



**MOTOROLA**

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# TCF6000

## Peripheral Clamping Array

The TCF6000 was designed to protect input/output lines of microprocessor systems against voltage transients.

- Optimized for HMOS System
- Minimal Component Count
- Low Board Space Requirement
- No P.C.B. Track Crossovers Required
- Applications Areas Include Automotive, Industrial, Telecommunications and Consumer Goods

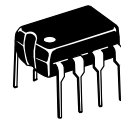
### PERIPHERAL CLAMPING ARRAY

#### SEMICONDUCTOR TECHNICAL DATA

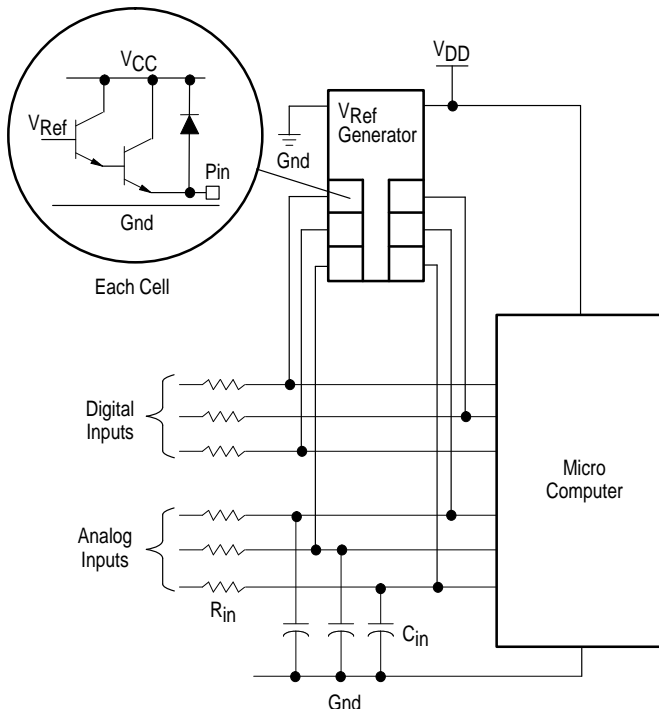


**D SUFFIX**  
PLASTIC PACKAGE  
CASE 751  
(SO-8)

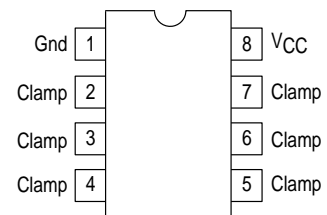
**NO SUFFIX**  
PLASTIC PACKAGE  
CASE 626



**Figure 1. Representative Block Diagram and Simplified Application**



### PIN CONNECTIONS



### ORDERING INFORMATION

Device	Operating Temperature Range	Package
TCF6000D	$T_A = -40^\circ \text{ to } +85^\circ \text{C}$	SO-8
TCF6000		Plastic DIP

# TCF6000

## MAXIMUM RATINGS (T<sub>A</sub> = 25°C, unless otherwise noted, Note 1.)

Rating	Symbol	Value	Unit
Supply Voltage	V <sub>CC</sub>	6.0	V
Supply Current	I <sub>i</sub>	300	mA
Clamping Current	I <sub>IK</sub>	±50	mA
Junction Temperature	T <sub>J</sub>	150	°C
Power Dissipation (T <sub>A</sub> = + 85°C)	P <sub>D</sub>	400	m/W
Thermal Resistance (Junction–Ambient)	θ <sub>JA</sub>	100	°C/W
Operating Ambient Temperature Range	T <sub>A</sub>	–40 to +85	°C
Storage Temperature Range	T <sub>stg</sub>	–55 to + 150	°C

