

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

**NEW PRODUCT**

### 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.

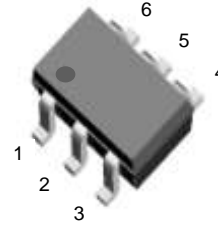


Fig. 1: SOT-363

### Features

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

### Mechanical Data

- Case: SOT-363
- 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 & Type Code Information: See Last Page
- Ordering Information: See Last Page
- Weight: 0.016 grams (approximate)

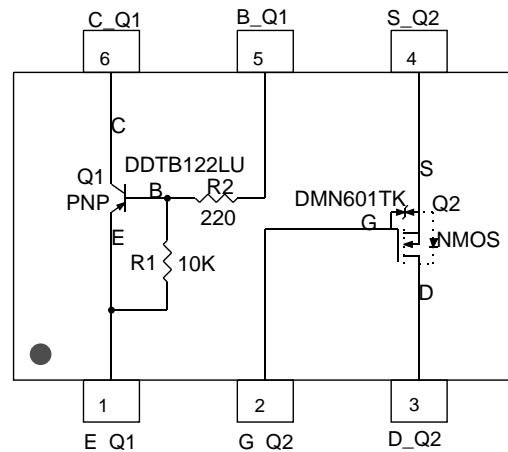


Fig 2 : Schematic and Pin Configuration

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			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)	$R_{JA}$	625	$^\circ\text{C}/\text{W}$

- Notes:
- No purposefully added lead.
  - 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).
  - 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 ( $R_{GS} = 1\text{M}\Omega$ )	$V_{DGR}$	60	V
Gate-Source Voltage	$V_{GSS}$	Continuous	+/-20
		Pulsed ( $t_p < 50 \mu\text{s}$ )	+/-40
Drain Current (Page 1: Note 3)	$I_D$	Continuous ( $V_{GS} = 10\text{V}$ )	300
		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>			-100	nA	V <sub>CB</sub> = -50V, I <sub>E</sub> = 0
Collector-Emitter Cut Off Current	I <sub>CEO</sub>			-500	nA	V <sub>CE</sub> = -50V, I <sub>B</sub> = 0
Emitter-Base Cut Off Current	I <sub>EBO</sub>			-1	mA	V <sub>EB</sub> = -5V, I <sub>C</sub> = 0
Collector-Base Breakdown Voltage	V <sub>(BR)CBO</sub>	-50			V	I <sub>C</sub> = -10 uA, I <sub>E</sub> = 0
Collector-Emitter Breakdown Voltage	V <sub>(BR)CEO</sub>	-50			V	I <sub>C</sub> = -2 mA, I <sub>B</sub> = 0
Input Off Voltage	V <sub>I(OFF)</sub>		-0.55	-0.3	V	V <sub>CE</sub> = -5V, I <sub>C</sub> = -100uA
Output Voltage	V <sub>OH</sub>	-4.9			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>			-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>			-0.15	V	I <sub>C</sub> = -10 mA, I <sub>B</sub> = -0.3 mA
				-0.15	V	I <sub>C</sub> = -200mA, I <sub>B</sub> = -20mA
				-0.3	V	I <sub>C</sub> = -100mA, I <sub>B</sub> = -1mA
				-0.2	V	I <sub>C</sub> = -300mA, I <sub>B</sub> = -30mA
				-0.25	V	I <sub>C</sub> = -400mA, I <sub>B</sub> = -40mA
				-0.3	V	I <sub>C</sub> = -500mA, I <sub>B</sub> = -50mA
Equivalent on-resistance*	R <sub>CE(SAT)</sub>			1.125		I <sub>C</sub> = -400mA, I <sub>B</sub> = -20mA
DC Current Gain	h <sub>FE</sub>	70	220			V <sub>CE</sub> = -5V, I <sub>C</sub> = -50 mA
		70	260			V <sub>CE</sub> = -5V, I <sub>C</sub> = -100 mA
		70	265			V <sub>CE</sub> = -5V, I <sub>C</sub> = -200 mA
		70	225			V <sub>CE</sub> = -5V, I <sub>C</sub> = -400 mA
Input On Voltage	V <sub>I(ON)</sub>	-2.45	-1.5		V <sub>dc</sub>	V <sub>O</sub> = -0.3V, I <sub>I</sub> = -2 mA
Output Voltage (equivalent to V <sub>CE(SAT)</sub> )	V <sub>O(on)</sub> (V <sub>OL</sub> )		-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>		-18	-28	mA	V <sub>I</sub> = -5V
Base-Emitter Turn-on Voltage	V <sub>BE(ON)</sub>		-1.2	-1.3	V	V <sub>CE</sub> = -5V, I <sub>C</sub> = -400mA
Base-Emitter Saturation Voltage	V <sub>BE(SAT)</sub>		-1.9	-2.2	V	I <sub>C</sub> = -50mA, I <sub>B</sub> = -5mA
			-5.25	-5.5	V	I <sub>C</sub> = -400mA, I <sub>B</sub> = -20mA
Input Resistor (Base), +/- 30%	R <sub>2</sub>	0.154	0.22	0.286	K	
Pull-up Resistor (Base to V <sub>CC</sub> supply), +/- 30%	R <sub>1</sub>		10		K	
Resistor Ratio (Input Resistor/Pullup resistor)	R <sub>1</sub> /R <sub>2</sub>	36	45	55		
<b>SMALL SIGNAL CHARACTERISTICS</b>						
Transition Frequency (gain bandwidth product)	f <sub>T</sub>		200		MHz	V <sub>CE</sub> = -10V, I <sub>E</sub> = -5mA, f = 100MHz
Collector capacitance, (C <sub>cb</sub> -Output Capacitance)	CC		20		pF	V <sub>CB</sub> = -10V, I <sub>E</sub> = 0A, f = 1MHz

