MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

MTM50N05E

Designer's Data Sheet

TMOS IV
Power Field Effect Transistors
N-Channel Enhancement-Mode Silicon Gate

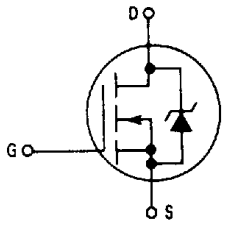
TMOS POWER FETs
50 AMPERES
$R_{DS(on)}$ = 0.028 OHM
50 VOLTS

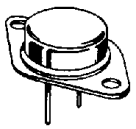
3

This advanced "E" series of TMOS power MOSFETs is designed to withstand high energy in the avalanche and commutation modes. These new energy efficient devices also offer drain-to-source diodes with fast recovery times. Designed for low voltage, high speed switching applications in power supplies, converters and PWM motor controls, these devices are particularly well suited for bridge circuits where diode speed and commutating safe operating area are critical, and offer additional safety margin against unexpected voltage transients.

- Internal Source-to-Drain Diode Designed to Replace External Zener Transient Suppressor — Absorbs High Energy in the Avalanche Mode — Unclamped Inductive Switching (UIS) Energy Capability Specified at 100°C.
- Commutating Safe Operating Area (CSOA) Specified for Use in Half and Full Bridge Circuits
- Source-to-Drain Diode Recovery Time Comparable to a Discrete Fast Recovery Diode
- Diode is Characterized for Use in Bridge Circuits
- DC Equivalent to IRFZ40

TMOS®





MTM50N05E
CASE 197A-03
TO-204AE

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Drain-Source Voltage	V_{DSS}	50	Vdc
Drain-Gate Voltage (R_{GS} = 1 MΩ)	V_{DGR}	50	Vdc
Gate-Source Voltage — Continuous — Non-repetitive ($t_p \leq 50\ \mu s$)	V_{GS} V_{GSM}	±20 ±40	Vdc Vpk
Drain Current — Continuous (T_C = 25°C) — Pulsed	I_D I_{DM}	50 160	Adc
Total Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	125 1	Watts W/°C
Operating and Storage Temperature Range	T_J, T_{stg}	−65 to 150	°C

THERMAL CHARACTERISTICS

Thermal Resistance Junction to Case Junction to Ambient	 $R_{\theta JC}$ $R_{\theta JA}$	 1.0 30	°C/W
Maximum Lead Temperature for Soldering Purposes, 1/8" from case for 5 seconds	T_L	300	°C

Designer's Data for "Worst Case" Conditions — The Designer's Data Sheet permits the design of most circuits entirely from the information presented SOA Limit curves — representing boundaries on device characteristics — are given to facilitate "worst case" design