**NOTE:** 1. Values beyond which damage may occur.

## ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C, 4.5 ≤ V<sub>CC</sub> ≤ 5.5 V, unless otherwise noted.)

Characteristics	Symbol	Min	Max	Unit
Positive Clamping Voltage (Note 2) (I <sub>IK</sub> = 10 mA, –40°C ≤ T <sub>A</sub> ≤ + 85°C)	V <sub>(IK)</sub>	–	V <sub>CC</sub> + 1.0	V
Positive Peak Clamping Current	I <sub>IK(P)</sub>	–	20	mA
Negative Peak Clamping Voltage (I <sub>IK</sub> = –10 mA, –40°C ≤ T <sub>A</sub> ≤ + 85°C)	V <sub>(IK)</sub>	–0.3	–	V
Negative Peak Clamping Current	I <sub>IK(P)</sub>	–20	–	mA
Output Leakage Current (0 V ≤ V <sub>in</sub> ≤ V <sub>CC</sub> ) (0 V ≤ V <sub>in</sub> ≤ V <sub>CC</sub> , –40°C ≤ T <sub>A</sub> ≤ + 85°C)	I <sub>L</sub> I <sub>LT</sub>	–	1.0 5.0	μA
Channel Crosstalk (A <sub>CT</sub> = 20 log I <sub>L</sub> /I <sub>IK</sub> )	A <sub>CT</sub>	100	–	dB
Quiescent Current (Package)	I <sub>B</sub>	–	2.0	mA

**NOTE:** 2. The device might not give 100% protection in CMOS applications.

## CIRCUIT DESCRIPTION

To ensure the reliable operation of any integrated circuit based electronics system, care has been taken that voltage transients do not reach the device I/O pins. Most NMOS, HMOS and Bipolar integrated circuits are particularly sensitive to negative voltage peaks which can provoke latch-up or otherwise disturb the normal functioning of the circuit, and in extreme cases may destroy the device.

Generally the maximum rating for a negative voltage transients on integral circuits is –0.3 V over the whole temperature range. Classical protection units have consisted of diode/resistor networks as shown in Figures 2a and 2b.

The arrangement in Figure 2a does not, in general, meet the specification and is therefore inadequate.

The problem with the solution shown in Figure 2b lies mainly with the high current drain through the biasing devices R<sub>1</sub> and D<sub>3</sub>. A second problem exists if the input line carries an analog signal. When V<sub>in</sub> is close to the ground potential, currents arising from leakage and mismatch between D<sub>3</sub> and D<sub>2</sub> can be sourced into the input line, thus disturbing the reading.

**Figure 2. Classical Protection Circuits**

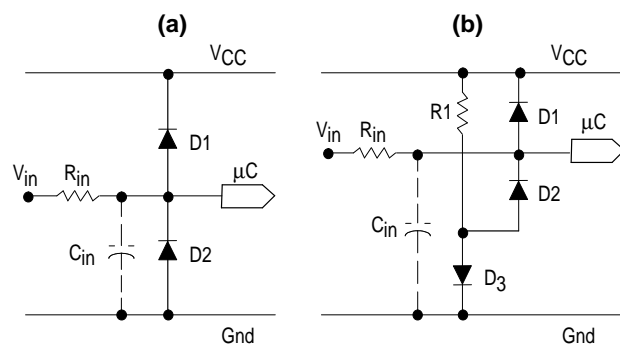
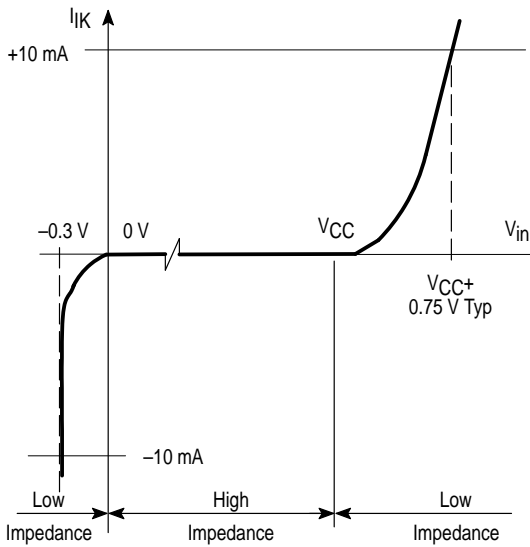


Figure 3 shows the clamping characteristics which are common to each of the six cells in the Peripheral Clamping Array.