\* Pulse Test: Pulse width, t<sub>p</sub> < 300 us, Duty Cycle, d = 0.02

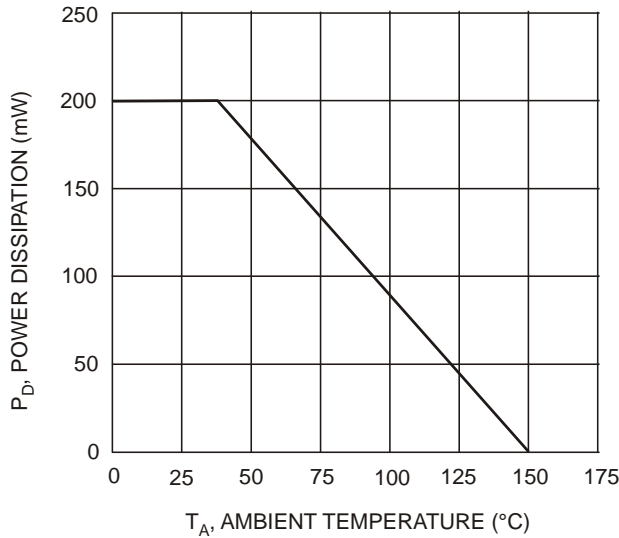
**Electrical Characteristics: ESD Protected N Channel MOSFET (Q2) @  $T_A = 25^\circ\text{C}$  unless otherwise specified**

Characteristic	Symbol	Min	Typ	Max	Unit	Test Condition
<b>OFF CHARACTERISTICS (Note 4)</b>						
Drain-Source Breakdown Voltage, BVDSS	$V_{(BR)DSS}$	60			V	$V_{GS} = 0V, I_D = 10\mu A$
Zero Gate Voltage Drain Current (Drain Leakage Current)	$I_{DSS}$			1	$\mu A$	$V_{GS} = 0V, V_{DS} = 60V$
Gate-Body Leakage Current, Forward	$I_{GSSF}$			10	$\mu A$	$V_{GS} = 20V, V_{DS} = 0V$
Gate-Body Leakage Current, Reverse	$I_{GSSR}$			-10	$\mu A$	$V_{GS} = -20V, V_{DS} = 0V$
<b>ON CHARACTERISTICS (Note 4)</b>						
Gate Source Threshold Voltage (Control Supply 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	1.5	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		$V_{GS} = 5V, I_D = 50mA$
			1.2	2		$V_{GS} = 10V, I_D = 500mA$
Forward Transconductance	$g_{FS}$	80	260		mS	$V_{DS} = 2 * V_{DS(on)}, I_D = 200mA$
<b>DYNAMIC CHARACTERISTICS</b>						
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	
<b>SWITCHING CHARACTERISTICS*</b>						
Turn-On Delay Time	$t_{d(on)}$			20	ns	$V_{DD} = 30V, V_{GS} = 10V, I_D = 200mA, R_G = 25\text{ Ohm}, R_L = 150\text{ Ohm}$
Turn-Off Delay Time	$t_{d(off)}$			40	ns	
<b>SOURCE-DRAIN (BODY) DIODE CHARACTERISTICS AND MAXIMUM RATINGS</b>						
Drain-Source Diode Forward On-Voltage	$V_{SD}$		0.88	1.5	V	$V_{GS} = 0V, I_S = 300mA^*$
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	

