



# TS2902

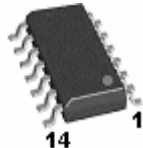
## Quad Operating Amplifier

Preliminary

DIP-14



SOP-14



Pin assignment:

- |                |                 |
|----------------|-----------------|
| 1. Output A    | 14. Output D    |
| 2. Input A (-) | 13. Input D (-) |
| 3. Input A (+) | 12. Input D (+) |
| 4. Vcc         | 11. Gnd         |
| 5. Input B (+) | 10. Input C (+) |
| 6. Input B (-) | 9. Input C (-)  |
| 7. Output B    | 8. Output C     |

**Supply Voltage Range 3 V to 26V**  
**Quad Channel Amplifier**

### General Description

The TS2902 contains four independent high gain operational amplifiers with internal frequency compensation. The four op-amps use a split power supply. The device has low power supply current drain, regardless of the power supply voltage. The low power drain also makes the TS2902 a good choice for battery operation.

When your project calls for a traditional op-amp function, now you can streamline your design with a simple single power supply. Use ordinary +5V common to practically any digital system or personal computer application, without requiring an extra 15V power supply just to have the interface electronics you need.

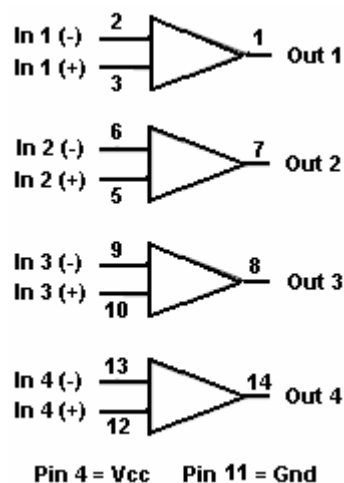
The TS2902 is a versatile, rugged workhorse with a thousand-and-one uses, from amplifying signals from a variety of transducers to dc gain blocks, or any op-amp function. The attached pages offer some recipes that will have your project cooking in no time.

The TS2902 is offered in 14 pin SOP-14 and DIP-14 package.

### Features

- ◇ Single supply operation: 3V to 32V
- ◇ Low input bias currents
- ◇ Internally compensated
- ◇ Common mode range extends to negative supply
- ◇ Single and split supply operation

### Block Diagram



### Ordering Information

| Part No.   | Operating Temp. | Package |
|------------|-----------------|---------|
| TS2902CD14 | -40 ~ +85°C     | DIP-14  |
| TS2902CS14 |                 | SOP-14  |

### Absolute Maximum Rating

|                                          |                  |            |    |
|------------------------------------------|------------------|------------|----|
| Supply Voltage                           | V <sub>CC</sub>  | 26         | V  |
| Differential Input Voltage (note 1)      | V <sub>IDR</sub> | 26         | V  |
| Input Common Mode Voltage Range (note 2) | V <sub>ICR</sub> | -0.3 to 26 | V  |
| Input Forward Current (note 3)           | I <sub>IF</sub>  | 50         | mA |
| Output Short Circuit Duration            | I <sub>SC</sub>  | Continuous | mA |
| Operating Junction Temperature Range     | T <sub>J</sub>   | 0 ~ +125   | °C |
| Storage Temperature Range                | T <sub>STG</sub> | -65 ~ +150 | °C |

NOTE :

1. Split Power Supplies.
2. For supply. Voltages less than 26V for the TS2902 the absolute maximum input voltage is equal to the supply voltage.
3. This input current will only exist when the voltage is negative at any of the input leads. Normal output states will reestablish when the input voltage returns to a voltage greater than -0.3V.