As with the classical protection circuits, positive voltage transients are clamped by means of a fast diode to the V<sub>CC</sub> supply line.

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**Figure 3. Clamping Characteristics**



## APPLICATIONS INFORMATION

Figure 4 depicts a typical application in a microcomputer based automotive ignition system.

The TCF6000 is being used not only to protect the system's normal inputs but also the (bidirectional) serial diagnostics port.

The value of the input resistors,  $R_{in}$ , is determined by the clamping current and the anticipated value of the spikes.

Thus:

$$R_{in} = \frac{V}{I_{IK}} \Omega$$

where:  $V$  = Peak Volts (V)

$I_{IK}$  = Clamping current (A)

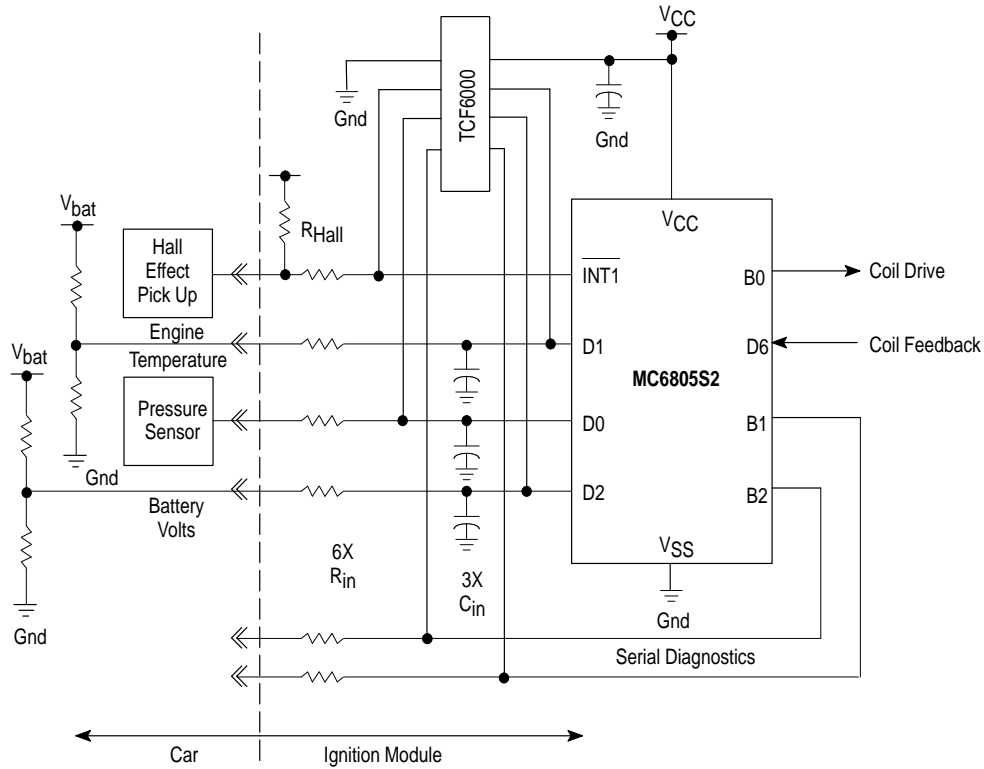
So, taking,  $V$  = 300 V typically (SAE J1211)

$I_{IK}$  = 10 mA (recommended)

gives,  $R_{in}$  = 30 k

Resistors of this value will not usually cause any problems in MOS systems, but their presence needs to be taken into account by the designer. Their effect will normally need to be compensated for Bipolar systems.

**Figure 4. Typical Automotive Application**



## TCF6000

The use of  $C_{in}$  is not mandatory, and is not recommended where the lines to be protected are used for output or for both input and output. For digital input lines, the use of a small capacitor in the range of 50 pF to 220 pF is recommended as this will reduce the rate of rise of voltage seen by the TCF6000 and hence the possibility of overshoot.

