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# 400mA LOAD SWITCH FEATURING PRE-BIASED PNP TRANSISTOR AND ESD PROTECTED N-MOSFET

## Features

- Voltage Controlled Small Signal Switch
- N-MOSFET with ESD Gate Protection
- Ideally Suited for Automated Assembly Processes
- **Lead Free By Design/ROHS Compliant (Note 1)**
- **"Green" Device (Note 2)**

## Description

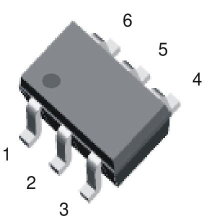
LMN400E01 is best suited for applications where the load needs to be turned on and off using control circuits like micro-controllers, comparators etc. particularly at a point of load. It features a discrete pass transistor with stable $V_{CE(SAT)}$ which does not depend on input voltage and can support continuous maximum current of 400 mA. It also contains an ESD protected discrete N-MOSFET that can be used as control. The component can be used as a part of a circuit or as a stand alone discrete device.

## Mechanical Data

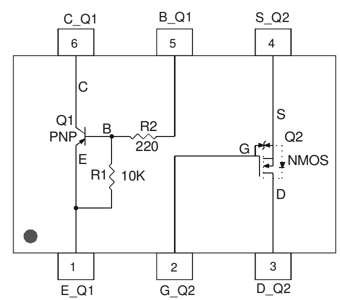
- Case: SOT363
- Case Material: Molded Plastic. "Green Molding" Compound. UL Flammability Classification Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020C
- Terminal Connections: See Diagram
- Terminals: Finish - Matte Tin annealed over Alloy 42 leadframe. Solderable per MIL- STD -202, Method 208
- Marking Information: See Page 8
- Ordering Information: See Page 8
- Weight: 0.006 grams (approximate)
-

| Reference | Device Type | R1(NOM) | R2(NOM) | Figure |
|---|---|---|---|---|
| Q1 | PNP Transistor | 10K | 220 | 2 |
| Q2 | N-MOSFET | — | — | 2 |

SOT363




Top View



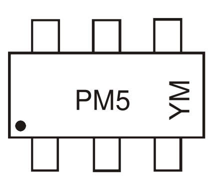

Top View
Internal Schematic

## Ordering Information (Note 3)

| Device | Packaging | Shipping |
|---|---|---|
| LMN400E01-7 | SOT363 | 3000/Tape & Reel |

Notes: 1. No purposefully added lead.
2. Diodes Inc.'s "Green" policy can be found on our website at http://www.diodes.com.
3. For packaging details, go to our website at http://www.diodes.com.

## Marking Information




PM5 = Product Type Marking Code,
YM = Date Code Marking
Y = Year, e.g., Y = 2011
M = Month, e.g., 9 = September

Date Code Key

| Year | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|---|---|
| Code | T | U | V | W | X | Y | Z | A |

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | O | N | D |

## Maximum Ratings, Total Device @$T_A$ = 25°C unless otherwise specified

| Characteristic | Symbol | Value | Unit |
|---|---|---|---|
| Power Dissipation (Note 4) | $P_D$ | 200 | mW |
| Power Derating Factor above 37.5°C | $P_{der}$ | 1.6 | mW/°C |
| Output Current | $I_{out}$ | 400 | mA |

## Thermal Characteristics @$T_A$ = 25°C unless otherwise specified

| Characteristic | Symbol | Value | Unit |
|---|---|---|---|
| Operating and Storage Temperature Range | $T_j$, $T_{STG}$ | -55 to +150 | °C |
| Thermal Resistance, Junction to Ambient Air (Note 4) | $R_{\theta JA}$ | 625 | °C/W |

## Maximum Ratings: Pre-Biased PNP Transistor (Q1) @$T_A$ = 25°C unless otherwise specified

| Characteristic | Symbol | Value | Unit |
|---|---|---|---|
| Collector-Base Voltage | $V_{CBO}$ | -50 | V |
| Collector-Emitter Voltage | $V_{CEO}$ | -50 | V |
| Supply Voltage | $V_{cc}$ | -50 | V |
| Input Voltage | $V_{in}$ | -6 to +5 | V |
| Output Current | $I_C$ | -400 | mA |

## Maximum Ratings: ESD Protected N-Channel MOSFET (Q2) @$T_A$ = 25°C unless otherwise specified

| Characteristic | Symbol | Value | Unit |
|---|---|---|---|
| Drain-Source Voltage | $V_{DSS}$ | 60 | V |
| Drain Gate Voltage ($R_{GS}$ ≤ 1M Ohm) | $V_{DGR}$ | 60 | V |
| Gate-Source Voltage Continuous | $V_{GSS}$ | +/-20 | V |
| Gate-Source Voltage Pulsed (tp<50 uS) | $V_{GSS}$ | +/-40 | V |
| Drain Current (Note 4) Continuous ($V_{gs}$ = 10V) | $I_D$ | 300 | mA |
| Drain Current (Note 4) Pulsed (tp <10 uS, Duty Cycle <1%) | $I_D$ | 800 | mA |
| Continuous Source Current | $I_S$ | 300 | mA |

Notes: 4. Device mounted on FR-4 PCB, 1 inch x 0.85 inch x 0.062 inch; pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at http://www.diodes.com/datasheets/ap02001.pdf.

