# **SWITCHMODE™ Series NPN Silicon Power Transistors**

These devices are designed for high-voltage, high-speed power switching inductive circuits where fall time is critical. They are particularly suited for 115 and 220 V SWITCHMODE applications such as Switching Regulator's, Inverters, Motor Controls, Solenoid/Relay drivers and Deflection circuits.

#### **Features**

- V<sub>CEO(sus)</sub> 400 V
- Reverse Bias SOA with Inductive Loads @  $T_C = 100$  °C
- Inductive Switching Matrix 2 to 4 A, 25 and 100°C t<sub>c</sub> @ 3A, 100°C is 180 ns (Typ)
- 700 V Blocking Capability
- SOA and Switching Applications Information
- These Devices are Pb-Free and are RoHS Compliant\*

#### **MAXIMUM RATINGS**

	Symbol	Value	Unit	
Collector-Emitter	Collector-Emitter Voltage			Vdc
Collector-Emitter	Voltage	V <sub>CEV</sub>	700	Vdc
Emitter-Base Volt	age	V <sub>EBO</sub>	9	Vdc
Collector Current	<ul><li>Continuous</li><li>Peak (Note 1)</li></ul>	I <sub>C</sub>	4 8	Adc
Base Current	<ul><li>Continuous</li><li>Peak (Note 1)</li></ul>	I <sub>B</sub> I <sub>BM</sub>	2 4	Adc
Emitter Current	<ul><li>Continuous</li><li>Peak (Note 1)</li></ul>	I <sub>E</sub>	6 12	Adc
Total Device Dissi Derate above 25°0	pation @ T <sub>A</sub> = 25°C C	P <sub>D</sub>	2 0.016	W W/°C
Total Device Dissi Derate above 25°0	P <sub>D</sub>	75 0.6	W W/°C	
Operating and Sto Temperature Rang	T <sub>J</sub> , T <sub>stg</sub>	-65 to +150	°C	

#### THERMAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Thermal Resistance, Junction-to-Ambient	$R_{\theta JA}$	62.5	°C/W
Thermal Resistance, Junction-to-Case	$R_{\theta JC}$	1.67	°C/W
Maximum Lead Temperature for Soldering Purposes 1/8" from Case for 5 Seconds	TL	275	°C

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.