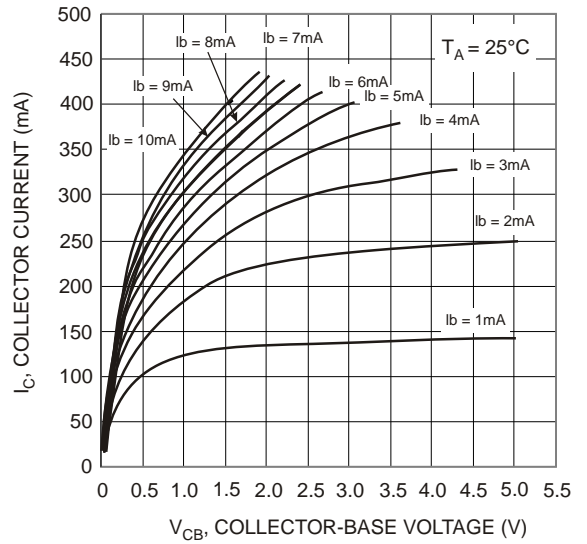
\* Pulse Test: Pulse width,  $t_p < 300\mu s$ , Duty Cycle,  $d = 0.02$

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

Typical Characteristics



$T_A$ , AMBIENT TEMPERATURE (°C)  
Fig. 3, Max Power Dissipation vs Ambient Temperature



$V_{CB}$ , COLLECTOR-BASE VOLTAGE (V)  
Fig. 4, Output Current vs. Voltage Drop (Pass Element PNP)

