

# NUS5531MT

## Main Switch Power MOSFET and Single Charging BJT

-12 V, -6.2 A, Single P-Channel FET with Single PNP low  $V_{ce(sat)}$  Transistor, 3x3 mm WDFN Package

This device integrates one high performance power MOSFET and one low  $V_{ce(sat)}$  transistor, greatly reducing the layout space and optimizing charging performance in battery-powered portable electronics.

### Features

- High Performance Power MOSFET
- Single Low  $V_{ce(sat)}$  Transistor as Charging Power Mux
- 3.0x3.0x0.8 mm WDFN Package
- Independent Pin-out Provides Circuit Flexibility
- Low Profile (<0.8 mm) for Easy Fit in Thin Environments
- This is a Pb-Free Device

### Applications

- Main Switch and Battery Charging Mux for Portable Electronics
- Optimized for Commercial PMUs from Top Suppliers (See Figure 2)

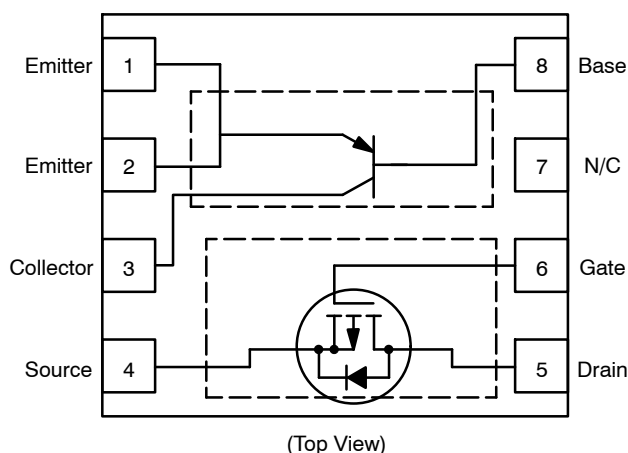


Figure 1. Simple Schematic



ON Semiconductor®

<http://onsemi.com>

### MOSFET

$V_{(BR)DSS}$	$R_{DS(on)}$ TYP	$I_D$ MAX
-12 V	32 mΩ @ -4.5 V	-6.2 A
	44 mΩ @ -2.5 V	

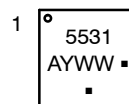
### Low $V_{ce(sat)}$ PNP (Wall/USB)

$V_{CE0}$ MAX	$V_{EBO}$ MAX	$I_C$ MAX
-20 V	-7.0 V	-2.0 A



WDFN8  
CASE 506BC

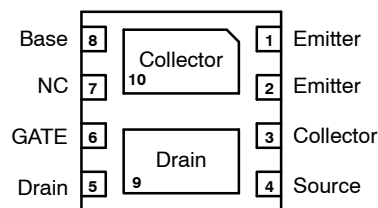
### MARKING DIAGRAM



5531 = Device Code  
A = Assembly Location  
Y = Year  
WW = Work Week  
▪ = Pb-Free Package

(Note: Microdot may be in either location)

### PIN ASSIGNMENT



(Bottom View)

### ORDERING INFORMATION

Device	Package	Shipping†
NUS5531MTR2G	WDFN8 (Pb-Free)	3000/Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

# NUS5531MT

## P-Channel Power MOSFET Maximum Ratings ( $T_J = 25^\circ\text{C}$ unless otherwise stated)

Parameter		Symbol	Value	Units	
Drain-to-Source Voltage		$V_{DSS}$	-12	V	
Gate-to-Source Voltage		$V_{GS}$	$\pm 8.0$	V	
Continuous Drain Current (Note 1)	Steady State	$I_D$	$T_A = 25^\circ\text{C}$	-5.47	A
			$T_A = 85^\circ\text{C}$	-4.0	
	$t \leq 5 \text{ s}$	$T_A = 25^\circ\text{C}$	-6.2		
Power Dissipation (Note 1)	Steady State	$P_D$	$T_A = 25^\circ\text{C}$	1.46	W
	$t \leq 10 \text{ s}$			2.1	
Continuous Drain Current (Note 2)	Steady State	$I_D$	$T_A = 25^\circ\text{C}$	-4.4	A
			$T_A = 85^\circ\text{C}$	-3.2	
Power Dissipation (Note 3)	$T_A = 25^\circ\text{C}$		$P_D$	0.418	W
Pulsed Drain Current	$t_p = 10 \mu\text{s}$		$I_{DM}$	-25	A
Operating Junction and Storage Temperature		$T_J, T_{STG}$	-55 to 150	$^\circ\text{C}$	
Operating Case Temperature (Note 3)		$T_C$	-55 to 125	$^\circ\text{C}$	
Source Current (Body Diode) <sup>2</sup>		$I_S$	-2.8	A	
Lead Temperature for Soldering Purposes (1/8" from case for 10 s)		$T_L$	260	$^\circ\text{C}$	

### THERMAL RESISTANCE RATINGS

Parameter	Symbol	Max	Units
Junction-to-Ambient – Steady State (Note 3)	$R_{\theta JA}$	299	$^\circ\text{C}/\text{W}$
Junction-to-Ambient – $t < 10 \text{ s}$ (Note 3)	$R_{\theta JA}$	81.4	$^\circ\text{C}/\text{W}$
Junction-to-Ambient – Steady State (Note 1)	$R_{\theta JA}$	85.5	$^\circ\text{C}/\text{W}$
Junction-to-Ambient – $t < 10 \text{ s}$ (Note 1)	$R_{\theta JA}$	58.7	$^\circ\text{C}/\text{W}$
Junction-to-Case – $t < 10 \text{ s}$ (Note 3)	$\psi_{JC}$	26	$^\circ\text{C}/\text{W}$

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

- Surface-mounted on FR4 board using 1 in sq pad size (Cu area = 1.127 sq in [1 oz] including traces).
- Surface-mounted on FR4 board using 0.5 in sq pad size, 1 oz. Cu.
- Surface-mounted on FR4 board using 50 sq mm pad size, 1 oz. Cu.