## Electrical Characteristics: Pre-Biased PNP Transistor (Q1)

@$T_A$ = 25°C unless otherwise specified

| Characteristic | Symbol | Min | Typ | Max | Unit | Test Condition |
|---|---|---|---|---|---|---|
| **OFF CHARACTERISTICS (Note 5)** | | | | | | |
| Collector-Base Cut Off Current | $I_{CBO}$ | — | — | -500 | nA | $V_{CB}$ = -50V, $I_E$ = 0 |
| Collector-Emitter Cut Off Current | $I_{CEO}$ | — | — | -1 | uA | $V_{CE}$ = -50V, $I_B$ = 0 |
| Collector-Base Breakdown Voltage | $V_{(BR)CBO}$ | -50 | — | — | V | $I_C$ = -10uA, $I_E$ = 0 |
| Collector-Emitter Breakdown Voltage | $V_{(BR)CEO}$ | -50 | — | — | V | $I_C$ = -2mA, $I_B$ = 0 |
| Input Off Voltage | $V_{I(OFF)}$ | -0.3 | -0.55 | — | V | $V_{CE}$ = -5V, $I_C$ = -100uA |
| Ouput Current | $I_{O(OFF)}$ | — | — | -1 | uA | $V_{CC}$ = -50V, $V_I$ = 0V |
| **ON CHARACTERISTICS (Note 5)** | | | | | | |
| Collector-Emitter Saturation Voltage | $V_{CE(SAT)}$ | — | — | -0.15 | V | $I_C$ = -10mA, $I_B$ = -0.3mA |
| | | — | — | -0.3 | V | $I_C$ = -200mA, $I_B$ = -20mA |
| | | — | — | -0.5 | V | $I_C$ = -400mA, $I_B$= -40mA |
| | | — | — | -0.6 | V | $I_C$ = -500mA, $I_B$ = -50mA |
| DC Current Gain | $h_{FE}$ | 55 | 220 | — | — | $V_{CE}$ = -5V, $I_C$ = -50mA |
| | | 55 | 225 | — | — | $V_{CE}$ = -5V, $I_C$ = -400mA |
| Input On Voltage | $V_{I(ON)}$ | -3 | -1.5 | — | V | $V_O$ = -0.3V, $I_C$ = -20mA |
| Output Voltage (Equivalent to $V_{CE(SAT)}$) | $V_{O(ON)}$ | — | -0.1 | -0.3 | V | $I_o/I_I$ = -50mA /-2.5mA |
| Input Current | $I_I$ | — | -18 | -45 | mA | $V_I$ = -5V |
| Base-Emitter Turn-on Voltage | $V_{BE(ON)}$ | — | -1.2 | -1.6 | V | $V_{CE}$ = -5V, $I_C$ = -400mA |
| Base-Emitter Saturation Voltage | $V_{BE(SAT)}$ | — | -1.9 | -2.5 | V | $I_C$ = -50mA, $I_B$ = -5mA |
| Input Resistor (Base), +/- 30% | R2 | 0.154 | 0.22 | 0.286 | KΩ | — |
| Pull-up Resistor (Base to Vcc supply), +/- 30% | R1 | 7 | 10 | 13 | KΩ | — |
| Resistor Ratio (Input Resistor/Pullup resistor) | R1/R2 | 36 | 45 | 55 | — | — |
| **SMALL SIGNAL CHARACTERISTICS** | | | | | | |
| Gain Bandwidth Product | $f_T$ | — | 200 | — | MHz | $V_{CE}$ = -10V, $I_E$ = -5mA, f = 100MHz |

Notes: 5. Short duration pulse test used to minimize self-heating effect.