Pre-Biased PNP Transistor Characteristics

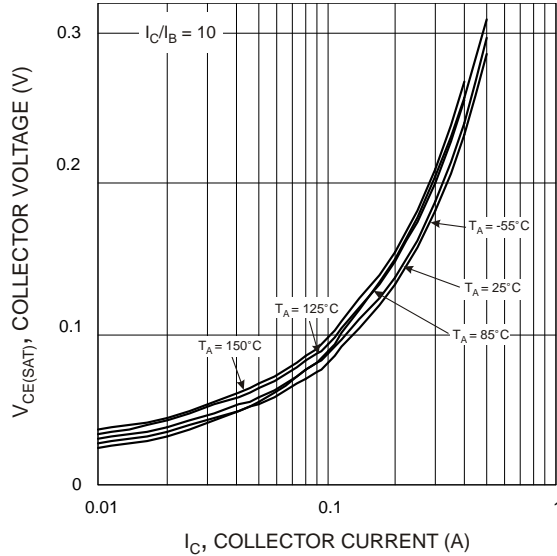


Fig. 5  $V_{CE(SAT)}$  vs.  $I_C$  @  $I_C/I_B = 10$

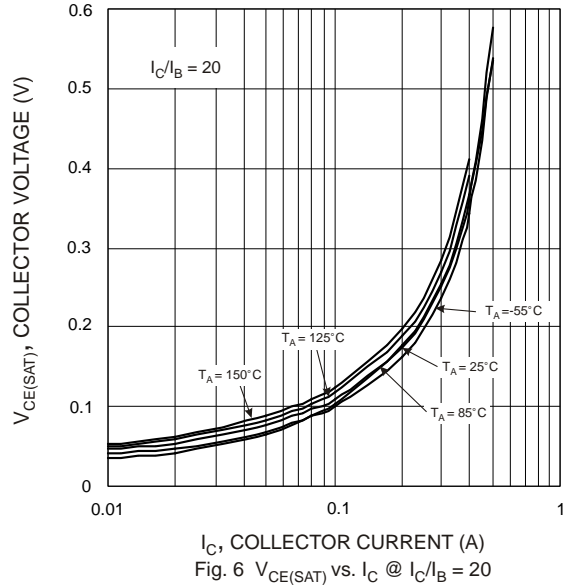


Fig. 6  $V_{CE(SAT)}$  vs.  $I_C$  @  $I_C/I_B = 20$

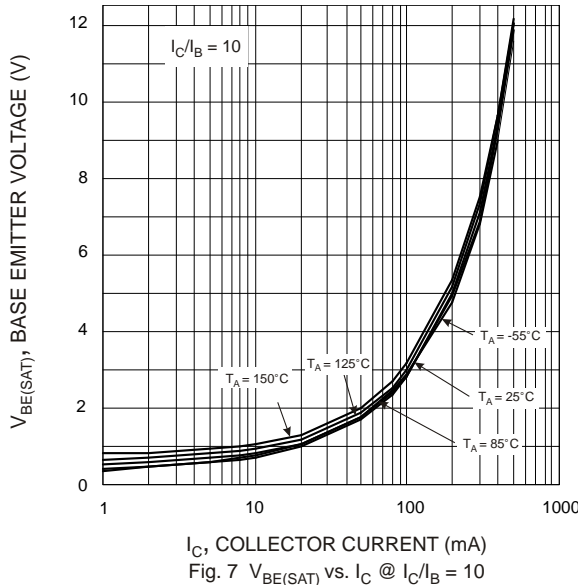


Fig. 7  $V_{BE(SAT)}$  vs.  $I_C$  @  $I_C/I_B = 10$

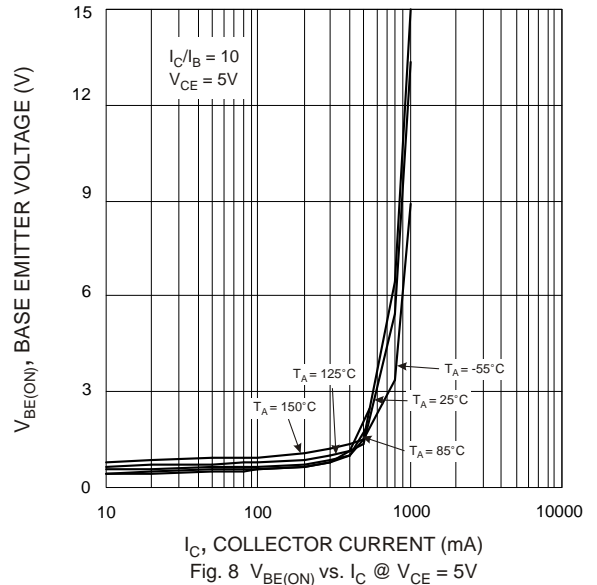


Fig. 8  $V_{BE(ON)}$  vs.  $I_C$  @  $V_{CE} = 5\text{V}$