## P-Channel MOSFET Electrical Characteristics ( $T_J = 25^\circ\text{C}$ unless otherwise specified)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
-----------	--------	----------------	-----	-----	-----	------

### OFF CHARACTERISTICS

Drain-to-Source Breakdown Voltage	$V_{(BR)DSS}$	$V_{GS} = 0 \text{ V}, I_D = -250 \mu\text{A}$	-12.0			V
Drain-to-Source Breakdown Voltage Temperature Coefficient	$V_{(BR)DSS}/T_J$	$I_D = -250 \mu\text{A}, \text{ref to } 25^\circ\text{C}$		-10.1		$\text{mV}/^\circ\text{C}$
Zero Gate Voltage Drain Current	$I_{DSS}$	$V_{GS} = 0 \text{ V}, V_{DS} = -12 \text{ V}$	$T_J = 25^\circ\text{C}$		-1.0	$\mu\text{A}$
			$T_J = 125^\circ\text{C}$		-10	
Gate-to-Source Leakage Current	$I_{GSS}$	$V_{DS} = 0 \text{ V}, V_{GS} = \pm 8 \text{ V}$			$\pm 200$	nA

### ON CHARACTERISTICS (Note 4)

Gate Threshold Voltage	$V_{GS(TH)}$	$V_{GS} = V_{DS}, I_D = -250 \mu\text{A}$	-0.45	-0.67	-1.1	V
Negative Threshold Temperature Coefficient	$V_{GS(TH)}/T_J$			2.68		$\text{mV}/^\circ\text{C}$
Drain-to-Source On Resistance	$R_{DS(on)}$	$V_{GS} = -4.5 \text{ V}, I_D = -3.0 \text{ A}$		32	40	$\text{m}\Omega$
		$V_{GS} = -2.5 \text{ V}, I_D = -3.0 \text{ A}$		44	50	
Forward Transconductance	$g_{FS}$	$V_{DS} = -16 \text{ V}, I_D = -3.0 \text{ A}$		5.9		S

- Pulsed Condition: Pulse Width = 300  $\mu\text{sec}$ , Duty Cycle  $\leq 2\%$

# NUS5531MT

## P-Channel MOSFET Electrical Characteristics (T<sub>J</sub> = 25°C unless otherwise specified)

Parameter	Symbol	Test Condition	Min	Typ	Max	Unit
-----------	--------	----------------	-----	-----	-----	------

### CHARGES, CAPACITANCES AND GATE RESISTANCE

Input Capacitance	C <sub>ISS</sub>	V <sub>GS</sub> = 0 V, f = 1.0 MHz, V <sub>DS</sub> = -12 V		1329		pF
Output Capacitance	C <sub>OSS</sub>			200		
Reverse Transfer Capacitance	C <sub>RSS</sub>			116		
Total Gate Charge	Q <sub>G(tot)</sub>	V <sub>GS</sub> = -4.5 V, V <sub>DS</sub> = -12 V, I <sub>D</sub> = -3.0 A		13		nC
Threshold Gate Charge	Q <sub>G(th)</sub>			1.1		
Gate-to-Source Charge	Q <sub>GS</sub>			1.7		
Gate-to-Drain Charge	Q <sub>GD</sub>			2.5		

### SWITCHING CHARACTERISTICS

Turn-On Delay Time	t <sub>d(on)</sub>	V <sub>GS</sub> = -4.5 V, V <sub>DD</sub> = -12 V, I <sub>D</sub> = -3.0 A, R <sub>G</sub> = 3.0		8		ns
Rise Time	t <sub>r</sub>			17.5		
Turn-Off Delay Time	t <sub>d(off)</sub>			80		
Fall Time	t <sub>f</sub>			56.5		

### DRAIN-SOURCE DIODE CHARACTERISTICS

Forward Recovery Voltage	V <sub>SD</sub>	V <sub>GS</sub> = 0 V, I <sub>S</sub> = -1.0 A	T <sub>J</sub> = 25°C		-0.66	-1.2	V
			T <sub>J</sub> = 125°C		-0.54		
Reverse Recovery Time	t <sub>rr</sub>	V <sub>GS</sub> = 0 V, dI <sub>SD</sub> /dt = 100 A/μs, I <sub>S</sub> = -1.0 A		70.8		ns	
Charge Time	t <sub>a</sub>			14.3			
Discharge Time	t <sub>b</sub>			56.4			
Reverse Recovery Charge	Q <sub>RR</sub>			44			nC

### Single-PNP Transistor Maximum Ratings (T<sub>J</sub> = 25°C unless otherwise stated)

Parameter	Symbol	Value	Units
Collector-Emitter Voltage	V <sub>CEO</sub>	-20	V
Collector-Base Voltage	V <sub>CB0</sub>	-20	V
Emitter-Base Voltage	V <sub>EBO</sub>	-7.0	V
Collector Current, Continuous	I <sub>C</sub>	-2.0	A
Collector Current, Peak	I <sub>C</sub>	-4.0	A
Operating Junction and Storage Temperature	T <sub>J</sub> , T <sub>STG</sub>	-55 to 150	°C
Power Dissipation, T <sub>A</sub> = 25°C (Note 5)	P <sub>D</sub>	1.58	W
Thermal Resistance (Note 5)	R <sub>θJA</sub>	61.5	°C/W
Power Dissipation, T <sub>A</sub> = 25°C (Note 6)	P <sub>D</sub>	0.43	W
Thermal Resistance (Note 6)	R <sub>θJA</sub>	293	°C/W

5. Surface-mounted on FR4 board using 1 in sq pad size (Cu area = 1.127 sq in [1 oz] including traces)  
 6. Surface-mounted on FR4 board using 50 sq mm pad size, 1 oz. Cu.