In the case of the analog inputs, such as that from the pressure sensor, the capacitor  $C_{in}$  is necessary for devices such as the MC6805S2 shown, which present a low impedance during the sampling period. The maximum value for  $C_{in}$  is determined by the accuracy required, the time taken to sample the input and the input impedance during that time, while the maximum value is determined by the required frequency response and the value of  $R_{in}$ .

Thus for a resistive input A/D connector where:

$T_s$  = Sample time (seconds)

$R_D$  = Device input resistance ( $\Omega$ )

$V_{in}$  = Input voltage (V)

$k$  = Required accuracy (%)

$Q_1$  = Charge on capacitor before sampling

$Q_2$  = Charge on capacitor after sampling

$I_D$  = Device input current (A)

$$\text{Thus: } Q_1 - Q_2 = \frac{k \times Q_1}{100}$$

$$\text{but, } Q_1 = C_{in} V_{in}$$

$$\text{and, } Q_1 - Q_2 = I_D \cdot T_s$$

$$\text{so that, } I_D T_s = \frac{k \cdot C_{in} V_{in}}{100}$$

$$\text{and, } C_{in} (\text{min}) = \frac{I_D \cdot T_s}{V_{in} \cdot k} \text{ Farad}$$

$$\text{so, } C_{in} (\text{min}) = \frac{100 \cdot T_s}{k \cdot R_D} \text{ Farad}$$

The calculation for a sample and hold type converter is even simpler:

$k$  = Required accuracy (%)

$C_H$  = Hold capacitor (Farad)

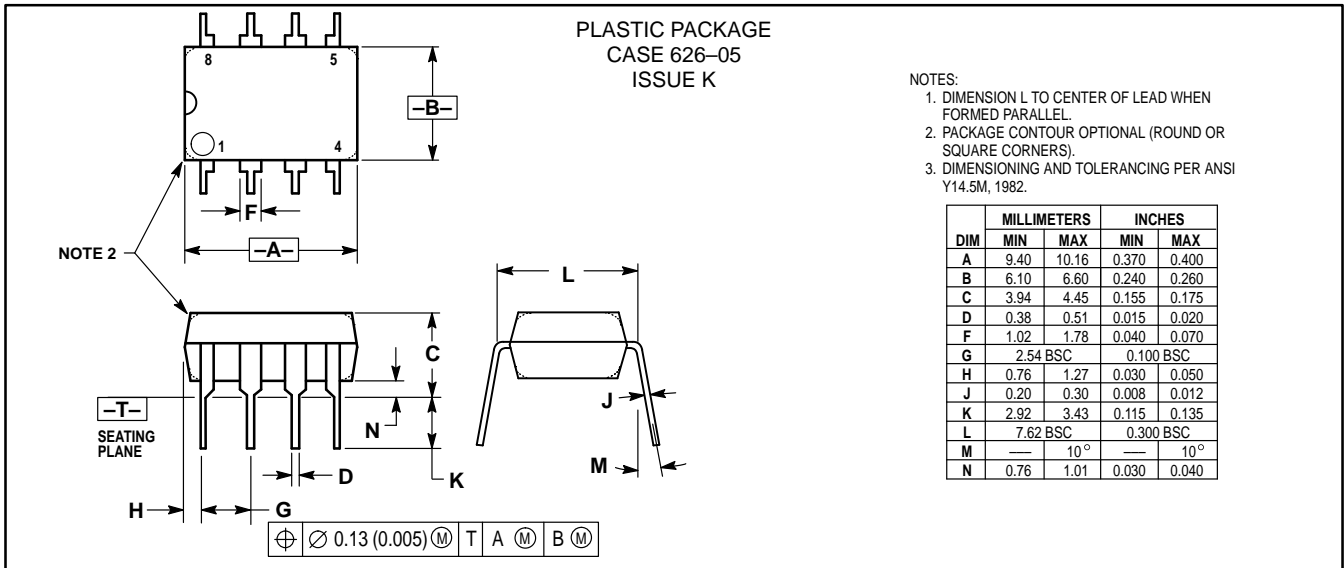
$$C_{in} (\text{min}) = \frac{100 \cdot C_H}{k} \text{ Farad}$$