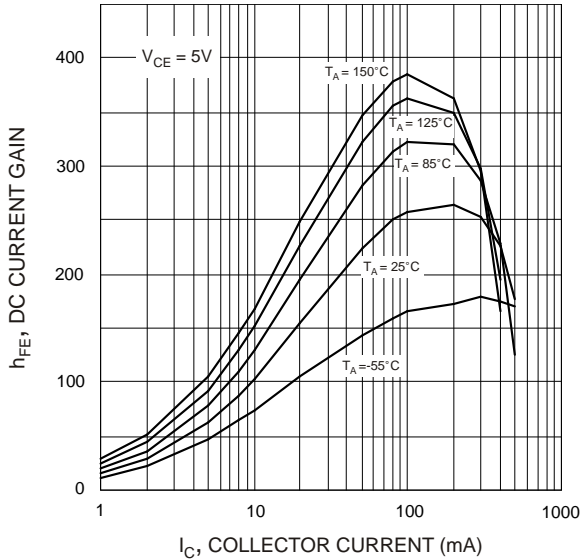


Fig. 9  $h_{FE}$  vs.  $I_C$  @  $V_{CE} = 5V$

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

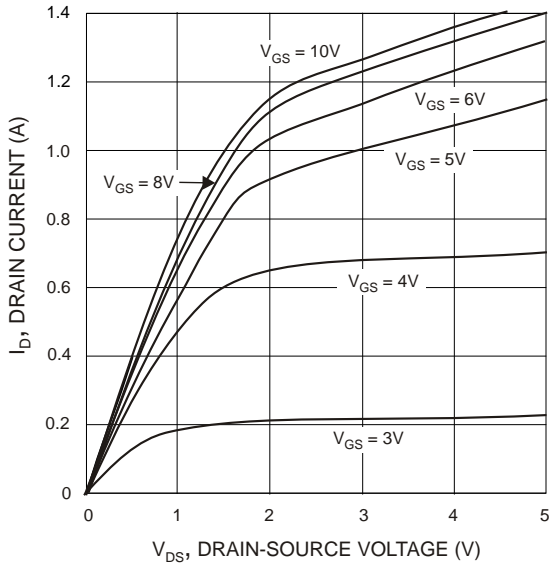


Fig. 10 Output Characteristics

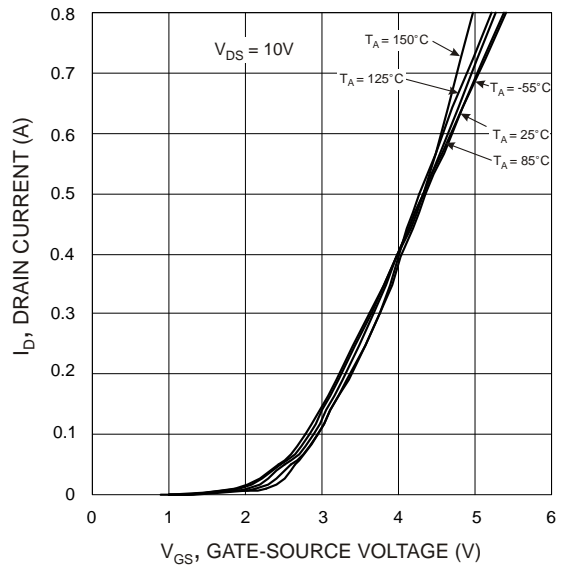


Fig. 11 Transfer Characteristics

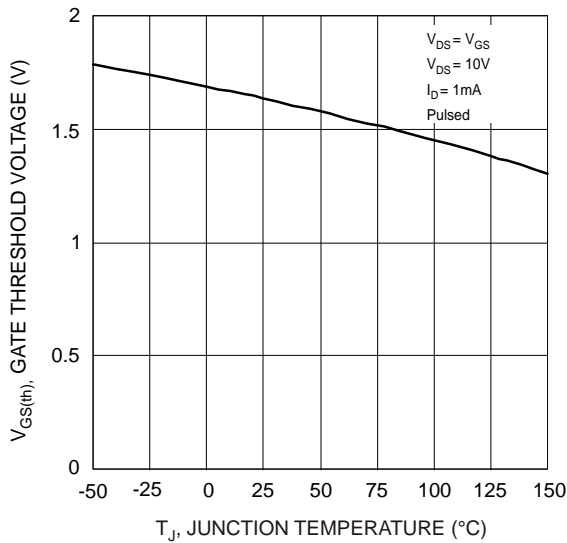


Fig. 12 Gate Threshold Voltage vs. Junction Temperature

