

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

### General 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.

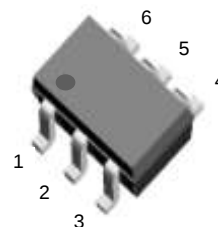


Fig. 1: SOT-363

### Features

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

### Mechanical Data

- Σ Case: SOT-363
- Σ Case Material: Molded Plastic. "Green Molding" Compound. UL Flammability Classification Rating 94V-0
- Σ Moisture sensitivity: Level 1 per J-STD-020C
- Σ Terminal Connections: See Diagram
- Σ Terminals: Finish - Matte Tin annealed over Alloy 42 leadframe. Solderable per MIL-STD-202, Method 208
- Σ Marking & Type Code Information: See Last Page
- Σ Ordering Information: See Last Page
- Σ Weight: 0.016 grams (approximate)

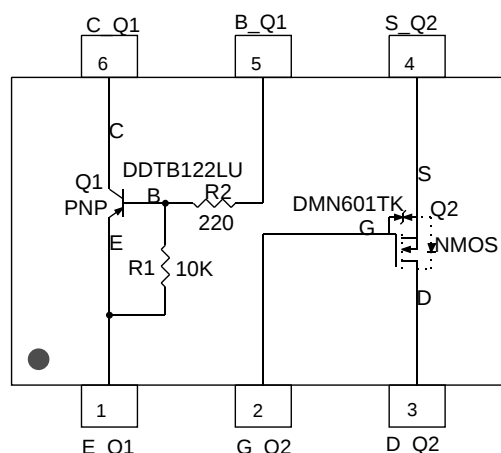


Fig 2 : Schematic and Pin Configuration

| Sub-Component P/N            | Reference | Device Type    | R1(NOM) | R2(NOM) | Figure |
|------------------------------|-----------|----------------|---------|---------|--------|
| DDTB122LU_DIE                | Q1        | PNP Transistor | 10K     | 220     | 2      |
| DMN601TK_DIE (ESD Protected) | Q2        | N-MOSFET       | æ       | æ       | 2      |

### Maximum Ratings, Total Device @ $T_A = 25^{\circ}\text{C}$ unless otherwise specified

| Characteristic                                     | Symbol    | Value | Unit                   |
|----------------------------------------------------|-----------|-------|------------------------|
| Power Dissipation (Note 3)                         | $P_d$     | 200   | mW                     |
| Power Derating Factor above $37.5^{\circ}\text{C}$ | $P_{der}$ | 1.6   | mW/ $^{\circ}\text{C}$ |
| Output Current                                     | $I_{out}$ | 400   | mA                     |

### Thermal Characteristics

| Characteristic                                                                                             | Symbol         | Value       | Unit                 |
|------------------------------------------------------------------------------------------------------------|----------------|-------------|----------------------|
| Junction Operation and Storage Temperature Range                                                           | $T_j, T_{stg}$ | -55 to +150 | $^{\circ}\text{C}$   |
| Thermal Resistance, Junction to Ambient Air (Note 3) (Equivalent to one heated junction of PNP transistor) | $R_{qJA}$      | 625         | $^{\circ}\text{C/W}$ |

- Notes:
1. No purposefully added lead.
  2. Diodes Inc.'s "Green" policy can be found on our website at [http://www.diodes.com/products/lead\\_free/index.php](http://www.diodes.com/products/lead_free/index.php).
  3. 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>.

**Maximum Ratings:** @  $T_A = 25^\circ\text{C}$  unless otherwise specified

**Sub-Component Device: Pre-Biased PNP Transistor (Q1)**

| 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             | $V_{in}$  | +5 to -6 | V    |
| Output Current            | $I_C$     | -400     | mA   |

**Sub-Component Device:** @  $T_A = 25^\circ\text{C}$  unless otherwise specified

**ESD Protected N-Channel MOSFET (Q2)**

| Characteristic                                                      | Symbol    | Value | Unit |
|---------------------------------------------------------------------|-----------|-------|------|
| Drain-Source Voltage                                                | $V_{DSS}$ | 60    | V    |
| Drain Gate Voltage ( $R_{GS} \leq 1\text{M}\Omega$ )                | $V_{DGR}$ | 60    | V    |
| Gate-Source Voltage Continuous                                      | $V_{GSS}$ | +/-20 | V    |
| Pulsed ( $t_p < 50 \mu\text{s}$ )                                   |           | +/-40 |      |
| Drain Current (Page 1: Note 3) Continuous ( $V_{GS} = 10\text{V}$ ) | $I_D$     | 300   | mA   |
| Pulsed ( $t_p < 10 \mu\text{s}$ , Duty Cycle $< 1\%$ )              |           | 800   |      |
| Continuous Source Current                                           | $I_S$     | 300   | mA   |