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage (V_{GS} = 0, I_D = 0.25 mA)	$V_{(BR)DSS}$	50	—	Vdc
Zero Gate Voltage Drain Current (V_{DS} = Rated V_{DSS}, V_{GS} = 0)	I_{DSS}	—	10	μA
(V_{DS} = 0.8 Rated V_{DSS}, V_{GS} = 0, T_J = 125°C)		—	80	
Gate-Body Leakage Current, Forward (V_{GSF} = 20 Vdc, V_{DS} = 0)	I_{GSSF}	—	100	nAdc
Gate-Body Leakage Current, Reverse (V_{GSR} = 20 Vdc, V_{DS} = 0)	I_{GSSR}	—	100	nAdc
ON CHARACTERISTICS*				
Gate Threshold Voltage (V_{DS} = V_{GS}, I_D = 250 μA)	$V_{GS(th)}$	2	4	Vdc
T_J = 100°C		1.5	3.5	
Static Drain-Source On-Resistance (V_{GS} = 10 Vdc, I_D = 25 Adc)	$R_{DS(on)}$	—	0.028	Ohm
Drain-Source On-Voltage (V_{GS} = 10 V) (I_D = 50 Adc)	$V_{DS(on)}$	—	1.4	Vdc
(I_D = 25 Adc, T_J = 100°C)		—	1.3	
Forward Transconductance (V_{DS} = 15 V, I_D = 25 A)	g_{FS}	17	—	mhos
DRAIN-TO-SOURCE AVALANCHE CHARACTERISTICS				
Unclamped Inductive Switching Energy See Figures 14 and 15 (I_D = 160 A, V_{DD} = 25 V, T_C = 25°C, Single Pulse, Non-repetitive)	W_{DSR}	—	55	mJ
(I_D = 50 A, V_{DD} = 25 V, T_C = 25°C, P.W. ≤ 35 μs, Duty Cycle ≤ 1%)		—	100	
(I_D = 20 A, V_{DD} = 25 V, T_C = 100°C, P.W. ≤ 35 μs, Duty Cycle ≤ 1%)		—	35	
DYNAMIC CHARACTERISTICS				
Input Capacitance	C_{iss}	—	3000	pF
Output Capacitance (V_{DS} = 25 V, V_{GS} = 0, f = 1 MHz) See Figure 16	C_{oss}	—	1200	
Reverse Transfer Capacitance	C_{rss}	—	400	
SWITCHING CHARACTERISTICS* (T_J = 100°C)				
Turn-On Delay Time	$t_{d(on)}$	—	25	ns
Rise Time (V_{DD} = 25 V, I_D = 0.5 Rated I_D R_{gen} = 4.7 ohms) See Figure 9	t_r	—	60	
Turn-Off Delay Time	$t_{d(off)}$	—	70	
Fall Time	t_f	—	25	
Total Gate Charge	Q_g	55 (Typ)	60	nC
Gate-Source Charge (V_{DS} = 0.8 Rated V_{DSS}, I_D = Rated I_D, V_{GS} = 10 V) See Figures 17 and 18	Q_{gs}	30 (Typ)	—	
Gate-Drain Charge	Q_{gd}	25 (Typ)	—	
SOURCE DRAIN DIODE CHARACTERISTICS*				
Forward On-Voltage (I_{SD} = 51 A, V_{GS} = 0, dI_S/dt = 100 A/μs)	V_{SD}	1.9 (Typ)	2.5	Vdc
Forward Turn-On Time	t_{on}	Limited by stray inductance		
Reverse Recovery Time	t_{rr}	(Typ)	250	ns
INTERNAL PACKAGE INDUCTANCE (TO-204)				
Internal Drain Inductance (Measured from the contact screw on the header closer to the source pin and the center of the die)	L_d	5 (Typ)	—	nH
Internal Source Inductance (Measured from the source pin, 0.25" from the package to the source bond pad)	L_s	12.5 (Typ)	—	