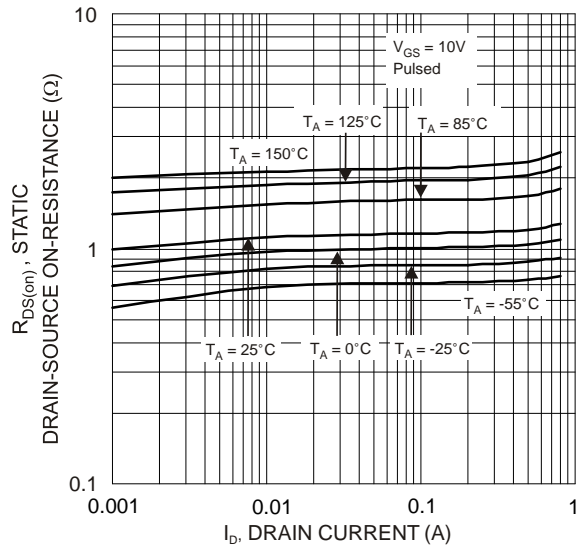


Fig. 13 Static Drain-Source On-Resistance vs. Drain Current

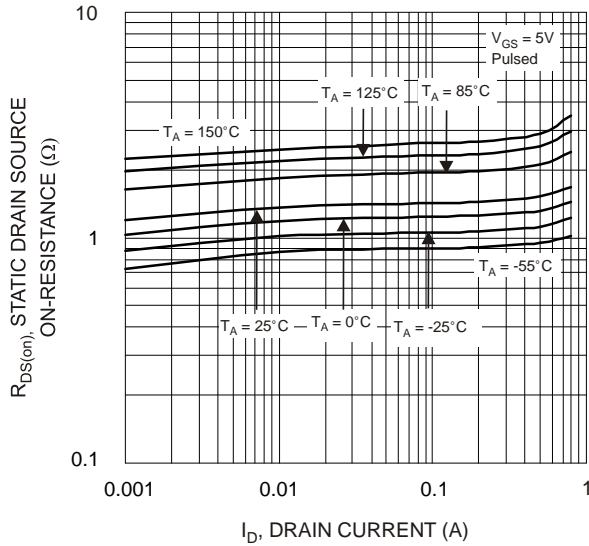


Fig. 14 Static Drain-Source On-Resistance vs. Drain Current

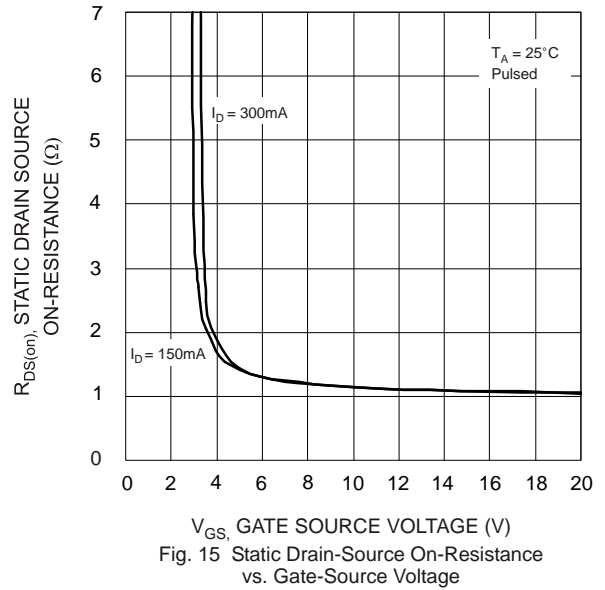


Fig. 15 Static Drain-Source On-Resistance vs. Gate-Source Voltage

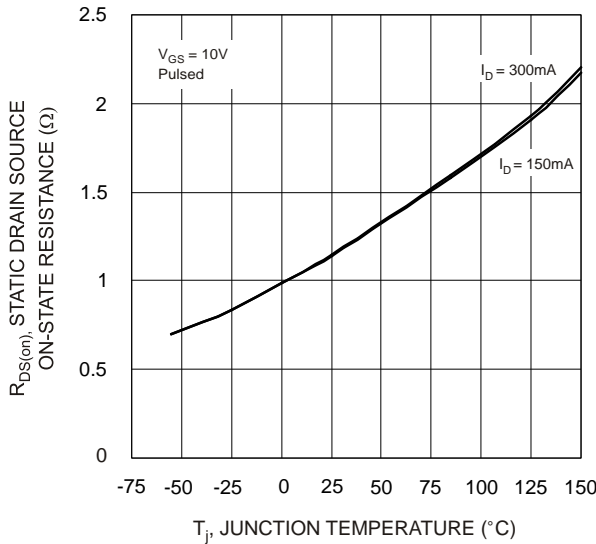


Fig. 16 Static Drain-Source On-State Resistance vs. Junction Temperature