1. Pulse Test: Pulse Width = 5 ms, Duty Cycle ≤ 10%.



### ON Semiconductor®

http://onsemi.com

# 4 AMPERE NPN SILICON POWER TRANSISTOR 400 VOLTS – 75 WATTS



#### **MARKING DIAGRAM**



= Assembly Location

Y = Year
WW = Work Week
G = Pb-Free Package

#### **ORDERING INFORMATION**

Device	Package	Shipping
MJE13005G	TO-220 (Pb-Free)	50 Units / Rail

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

## **ELECTRICAL CHARACTERISTICS** (T<sub>C</sub> = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Тур	Max	Unit
OFF CHARACTERISTICS	S (Note 2)	<u> </u>	l		1	l
Collector-Emitter Sustain (I <sub>C</sub> = 10 mA, I <sub>B</sub> = 0)	V <sub>CEO(sus)</sub>	400	-	-	Vdc	
Collector Cutoff Current (V <sub>CEV</sub> = Rated Value, (V <sub>CEV</sub> = Rated Value,	V <sub>BE(off)</sub> = 1.5 Vdc) V <sub>BE(off)</sub> = 1.5 Vdc, T <sub>C</sub> = 100°C)	I <sub>CEV</sub>	- -	_ _	1 5	mAdc
Emitter Cutoff Current (V <sub>EB</sub> = 9 Vdc, I <sub>C</sub> = 0)		I <sub>EBO</sub>	-	-	1	mAdc
SECOND BREAKDOWN		•		•	•	
Second Breakdown Colle	ector Current with base forward biased	I <sub>S/b</sub>	-	S	See Figure	11
Clamped Inductive SOA	with Base Reverse Biased	RBSOA	_	S	See Figure	12
ON CHARACTERISTICS	(Note 2)	•	•	•		
DC Current Gain (I <sub>C</sub> = 1 Adc, V <sub>CE</sub> = 5 V (I <sub>C</sub> = 2 Adc, V <sub>CE</sub> = 5 V	•	h <sub>FE</sub>	10 8	_ _	60 40	-
	V <sub>CE(sat)</sub>	- - -	- - - -	0.5 0.6 1	Vdc	
Base–Emitter Saturation Voltage ( $I_C$ = 1 Adc, $I_B$ = 0.2 Adc) ( $I_C$ = 2 Adc, $I_B$ = 0.5 Adc) ( $I_C$ = 2 Adc, $I_B$ = 0.5 Adc, $I_C$ = 100°C)		V <sub>BE(sat)</sub>	- - -	- - -	1.2 1.6 1.5	Vdc
DYNAMIC CHARACTERI	ISTICS	<b>'</b>	I.	-L	I	I.
Current-Gain - Bandwid (I <sub>C</sub> = 500 mAdc, V <sub>CE</sub> =		f <sub>T</sub>	4	-	_	MHz
Output Capacitance (V <sub>CB</sub> = 10 Vdc, I <sub>E</sub> = 0,	f = 0.1 MHz)	C <sub>ob</sub>	-	65	-	pF
SWITCHING CHARACTE	RISTICS	•			1	
Resistive Load (Table 2	)					
Delay Time		t <sub>d</sub>	_	0.025	0.1	μs
Rise Time	(V <sub>CC</sub> = 125 Vdc, I <sub>C</sub> = 2 A,	t <sub>r</sub>	-	0.3	0.7	μs
Storage Time	l <sub>B1</sub> = l <sub>B2</sub> = 0.4 A, t <sub>p</sub> = 25 μs, Duty Cycle ≤ 1%)	t <sub>s</sub>	_	1.7	4	μs
Fall Time		t <sub>f</sub>	_	0.4	0.9	μs
Inductive Load, Clampe	ed (Table 2, Figure 13)	1	1	1	1	ı
Voltage Storage Time		t <sub>sv</sub>	-	0.9	4	μs
Crossover Time	(I <sub>C</sub> = 2 A, V <sub>clamp</sub> = 300 Vdc, I <sub>B1</sub> = 0.4 A, V <sub>BE(off)</sub> = 5 Vdc, T <sub>C</sub> = 100°C)	t <sub>c</sub>	_	0.32	0.9	μs
Fall Time	1 181 - 0.4 A, VBE(off) - 3 Vac, IC = 100 C)	t <sub>fi</sub>	_	0.16	_	μs

<sup>2.</sup> Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%.