## Electrical Characteristics:
## ESD Protected N-Channel MOSFET (Q2)

@$T_A$ = 25°C unless otherwise specified

| Characteristic | Symbol | Min | Typ | Max | Unit | Test Condition |
|---|---|---|---|---|---|---|
| **OFF CHARACTERISTICS (Note 5)** | | | | | | |
| Drain-Source Breakdown Voltage | $V_{(BR)DSS}$ | 60 | — | — | V | $V_{GS}$ = 0V, $I_D$ = 10uA |
| Zero Gate Voltage Drain Current | $I_{DSS}$ | — | — | 1 | μA | $V_{GS}$ = 0V, $V_{DS}$ = 60V |
| Gate-Body Leakage Current, Forward | $I_{GSSF}$ | — | — | 10 | μA | $V_{GS}$ = 20V, $V_{DS}$ = 0V |
| Gate-Body Leakage Current, Reverse | $I_{GSSR}$ | — | — | -10 | μA | $V_{GS}$ = -20V, $V_{DS}$ = 0V |
| **ON CHARACTERISTICS (Note 5)** | | | | | | |
| Gate Source Threshold Voltage | $V_{GS(th)}$ | 1 | 1.6 | 2.5 | V | $V_{DS}$ = $V_{GS}$, $I_D$ = 0.25mA |
| Static Drain-Source On-State Voltage | $V_{DS(on)}$ | — | 0.09 | 1.9 | V | $V_{GS}$ = 5V, $I_D$ = 50mA |
| | | — | 0.6 | 3.75 | | $V_{GS}$ = 10V, $I_D$ = 500mA |
| On-State Drain Current | $I_{D(on)}$ | 500 | — | — | mA | $V_{GS}$ = 10V, $V_{DS}$ ≥2*$V_{DS}$(ON) |
| Static Drain-Source On Resistance | $R_{DS(on)}$ | — | 1.6 | 3 | Ω | $V_{GS}$ = 5V, $I_D$ = 50mA |
| | | — | 1.2 | 2 | | $V_{GS}$ = 10V, $I_D$ = 500mA |
| Forward Transconductance | $g_{FS}$ | 80 | 260 | — | mS | $V_{DS}$ ≥2*$V_{DS(ON)}$, $I_D$ = 200 mA |
| **DYNAMIC CHARACTERISTICS** | | | | | | |
| Input Capacitance | $C_{iss}$ | — | — | 50 | pF | $V_{DS}$ = -25V, $V_{GS}$ = 0V, f = 1MHz |
| Output Capacitance | $C_{oss}$ | — | — | 25 | pF | |
| Reverse Transfer Capacitance | $C_{rss}$ | — | — | 5 | pF | |
| **SWITCHING CHARACTERISTICS (Note 5)** | | | | | | |
| Turn-On Delay Time | $td_{(on)}$ | — | — | 20 | ns | $V_{DD}$ = 30V, $V_{GS}$ =10V, $I_D$ = 200mA, $R_G$ = 25 Ohm, $R_L$ = 150 Ohm |
| Turn-Off Delay Time | $td_{(off)}$ | — | — | 40 | ns | |
| **SOURCE-DRAIN (BODY) DIODE CHARACTERISTICS AND MAXIMUM RATINGS** | | | | | | |
| Drain-Source Diode Forward On-Voltage | $V_{SD}$ | — | 0.88 | 1.5 | V | $V_{GS}$ = 0V, $I_S$ = 300 mA* |
| Maximum Continuous Drain-Source Diode Forward Current (Reverse Drain Current) | $I_S$ | — | — | 300 | mA | |
| Maximum Pulsed Drain-Source Diode Forward Current | $I_{SM}$ | — | — | 800 | mA | |

Notes: 5. Short duration pulse test used to minimize self-heating effect.

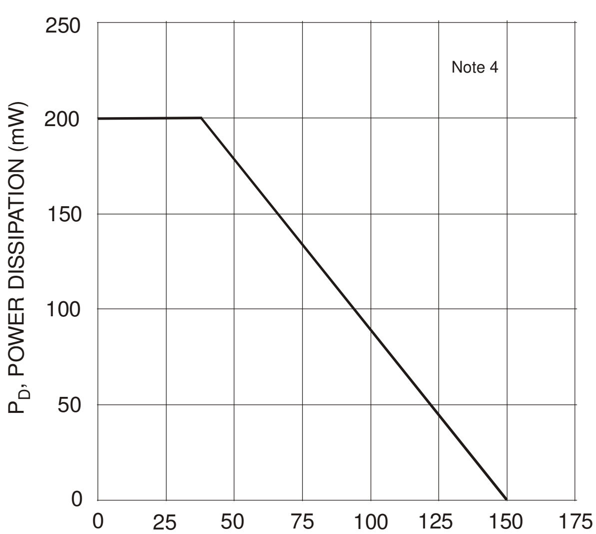



Fig. 3 Max Power Dissipation vs. Ambient Temperature

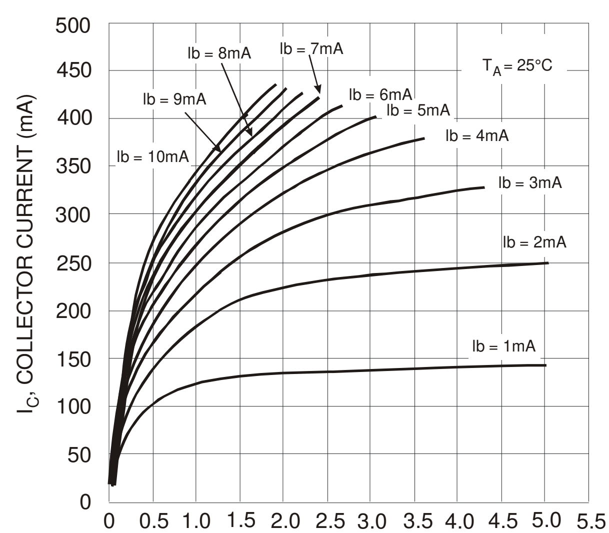



Fig. 4 Output Current vs. Voltage Drop (Pass Element PNP)

