# ULTRA- LOW ON RESISTANCE, 6A LOAD SWITCH WITH CONTROLLED TURN-ON

## FEATURES

- Integrated 6A Single Channel Load Switch
- Input Voltage Range: 0.8V to 5.5V
- Ultra-low ON-Resistance $R_{ON}$ = 4.5mΩ (VBAIS=5V, VIN=1.05V)
- Low Threshold Control Input
- Quick Output Discharge Transistor
- Halogen Free Product

## APPLICATIONS

- Telecom Systems
- Industrial Systems
- Consumer Electronics
- Notebooks / Netbooks

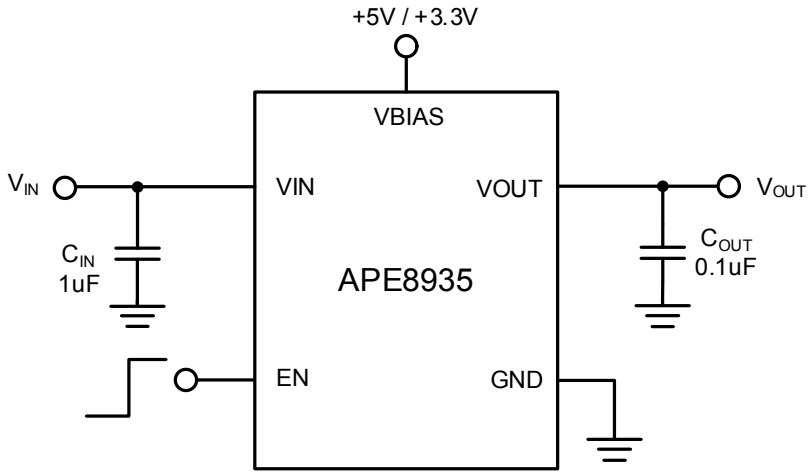
## DESCRIPTION

The APE8935 is a small, ultra-low $R_{ON}$ load switch with controlled turn on. It contains one N-channel MOSFET that can operate over an input voltage range of 0.8V to 5.5V and support maximum continuous current up to 6A. The switch is controlled by an on/off input (EN), which is capable of interfacing directly with low-voltage control signals.

Additional features include a 330Ω on-chip load resistor is added for output quick discharge when switch is turned off.

The APE8935 is available in 8-pin DFN 3x3-8L package with smallest components.

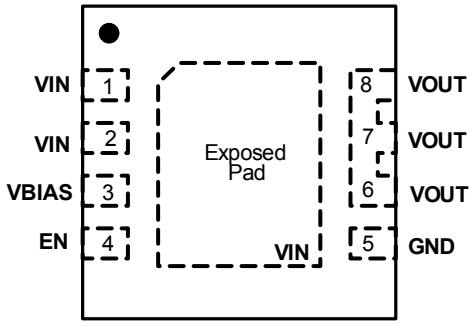
## TYPICAL APPLICATION



## ORDERING / PACKAGE INFORMATION

APE8935X
└ Package Type
GN3: DFN 3x3-8L

Top View
DFN 3x3-8L




## ABSOLUTE MAXIMUM RATINGS (at $T_A$=25°C)

| | |
|---|---|
| VIN | -0.3V to 6V |
| VOUT | VIN+0.3V |
| EN | -0.3V to 6V |
| VBIAS | -0.3 to 6V |
| $I_{MAX}$ | 6A |
| Storage Temperature Range ($T_{ST}$) | -65 to +150°C |
| Junction Temperature ($T_J$) | 150°C |
| Lead Temperature (Soldering, 10sec.) | 260°C |
| Thermal Resistance from Junction to Ambient ($R\theta_{JA}$) | |
| DFN 3x3-8L | 43°C/W |

## RECOMMENDED OPERATING CONDITIONS

| | |
|---|---|
| VIN | 0.8V to 5.5V |
| VBIAS | 2.5V to 5.5V (VBIAS≧VIN) |
| VOUT | $V_{IN}$ |
| CIN | ≧0.1uF |
| Junction Temperature ($T_J$) | 125°C |
| Operating Temperature Range | -40°C to 85°C |

## ELECTRICAL SPECIFICATIONS

($V_{IN}$=0.8V to 5.5V, $V_{BIAS}$=5V, $C_{IN}$=1uF, $C_{OUT}$=0.1uF, $T_A$ =25°C, unless otherwise specified)