| <b>Electrical Characteristics</b>                                                                                                                                                                                                                                                                                                                                                                                                                         |                      |     |      |                 |       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----|------|-----------------|-------|
| (V <sub>CC</sub> = 5V, Ta=25 °C; unless otherwise specified.)                                                                                                                                                                                                                                                                                                                                                                                             |                      |     |      |                 |       |
| Characteristics                                                                                                                                                                                                                                                                                                                                                                                                                                           | Symbol               | Min | Typ  | Max             | Unit  |
| Input Offset Voltage<br>V <sub>CC</sub> = 5.0V to 26V, V <sub>IC</sub> = 0V to V <sub>CC</sub> -1.7 V, V <sub>O</sub> = 1.4V, R <sub>S</sub> = 0Ω<br>T <sub>LOW</sub> ≤ Ta ≤ T <sub>HIGH</sub>                                                                                                                                                                                                                                                            | V <sub>IO</sub>      | --  | 2.0  | 7.0             | mV    |
| Average Temperature Coefficient of Input Offset Voltage                                                                                                                                                                                                                                                                                                                                                                                                   | ΔI <sub>IO</sub> /ΔT | --  | 7.0  | --              | μV/°C |
| Input Offset Current<br>T <sub>LOW</sub> ≤ Ta ≤ T <sub>HIGH</sub>                                                                                                                                                                                                                                                                                                                                                                                         | I <sub>IO</sub>      | --  | 5.0  | 50              | nA    |
| Average Temperature Coefficient of input Offset Current                                                                                                                                                                                                                                                                                                                                                                                                   | ΔI <sub>IO</sub> /ΔT | --  | 10   | --              | pA/°C |
| Input Bias Current<br>T <sub>LOW</sub> ≤ Ta ≤ T <sub>HIGH</sub>                                                                                                                                                                                                                                                                                                                                                                                           | I <sub>IB</sub>      | --  | 90   | 250             | μA    |
| Input Common-Mode Voltage Range (Note1)<br>V <sub>CC</sub> = 26 V<br>V <sub>CC</sub> = 26 V, T <sub>LOW</sub> ≤ Ta ≤ T <sub>HIGH</sub>                                                                                                                                                                                                                                                                                                                    | V <sub>ICR</sub>     | 0   | --   | 24.3            | V     |
| Differential Input Voltage Range                                                                                                                                                                                                                                                                                                                                                                                                                          | V <sub>IDR</sub>     | --  | --   | V <sub>CC</sub> | V     |
| Large Signal Open-Loop Voltage Gain<br>R <sub>L</sub> = 2.0K, V <sub>CC</sub> =15V, For Large V <sub>O</sub> Swing,<br>T <sub>LOW</sub> ≤ Ta ≤ T <sub>HIGH</sub>                                                                                                                                                                                                                                                                                          | A <sub>VOL</sub>     | --  | 100  | --              | V/mV  |
| Channel Separation<br>1.0 KHz to 20KHz                                                                                                                                                                                                                                                                                                                                                                                                                    | --                   | --  | -120 | --              | dB    |
| Common Mode Rejection Ratio<br>R <sub>S</sub> ≤ 10 kΩ                                                                                                                                                                                                                                                                                                                                                                                                     | CMRR                 | 50  | 70   | --              | dB    |
| Power Supply Rejection Ratio                                                                                                                                                                                                                                                                                                                                                                                                                              | PSRR                 | 50  | 100  | --              | dB    |
| Output Voltage -- High Limit<br>V <sub>CC</sub> = 26 V, R <sub>L</sub> = 2 kΩ<br>V <sub>CC</sub> = 26 V, R <sub>L</sub> = 10 kΩ                                                                                                                                                                                                                                                                                                                           | V <sub>OH</sub>      | 22  | --   | --              | V     |
| Output Voltage -- Low Limit<br>V <sub>CC</sub> = 5.0 V, R <sub>L</sub> = 10 kΩ                                                                                                                                                                                                                                                                                                                                                                            | V <sub>OL</sub>      | --  | 5.0  | 100             | mV    |
| Output Source Current V <sub>ID</sub> =+1.0V, V <sub>CC</sub> =15V                                                                                                                                                                                                                                                                                                                                                                                        | I <sub>O+</sub>      | 20  | 40   | --              | mA    |
| Output Sink Current<br>V <sub>ID</sub> = -1.0 V, V <sub>CC</sub> = 15 V<br>V <sub>ID</sub> = -1.0 V, V <sub>O</sub> = 200 mV                                                                                                                                                                                                                                                                                                                              | I <sub>O-</sub>      | 10  | 20   | --              | mA    |
| Output Short Circuit to Ground (Note 2)                                                                                                                                                                                                                                                                                                                                                                                                                   | I <sub>OS</sub>      | --  | 40   | 60              | mA    |
| Power Supply Current ,<br>V <sub>CC</sub> = 26V, V <sub>O</sub> = 0 V, R <sub>L</sub> = ∞<br>V <sub>CC</sub> = 5V, V <sub>O</sub> = 0 V, R <sub>L</sub> = ∞                                                                                                                                                                                                                                                                                               | I <sub>CC</sub>      | --  | 1.5  | 3.0             | mA    |
| <b>Notes :</b><br>1. The input common mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common mode voltage range is V <sub>CC</sub> 17V, but either or both inputs can go to +26V.<br>2. Short circuits from the output to V <sub>CC</sub> can cause excessive heating and eventual destruction. Destructive dissipation can recruit from simultaneous shorts on all amplifiers. |                      |     |      |                 |       |