**Electrical Characteristics: Pre-Biased PNP Transistor (Q1) @ T<sub>A</sub> = 25°C unless otherwise specified**

| Characteristic                                               | Symbol                                | Min   | Typ   | Max   | Unit            | Test Condition                                                                                 |
|--------------------------------------------------------------|---------------------------------------|-------|-------|-------|-----------------|------------------------------------------------------------------------------------------------|
| <b>OFF CHARACTERISTICS</b>                                   |                                       |       |       |       |                 |                                                                                                |
| Collector-Base Cut Off Current                               | I <sub>CBO</sub>                      | æ     | æ     | -100  | nA              | V <sub>CB</sub> = -50V, I <sub>E</sub> = 0                                                     |
| Collector-Emitter Cut Off Current                            | I <sub>CEO</sub>                      | æ     | æ     | -500  | nA              | V <sub>CE</sub> = -50V, I <sub>B</sub> = 0                                                     |
| Emitter-Base Cut Off Current                                 | I <sub>EBO</sub>                      | æ     | æ     | -1    | mA              | V <sub>EB</sub> = -5V, I <sub>C</sub> = 0                                                      |
| Collector-Base Breakdown Voltage                             | V <sub>(BR)CBO</sub>                  | -50   | æ     | æ     | V               | I <sub>C</sub> = -10 µA, I <sub>E</sub> = 0                                                    |
| Collector-Emitter Breakdown Voltage                          | V <sub>(BR)CEO</sub>                  | -50   | æ     | æ     | V               | I <sub>C</sub> = -2 mA, I <sub>B</sub> = 0                                                     |
| Input Off Voltage                                            | V <sub>I(OFF)</sub>                   | æ     | -0.55 | -0.3  | V               | V <sub>CE</sub> = -5V, I <sub>C</sub> = -100µA                                                 |
| Output Voltage                                               | V <sub>OH</sub>                       | -4.9  | æ     | æ     | V               | V <sub>CC</sub> = -5V, V <sub>B</sub> = -0.05V, R <sub>L</sub> = 1K                            |
| Output Current (leakage current same as I <sub>CEO</sub> )   | I <sub>O(OFF)</sub>                   | æ     | æ     | -500  | nA              | V <sub>CC</sub> = -50V, V <sub>I</sub> = 0V                                                    |
| <b>ON CHARACTERISTICS</b>                                    |                                       |       |       |       |                 |                                                                                                |
| Collector-Emitter Saturation Voltage                         | V <sub>CE(SAT)</sub>                  | æ     | æ     | -0.15 | V               | I <sub>C</sub> = -10 mA, I <sub>B</sub> = -0.3 mA                                              |
|                                                              |                                       | æ     | æ     | -0.15 | V               | I <sub>C</sub> = -200mA, I <sub>B</sub> = -20mA                                                |
|                                                              |                                       | æ     | æ     | -0.3  | V               | I <sub>C</sub> = -100mA, I <sub>B</sub> = -1mA                                                 |
|                                                              |                                       | æ     | æ     | -0.2  | V               | I <sub>C</sub> = -300mA, I <sub>B</sub> = -30mA                                                |
|                                                              |                                       | æ     | æ     | -0.25 | V               | I <sub>C</sub> = -400mA, I <sub>B</sub> = -40mA                                                |
|                                                              |                                       | æ     | æ     | -0.3  | V               | I <sub>C</sub> = -500mA, I <sub>B</sub> = -50mA                                                |
| Equivalent on-resistance*                                    | R <sub>CE(SAT)</sub>                  | æ     | æ     | 1.125 | W               | I <sub>C</sub> = -400mA, I <sub>B</sub> = -20mA                                                |
| DC Current Gain                                              | h <sub>FE</sub>                       | 70    | 220   | æ     | æ               | V <sub>CE</sub> = -5V, I <sub>C</sub> = -50 mA                                                 |
|                                                              |                                       | 70    | 260   | æ     | æ               | V <sub>CE</sub> = -5V, I <sub>C</sub> = -100 mA                                                |
|                                                              |                                       | 70    | 265   | æ     | æ               | V <sub>CE</sub> = -5V, I <sub>C</sub> = -200 mA                                                |
|                                                              |                                       | 70    | 225   | æ     | æ               | V <sub>CE</sub> = -5V, I <sub>C</sub> = -400 mA                                                |
| Input On Voltage                                             | V <sub>I(ON)</sub>                    | -2.45 | -1.5  | æ     | V <sub>dc</sub> | V <sub>O</sub> = -0.3V, I <sub>C</sub> = -2 mA                                                 |
| Output Voltage (equivalent to V <sub>CE(SAT)</sub> )         | V <sub>O(on)</sub> (V <sub>OL</sub> ) | æ     | -0.1  | -0.3  | V <sub>dc</sub> | V <sub>CC</sub> = -5V, V <sub>B</sub> = -2.5V, I <sub>O</sub> /I <sub>I</sub> = -50mA / -2.5mA |
| Input Current                                                | I <sub>i</sub>                        | æ     | -18   | -28   | mA              | V <sub>I</sub> = -5V                                                                           |
| Base-Emitter Turn-on Voltage                                 | V <sub>BE(ON)</sub>                   | æ     | -1.2  | -1.3  | V               | V <sub>CE</sub> = -5V, I <sub>C</sub> = -400mA                                                 |
| Base-Emitter Saturation Voltage                              | V <sub>BE(SAT)</sub>                  | æ     | -1.9  | -2.2  | V               | I <sub>C</sub> = -50mA, I <sub>B</sub> = -5mA                                                  |
|                                                              |                                       | æ     | -5.25 | -5.5  |                 | I <sub>C</sub> = -400mA, I <sub>B</sub> = -20mA                                                |
| Input Resistor (Base), +/- 30%                               | R2                                    | 0.154 | 0.22  | 0.286 | KW              | æ                                                                                              |
| Pull-up Resistor (Base to Vcc supply), +/- 30%               | R1                                    | æ     | 10    | æ     | KW              | æ                                                                                              |
| Resistor Ratio (Input Resistor/Pullup resistor)              | R1/R2                                 | 36    | 45    | 55    | æ               | æ                                                                                              |
| <b>SMALL SIGNAL CHARACTERISTICS</b>                          |                                       |       |       |       |                 |                                                                                                |
| Transition Frequency (gain bandwidth product)                | f <sub>T</sub>                        | æ     | 200   | æ     | MHz             | V <sub>CE</sub> = -10V, I <sub>E</sub> = -5mA, f = 100MHz                                      |
| Collector capacitance, (C <sub>cb</sub> -Output Capacitance) | CC                                    | æ     | 20    | æ     | pF              | V <sub>CB</sub> = -10V, I <sub>E</sub> = 0A, f = 1MHz                                          |