| PARAMETER | SYM | TEST CONDITION | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| Quiescent Current | $I_{BIAS}$ | $V_{BIAS}$=$V_{EN}$=5V, $V_{IN}$=1.05V, $I_{OUT}$=0A | | | 30 | 50 | uA |
| | | $V_{BIAS}$=$V_{EN}$=5V, $V_{IN}$=1.5V, $I_{OUT}$=0A | | | 30 | 50 | uA |
| Shutdown Current | $I_{SD}$ | $V_{EN}$=GND | | | | 1 | uA |
| ON Resistance(Note1) | $R_{ON}$ | $V_{BIAS}$=$V_{EN}$=5V, $V_{IN}$=1.05V, $I_{OUT}$=200mA | $T_A$=25°C | | 4.5 | 5 | mΩ |
| | | | -40~85°C(NOTE1) | | 5.5 | 6 | |
| | | $V_{BIAS}$=$V_{EN}$=5V, $V_{IN}$=1.5V, $I_{OUT}$=200mA | $T_A$=25°C | | 4.5 | 5 | mΩ |
| | | | -40~85°C(NOTE1) | | 5.5 | 6 | |
| Output Pull-Down Resistance | $R_{OPD}$ | $V_{IN}$=5V, $V_{EN}$=0V | | | 330 | 400 | Ω |
| EN Input Leakage Current | $I_{EN}$ | $V_{EN}$=5V or GND | | | | 1 | uA |
| EN Threshold | $V_{IH}$ | on | | 1.3 | | | V |
| | $V_{IL}$ | off | | | | 0.5 | V |

Note1: Make sure $V_{BAIS} \geqq V_{IN}$ for optimum $R_{ON}$ performance.

## SWITCHING SPECIFICATIONS

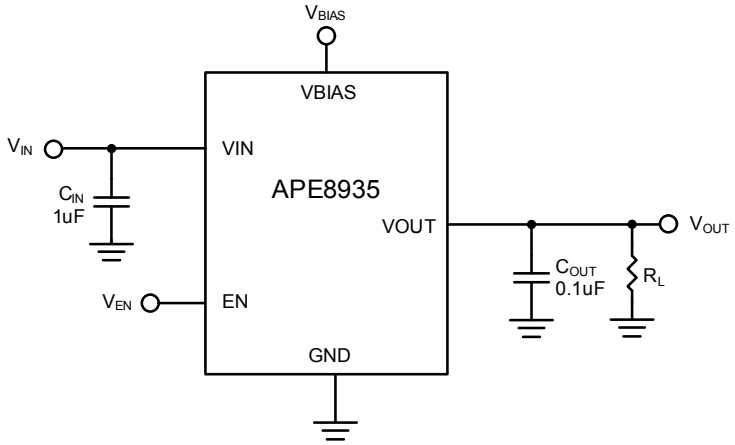



Fig.1 Test Circuit

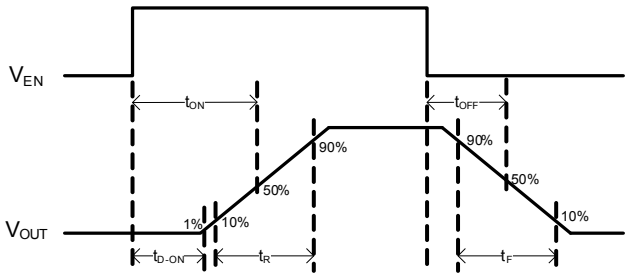



Fig.2 ON/OFF Waveforms

| PARAMETER | SYM | TEST CONDITION | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| Turn-on Time | $t_{ON}$ | $V_{BIAS}$=$V_{EN}$=5V, $R_L$=10Ω | $V_{IN}$=1.05V | | 905 | | us |
| | | | $V_{IN}$=1.5V | | 940 | | us |
| Turn-off Time | $t_{OFF}$ | $V_{BIAS}$=$V_{EN}$=5V, $R_L$=10Ω | $V_{IN}$=1.05V | | 5.4 | | us |
| | | | $V_{IN}$=1.5V | | 5.2 | | us |
| VOUT Rise Time | $t_R$ | $V_{BIAS}$=$V_{EN}$=5V, $R_L$=10Ω | $V_{IN}$=1.05V | 308 | 440 | 572 | us |
| | | | $V_{IN}$=1.5V | 381 | 545 | 708 | us |
| VOUT Fall Time | $t_F$ | $V_{BIAS}$=$V_{EN}$=5V, $R_L$=10Ω | $V_{IN}$=1.05V | | 1.7 | | us |
| | | | $V_{IN}$=1.5V | | 1.8 | | us |
| VOUT Turn-on Delay Time | $t_{D-ON}$ | $V_{BIAS}$=$V_{EN}$=5V, $R_L$=10Ω | $V_{IN}$=1.05V | 388 | 555 | 721 | us |
| | | | $V_{IN}$=1.5V | 381 | 545 | 708 | us |