## Circuit Description

The TS2902 made using four internally compensated, two-stage operational amplifiers. The first stage performs not only the first stage gain function but also performs the level shifting and transconductance reduction functions. By reducing the transconductance, a smaller compensation capacitor (only 5.0pF) can be employed, thus saving chip area. Another feature of this input stage is that the input common mode range can include the negative supply or ground, in single supply operation, without saturating either the input devices or the differential to single-ended converter. The second stage consists of a standard current source load amplifier stage.

Each amplifier is biased from an internal-voltage regulator, and which has a low temperature coefficient thus giving each amplifier good temperature characteristics as well as excellent power supply rejection.

## Electrical Characteristics Curve

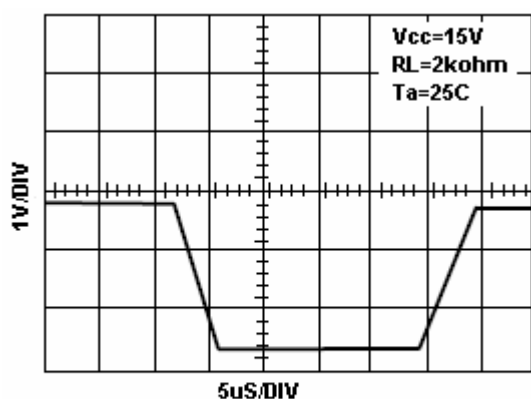


Figure 1. large signal voltage follower response

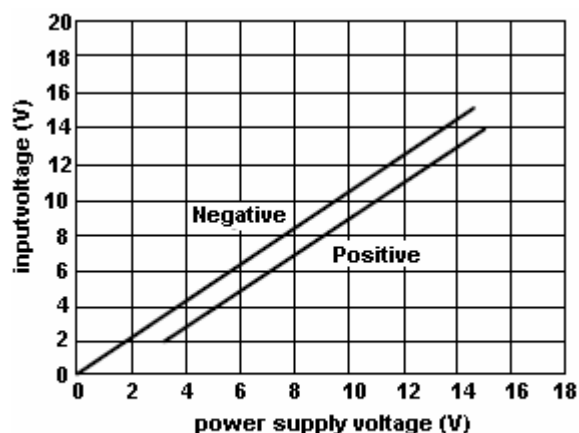


Figure 2. input voltage range

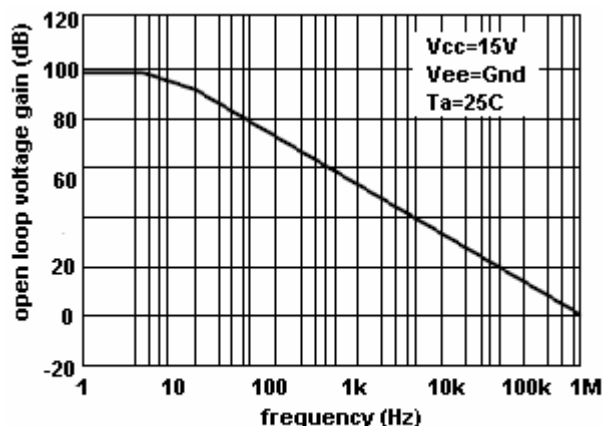


Figure 3. large signal open loop voltage gain

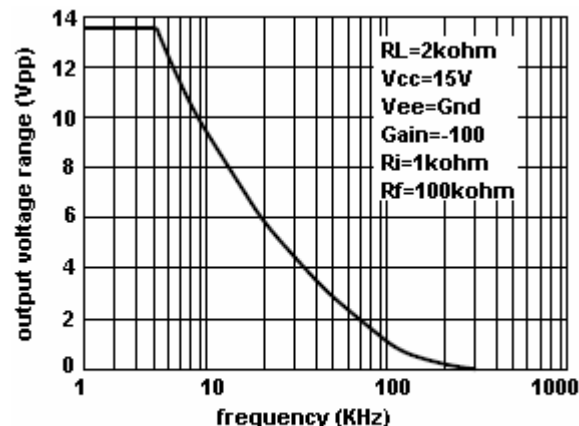


Figure 4. larger signal frequency response

## Circuit Description

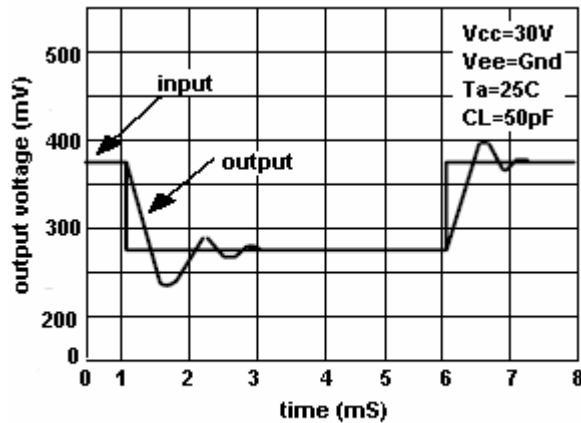


Figure 5. small signal voltage follower pulse response (noninverting)