\* Pulse Test: Pulse width, tp < 300 µs, Duty Cycle, d ≤ 0.02

**Electrical Characteristics: ESD Protected N Channel MOSFET (Q2) @  $T_A = 25^\circ\text{C}$  unless otherwise specified**

| Characteristic                                                                | Symbol               | Min | Typ  | Max  | Unit | Test Condition                                                                                                               |
|-------------------------------------------------------------------------------|----------------------|-----|------|------|------|------------------------------------------------------------------------------------------------------------------------------|
| OFF CHARACTERISTICS (Note 4)                                                  |                      |     |      |      |      |                                                                                                                              |
| Drain-Source Breakdown Voltage, BVDSS                                         | V <sub>(BR)DSS</sub> | 60  | æ    | æ    | V    | V <sub>GS</sub> = 0V, I <sub>D</sub> = 10uA                                                                                  |
| Zero Gate Voltage Drain Current (Drain Leakage Current)                       | I <sub>DSS</sub>     | æ   | æ    | 1    | nA   | V <sub>GS</sub> =0V, V <sub>DS</sub> = 60V                                                                                   |
| Gate-Body Leakage Current, Forward                                            | I <sub>GSSF</sub>    | æ   | æ    | 10   | nA   | V <sub>GS</sub> = 20V, V <sub>DS</sub> = 0V                                                                                  |
| Gate-Body Leakage Current, Reverse                                            | I <sub>GSSR</sub>    | æ   | æ    | -10  | nA   | V <sub>GS</sub> = -20V, V <sub>DS</sub> = 0V                                                                                 |
| ON CHARACTERISTICS (Note 4)                                                   |                      |     |      |      |      |                                                                                                                              |
| Gate Source Threshold Voltage (Control Supply Voltage)                        | V <sub>GS(th)</sub>  | 1   | 1.6  | 2.5  | V    | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 0.25mA                                                                  |
| Static Drain-Source On-State Voltage                                          | V <sub>DS(on)</sub>  | æ   | 0.09 | 1.5  | V    | V <sub>GS</sub> = 5V, I <sub>D</sub> = 50mA                                                                                  |
|                                                                               |                      | æ   | 0.6  | 3.75 |      | V <sub>GS</sub> = 10V, I <sub>D</sub> = 500mA                                                                                |
| On-State Drain Current                                                        | I <sub>D(on)</sub>   | 500 | æ    | æ    | mA   | V <sub>GS</sub> = 10V,<br>V <sub>DS</sub> ≥2*V <sub>DS(ON)</sub>                                                             |
| Static Drain-Source On Resistance                                             | R <sub>DS(on)</sub>  | æ   | 1.6  | 3    | W    | V <sub>GS</sub> = 5V, I <sub>D</sub> = 50mA                                                                                  |
|                                                                               |                      | æ   | 1.2  | 2    |      | V <sub>GS</sub> = 10V, I <sub>D</sub> = 500mA                                                                                |
| Forward Transconductance                                                      | g <sub>FS</sub>      | 80  | 260  | æ    | mS   | V <sub>DS</sub> ≥2*V <sub>DS(ON)</sub> ,<br>I <sub>D</sub> = 200 mA                                                          |
| DYNAMIC CHARACTERISTICS                                                       |                      |     |      |      |      |                                                                                                                              |
| Input Capacitance                                                             | C <sub>ISS</sub>     | æ   | æ    | 50   | pF   | V <sub>DS</sub> = -25V, V <sub>GS</sub> = 0V,<br>f = 1MHz                                                                    |
| Output Capacitance                                                            | C <sub>OSS</sub>     | æ   | æ    | 25   | pF   |                                                                                                                              |
| Reverse Transfer Capacitance                                                  | C <sub>RSS</sub>     | æ   | æ    | 5    | pF   |                                                                                                                              |
| SWITCHING CHARACTERISTICS*                                                    |                      |     |      |      |      |                                                                                                                              |
| Turn-On Delay Time                                                            | td <sub>(on)</sub>   | æ   | æ    | 20   | ns   | V <sub>DD</sub> = 30V, V <sub>GS</sub> =10V,<br>I <sub>D</sub> = 200mA,<br>R <sub>G</sub> = 25 Ohm, R <sub>L</sub> = 150 Ohm |
| Turn-Off Delay Time                                                           | td <sub>(off)</sub>  | æ   | æ    | 40   | ns   |                                                                                                                              |
| SOURCE-DRAIN (BODY) DIODE CHARACTERISTICS AND MAXIMUM RATINGS                 |                      |     |      |      |      |                                                                                                                              |
| Drain-Source Diode Forward On-Voltage                                         | V <sub>SD</sub>      | æ   | 0.88 | 1.5  | V    | V <sub>GS</sub> = 0V, I <sub>S</sub> = 300 mA*                                                                               |
| Maximum Continuous Drain-Source Diode Forward Current (Reverse Drain Current) | I <sub>S</sub>       | æ   | æ    | 300  | mA   |                                                                                                                              |
| Maximum Pulsed Drain-Source Diode Forward Current                             | I <sub>SM</sub>      | æ   | æ    | 800  | mA   |                                                                                                                              |

\* Pulse Test: Pulse width,  $t_p < 300\mu s$ , Duty Cycle,  $d \leq 0.02$

Notes: 4. Short duration test pulse used to minimize self-heating effect.