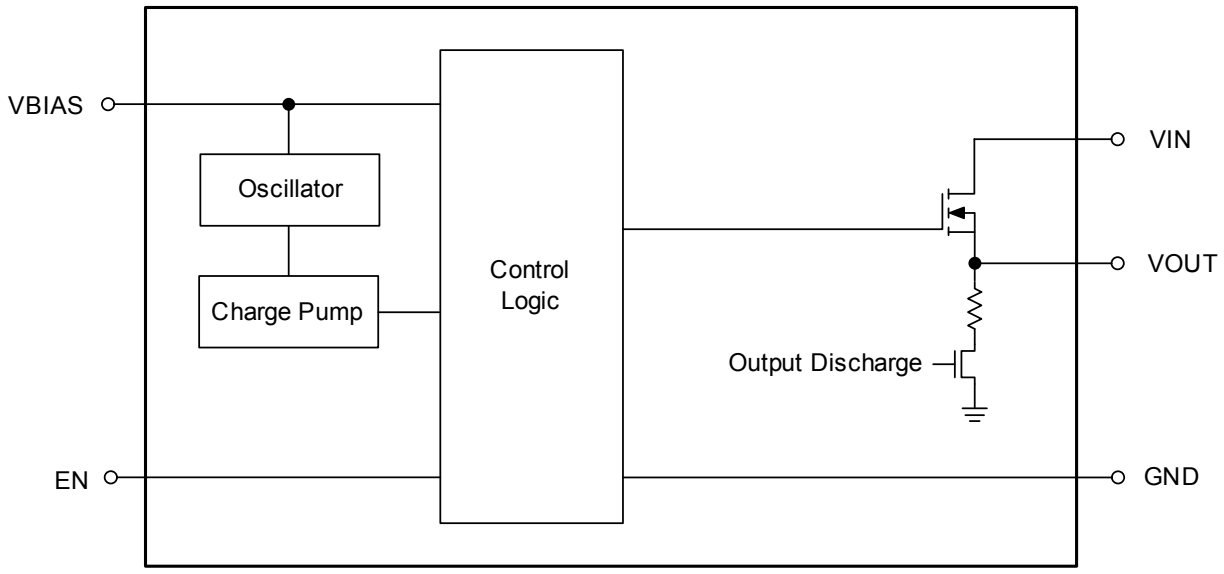
## SWITCHING SPECIFICATIONS (Continued)

| PARAMETER | SYM | TEST CONDITION | | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| Turn-on Time | $t_{ON}$ | $V_{BIAS}$=$V_{EN}$=5V, $I_{OUT}$=6A | $V_{IN}$=1.05V | | 1345 | | us |
| | | | $V_{IN}$=1.5V | | 1480 | | us |
| Turn-off Time | $t_{OFF}$ | $V_{BIAS}$=$V_{EN}$=5V, $I_{OUT}$=6A | $V_{IN}$=1.05V | | 4.8 | | us |
| | | | $V_{IN}$=1.5V | | 4.8 | | us |
| VOUT Rise Time | $t_R$ | $V_{BIAS}$=$V_{EN}$=5V, $I_{OUT}$=6A | $V_{IN}$=1.05V | 602 | 860 | 1118 | us |
| | | | $V_{IN}$=1.5V | 616 | 880 | 1144 | us |
| VOUT Fall Time | $t_F$ | $V_{BIAS}$=$V_{EN}$=5V, $I_{OUT}$=6A | $V_{IN}$=1.05V | | 0.5 | | us |
| | | | $V_{IN}$=1.5V | | 0.7 | | us |
| VOUT Turn-on Delay Time | $t_{D-ON}$ | $V_{BIAS}$=$V_{EN}$=5V, $I_{OUT}$=6A | $V_{IN}$=1.05V | 497 | 710 | 923 | us |
| | | | $V_{IN}$=1.5V | 495 | 708 | 920 | us |

## PIN DESCRIPTIONS

| PIN No. | PIN SYMBOL | PIN DESCRIPTION |
|---|---|---|
| 1, 2 | VIN | Input Power Supply |
| 3 | VBIAS | Bias Voltage |
| 4 | EN | Switch control input, active high. Do not leave floating. |
| 5 | GND | Ground |
| 6, 7, 8 | VOUT | Switch output |
| Exposed pad | VIN | Input Power Supply |

## BLOCK DIAGRAM



## TYPICAL PERFORMANCE CHARACTERISTICS

Condition: VBIAS=VEN=5V, RL=10Ω, Cin=1uF, Cout=0.1uF, ch1:EN, ch2:VOUT, ch4:$I_{IN}$