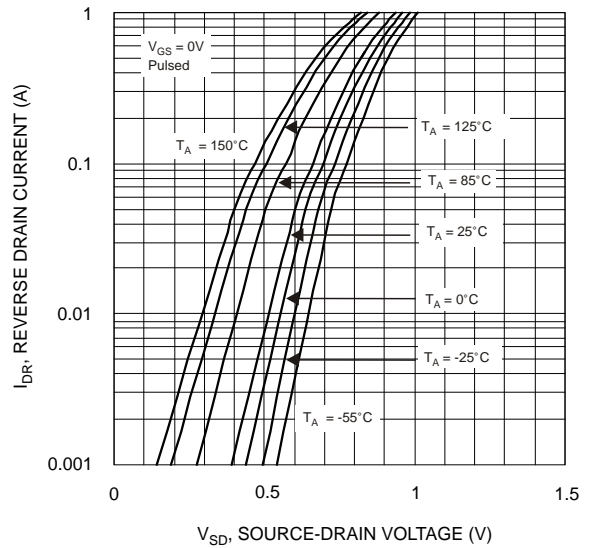


Fig. 17 Reverse Drain Current vs. Source-Drain Voltage

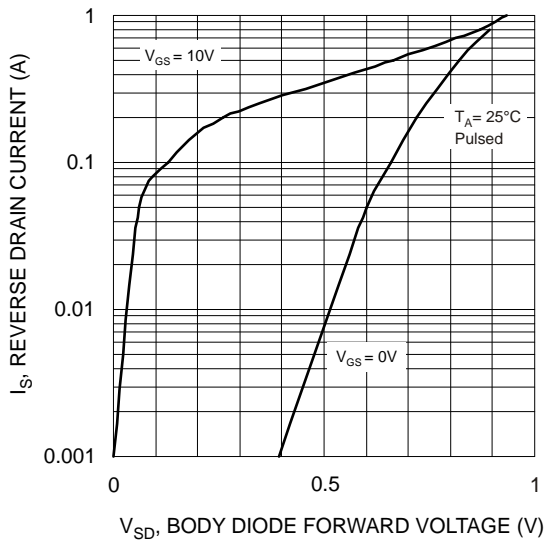


Fig. 18 Reverse Drain Current vs. Source-Drain Voltage

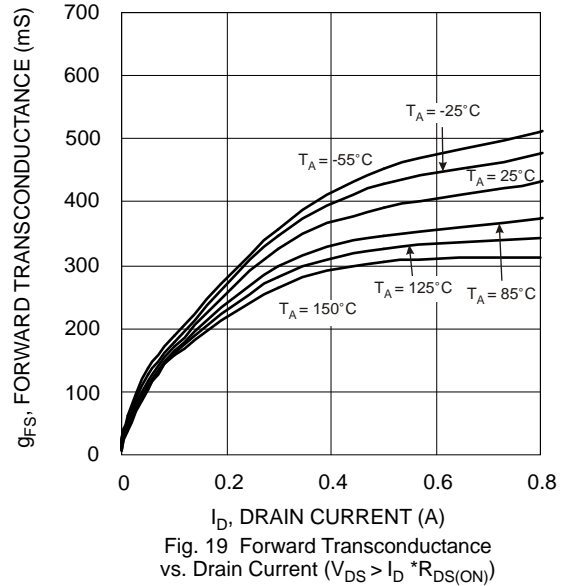


Fig. 19 Forward Transconductance vs. Drain Current ( $V_{DS} > I_D \cdot R_{DS(on)}$ )

**Application Details**

- 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).

