

6367254 MOTOROLA SC (XSTRS/R F)

96D 82498 D

MPQ2906, 2907 For Specifications, See MHQ2906 Data.**MAXIMUM RATINGS**

Rating	Symbol	Value	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CBO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	4.0	Vdc
Collector Current — Continuous	I_C	1.0	Adc
		Each Transistor	Four Transistors Equal Power
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	650 5.2	mW mW/°C
Total Device Dissipation @ $T_C = 25^\circ\text{C}$ Derate above 25°C	P_D'	1.0 8.0	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +150	°C

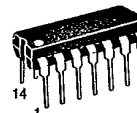
THERMAL CHARACTERISTICS

Characteristic	Junction to Case	Junction to Ambient	Unit
Thermal Resistance Each Die Effective, 4 Die	125 41.6	193* 100*	°C/W °C/W
Coupling Factors Q1-Q4 or Q2-Q3 Q1-Q2 or Q3-Q4	30 2.0	60 25	% %

(1) $R_{\theta JA}$ is measured with the device soldered into a typical printed circuit board.**ELECTRICAL CHARACTERISTICS** ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage ($I_C = 10 \text{ mAdc}, I_B = 0$)	$V_{(BR)CEO}$	12	—	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100 \mu\text{Adc}, I_E = 0$)	$V_{(BR)CBO}$	25	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100 \mu\text{Adc}, I_C = 0$)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector Cutoff Current ($V_{CE} = 15 \text{ Vdc}, V_{BE} = 0$)	I_{CES}	—	—	100	μAdc
ON CHARACTERISTICS					
DC Current Gain ($I_C = 100 \text{ mAdc}, V_{CE} = 0.5 \text{ Vdc}$) ($I_C = 300 \text{ mAdc}, V_{CE} = 0.5 \text{ Vdc}$)	h_{FE}	30 40	45 55	— 200	—
Collector-Emitter Saturation Voltage ($I_C = 300 \text{ mAdc}, I_B = 30 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 0.1 \text{ Adc}$)	$V_{CE(sat)}$	— —	0.22 0.52	0.33 0.7	Vdc
Base-Emitter Saturation Voltage ($I_C = 300 \text{ mAdc}, I_B = 30 \text{ mAdc}$) ($I_C = 1.0 \text{ Adc}, I_B = 0.1 \text{ Adc}$)	$V_{BE(sat)}$	— —	0.87 1.04	1.1 1.4	Vdc
SMALL-SIGNAL CHARACTERISTICS					
Current-Gain — Bandwidth Product ($I_C = 100 \text{ mAdc}, V_{CE} = 5.0 \text{ Vdc}, f = 100 \text{ MHz}$)	f_T	400	500	—	MHz
Output Capacitance ($V_{CB} = 5.0 \text{ Vdc}, I_E = 0, f = 1 \text{ MHz}$)	C_{obo}	—	5.0	10	pF
Input Capacitance ($V_{BE} = 0.5 \text{ Vdc}, I_C = 0, f = 1 \text{ MHz}$)	C_{ibo}	—	22	30	pF
SWITCHING CHARACTERISTICS					
Turn-On Time ($V_{CC} = 12 \text{ Vdc}, I_C = 1.0 \text{ Adc}, V_{BE(off)} = 4.0 \text{ Vdc}, I_{B1} = 100 \text{ mAdc}$)	t_{on}	—	12	15	ns
Turn-Off Time ($V_{CC} = 12 \text{ Vdc}, I_C = 1.0 \text{ Adc}, I_{B1} = I_{B2} = 100 \text{ mAdc}$)	t_{off}	—	18	25	ns

T-43-25

MPQ3303CASE 646-06, STYLE 1
TO-116**QUAD
SWITCHING TRANSISTOR**

NPN SILICON

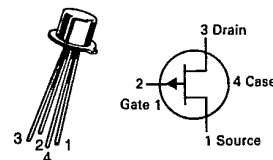
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6367254 MOTOROLA SC (XSTRS/R F)