# NUS5531MT

## Single-PNP Transistor Electrical Characteristics ( $T_J = 25^\circ\text{C}$ unless otherwise stated)

Parameter	Symbol	Test Condition	Min	Typ	Max	Units
<b>OFF CHARACTERISTICS</b>						
Collector-Emitter Breakdown Voltage	$V_{br_{CEO}}$	$I_C = -10\text{ mA}, I_B = 0$	-20			V
Collector-Base Breakdown Voltage	$V_{br_{CBO}}$	$I_C = -0.1\text{ mA}, I_E = 0$	-20			V
Emitter-Base Breakdown Voltage	$V_{br_{EBO}}$	$I_E = -0.1\text{ mA}, I_C = 0$	-7.0			V
Collector-Emitter Cutoff Current	$I_{CES}$	$V_{CES} = -15\text{ V}$			-0.1	$\mu\text{A}$

## ON CHARACTERISTICS

DC Current Gain (Note 7)	$h_{FE}$	$I_C = -1.0\text{ A}, V_{CE} = -2.0\text{ V}$	180			-
DC Current Gain (Note 7)	$h_{FE}$	$I_C = -2.0\text{ A}, V_{CE} = -2.0\text{ V}$	150			-
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = -1.0\text{ A}, I_B = -0.01\text{ A}$		-0.10	-0.12	V
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = -1.0\text{ A}, I_B = -0.1\text{ A}$		-0.065	-0.09	V
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	$I_C = -2.0\text{ A}, I_B = -0.2\text{ A}$		-0.13	-0.18	V
Base-Emitter Saturation Voltage (Note 7)	$V_{BE(sat)}$	$I_C = -1.0\text{ A}, I_B = -0.01\text{ A}$			-0.9	V
Base-Emitter Turn-On Voltage (Note 7)	$V_{BE(on)}$	$I_C = -1.0\text{ A}, I_B = -2.0\text{ A}$			-0.9	V
Cutoff Frequency (Note 8)	$f_T$	$I_C = -100\text{ mA}, V_{CE} = -5.0\text{ V}$ $f = 100\text{ MHz}$	100			MHz
Input Capacitance (Note 8)	$C_{ibo}$	$V_{EB} = -0.5\text{ V}, f = 1.0\text{ MHz}$			330	pF
Output Capacitance (Note 8)	$C_{obo}$	$V_{CB} = -3.0\text{ V}, f = 1.0\text{ MHz}$			100	pF

7. Pulsed Condition: Pulse Width = 300  $\mu\text{sec}$ , Duty Cycle  $\leq 2\%$   
 8. Guaranteed by design but not tested.

