-zener diode | - | 1 |
| E-cap | C4 | 10Uf/50V | - | 1 |
| **Others Component (B)** | | | | |
| Part Name | Part No. | Specification | Manufacturing | Qty. |
| SMD 0603 Res | R11 | 3k/0603 | - | 1 |
| | R5 | 10k/0603 | - | 1 |
| | R19 | 82.5k/0603 | - | 1 |

| | | | | |
|---|---|---|---|---|
| | R30, R31, R40, R41 | 0R/0603 | - | 4 |
| | R17 | 120k/0603 | - | 1 |
| | R20 | 1.5k/0603 | - | 1 |
| | NTC1 | 100k/0603 | - | 1 |
| | R24, R25 | 10R/0603 | - | 2 |
| | R43, R44 | 1k/0603 | - | 2 |
| | R26 | 97.6k/0603 | - | 1 |
| | R42 | 20k/0603 | - | 1 |
| | R22 | 10k/0603 | - | 1 |
| | R6 | 47R/0603 | - | 1 |
| | R27 | 7.15k/0603 | - | 1 |
| | R18 | 13.3k/0603 | - | 1 |
| | R7 | 174R/0603 | - | 1 |
| SMD 0805 Res | R1, R2 | 75k/0805 | - | 2 |
| | R12 | 10k/0805 | - | 1 |
| | R13 | 0/0805 | - | 1 |
| | R32 | 49.9k/0805 | - | 1 |
| | R16 | 33R/0805 | - | 1 |
| | R8,R9,R36 | 1.5R/0805 | - | 3 |
| | R10 | 43k/0805 | - | 1 |
| | R35 | 0R/0805 | - | 1 |
| SMD 1206 Res | R14 | 5.1k/1206 | - | 1 |
| | R3 | 300K/1206 | - | 1 |
| | R15 | 0R/1206 | - | 1 |
| | R4,R34 | 68R/1206 | - | 2 |
| SMD 0603 Cap | C12 | 100nF/0603/16V | - | 1 |
| | C24 | 10nF/0603/16V | - | 1 |
| | C10 | 2.2nF/0603/16V | - | 1 |
| | C7 | 22pF/0603/16V | - | 1 |
| | C20, C21 | 220pF/0603/16V | - | 2 |
| | C6 | 470pF/0603V/16V | - | 1 |
| | C11 | 33nF/0603V/16V | - | 1 |
| | C13 | 47nF/0603/16V | - | 1 |
| | C22 | 1nF/0603/16V | - | 1 |
| | C5 | 100nF/0603/25V | - | 1 |
| | C23 | 1uF/0603/16V | - | 1 |
| SMD 0805 Cap | C8 | 10uF/0805/25V | - | 1 |
| | C19 | 1uF/0805/25V | - | 1 |

| | | | | |
|---|---|---|---|---|
| | C9 | 220pF/0805/100V | - | 1 |
| SMD 1206 Cap | C3 | 1nF/1206/1kV | - | 1 |

# 7. Transformer Specifications

- Core:TPW33
- Bobbin: RM7

| Winding | Margin Tape (mm) | Terminal(pin) | | Wire Gauge (mm) | Turns (T) | Note |
|---|---|---|---|---|---|---|
| | | Start | End | | | |
| Bobbin | | | | | | |
| N1 | NC | 4 | 5 | ϕ0.22*1 | 25 | - |
| Mylar Tape *2T | | | | | | |
| N2 | NC | 12 | 11 | ϕ0.12*1 | 17 | - |
| | | 11 | X | ϕ0.12*2 | 17 | - |
| Mylar Tape *2T | | | | | | |
| N3 | NC | FLY+ | FLY- | ϕ0.7*1 | 6 | - |
| Mylar Tape *2T | | | | | | |
| N4 | NC | 11 | X | ϕ0.18*3 | 9 | - |
| Mylar Tape *2T | | | | | | |
| N5 | NC | 5 | 6 | ϕ0.22*1 | 25 | - |

| **Mylar Tape *2T** | | | |
|---|---|---|---|
| Specifications | Terminal (pin) | Inductance (µH) | Remark |
| Primary-side Inductance | 2－1 | 450µH ± 5% | 100kHz, 1V |
| Primary-side Effective Leakage Inductance | 2－1 | < 10 µH Max. | Short All Other Pins |