## Typical Characteristics

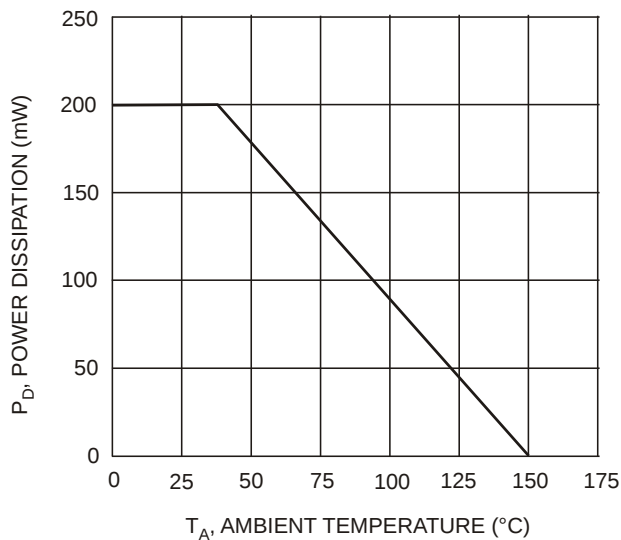


Fig. 3, Max Power Dissipation vs Ambient Temperature

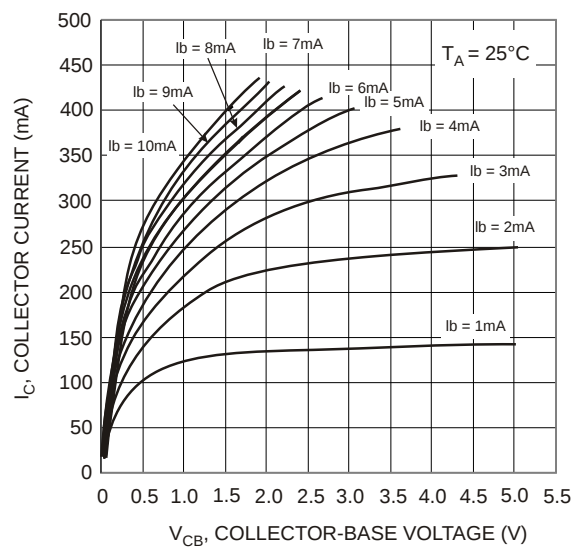


Fig. 4, Output Current vs. Voltage Drop (Pass Element PNP)