## Pre-Biased PNP Transistor Characteristics

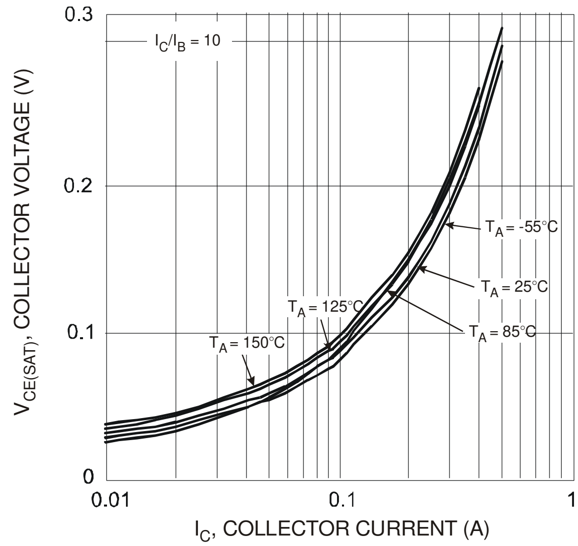



Fig. 5 $V_{CE(SAT)}$ vs. $I_C$ @ $I_C/I_B$ = 10

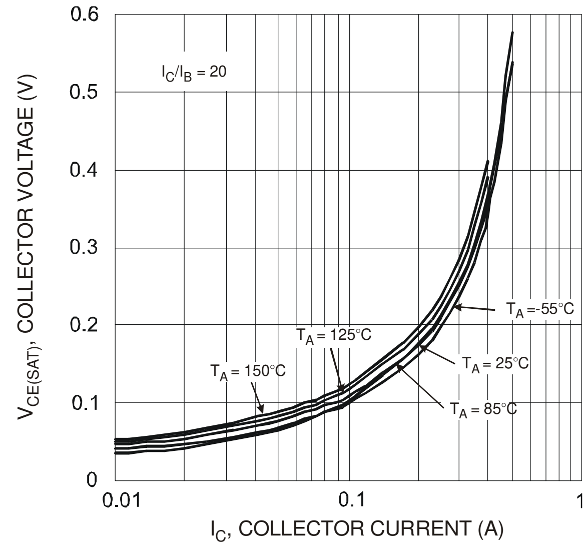



Fig. 6 $V_{CE(SAT)}$ vs. $I_C$ @ $I_C/I_B$ = 20

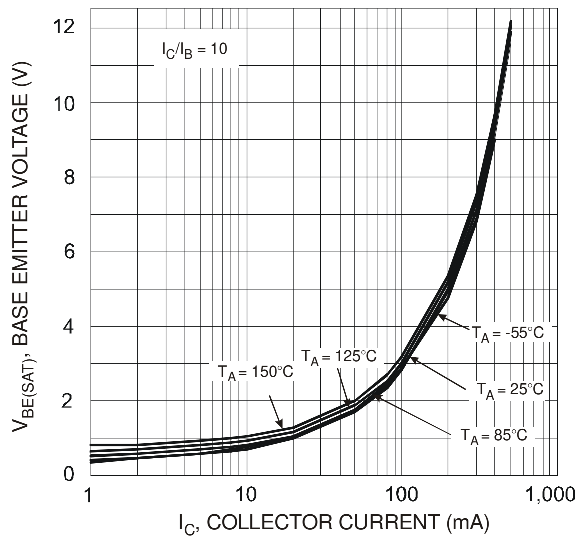



Fig. 7 $V_{BE(SAT)}$ vs. $I_C$ @ $I_C/I_B$ = 10

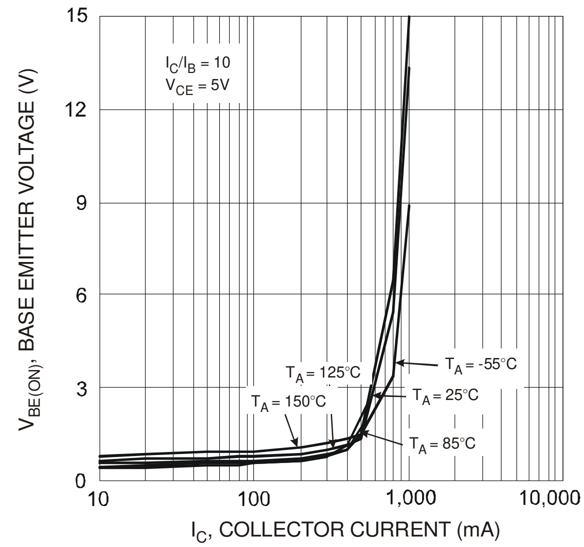



Fig. 8 $V_{BE(ON)}$ vs. $I_C$ @ $V_{CE}$ = 5V

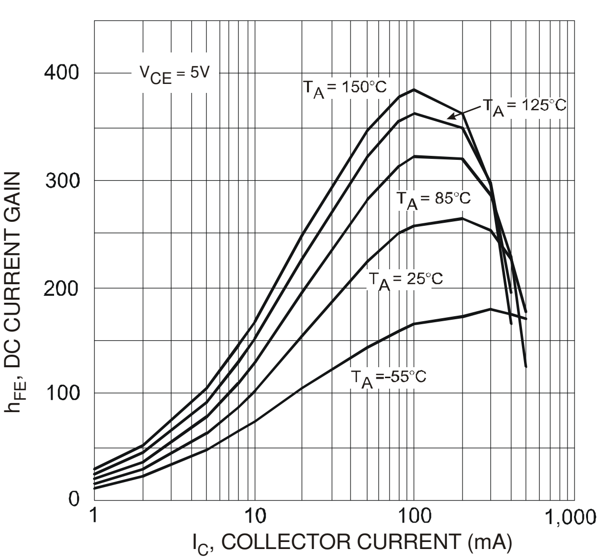



Fig. 9 $h_{FE}$ vs. $I_C$ @ $V_{CE}$ = 5V

# Typical N-Channel MOSFET (ESD Protected) Characteristics

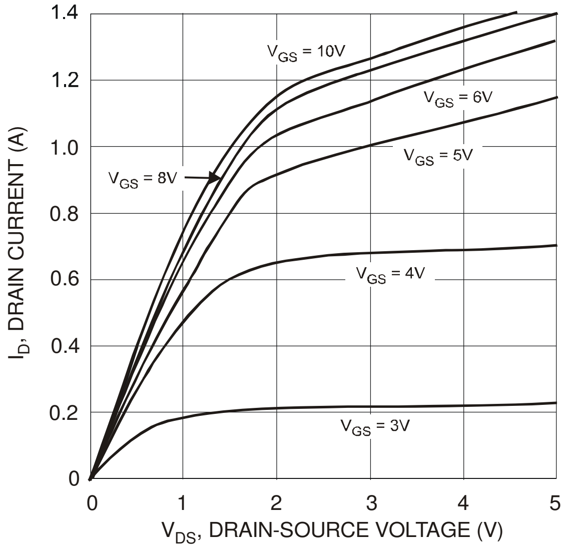



Fig. 10 Output Characteristics