*Pulse Test Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%

TYPICAL ELECTRICAL CHARACTERISTICS

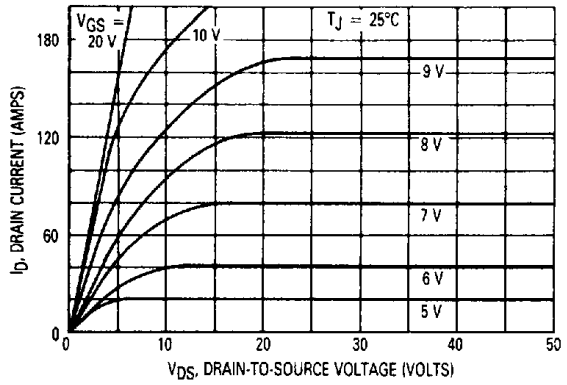


Figure 1. On-Region Characteristics

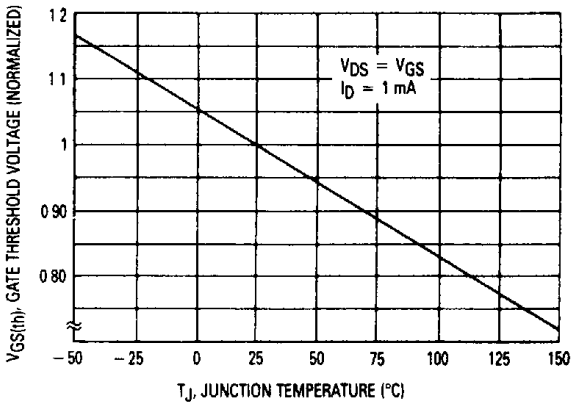


Figure 2. Gate-Threshold Voltage Variation With Temperature

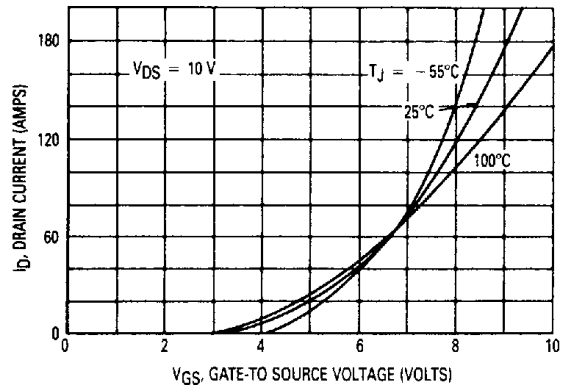


Figure 3. Transfer Characteristics

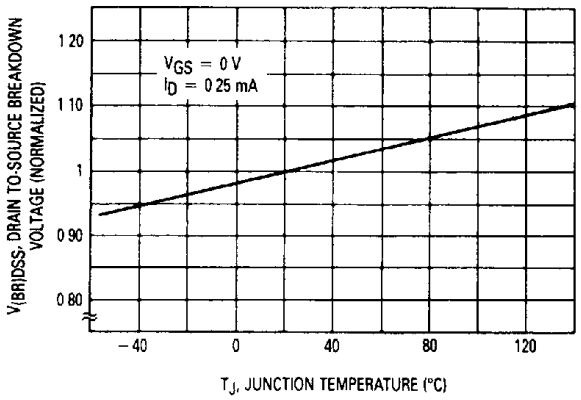


Figure 4. Breakdown Voltage Variation With Temperature

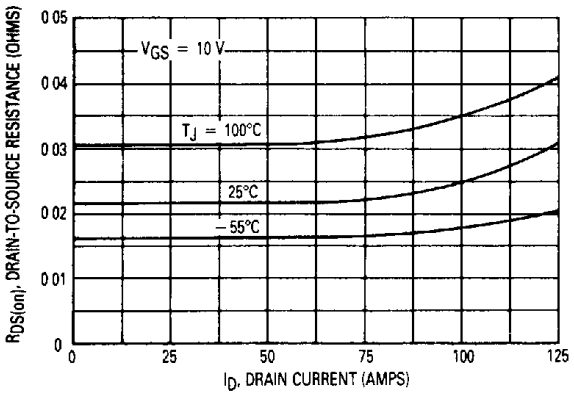


Figure 5. On-Resistance versus Drain Current

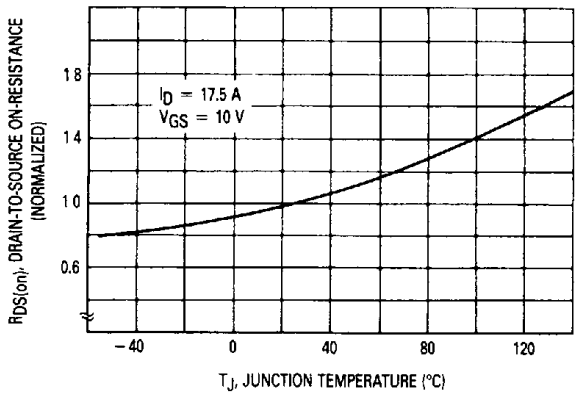


Figure 6. On-Resistance Variation With Temperature

SAFE OPERATING AREA INFORMATION

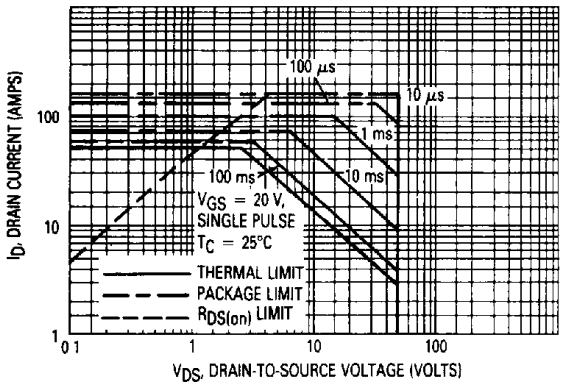


Figure 7. Maximum Rated Forward Biased Safe Operating Area

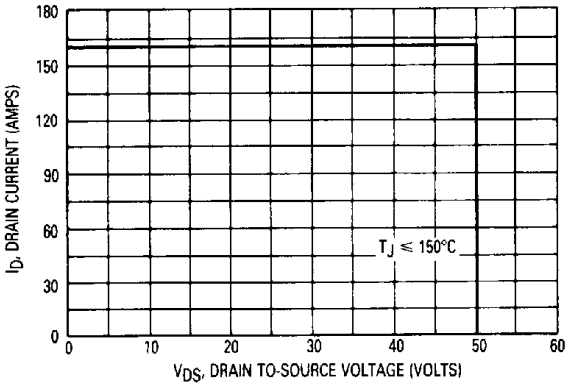


Figure 8. Maximum Rated Switching Safe Operating Area

FORWARD BIASED SAFE OPERATING AREA

The FBSOA curves define the maximum drain-to-source voltage and drain current that a device can safely handle when it is forward biased, or when it is on, or being turned on. Because these curves include the limitations of simultaneous high voltage and high current, up to the rating of the device, they are especially useful to designers of linear systems. The curves are based on a case temperature of 25°C and a maximum junction temperature of 150°C. Limitations for repetitive pulses at various case temperatures can be determined by using the thermal response curves. Motorola Application Note, AN569, "Transient Thermal Resistance-General Data and Its Use" provides detailed instructions.