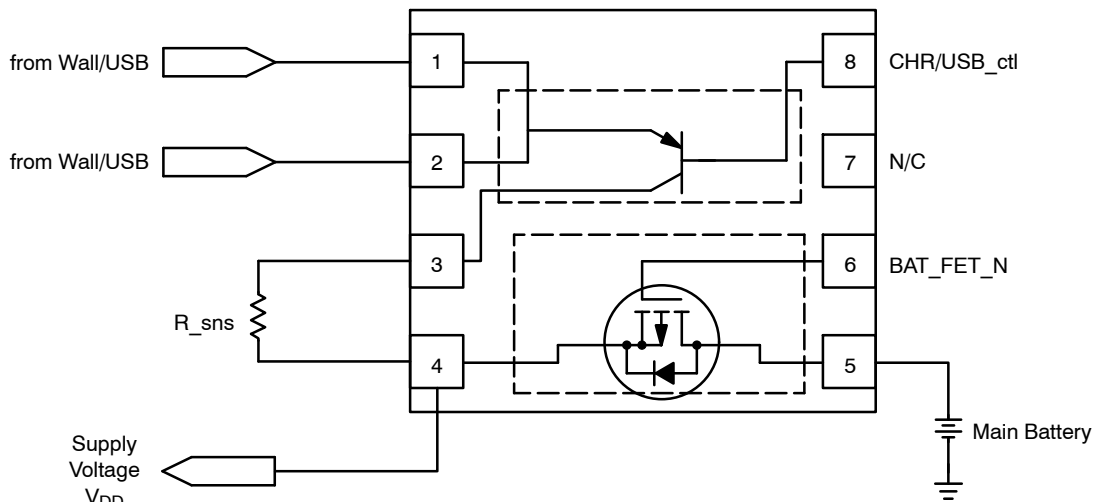


Figure 2. Typical Application Circuit

TYPICAL CHARACTERISTICS - MOSFET

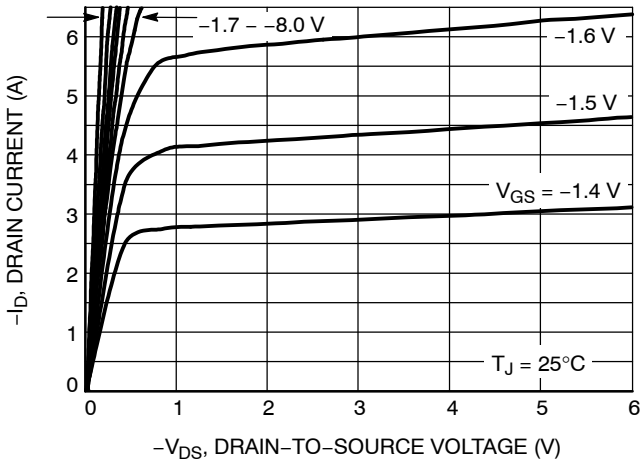


Figure 3. On-Region Characteristics

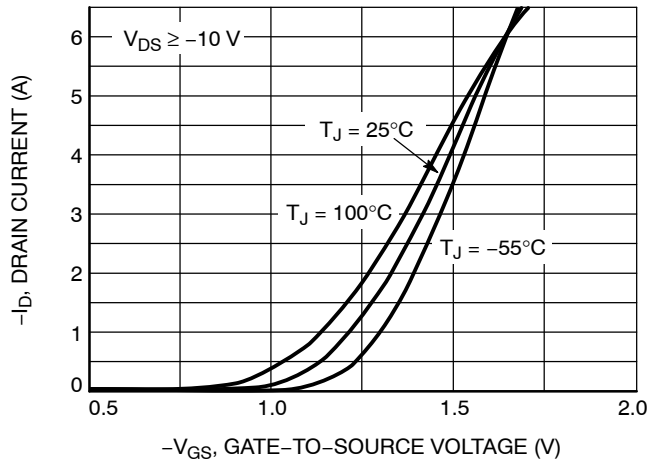


Figure 4. Transfer Characteristics

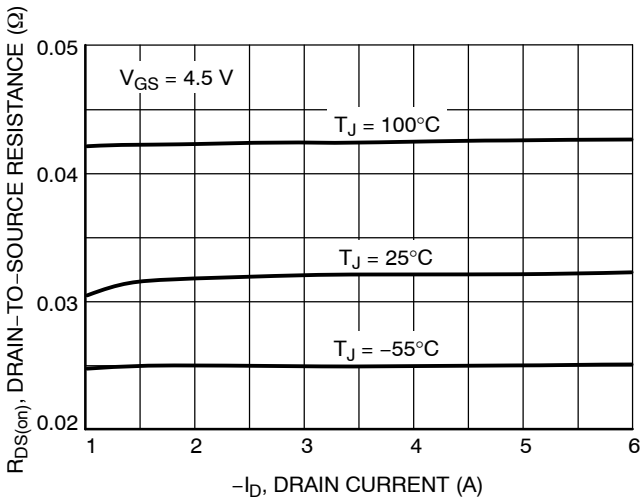


Figure 5. On-Resistance vs. Drain Current

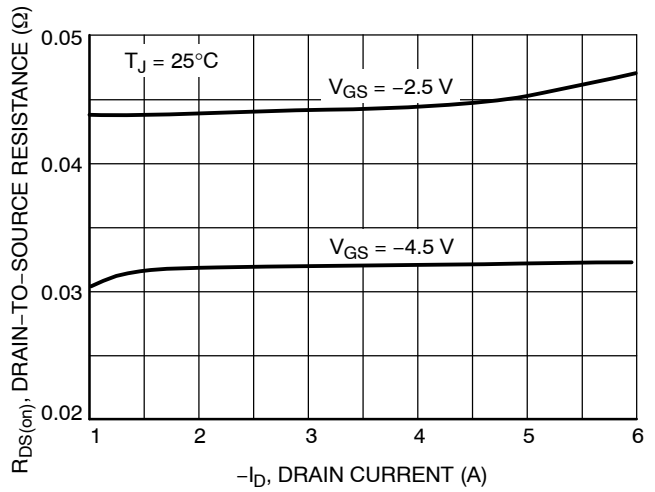


Figure 6. On-Resistance vs. Drain Current and Gate Voltage

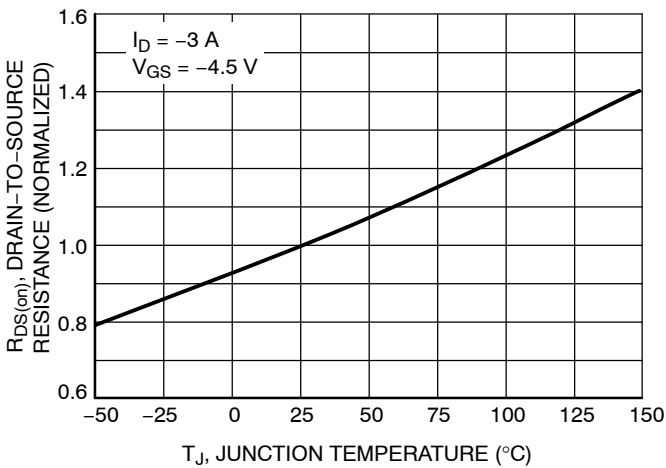


Figure 7. On-Resistance Variation with Temperature

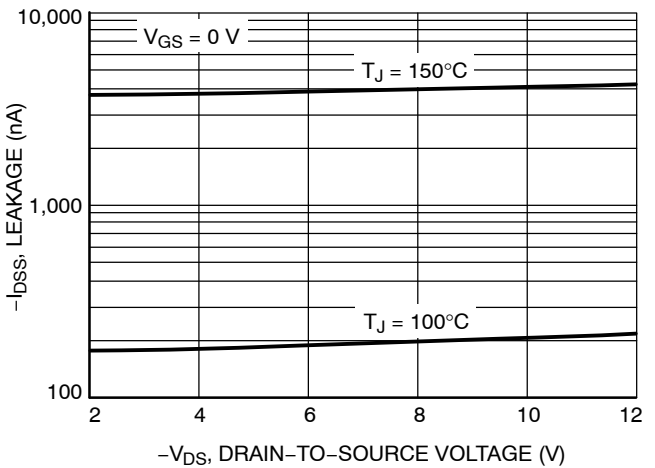