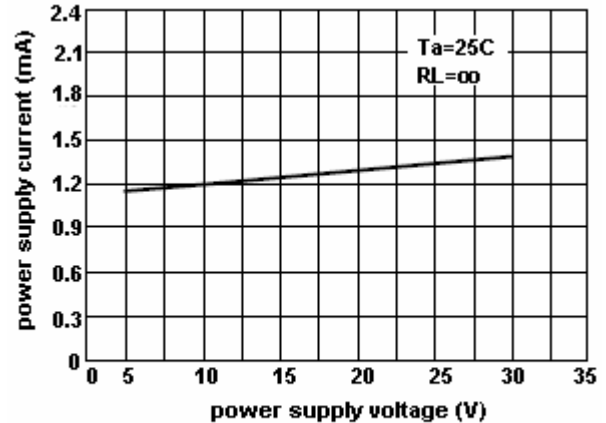


Figure 6. power supply current vs supply voltage

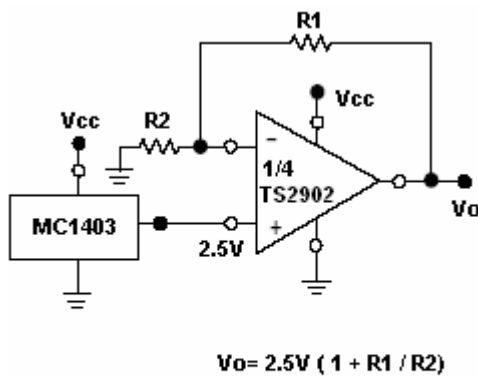


Figure 7. voltage reference

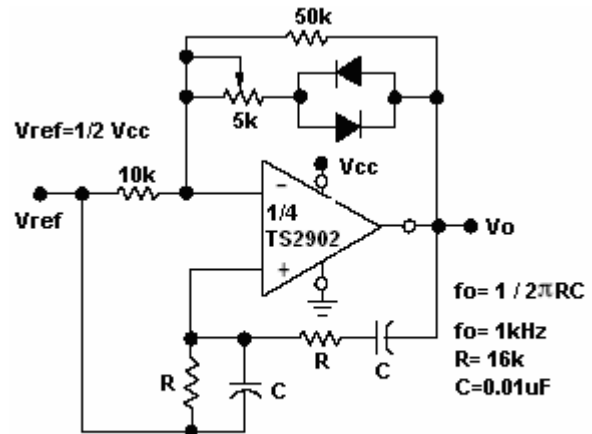


Figure 8. wien bridge oscillator

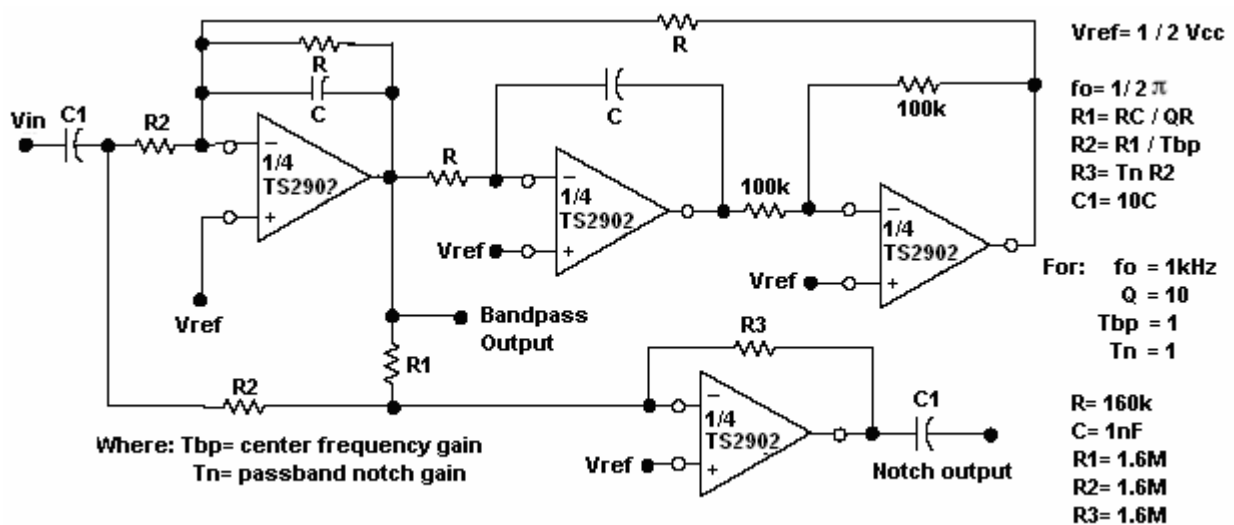


Figure 9. bi-quad filter

## Circuit Description (continued)

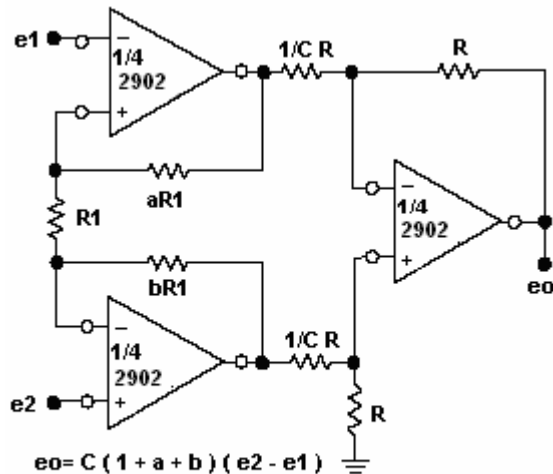