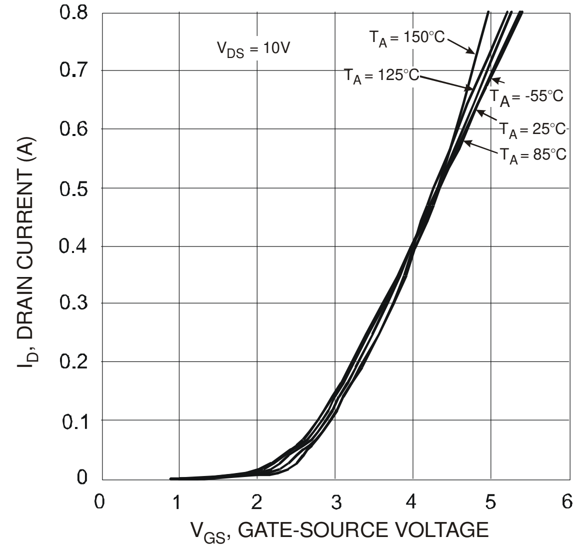



Fig. 11 Transfer Characteristics

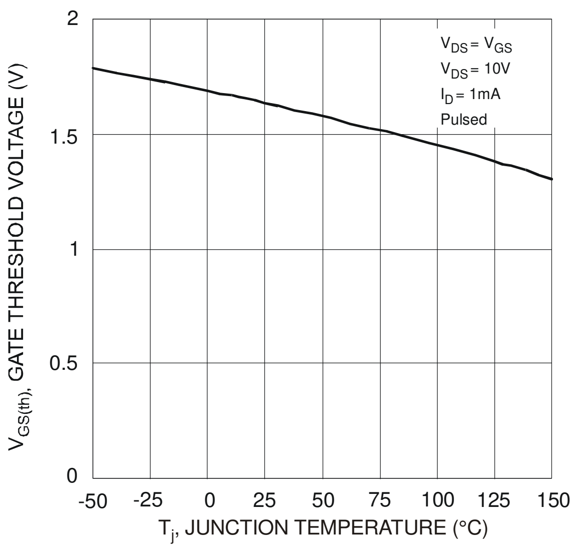



Fig. 12 Gate Threshold Voltage vs. Junction Temperature

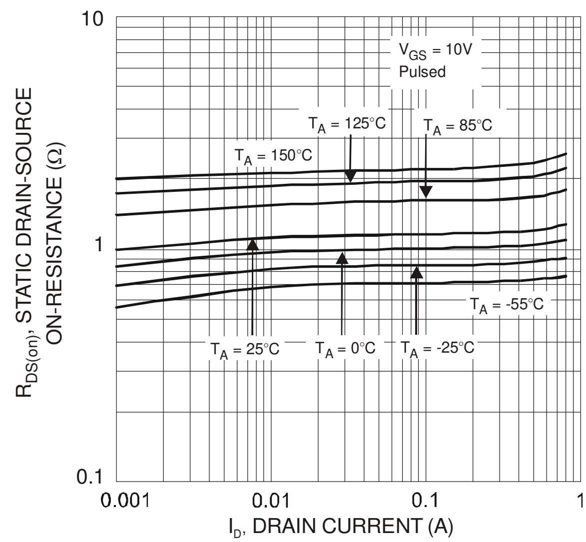



Fig. 13 Static Drain-Source On-Resistance vs. Drain Current

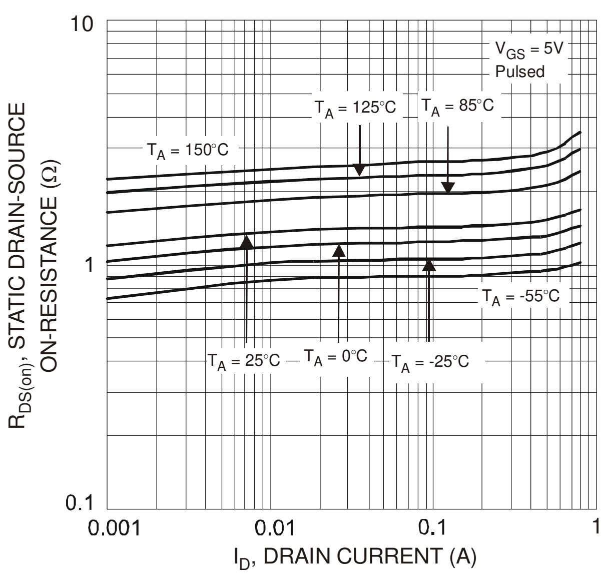



Fig. 14 Static Drain-Source On-Resistance vs. Drain Current

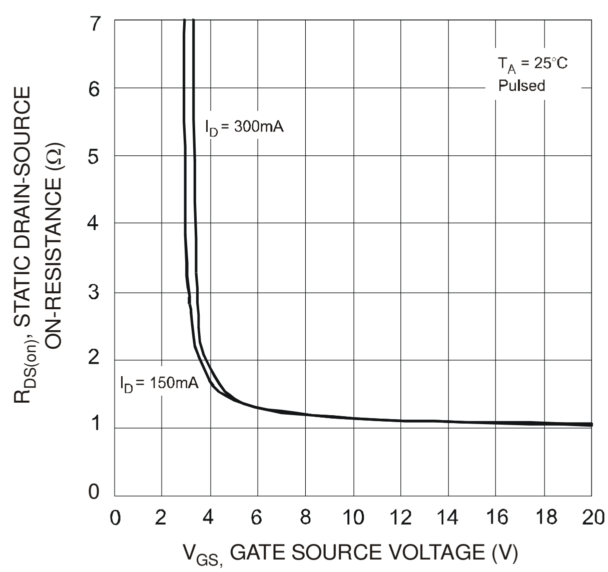



Fig. 15 Static Drain-Source On-Resistance vs. Gate-Source Voltage

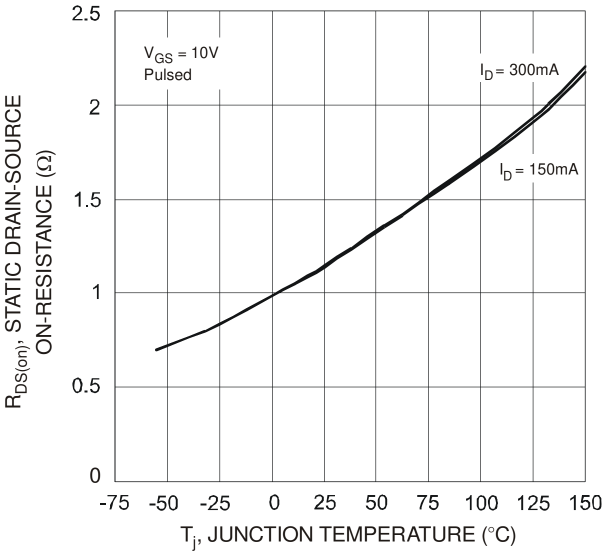



Fig. 16 Static Drain-Source On-State Resistance vs. Junction Temperature

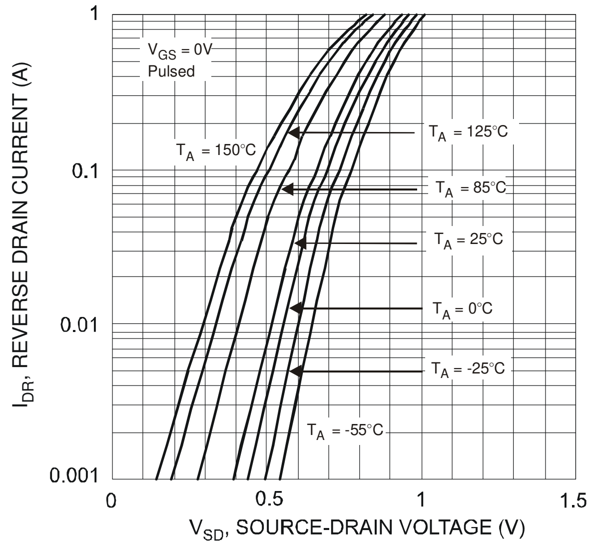