SWITCHING SAFE OPERATING AREA

The switching safe operating area (SOA) of Figure 8 is the boundary that the load line may traverse without incurring damage to the MOSFET. The fundamental limits are the peak current, I_{DM} and the breakdown voltage, $V_{(BR)DSS}$. The switching SOA shown in Figure 8 is applicable for both turn-on and turn-off of the devices for switching times less than one microsecond.

The power averaged over a complete switching cycle must be less than:

$$\frac{T_{J(max)} - T_C}{R_{\theta JC}}$$

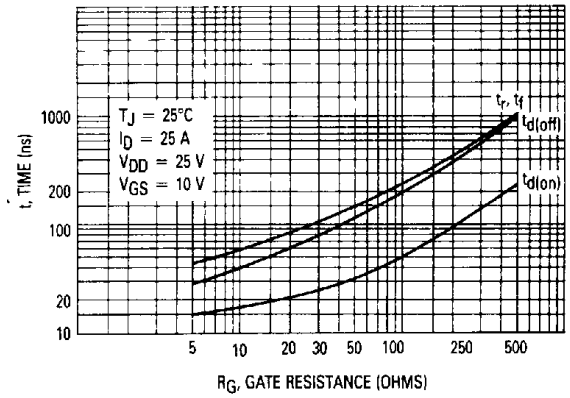


Figure 9. Resistive Switching Time Variation versus Gate Resistance

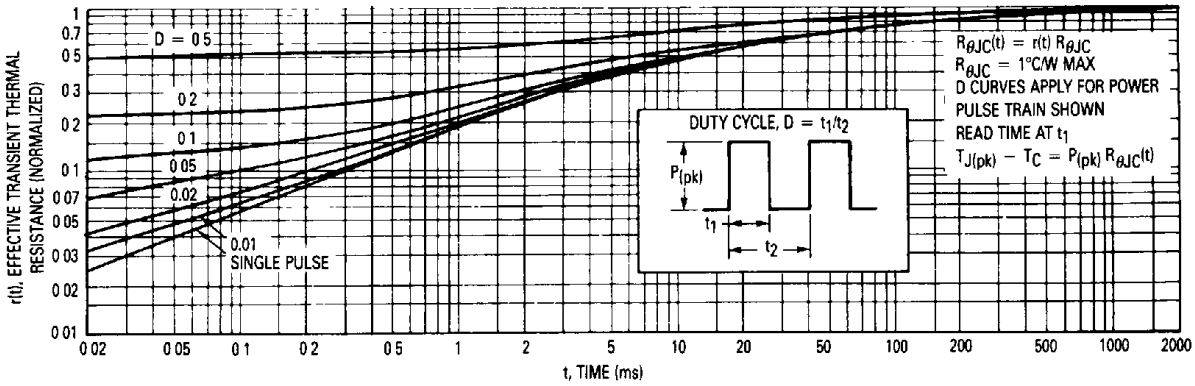


Figure 10. Thermal Response

COMMUTATING SAFE OPERATING AREA (CSOA)

The Commutating Safe Operating Area (CSOA) of Figure 12 defines the limits of safe operation for commutated source-drain current versus re-applied drain voltage when the source-drain diode has undergone forward bias. The curve shows the limitations of I_{FM} and peak V_{DS} for a given rate of change of source current. It is applicable when waveforms similar to those of Figure 11 are present. Full or half-bridge PWM DC motor controllers are common applications requiring CSOA data.