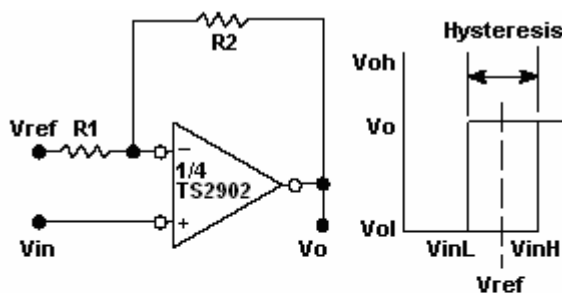


Figure 10. high impedance differential amplifier



$$VinL = R1 / (R1 + R2) * (Vol - Vref) + Vref$$

$$VinH = R1 / (R1 + R2) * (Voh - Vref) + Vref$$

$$H = R1 / (R1 + R2) * (Voh - Vol)$$

Figure 11. comparator with hysteresis

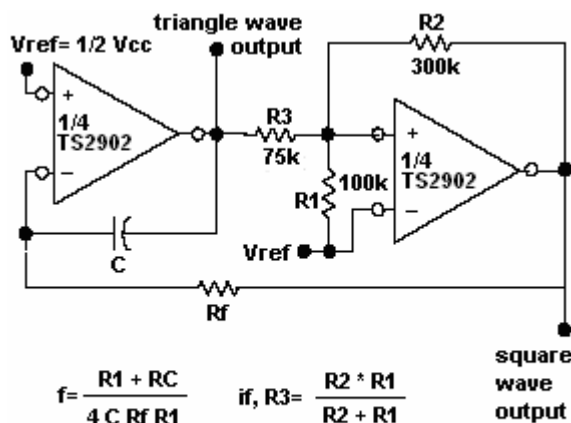
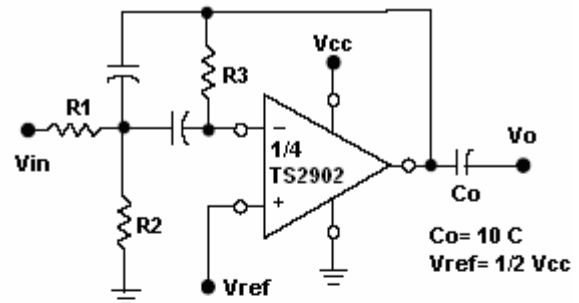