96D 82543 D

T-35-25
2N3993,A
2N3994

CASE 20-03, STYLE 5
 TO-72 (TO-206AF)



JFET
SWITCHING

P-CHANNEL — DEPLETION

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DS}	-25	Vdc
Drain-Gate Voltage	V_{DG}	-25	Vdc
Reverse Gate-Source Voltage	V_{GSR}	25	Vdc
Forward Gate Current	I_{GF}	10	mAdc
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C	P_D	300 2.0	mW mW/ $^\circ\text{C}$
Storage Temperature Range	T_{stg}	-65 to +200	$^\circ\text{C}$

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage ($I_G = 1.0 \mu\text{Adc}$, $V_{DS} = 0$)	$V_{(BR)GSS}$	25	—	Vdc
Drain Reverse Current ($V_{DG} = -15 \text{ Vdc}$, $I_S = 0$) ($V_{DG} = -15 \text{ Vdc}$, $I_S = 0$, $T_A = 150^\circ\text{C}$)	I_{DGO}	—	1.2 1.2	nAdc μAdc
Drain Cutoff Current ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 10 \text{ Vdc}$) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 6.0 \text{ Vdc}$) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 10 \text{ Vdc}$, $T_A = 150^\circ$) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 6.0 \text{ Vdc}$, $T_A = 150^\circ$)	$I_{D(off)}$	— — — —	1.2 1.2 1.0 1.0	nAdc μAdc
Gate Source Voltage ($V_{DS} = -10 \text{ Vdc}$, $I_D = -1.0 \mu\text{Adc}$)	V_{GS}	4.0 1.0	9.5 5.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current(1) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	10 2.0	— —	mAdc
SMALL-SIGNAL CHARACTERISTICS				
Drain-Source "ON" Resistance ($V_{GS} = 0$, $I_D = 0$, $f = 1.0 \text{ kHz}$)	$r_{ds(on)}$	— —	150 300	Ohms
Forward Transfer Admittance(1) ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	6.0 7.0 4.0	12 12 10	mmhos
Input Capacitance ($V_{DS} = -10 \text{ Vdc}$, $V_{GS} = 0$, $f = 1.0 \text{ MHz}$)	C_{iss}	— —	16 12	pF
Reverse Transfer Capacitance ($V_{DS} = 0$, $V_{GS} = 10 \text{ Vdc}$, $f = 1.0 \text{ MHz}$) ($V_{DS} = 0$, $V_{GS} = 6.0 \text{ Vdc}$, $f = 1.0 \text{ MHz}$)	C_{rss}	— — —	4.5 3.0 5.0	pF

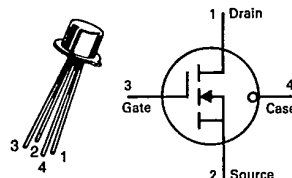
(1) Pulse Test: Pulse Width = 100 ms, Duty Cycle $\leq 10\%$.

MOTOROLA SMALL-SIGNAL SEMICONDUCTORS

6367254 MOTOROLA SC (XSTRS/R F)

96D 82603 D

T-37-25

3N157
3N158CASE 20-03, STYLE 2
TO-72 (TO-206AF)**MOSFET**
AMPLIFIER AND SWITCHING

P-CHANNEL — ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain-Source Voltage*	V_{DS}	± 35	Vdc
Drain-Gate Voltage*	V_{DG}	± 50	Vdc
Gate-Source Voltage*	V_{GS}	± 50	Vdc
Drain Current*	I_D	30	mA
Total Device Dissipation @ $T_A = 25^\circ\text{C}$ Derate above 25°C *	P_D	300 1.7	mW mW/ $^\circ\text{C}$
Junction Temperature Range*	T_J	-65 to $+175$	$^\circ\text{C}$
Storage Channel Temperature Range*	T_{stg}	-65 to $+175$	$^\circ\text{C}$