## Pre-Biased PNP Transistor Characteristics

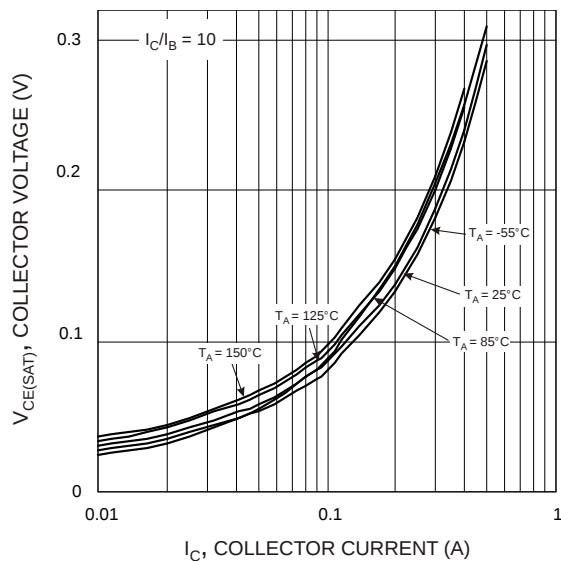


Fig. 5  $V_{CE(SAT)}$  vs.  $I_C$  @  $I_C/I_B = 10$

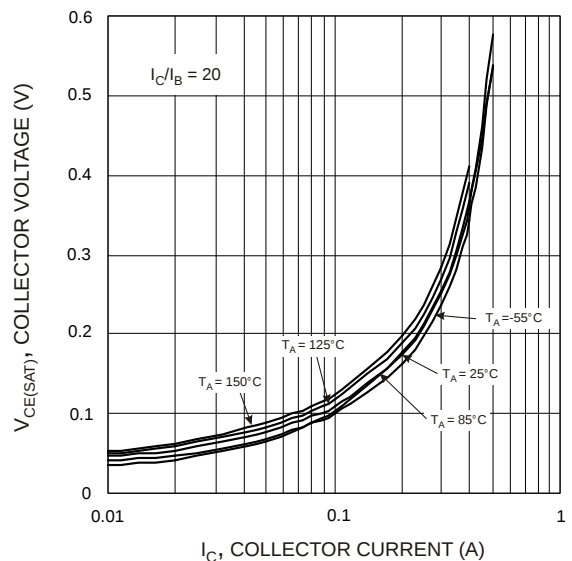


Fig. 6  $V_{CE(SAT)}$  vs.  $I_C$  @  $I_C/I_B = 20$

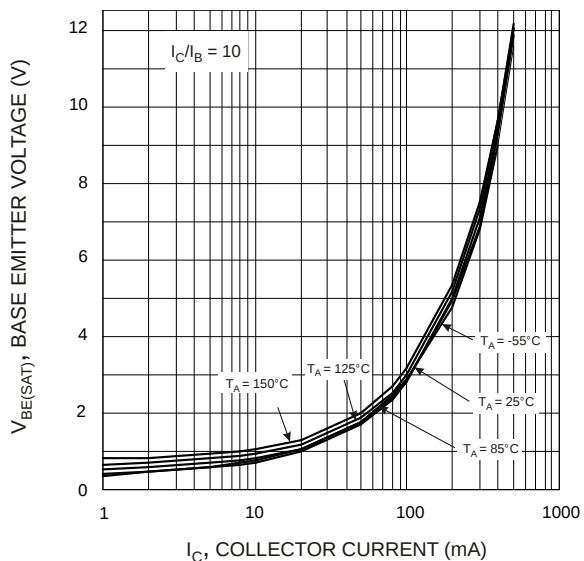