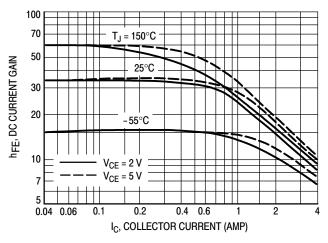


Figure 1. DC Current Gain

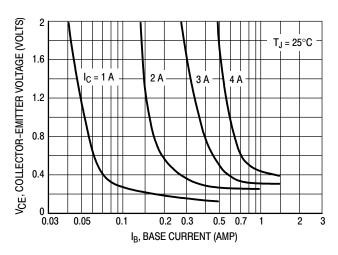


Figure 2. Collector Saturation Region

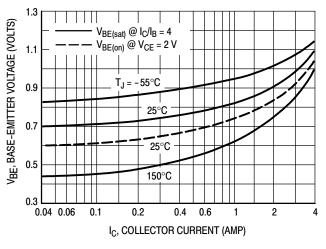


Figure 3. Base-Emitter Voltage

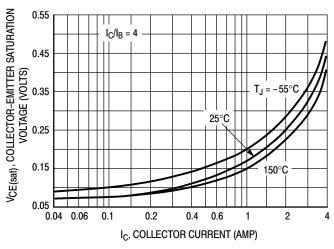


Figure 4. Collector-Emitter Saturation Voltage

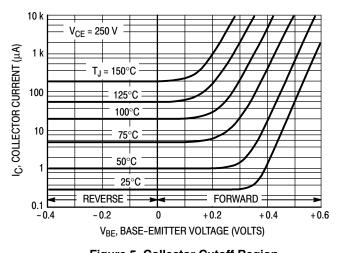


Figure 5. Collector Cutoff Region

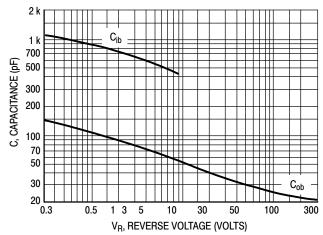


Figure 6. Capacitance

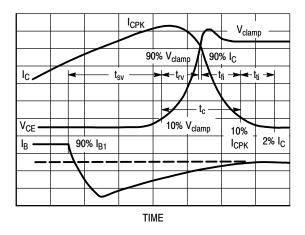


Figure 7. Inductive Switching Measurements

**Table 1. Typical Inductive Switching Performance** 

I <sub>C</sub>	T <sub>C</sub> °C	t <sub>sv</sub>	t <sub>rv</sub>	t <sub>fi</sub>	t <sub>ti</sub>	t <sub>c</sub>
AMP		ns	ns	ns	ns	ns
2	25	600	70	100	80	180
	100	900	110	240	130	320
3	25	650	60	140	60	200
	100	950	100	330	100	350
4	25	550	70	160	100	220
	100	850	110	350	160	390

NOTE: All Data recorded in the inductive Switching Circuit In Table 2.

#### **SWITCHING TIMES NOTE**

In resistive switching circuits, rise, fall, and storage times have been defined and apply to both current and voltage waveforms since they are in phase. However, for inductive loads which are common to SWITCHMODE power supplies and hammer drivers, current and voltage waveforms are not in phase. Therefore, separate measurements must be made on each waveform to determine the total switching time. For this reason, the following new terms have been defined.

 $t_{sv}$  = Voltage Storage Time, 90%  $I_{B1}$  to 10%  $V_{clamp}$ 

 $t_{rv}$  = Voltage Rise Time, 10-90%  $V_{clamp}$ 

 $t_{fi}$  = Current Fall Time, 90-10%  $I_{C}$ 

 $t_{ti}$  = Current Tail, 10-2% I<sub>C</sub>

 $t_c$  = Crossover Time, 10%  $V_{clamp}$  to 10%  $I_C$ 

An enlarged portion of the inductive switching waveforms is shown in Figure 7 to aid in the visual identity of these terms.

For the designer, there is minimal switching loss during storage time and the predominant switching power losses occur during the crossover interval and can be obtained using the standard equation from AN-222:

$$P_{SWT} = 1/2 V_{CC}I_{C}(t_{c})f$$

In general,  $t_{rv} + t_{fi} \approx t_c$ . However, at lower test currents this relationship may not be valid.

As is common with most switching transistors, resistive switching is specified at  $25^{\circ}$ C and has become a benchmark for designers. However, for designers of high frequency converter circuits, the user oriented specifications which make this a "SWITCHMODE" transistor are the inductive switching speeds ( $t_c$  and  $t_{sv}$ ) which are guaranteed at  $100^{\circ}$ C.