*JEDEC Registered Limits

ELECTRICAL CHARACTERISTICS ($T_A = 25^\circ\text{C}$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage ($I_D = -10 \mu\text{A}$, $V_G = V_S = 0$)	$V_{(BR)DSX}$	-35	—	—	Vdc
Zero-Gate-Voltage Drain Current ($V_{DS} = -15 \text{ Vdc}$, $V_{GS} = 0$)	I_{DSS}	—	—	-1.0 -10	nA μA
Gate Reverse Current* ($V_{GS} = +25 \text{ Vdc}$, $V_{DS} = 0$)	I_{GSS}	—	—	+10 +10	pA nA
Input Resistance ($V_{GS} = -25 \text{ Vdc}$)	R_{GS}	—	1×10^{12}	—	Ohms
Gate Source Voltage* ($V_{DS} = -15 \text{ Vdc}$, $I_D = -0.5 \text{ mA}$)	V_{GS}	-1.5 -3.0	—	-5.5 -7.0	Vdc
Gate Forward Current* ($V_{GS} = -25 \text{ Vdc}$, $V_{DS} = 0$)	$I_{G(f)}$	—	—	-10 -1.0 -10 -1.0	pA nA nA μA

ON CHARACTERISTICS

Gate Threshold Voltage* ($V_{DS} = -15 \text{ Vdc}$, $I_D = -10 \mu\text{A}$)	$V_{GS(Th)}$	-1.5 -3.0	—	-3.2 -5.0	Vdc
On-State Drain Current* ($V_{DS} = -15 \text{ Vdc}$, $V_{GS} = -10 \text{ Vdc}$)	$I_{D(on)}$	-5.0	—	—	mA

SMALL-SIGNAL CHARACTERISTICS

Forward Transfer Admittance* ($V_{DS} = -15 \text{ Vdc}$, $I_D = -2.0 \text{ mA}$, $f = 1.0 \text{ kHz}$)	$ y_{fs} $	1000	—	4000	μmhos
Output Admittance* ($V_{DS} = -15 \text{ Vdc}$, $I_D = -2.0 \text{ mA}$, $f = 1.0 \text{ kHz}$)	$ y_{os} $	—	—	60	μmhos
Input Capacitance* ($V_{DS} = -15 \text{ Vdc}$, $V_{GS} = 0$, $f = 140 \text{ kHz}$)	C_{iss}	—	—	6.0	pF
Reverse Transfer Capacitance* ($V_{DS} = -15 \text{ Vdc}$, $V_{GS} = 0$, $f = 140 \text{ kHz}$)	C_{rss}	—	—	1.3	pF
Drain-Substrate Capacitance ($V_{D(SUB)} = -10 \text{ Vdc}$, $f = 140 \text{ kHz}$)	$C_{d(sub)}$	—	—	4.0	pF
Noise Voltage ($R_S = 0$, $BW = 1.0 \text{ Hz}$, $V_{DS} = -15 \text{ Vdc}$, $I_D = -2.0 \text{ mA}$, $f = 100 \text{ Hz}$)	e_n	—	300	—	NV/ $\sqrt{\text{Hz}}$
($R_S = 0$, $BW = 1.0 \text{ Hz}$, $V_{DS} = -15 \text{ Vdc}$, $I_D = -2.0 \text{ mA}$, $f = 1.0 \text{ kHz}$)		—	120	500	