For the MC6805S2 this comes out at:

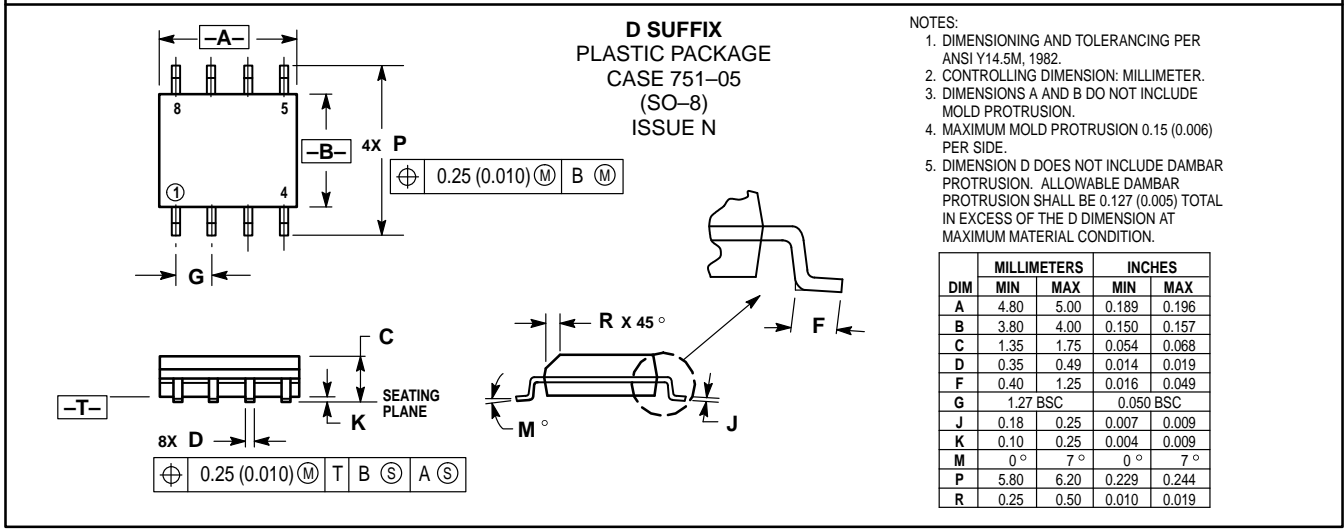
$$C_{in} (\text{min}) = \frac{100.25 \text{ pF}}{0.25} = 10 \text{ nF for } 1/4\% \text{ accuracy}$$

# TCF6000

## OUTLINE DIMENSIONS




- NOTES:
1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
  2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
  3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
  2. CONTROLLING DIMENSION: MILLIMETER.
  3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
  4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
  5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

# TCF6000

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**USA/EUROPE/Locations Not Listed:** Motorola Literature Distribution;  
P.O. Box 20912; Phoenix, Arizona 85036. 1-800-441-2447 or 602-303-5454

**MFAX:** RMFAX0@email.sps.mot.com – TOUCHTONE 602-244-6609

**INTERNET:** <http://Design-NET.com>

**JAPAN:** Nippon Motorola Ltd.; Tatsumi-SPD-JLDC, 6F Seibu-Butsuryu-Center,  
3-14-2 Tatsumi Koto-Ku, Tokyo 135, Japan. 03-81-3521-8315

**ASIA/PACIFIC:** Motorola Semiconductors H.K. Ltd.; 8B Tai Ping Industrial Park,  
51 Ting Kok Road, Tai Po, N.T., Hong Kong. 852-26629298



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