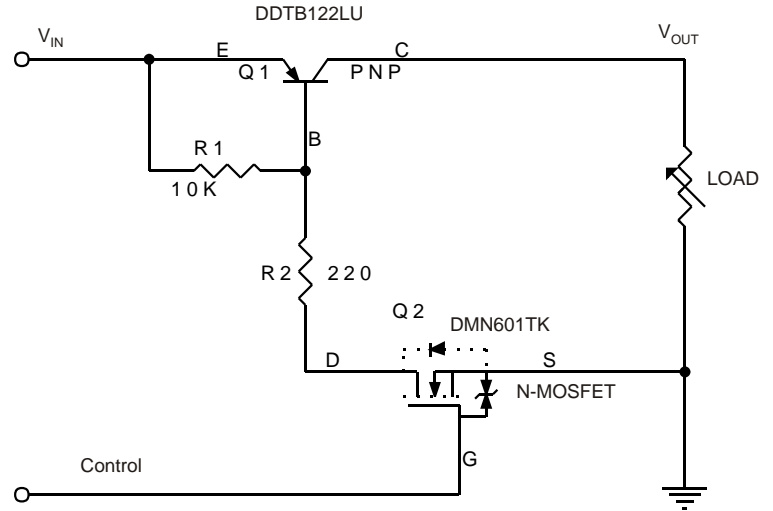


Fig 20 : Circuit Diagram

**Typical Application Circuit**

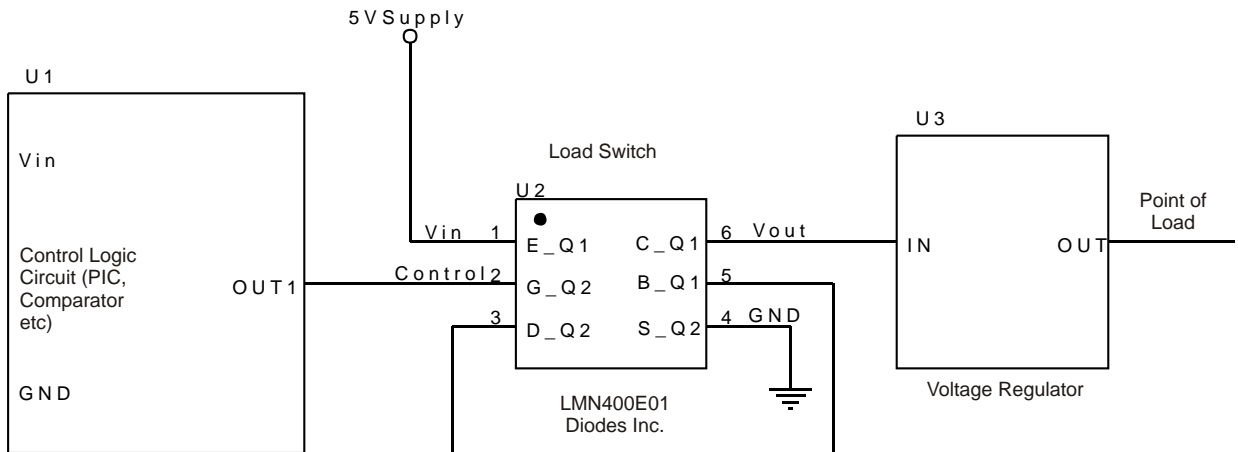


Fig 21

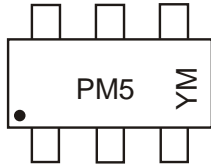


**Ordering Information** (Note 4)

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**



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

Fig. 22

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**

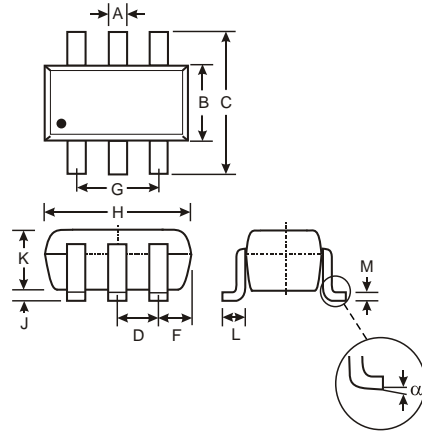


Fig. 23

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

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

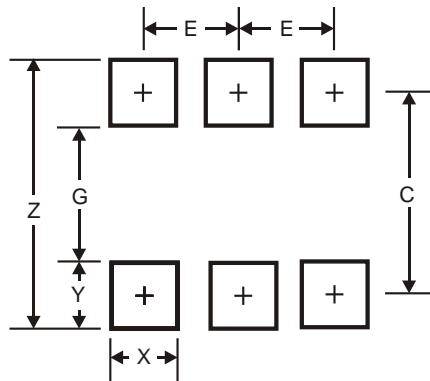


Fig. 24

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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