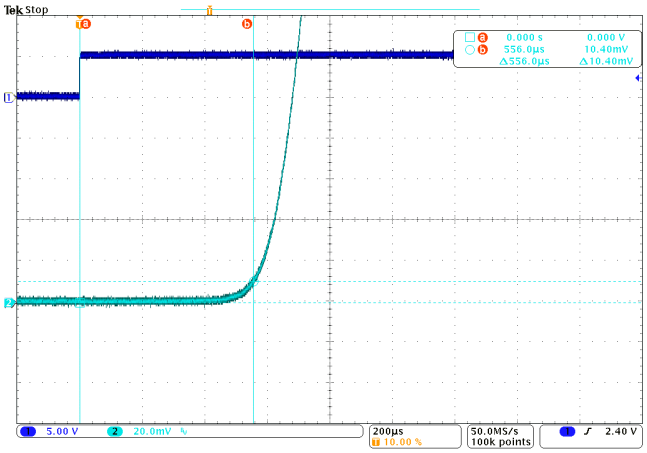



Fig.1 Waveform for $t_{D-ON}$, VIN=1.05V

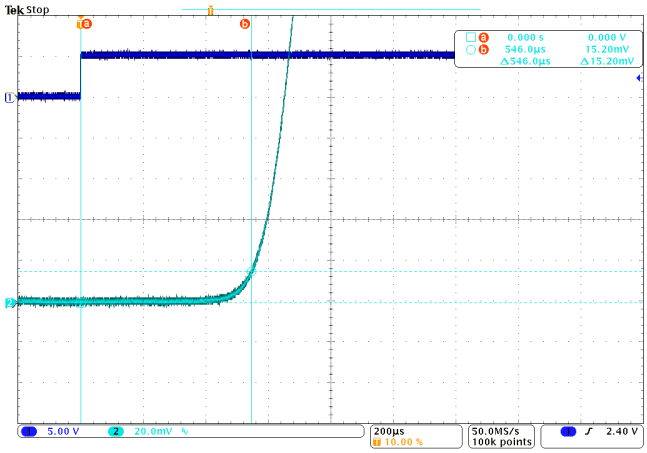



Fig.2 Waveform for $t_{D-ON}$, VIN=1.5V

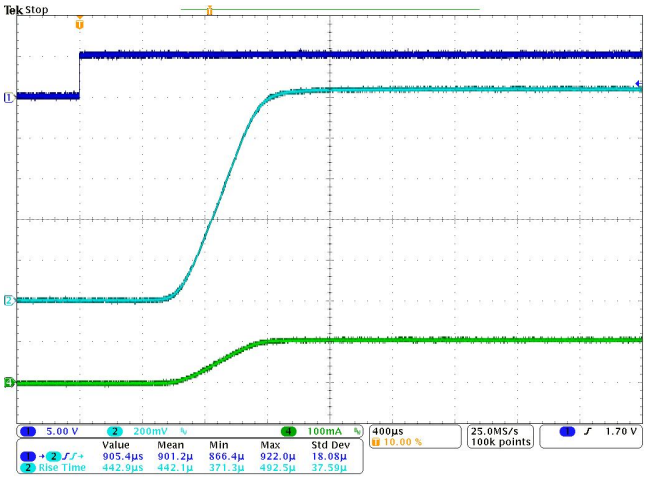



Fig.3 Waveform for $t_{ON}$ and $t_R$, VIN=1.05V

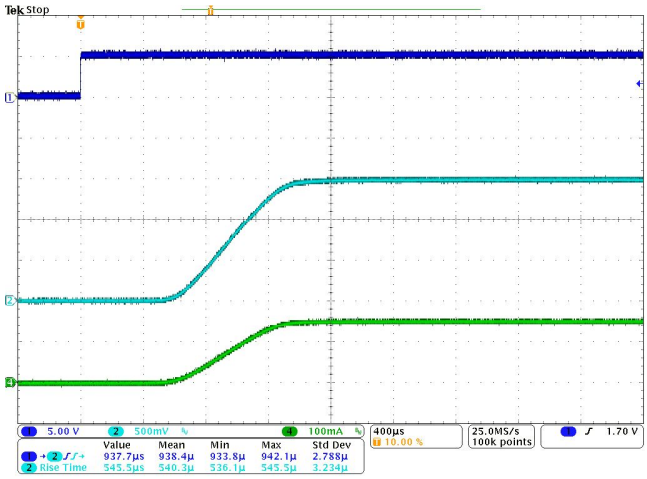



Fig.4 Waveform for $t_{ON}$ and $t_R$, VIN=1.5V

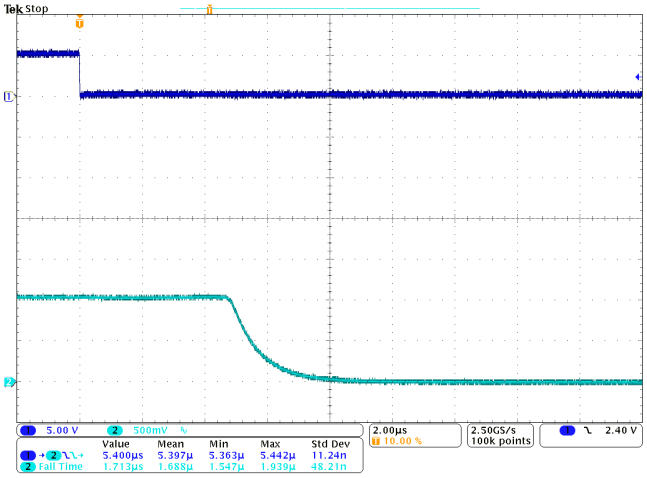



Fig.5 Waveform for $t_{OFF}$ and $t_F$, VIN=1.05V

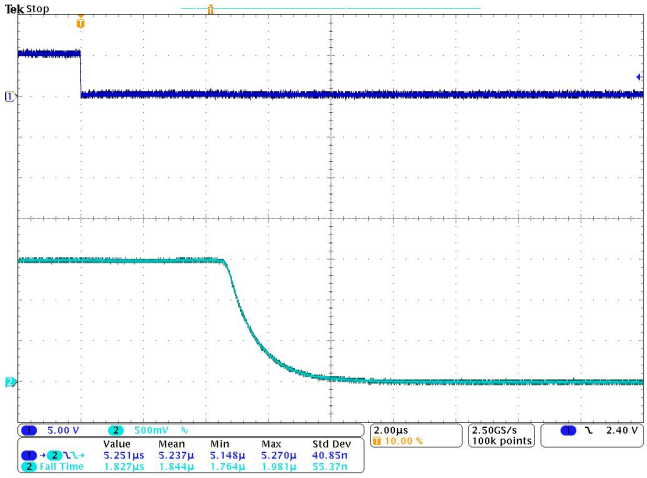



Fig.6 Waveform for $t_{OFF}$ and $t_F$, VIN=1.5V

## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

Condition: VBIAS=VEN=5V, IOUT=6A, Cin=1uF, Cout=0.1uF, ch1:EN, ch2:VOUT, ch4:$I_{IN}$