Fig. 7  $V_{BE(SAT)}$  vs.  $I_C$  @  $I_C/I_B = 10$

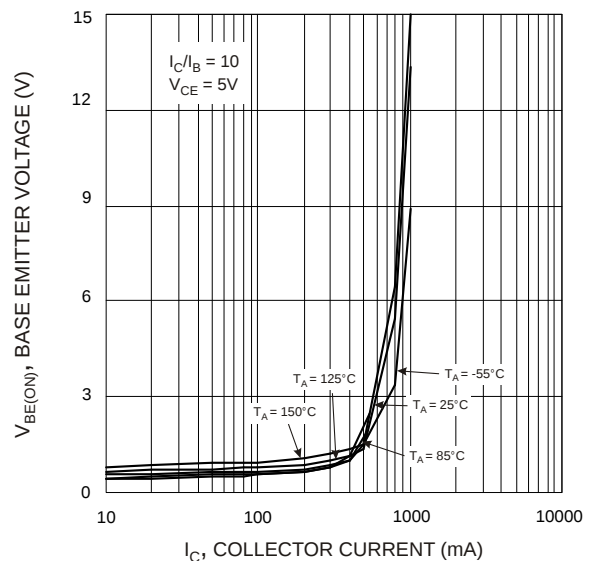
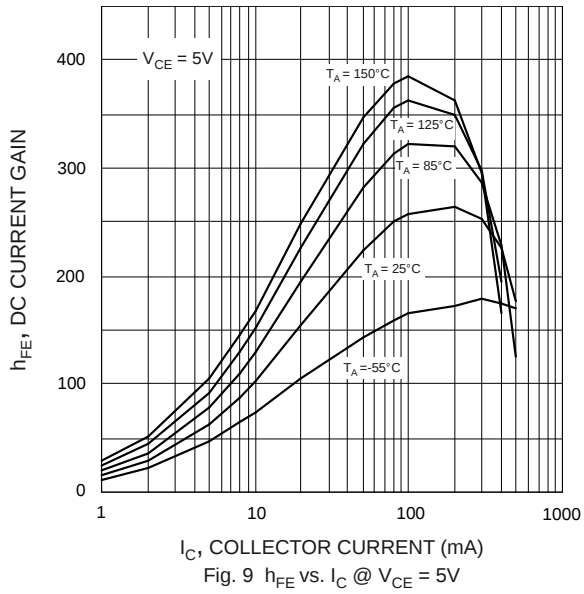
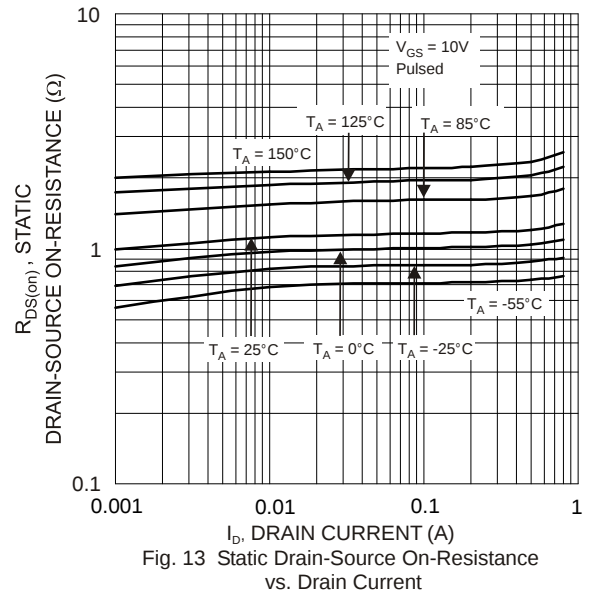
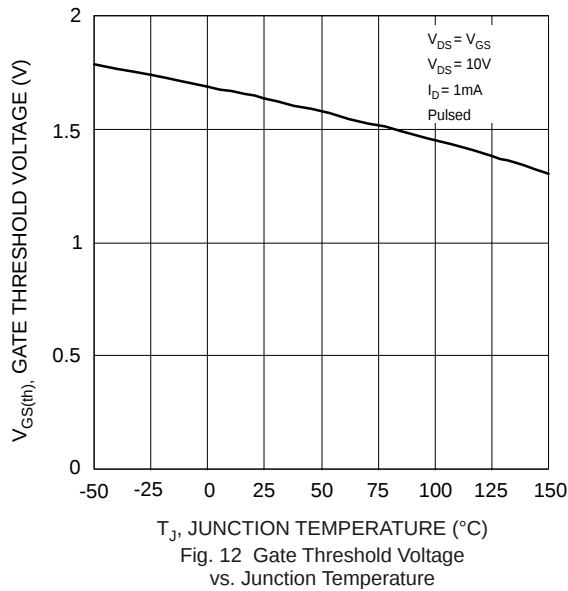
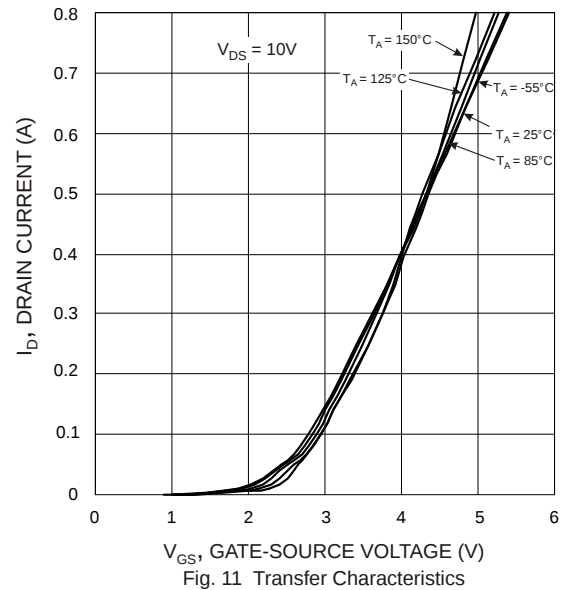
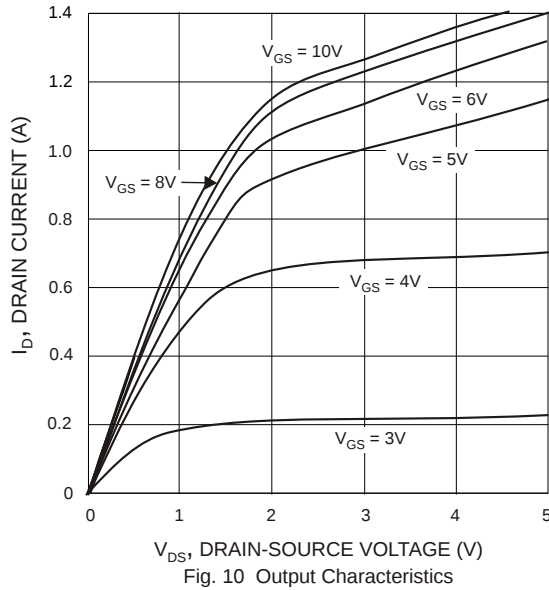