Device stresses increase with increasing rate of change of source current so dI_S/dt is specified with a maximum value. Higher values of dI_S/dt require an appropriate derating of I_{FM}, peak V_{DS} or both. Ultimately dI_S/dt is limited primarily by device, package, and circuit impedances. Maximum device stress occurs during t_{rr} as the diode goes from conduction to reverse blocking.

$V_{DS(pk)}$ is the peak drain-to-source voltage that the device must sustain during commutation; I_{FM} is the maximum forward source-drain diode current just prior to the onset of commutation.

V_R is specified at 80% of $V_{(BR)DSS}$ to ensure that the CSOA stress is maximized as I_S decays from I_{RM} to zero.

R_{GS} should be minimized during commutation. T_J has only a second order effect on CSOA.

Stray inductances in Motorola's test circuit are assumed to be practical minimums. dV_{DS}/dt in excess of 10 V/ns was attained with dI_S/dt of 400 A/μs.

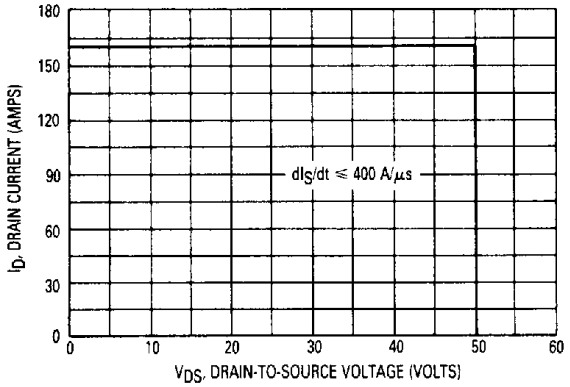


Figure 12. Commutating Safe Operating Area (CSOA)