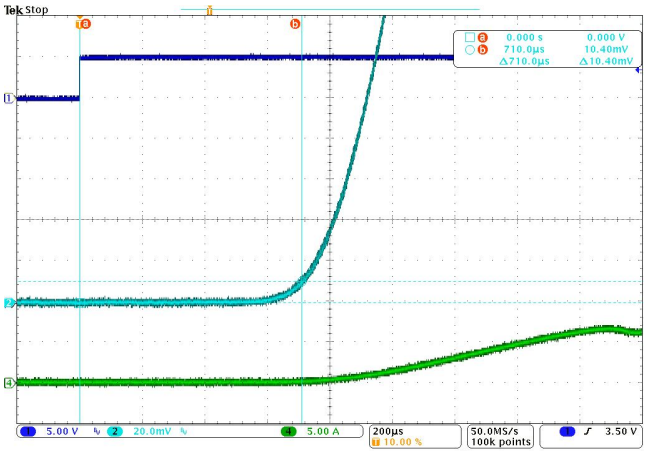



Fig.7 Waveform for $t_{D-ON}$, VIN=1.05V

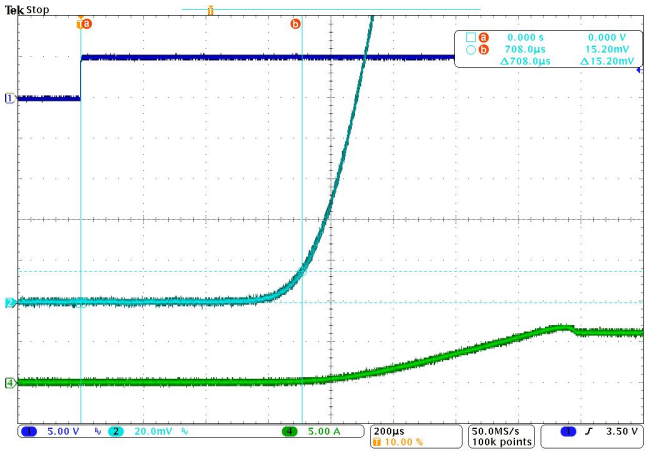



Fig.8 Waveform for $t_{D-ON}$, VIN=1.5V

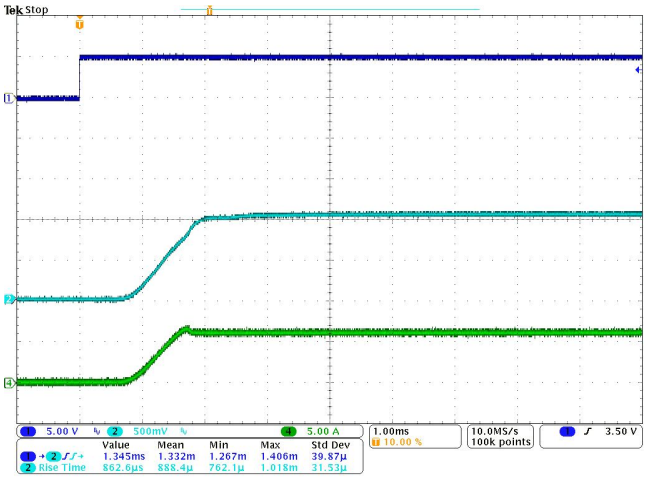



Fig.9 Waveform for $t_{ON}$ and $t_R$, VIN=1.05V

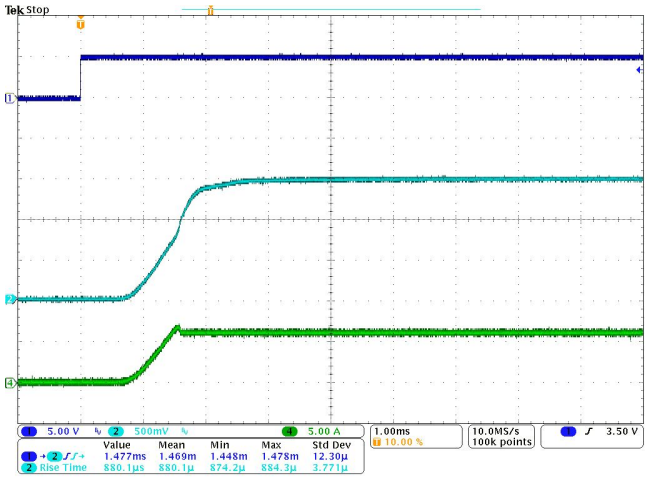



Fig.10 Waveform for $t_{ON}$ and $t_R$, VIN=1.5V

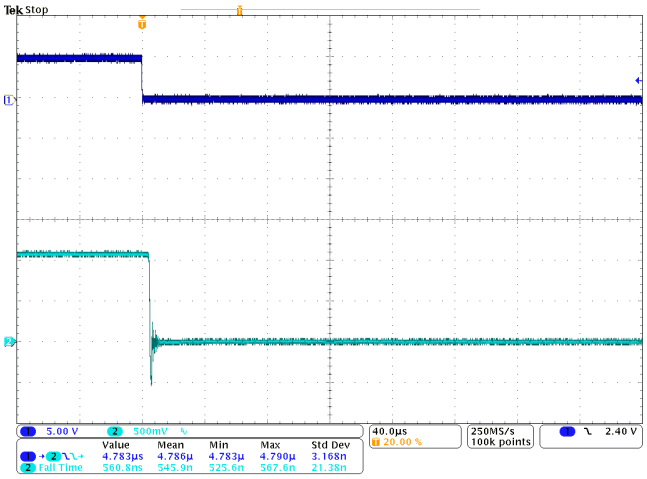



Fig.11 Waveform for $t_{OFF}$ and $t_F$, VIN=1.05V

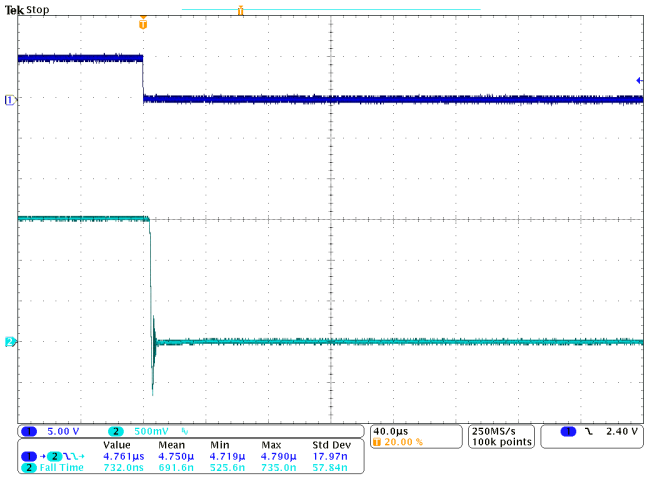



Fig.12 Waveform for $t_{OFF}$ and $t_F$, VIN=1.5V

## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

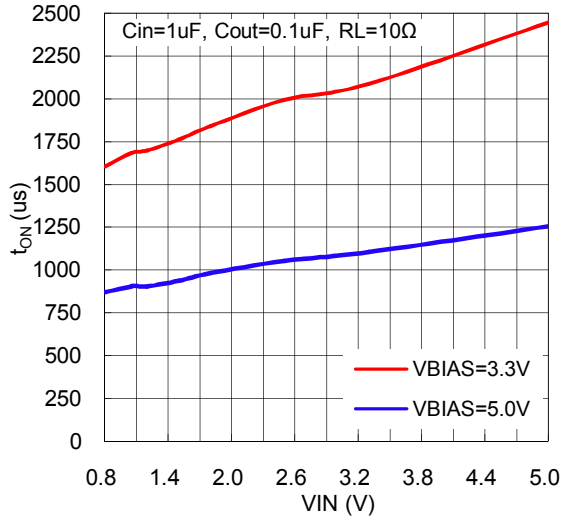



Fig.13 $t_{ON}$ vs. VIN