#### **RESISTIVE SWITCHING PERFORMANCE**

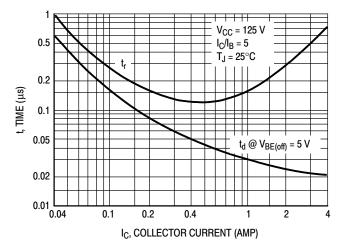


Figure 8. Turn-On Time

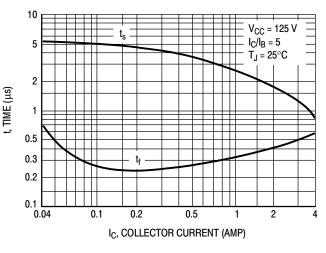


Figure 9. Turn-Off Time

**Table 2. Test Conditions for Dynamic Performance** 

	REVERSE BIAS SAFE OPERATING AREA AND INDUCTIVE SWITCHING	RESISTIVE SWITCHING
TEST CIRCUITS	DUTY CYCLE $\leq$ 10% $_{0.001}$ $_{\mu}$ F $_{0.001}$ $_{\mu}$ F $_{0.001}$ $_{\mu}$ F $_{0.001}$ $_{\mu}$ F $_{0.022}$ $_{1}$ $_{1}$ $_{2}$ $_{2}$ $_{1}$ $_{2}$	+125 V  RC  TUT  SCOPE  -4.0  V
CIRCUIT	Coil Data: GAP for 200 $\mu$ H/20 A $V_{CC}$ = 20 V Full Bobbin (~16 Turns) #16 $V_{coil}$ = 200 $\mu$ H $V_{clamp}$ = 300 Vdc	$V_{CC}$ = 125 V $R_C$ = 62 $\Omega$ D1 = 1N5820 or Equiv. $R_B$ = 22 $\Omega$
TEST WAVEFORMS	OUTPUT WAVEFORMS $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$t_{r}, t_{f} < 10 \text{ ns}$ Duty Cycle = 1.0% $R_{B}$ and $R_{C}$ adjusted for desired $I_{B}$ and $I_{C}$

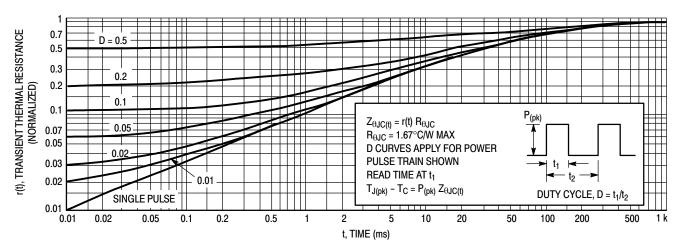


Figure 10. Typical Thermal Response  $[Z_{\theta JC}(t)]$ 

#### SAFE OPERATING AREA INFORMATION

The Safe Operating Area Figures 11 and 12 are specified ratings for these devices under the test conditions shown.

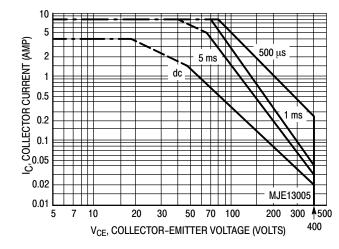


Figure 11. Forward Bias Safe Operating Area

# (C(pk), COLLECTOR CURRENT (AMP) $V_{BE(off)} = 9 V$ MJE13005 5 V 3 V 100 200 300 400 500 800 700 V<sub>CE</sub>, COLLECTOR-EMITTER CLAMP VOLTAGE (VOLTS)

 $T_C \leq 100^{\circ}C$ 

 $I_{B1} = 2.0 A$ 

Figure 12. Reverse Bias Switching Safe Operating Area

#### **FORWARD BIAS**

There are two limitations on the power handling ability of a transistor: average junction temperature and second breakdown. Safe operating area curves indicate I<sub>C</sub> - V<sub>CE</sub> limits of the transistor that must be observed for reliable operation; i.e., the transistor must not be subjected to greater dissipation than the curves indicate.

The data of Figure 11 is based on  $T_C = 25^{\circ}C$ ;  $T_{J(pk)}$  is variable depending on power level. Second breakdown pulse limits are valid for duty cycles to 10% but must be derated when  $T_C \ge 25^{\circ}$ C. Second breakdown limitations do not derate the same as thermal limitations. Allowable current at the voltages shown on Figure 11 may be found at any case temperature by using the appropriate curve on Figure 13.

 $T_{J(pk)}$  may be calculated from the data in Figure 10. At high case temperatures, thermal limitations will reduce the power that can be handled to values less than the limitations imposed by second breakdown.

#### **REVERSE BIAS**

For inductive loads, high voltage and high current must be sustained simultaneously during turn-off, in most cases, with the base to emitter junction reverse biased. Under these conditions the collector voltage must be held to a safe level at or below a specific value of collector current. This can be accomplished by several means such as active clamping, RC snubbing, load line shaping, etc. The safe level for these devices is specified as Reverse Bias Safe Operating Area and represents the voltage-current conditions during reverse biased turn-off. This rating is verified under clamped conditions so that the device is never subjected to an avalanche mode. Figure 12 gives the complete RBSOA characteristics.