Fig. 8  $V_{BE(ON)}$  vs.  $I_C$  @  $V_{CE} = 5V$



### Typical N-Channel MOSFET (ESD Protected) Characteristics



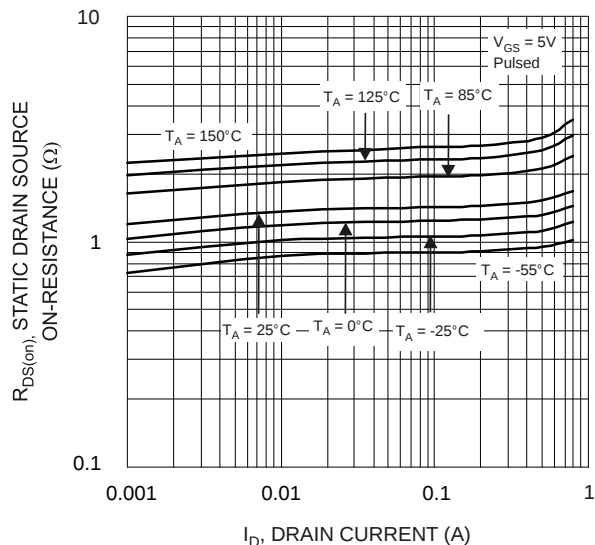


Fig. 14 Static Drain-Source On-Resistance vs. Drain Current

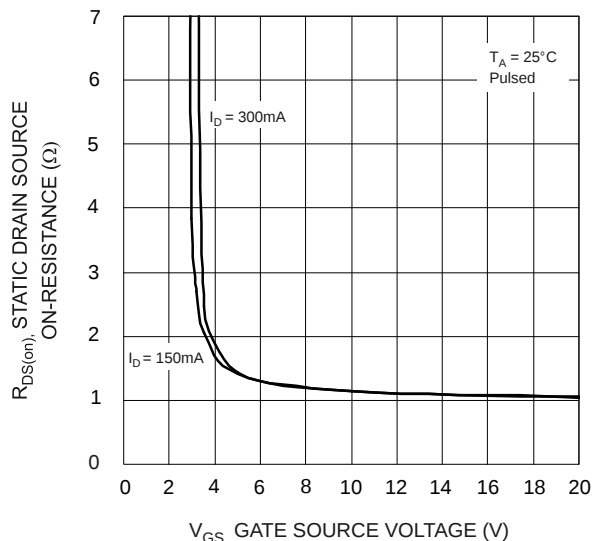


Fig. 15 Static Drain-Source On-Resistance vs. Gate-Source Voltage

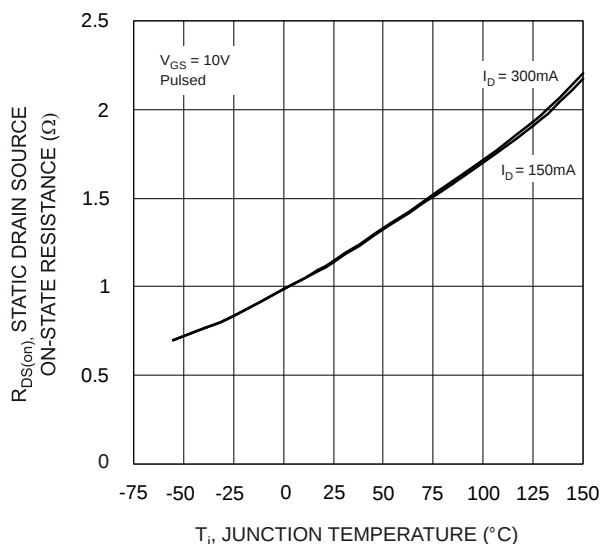


Fig. 16 Static Drain-Source On-State Resistance vs. Junction Temperature

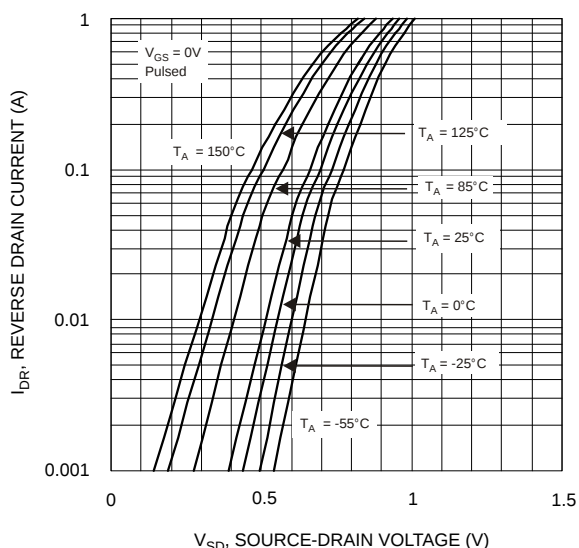


Fig. 17 Reverse Drain Current vs. Source-Drain Voltage

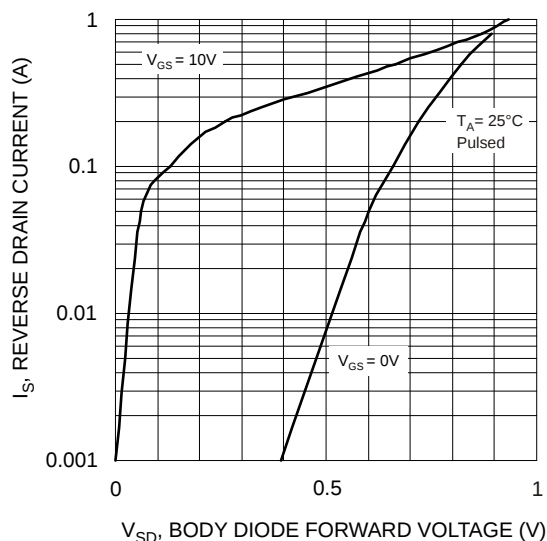


Fig. 18 Reverse Drain Current vs. Source-Drain Voltage

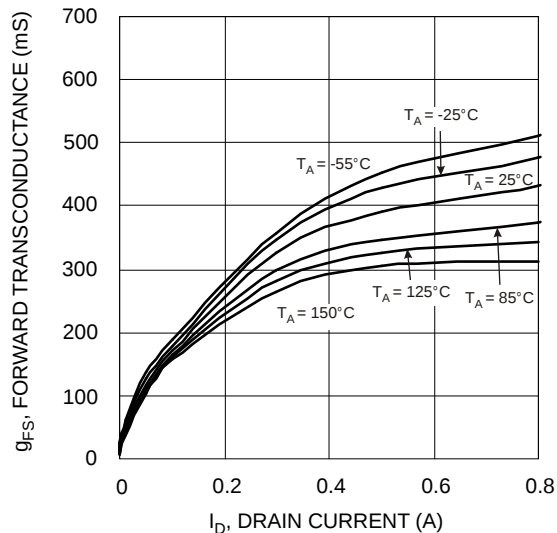


Fig. 19 Forward Transconductance vs. Drain Current ( $V_{DS} > I_D \cdot R_{DS(on)}$ )

## Application Details

Σ PNP Transistor (DDTB122LU) and ESD Protected N-MOSFET (DMN601TK) 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).