Fig. 17 Reverse Drain Current vs. Source-Drain Voltage

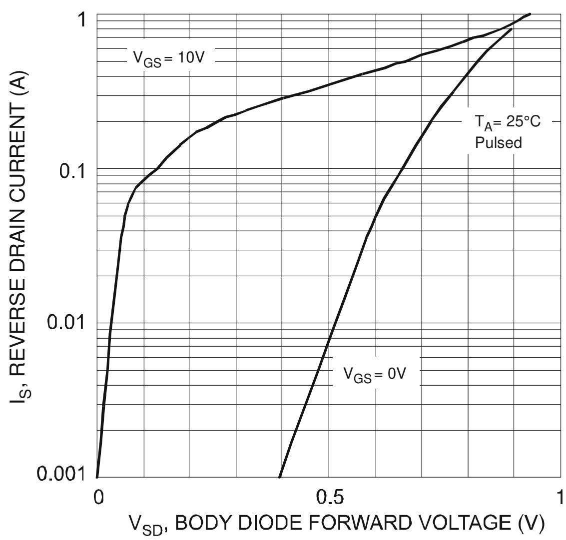



Fig. 18 Reverse Drain Current vs. Source-Drain Voltage

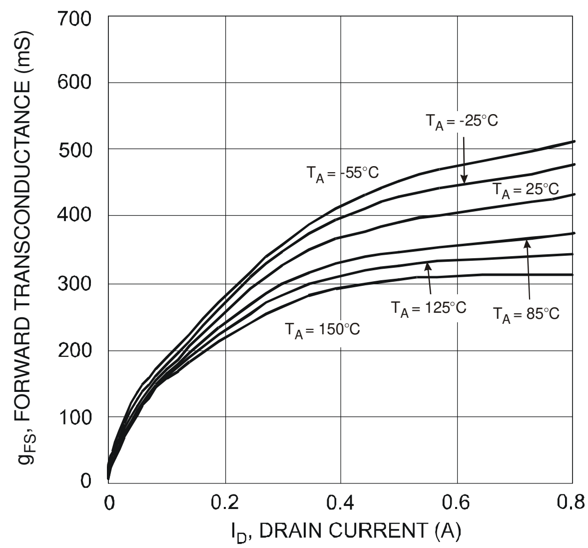



Fig. 19 Forward Transconductance vs. Drain Current ($V_{DS} > I_D * R_{DS(ON)}$)

## Application Details

PNP Transistor and ESD Protected N-MOSFET integrated as one in LMN400E01 can be used as a discrete entity for general application or as an integrated circuit to function as a Load Switch. When it is used as the latter as shown in Fig. 20, various input voltage sources can be used as long as it does not exceed the maximum ratings of the device. These devices are designed to deliver continuous output load current up to a maximum of 400 mA. The MOSFET Switch draws no current, hence loading of control circuitry is prevented. Care must be taken for higher levels of dissipation while designing for higher load conditions. These devices provide high power and also consume less space. The product mainly helps in optimizing power usage, thereby conserving battery life in a controlled load system like portable battery powered applications. (Please see Fig. 21 for one example of a typical application circuit used in conjunction with a voltage regulator as a part of power management system).