*JEDEC Registered Limits

MOTOROLA SMALL-SIGNAL SEMICONDUCTORS

6367254 MOTOROLA SC (XSTRS/R F)

96D 82604 D

3N157, 3N158

T-37-25

FIGURE 1 – FORWARD TRANSCONDUCTANCE

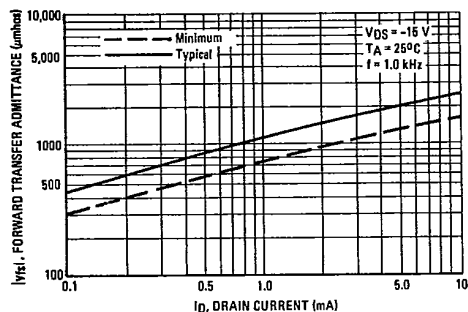


FIGURE 2 – OUTPUT TRANSCONDUCTANCE

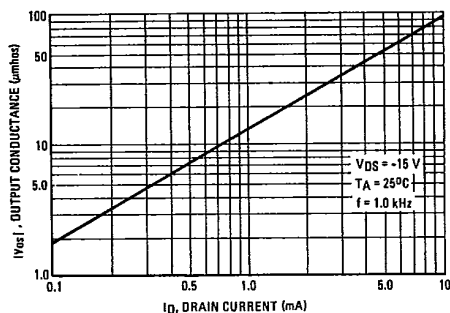
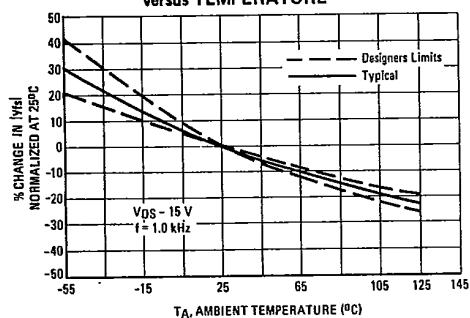
FIGURE 3 – FORWARD TRANSCONDUCTANCE
versus TEMPERATURE

FIGURE 4 – BIAS CURVE

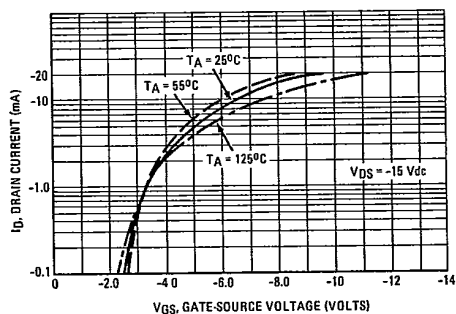


FIGURE 5 – "ON" DRAIN-SOURCE VOLTAGE

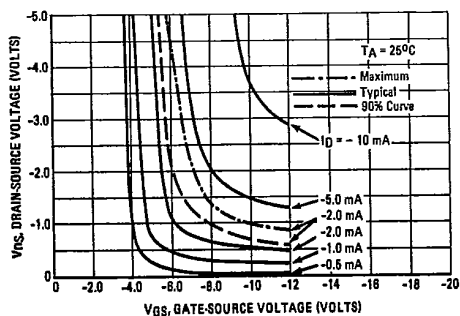
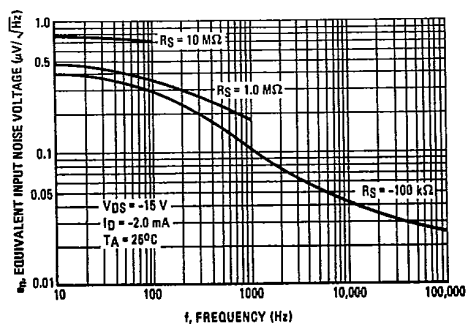


FIGURE 6 – EQUIVALENT INPUT NOISE VOLTAGE



MOTOROLA SMALL-SIGNAL SEMICONDUCTORS

6367254 MOTOROLA SC (XSTRS/R F)

96D 82605 D

3N157, 3N158

T-37-25

SWITCHING CHARACTERISTICS

(T_A = 25°C)