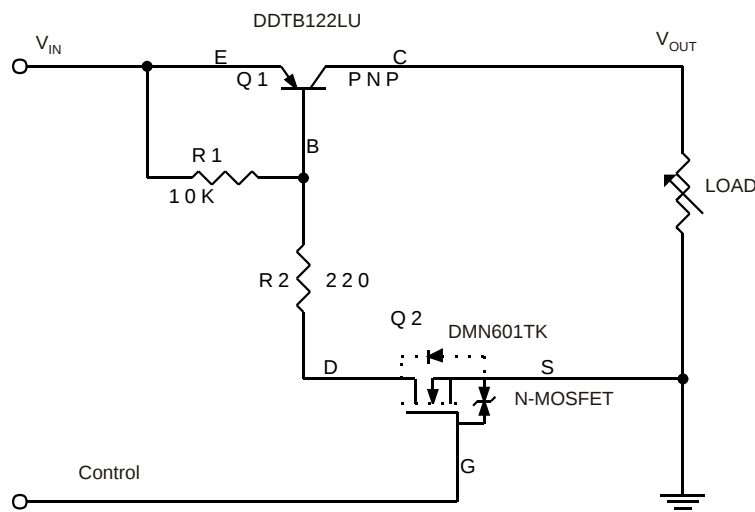


Fig 20 : Circuit Diagram

## Typical Application Circuit

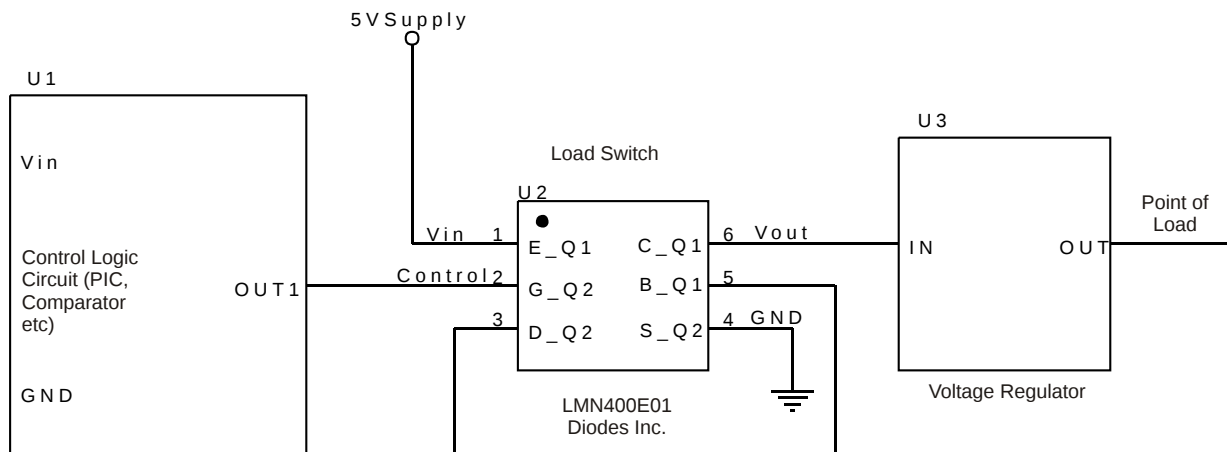


Fig 21

**Ordering Information** (Note 4)

| Device      | Marking Code | Packaging | Shipping         |
|-------------|--------------|-----------|------------------|
| LMN400E01-7 | PM5          | SOT-363   | 3000/Tape & Reel |

Notes: 4. For Packaging Details, go to our website at <http://www.diodes.com/datasheets/ap02007.pdf>.

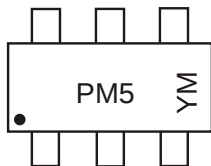
**Marking Information**


Fig. 22

PM5 = Product Type Marking Code,  
 YM = Date Code Marking  
 Y = Year, e.g., T = 2006  
 M = Month, e.g., 9 = September

**Date Code Key**

| Year | 2006 | 2007 | 2008 | 2009 |
|------|------|------|------|------|
| Code | T    | U    | V    | W    |

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

## Package Details

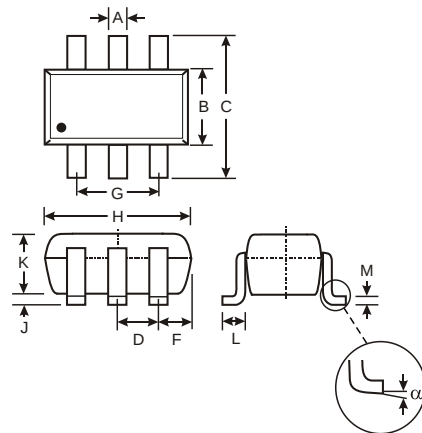


Fig. 23

| 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                    | æ            | 0.10 |
| K                    | 0.90         | 1.00 |
| L                    | 0.25         | 0.40 |
| M                    | 0.10         | 0.25 |
| a                    | 0°           | 8°   |
| All Dimensions in mm |              |      |

## Suggested Pad Layout: (Based on IPC-SM-782)

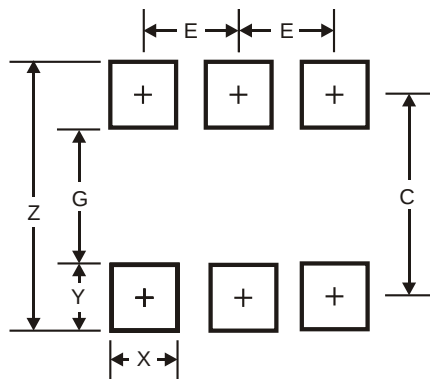


Fig. 24

| Figure 14 Dimensions | SOT-363* |
|----------------------|----------|
| Z                    | 2.5      |
| G                    | 1.3      |
| X                    | 0.42     |
| Y                    | 0.6      |
| C                    | 1.9      |
| E                    | 0.65     |

\* Typical dimensions in mm

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