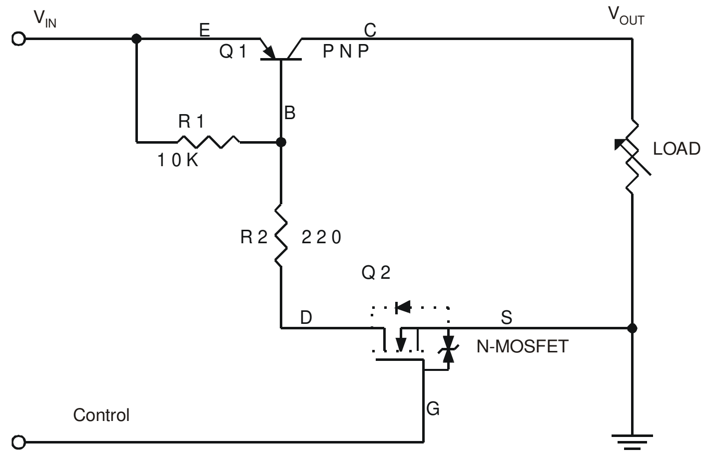



Fig. 20 Circuit Diagram

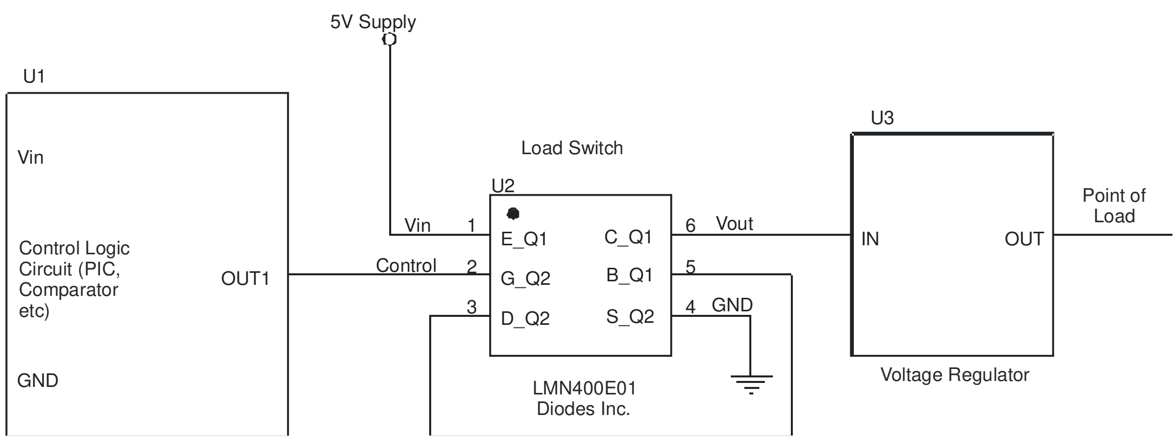
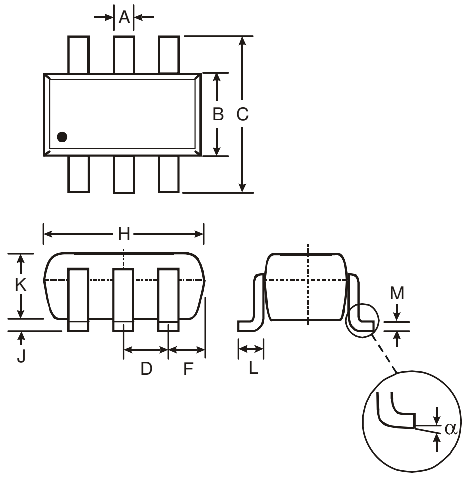


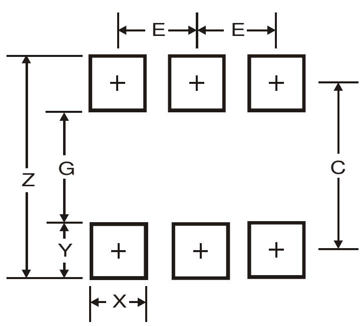

Fig. 21 Typical Application Circuirt

## Package Outline Dimensions




| SOT-363 | | |
|---|---|---|
| **Dim** | **Min** | **Max** |
| **A** | 0.10 | 0.30 |
| **B** | 1.15 | 1.35 |
| **C** | 2.00 | 2.20 |
| **D** | 0.65 Nominal | |
| **F** | 0.30 | 0.40 |
| **H** | 1.80 | 2.20 |
| **J** | - | 0.10 |
| **K** | 0.90 | 1.00 |
| **L** | 0.25 | 0.40 |
| **M** | 0.10 | 0.25 |
| **α** | 0° | 8° |
| **All Dimensions in mm** | | |

## Suggested Pad Layout




| Dimensions | Value (mm) |
|---|---|
| **Z** | 2.5 |
| **G** | 1.3 |
| **X** | 0.42 |
| **Y** | 0.6 |
| **C** | 1.9 |
| **E** | 0.65 |

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