Figure 8. Drain-to-Source Leakage Current vs. Voltage

TYPICAL CHARACTERISTICS - MOSFET

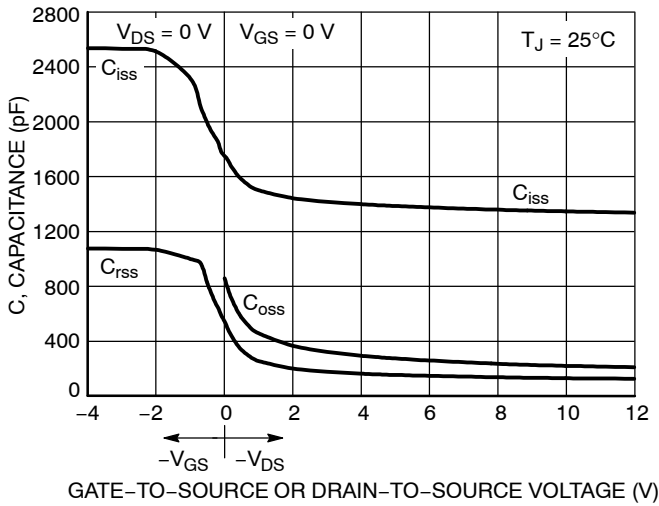


Figure 9. Capacitance Variation

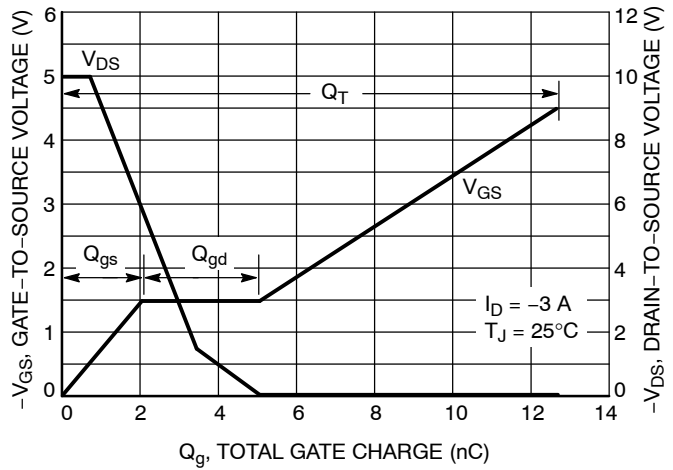


Figure 10. Gate-to-Source and Drain-to-Source Voltage vs. Total Charge

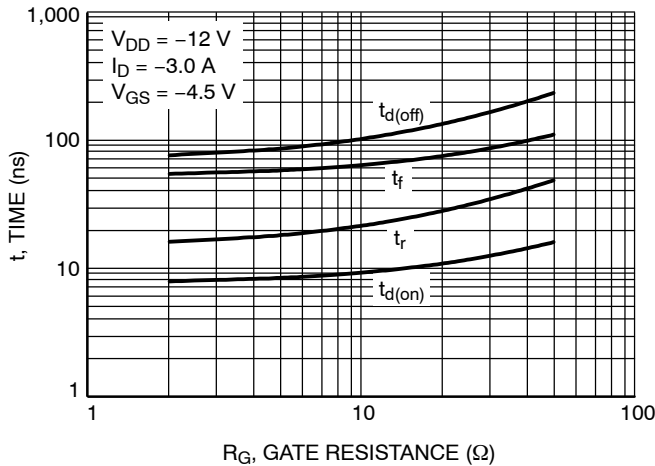


Figure 11. Resistive Switching Time Variation vs. Gate Resistance

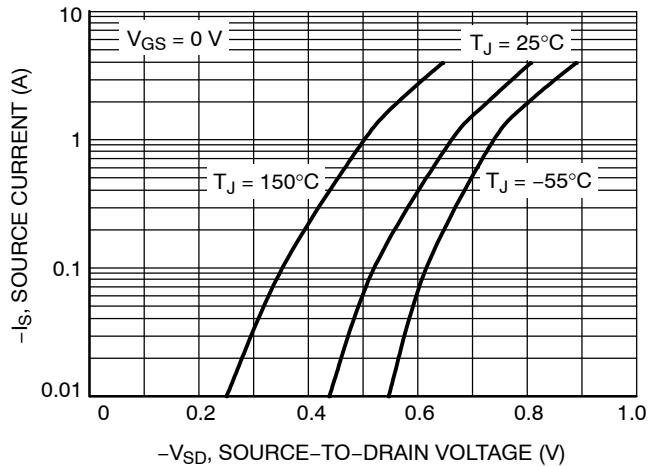
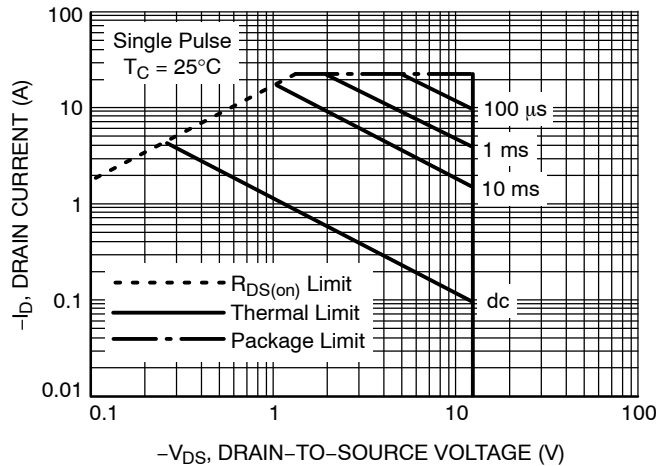


Figure 12. Diode Forward Voltage vs. Current



Mounted on 2" sq. FR4 board (0.5" sq. 2 oz. Cu single sided) with MOSFET die operating.