FIGURE 7 – TURN-ON DELAY TIME

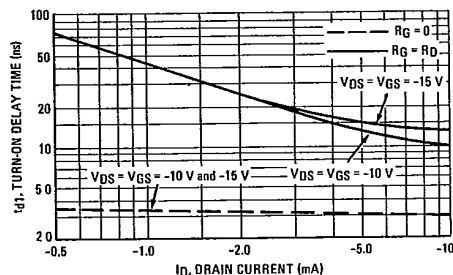


FIGURE 8 – RISE TIME

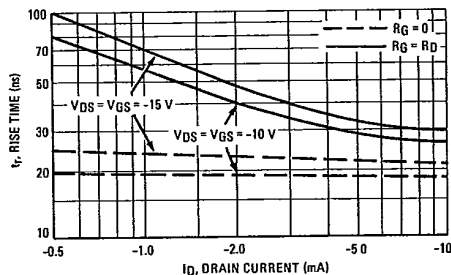


FIGURE 9 – TURN-OFF DELAY TIME

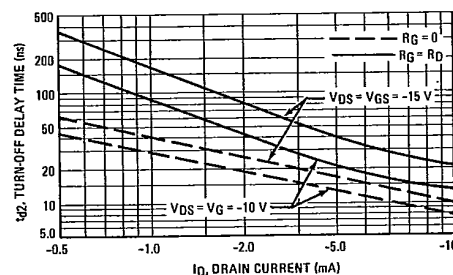


FIGURE 10 – FALL TIME

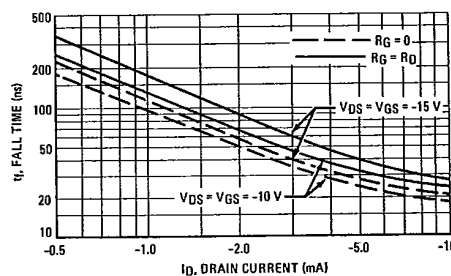


FIGURE 11 – SWITCHING CIRCUIT and WAVEFORMS

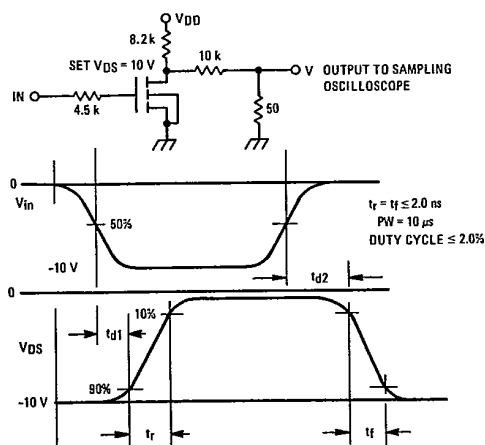
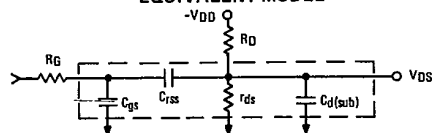


FIGURE 12 – SWITCHING CIRCUIT with MOSFET EQUIVALENT MODEL



The switching characteristics shown above were measured in a test circuit similar to Figure 11. At the beginning of the switching interval, the gate voltage is at ground and the gate source capacitance ($C_{GS} \cdot C_{RSS} \cdot C_{RSS}$) has no charge. The drain voltage is at V_{DD} and thus the feedback capacitance (C_{RSS}) is charged to V_{DD} . Similarly, the drain substrate capacitance ($C_{D(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

During the turn-on interval C_{GS} is charged to V_{GS} (the input voltage) through R_G (generator impedance) (Figure 12). C_{RSS} must be discharged to $V_{GS} \cdot V_{D(on)}$ through R_G and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{D(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds} . During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate voltage (V_{GS}). As C_{GS} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 5) and since C_{RSS} and $C_{D(sub)}$ are charged through r_{ds} , turn-on time is quite non-linear.

If the charging time of C_{GS} is short compared to that of C_{RSS} and $C_{D(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{RSS} and $C_{D(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_G = 0$ and C_{GS} is charged through the pulse generator impedance only.

The switching curves shown with $R_G = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_G = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.