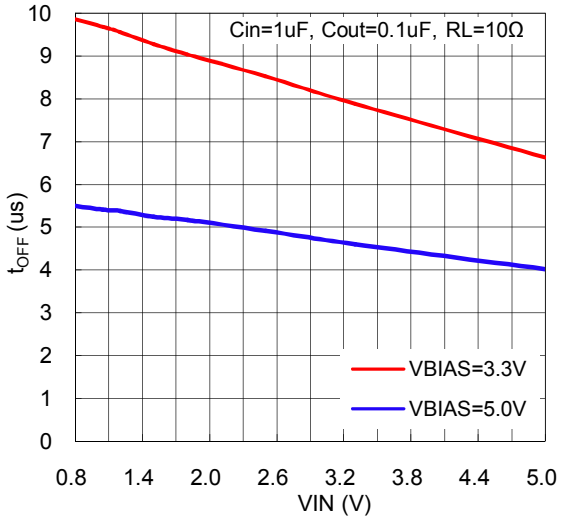



Fig.14 $t_{OFF}$ vs. VIN

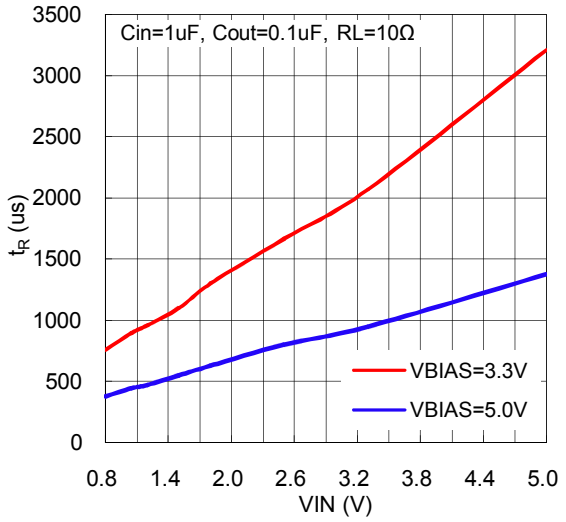



Fig.15 $t_R$ vs. VIN

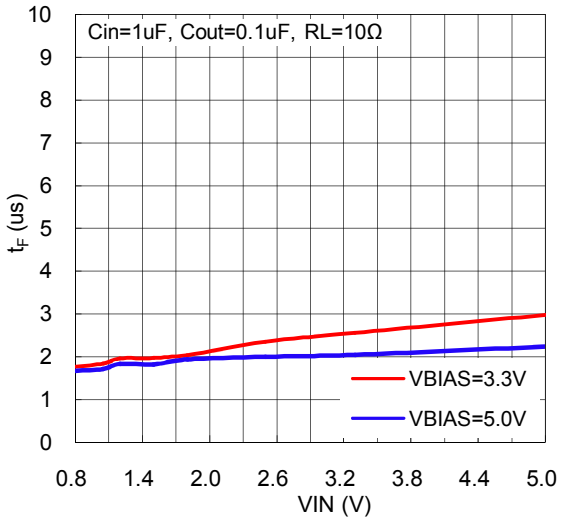



Fig.16 $t_F$ vs. VIN

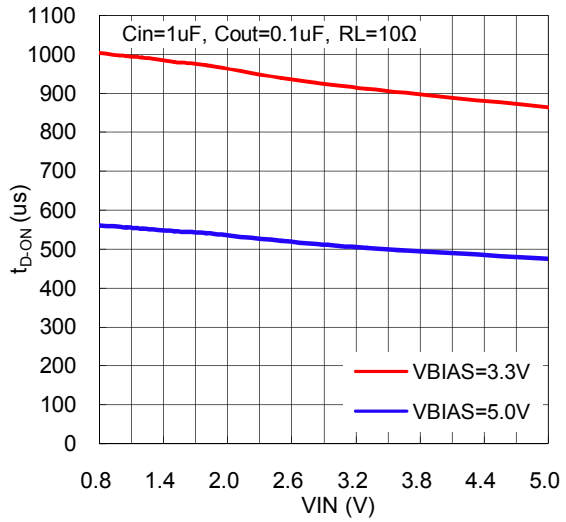



Fig.17 $t_{D\text{-}ON}$ vs. VIN

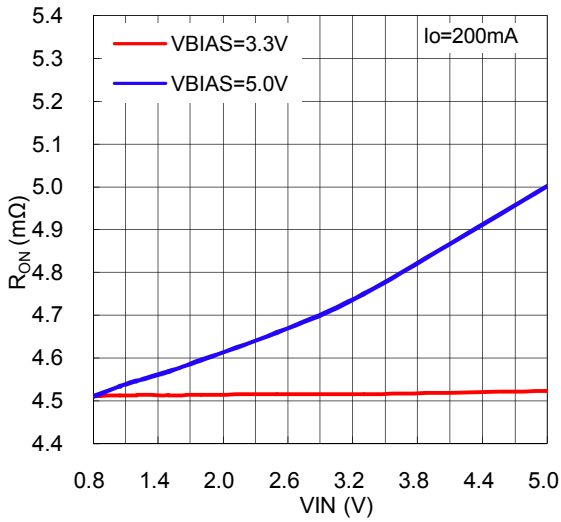



Fig.18 $R_{ON}$ vs. VIN

## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

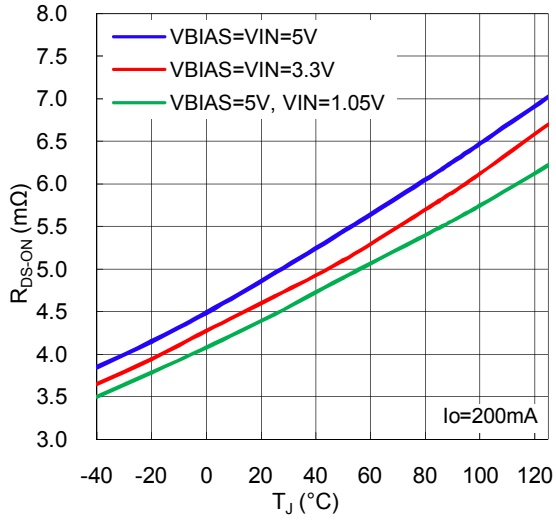



Fig.19 $R_{ON}$ vs. Temperature

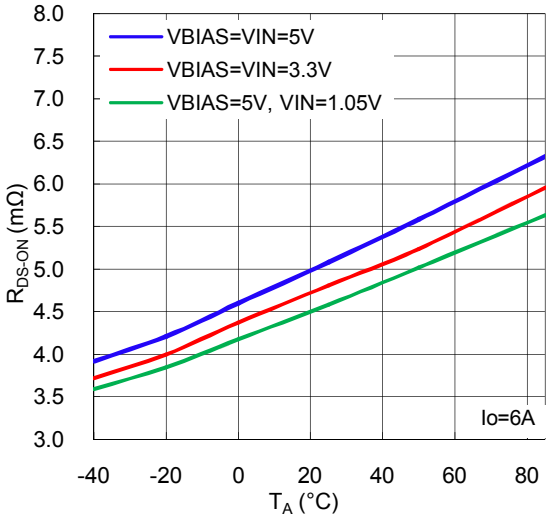



Fig.20 $R_{ON}$ vs. Temperature

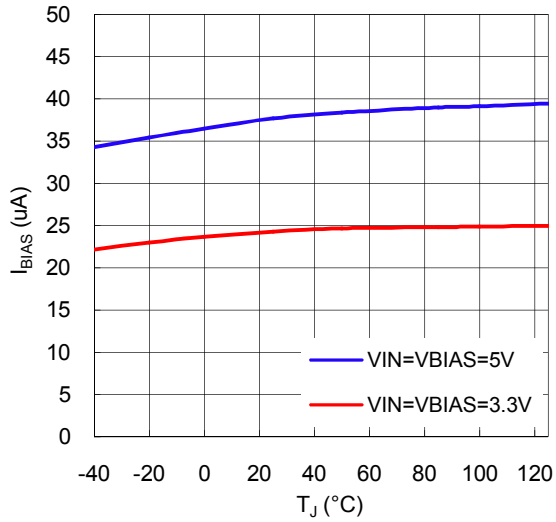



Fig.21 Quiescent Current vs. Temperature

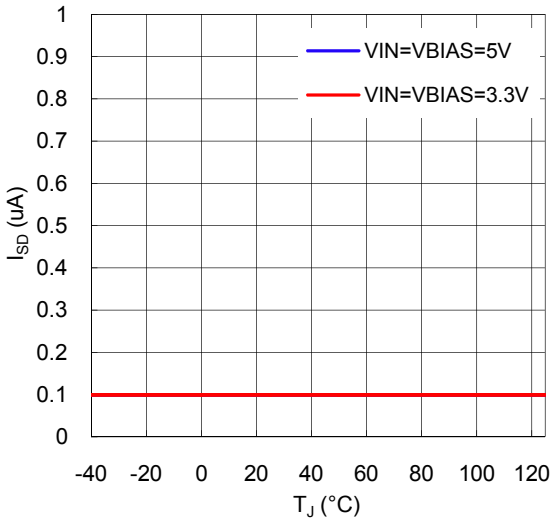



Fig.22 Shutdown Current vs. Temperature