Figure 13. Maximum Rated Forward Biased Safe Operating Area

# NUS5531MT

## TYPICAL CHARACTERISTICS - MOSFET

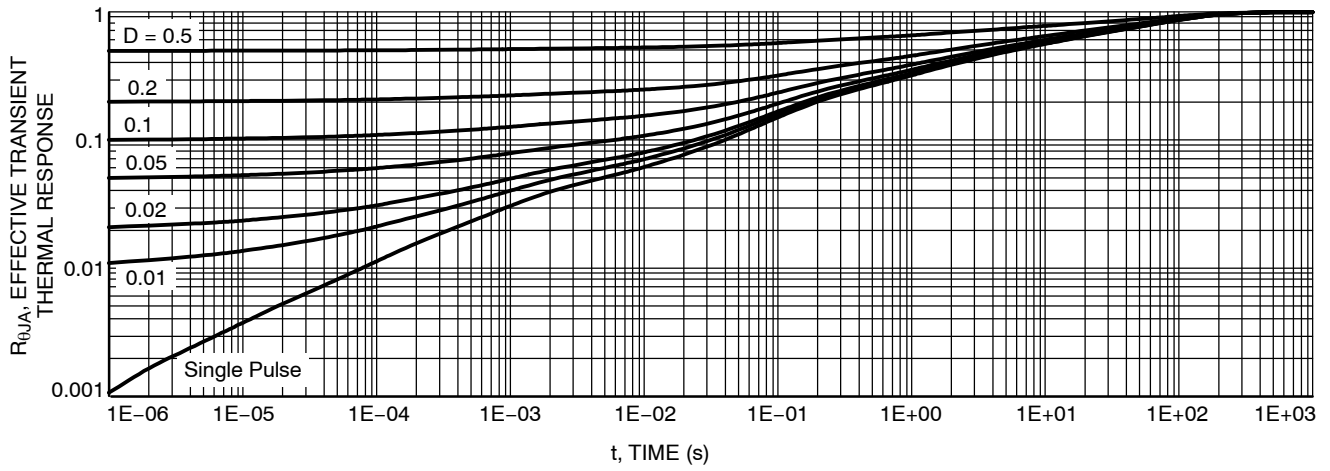


Figure 14. FET Thermal Response

TYPICAL CHARACTERISTICS - BJT

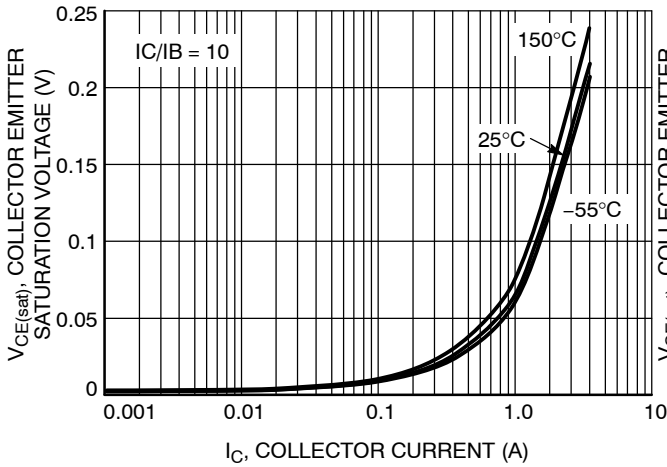


Figure 15. Collector Emitter Saturation Voltage vs. Collector Current

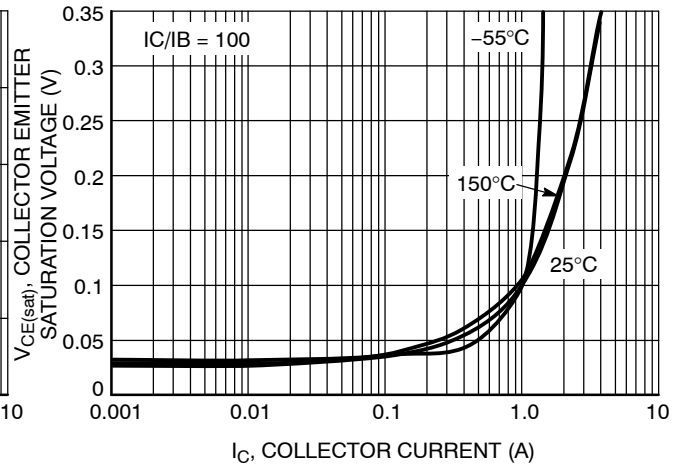


Figure 16. Collector Emitter Saturation Voltage vs. Collector Current

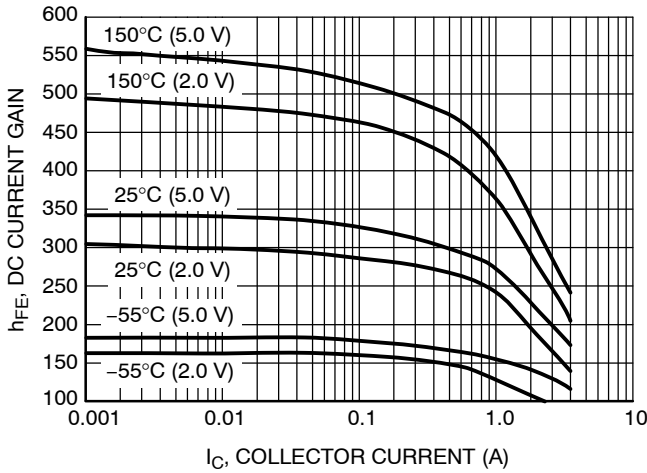


Figure 17. DC Current Gain vs. Collector Current

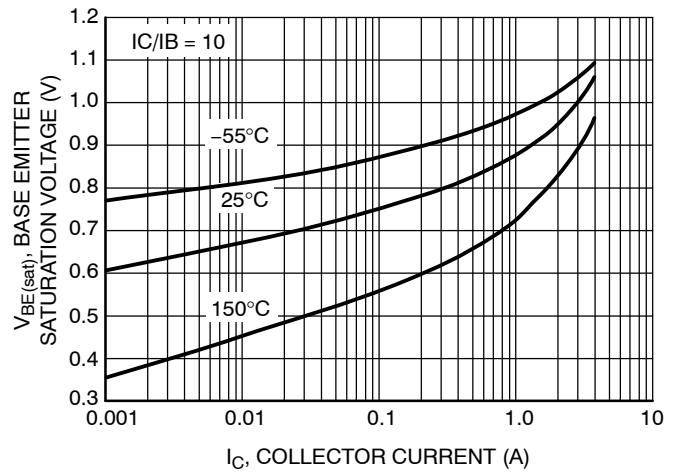


Figure 18. Base Emitter Saturation Voltage vs. Collector Current

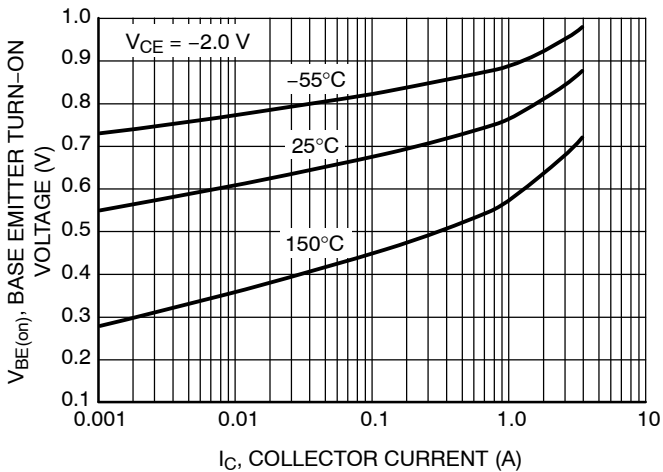


Figure 19. Base Emitter Turn-On Voltage vs. Collector Current

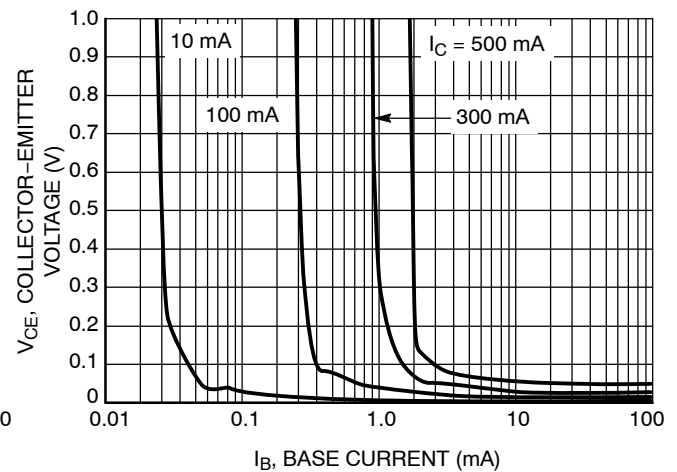


Figure 20. Saturation Region



# NUS5531MT

## TYPICAL CHARACTERISTICS - BJT

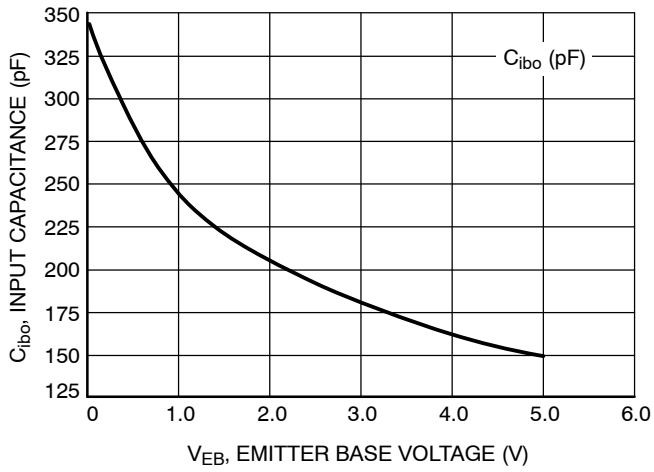


Figure 21. Input Capacitance

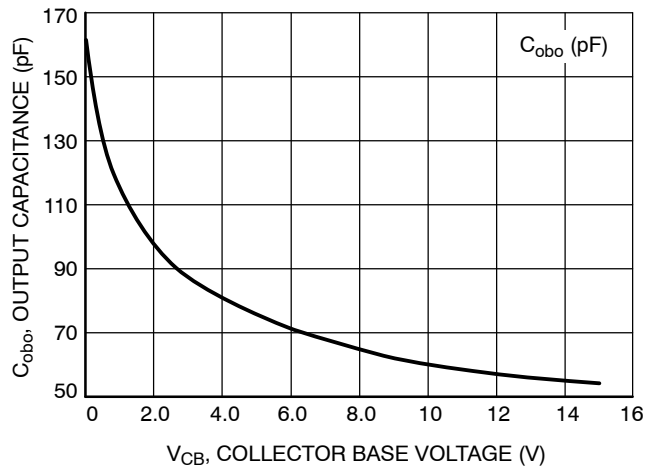
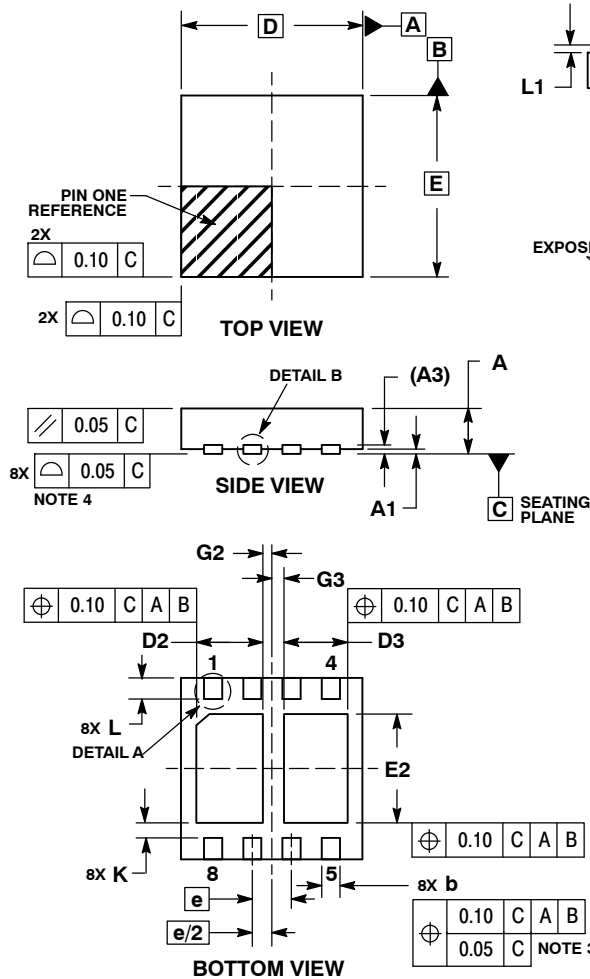


Figure 22. Output Capacitance

# NUS5531MT

## PACKAGE DIMENSIONS

WDFN8, 3x3, 0.65P  
CASE 506BC-01  