Figure 12. function generator



Given:  $f_o$  = center frequency  
 $A(f_o)$  = gain at center frequency

Choose value  $f_o$ ,  $C$

Then:  $R3 = Q / \pi f_o C$

$$R1 = R3 / 2A(f_o)$$

$$R2 = R1 * R3 / 4Q^2 * R1 - R3$$

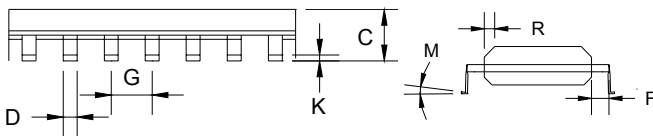
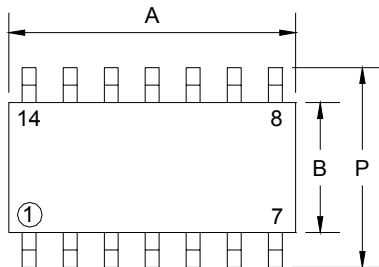
For less than 10% error from operational amplifier,  
 $Qo f_o / BW < 0.1$

Where  $f_o$  and  $BW$  are expressed in Hz

If source impedance varies, filter may be preceded with Voltage follower buffer stabilize filter parameters

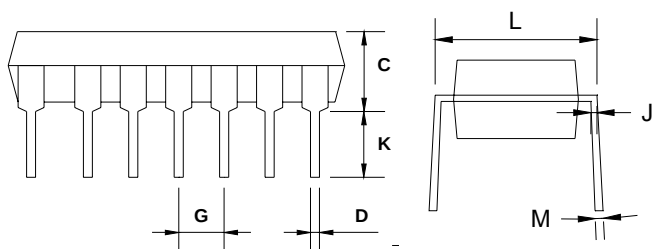
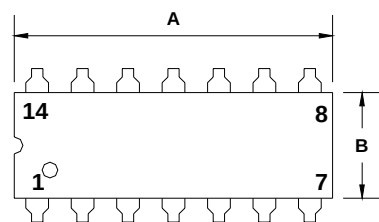
Figure 13. multiple feedback bandpass filter

## SOP-14 Mechanical Drawing



| SOP-14 DIMENSION |             |      |            |       |
|------------------|-------------|------|------------|-------|
| DIM              | MILLIMETERS |      | INCHES     |       |
|                  | MIN         | MAX  | MIN        | MAX   |
| A                | 8.55        | 8.75 | 0.337      | 0.344 |
| B                | 3.80        | 4.00 | 0.150      | 0.157 |
| C                | 1.35        | 1.75 | 0.054      | 0.068 |
| D                | 0.35        | 0.49 | 0.014      | 0.019 |
| F                | 0.40        | 1.25 | 0.016      | 0.049 |
| G                | 1.27 (typ)  |      | 0.05 (typ) |       |
| K                | 0.10        | 0.25 | 0.004      | 0.009 |
| M                | 0°          | 7°   | 0°         | 7°    |
| P                | 5.80        | 6.20 | 0.229      | 0.244 |
| R                | 0.25        | 0.50 | 0.010      | 0.019 |

## DIP-14 Mechanical Drawing



| DIP-14 DIMENSION |             |       |            |       |
|------------------|-------------|-------|------------|-------|
| DIM              | MILLIMETERS |       | INCHES     |       |
|                  | MIN         | MAX   | MIN        | MAX   |
| A                | 18.55       | 19.56 | 0.730      | 0.770 |
| B                | 6.22        | 6.48  | 0.245      | 0.255 |
| C                | 3.18        | 4.45  | 0.125      | 0.135 |
| D                | 0.35        | 0.55  | 0.019      | 0.020 |
| G                | 2.54 (typ)  |       | 0.10 (typ) |       |
| J                | 0.29        | 0.31  | 0.011      | 0.012 |
| K                | 3.25        | 3.35  | 0.128      | 0.132 |
| L                | 7.75        | 8.00  | 0.305      | 0.315 |
| M                | -           | 10°   | -          | 10°   |