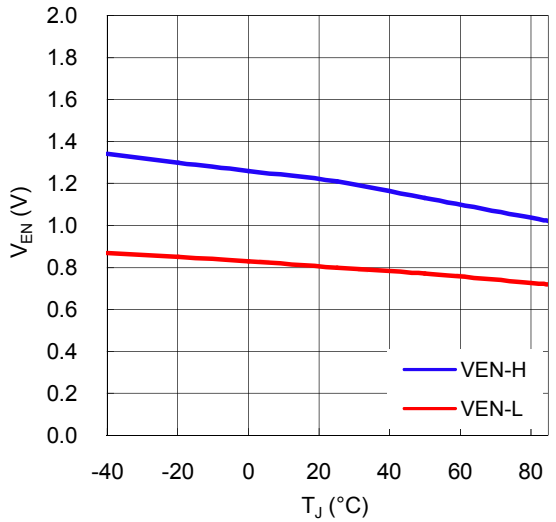



Fig.23 EN Threshold vs. Temperature

## APPLICATION INFORMATION

**On/Off Control**

The load switch is controlled by the EN pin. The EN pin is active high and has a low threshold making it capable of interfacing with low voltage signals. The EN pin can be used with standard 1.5V, 1.8V, 2.5V or 3.3V GPIO logic threshold. Do not leave the EN pin float.

**Input Capacitor**

An input capacitor is recommended to be placed between VIN and GND to limit the voltage drop on the input supply during high current application.

**Output Capacitor**

Setting a $C_{IN}$ greater than the $C_{OUT}$ is highly recommended. Since the internal body diode is in the NMOS switch, this prevents the current flows through the body diode from VOUT to VIN when the system supply is removed.

**Layout Considerations**

Follow the below guidelines for PCB layout to achieve stable operation. Take below figure for reference.

1. Keep the high current paths (VIN, VOUT and GND) wide and short to obtain the best effect.
2. The input and output capacitors should be close to the device as possible to minimize the parasitic trace inductances.
3. Place the thermal vias under the exposed pad. This help for thermal diffusion away from the device.

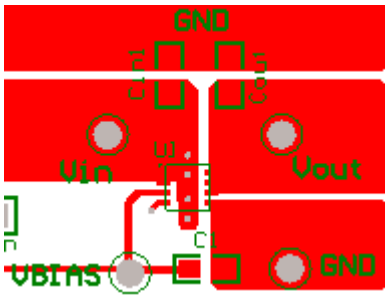



Fig.24 Reference layout

## MARKING INFORMATION

**DFN 3x3-8L**