ISSUE A

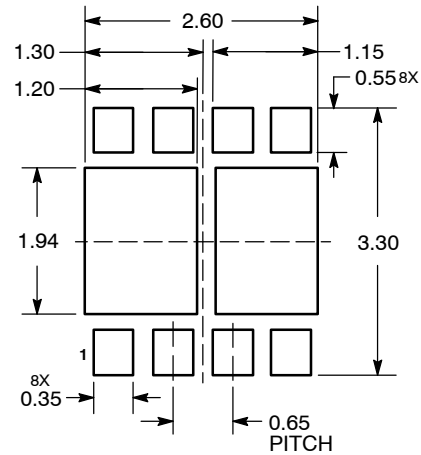


**NOTES:**

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION *b* APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30mm.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

MILLIMETERS		
DIM	MIN	MAX
A	0.70	0.80
A1	0.00	0.05
A3	0.20	REF
b	0.25	0.35
D	3.00	BSC
D2	1.00	1.20
D3	0.95	1.15
E	3.00	BSC
E2	1.70	1.90
e	0.65	BSC
G2	0.15	BSC
G3	0.20	BSC
K	0.20	---
L	0.25	0.45
L1	---	0.15

### SOLDERING FOOTPRINT\*



\*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

ON Semiconductor and are registered trademarks of Semiconductor Components Industries, LLC (SCILLC). SCILLC reserves the right to make changes without further notice to any products herein. SCILLC makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does SCILLC assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. "Typical" parameters which may be provided in SCILLC data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. SCILLC does not convey any license under its patent rights nor the rights of others. SCILLC products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the SCILLC product could create a situation where personal injury or death may occur. Should Buyer purchase or use SCILLC products for any such unintended or unauthorized application, Buyer shall indemnify and hold SCILLC and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that SCILLC was negligent regarding the design or manufacture of the part. SCILLC is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

### PUBLICATION ORDERING INFORMATION

**LITERATURE FULFILLMENT:**  
Literature Distribution Center for ON Semiconductor  
P.O. Box 5163, Denver, Colorado 80217 USA  
**Phone:** 303-675-2175 or 800-344-3860 Toll Free USA/Canada  
**Fax:** 303-675-2176 or 800-344-3867 Toll Free USA/Canada  
**Email:** orderlit@onsemi.com

**N. American Technical Support:** 800-282-9855 Toll Free USA/Canada  
**Europe, Middle East and Africa Technical Support:**  
Phone: 421 33 790 2910  
**Japan Customer Focus Center**  
Phone: 81-3-5773-3850

**ON Semiconductor Website:** [www.onsemi.com](http://www.onsemi.com)  
**Order Literature:** <http://www.onsemi.com/orderlit>  
For additional information, please contact your local Sales Representative