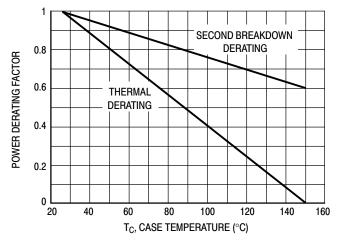
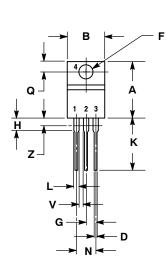
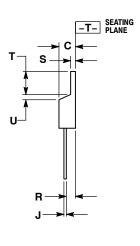


Figure 13. Forward Bias Power Derating

#### PACKAGE DIMENSIONS

#### TO-220AB CASE 221A-09 ISSUE AF





#### NOTES:

- DIMENSIONING AND TOLERANCING PER ANSI
- Y14.5M, 1982. 2. CONTROLLING DIMENSION: INCH.
- 3. DIMENSION Z DEFINES A ZONE WHERE ALL BODY AND LEAD IRREGULARITIES ARE ALLOWED.

	INC	HES	MILLIN	MILLIMETERS		
DIM	MIN	MAX	MIN	MAX		
Α	0.570	0.620	14.48	15.75		
В	0.380	0.405	9.66	10.28		
С	0.160	0.190	4.07	4.82		
D	0.025	0.035	0.64	0.88		
F	0.142	0.161	3.61	4.09		
G	0.095	0.105	2.42	2.66		
Н	0.110	0.155	2.80	3.93		
J	0.014	0.025	0.36	0.64		
K	0.500	0.562	12.70	14.27		
L	0.045	0.060	1.15	1.52		
N	0.190	0.210	4.83	5.33		
Q	0.100	0.120	2.54	3.04		
R	0.080	0.110	2.04	2.79		
S	0.045	0.055	1.15	1.39		
T	0.235	0.255	5.97	6.47		
U	0.000	0.050	0.00	1.27		
٧	0.045		1.15			
Z		0.080		2.04		

STYLE 1:

PIN 1. BASE

- 2. COLLECTOR
- 3. EMITTER
- 4. COLLECTOR

SWITCHMODE is a trademark of Semiconductor Components Industries, LLC.

ON Semiconductor and the 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, 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

Order Literature: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative

# **ПОСТАВКА** ЭЛЕКТРОННЫХ КОМПОНЕНТОВ

многоканальный

Общество с ограниченной ответственностью «МосЧип» ИНН 7719860671 / КПП 771901001 Адрес: 105318, г.Москва, ул.Щербаковская д.3, офис 1107

# Данный компонент на территории Российской Федерации Вы можете приобрести в компании MosChip.

Для оперативного оформления запроса Вам необходимо перейти по данной ссылке:

# http://moschip.ru/get-element

Вы можете разместить у нас заказ для любого Вашего проекта, будь то серийное производство или разработка единичного прибора.

В нашем ассортименте представлены ведущие мировые производители активных и пассивных электронных компонентов.

Нашей специализацией является поставка электронной компонентной базы двойного назначения, продукции таких производителей как XILINX, Intel (ex.ALTERA), Vicor, Microchip, Texas Instruments, Analog Devices, Mini-Circuits, Amphenol, Glenair.

Сотрудничество с глобальными дистрибьюторами электронных компонентов, предоставляет возможность заказывать и получать с международных складов практически любой перечень компонентов в оптимальные для Вас сроки.

На всех этапах разработки и производства наши партнеры могут получить квалифицированную поддержку опытных инженеров.

Система менеджмента качества компании отвечает требованиям в соответствии с ГОСТ Р ИСО 9001, ГОСТ РВ 0015-002 и ЭС РД 009

# Офис по работе с юридическими лицами:

105318, г. Москва, ул. Щербаковская д. 3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: info@moschip.ru

Skype отдела продаж:

moschip.ru moschip.ru\_6 moschip.ru 4 moschip.ru 9