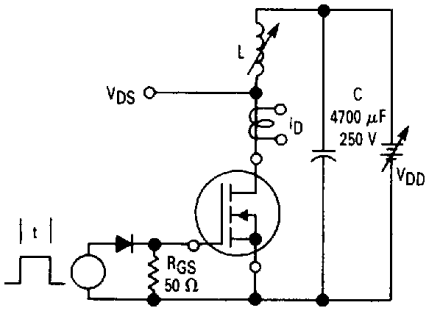


Figure 14. Unclamped Inductive Switching Test Circuit

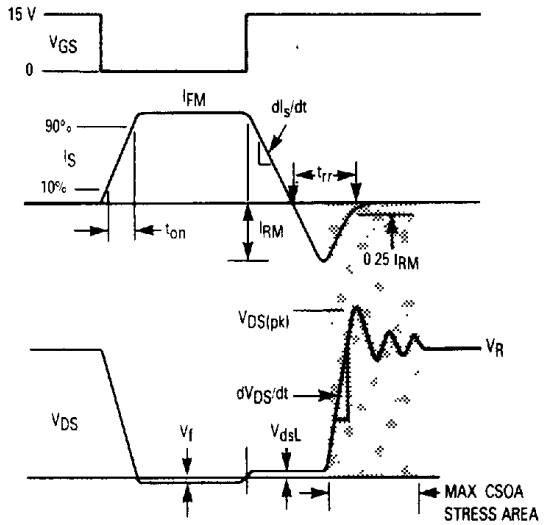


Figure 11. Commutating Waveforms

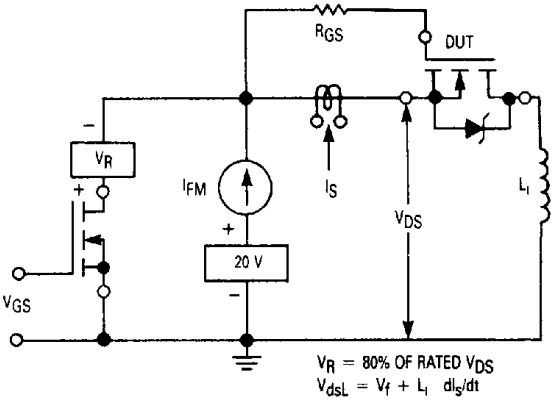


Figure 13. Commutating Safe Operating Area Test Circuit

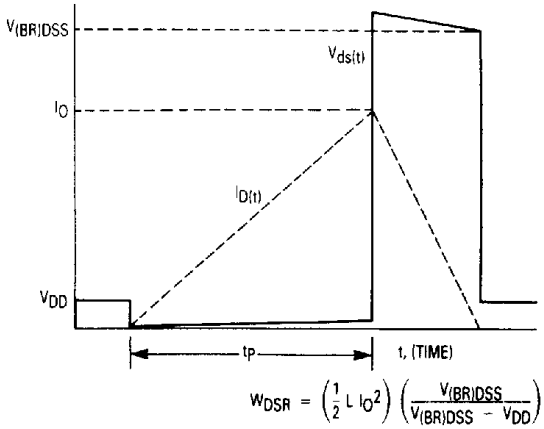


Figure 15. Unclamped Inductive Switching Waveforms

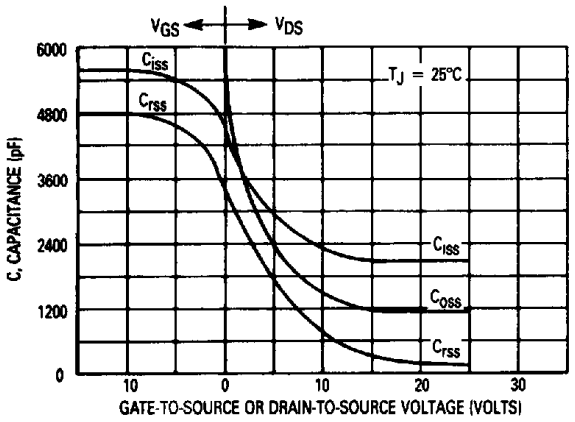


Figure 16. Capacitance Variation

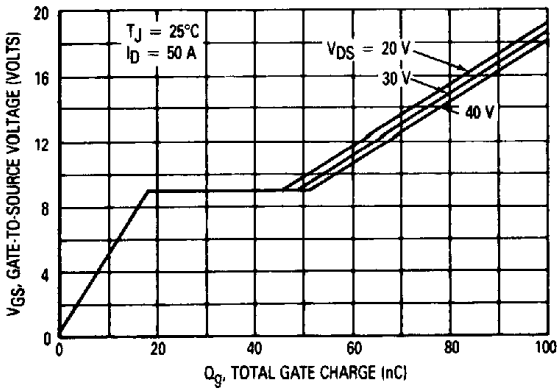
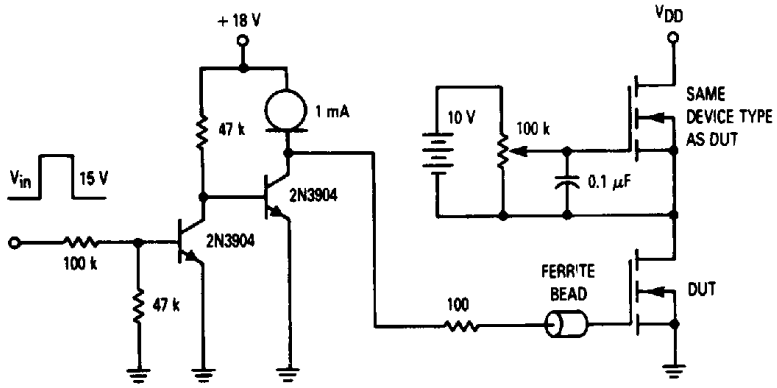


Figure 17. Gate Charge versus Gate-to-Source Voltage



V_{in} = 15 V_{pk}, PULSE WIDTH ≤ 100 μs, DUTY CYCLE ≤ 10%

Figure 18. Gate Charge Test Circuit