**DC Servo Motor Controller/Driver**

The MC33030 is a monolithic DC servo motor controller providing all active functions necessary for a complete closed loop system. This device consists of an on-chip op amp and window comparator with wide input common-mode range, drive and brake logic with direction memory, Power H–Switch driver capable of 1.0 A, independently programmable over–current monitor and shutdown delay, and over–voltage monitor. This part is ideally suited for almost any servo positioning application that requires sensing of temperature, pressure, light, magnetic flux, or any other means that can be converted to a voltage.

Although this device is primarily intended for servo applications, it can be used as a switchmode motor controller.

- On–Chip Error Amp for Feedback Monitoring
- Window Detector with Deadband and Self Centering Reference Input
- Drive/Brake Logic with Direction Memory
- 1.0 A Power H–Switch
- Programmable Over–Current Detector
- Programmable Over–Current Shutdown Delay
- Over–Voltage Shutdown

**Representative Block Diagram**

This device contains 119 active transistors.

**PIN CONNECTIONS**

This device contains 119 active transistors.
MAXIMUM RATINGS

<table>
<thead>
<tr>
<th>Rating</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Supply Voltage</td>
<td>V_CC</td>
<td>36</td>
<td>V</td>
</tr>
<tr>
<td>Input Voltage Range</td>
<td>V_IR</td>
<td>–0.3 to V_CC</td>
<td>V</td>
</tr>
<tr>
<td>Op Amp, Comparator, Current Limit (Pins 1, 2, 3, 6, 7, 8, 9, 15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Differential Voltage Range</td>
<td>V_IDR</td>
<td>–0.3 to V_CC</td>
<td>V</td>
</tr>
<tr>
<td>Op Amp, Comparator (Pins 1, 2, 3, 6, 7, 8, 9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delay Pin Sink Current (Pin 16)</td>
<td>I_DL(sink)</td>
<td>20</td>
<td>mA</td>
</tr>
<tr>
<td>Output Source Current (Op Amp)</td>
<td>I_source</td>
<td>10</td>
<td>mA</td>
</tr>
<tr>
<td>Drive Output Voltage Range (Note 1)</td>
<td>V_DRV</td>
<td>–0.3 to (V_CC + V_F)</td>
<td>V</td>
</tr>
<tr>
<td>Drive Output Source Current (Note 2)</td>
<td>I_DRV(source)</td>
<td>1.0</td>
<td>A</td>
</tr>
<tr>
<td>Drive Output Sink Current (Note 2)</td>
<td>I_DRV(sink)</td>
<td>1.0</td>
<td>A</td>
</tr>
<tr>
<td>Brake Diode Forward Current (Note 2)</td>
<td>I_F</td>
<td>1.0</td>
<td>A</td>
</tr>
<tr>
<td>Power Dissipation and Thermal Characteristics</td>
<td></td>
<td></td>
<td>°C/W</td>
</tr>
<tr>
<td>P Suffix, Dual In Line Case 648C</td>
<td>RθJA</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance, Junction–to–Air (Pins 4, 5, 12, 13)</td>
<td>RθJC</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>DW Suffix, Dual In Line Case 751G</td>
<td>RθJA</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance, Junction–to–Case (Pins 4, 5, 12, 13)</td>
<td>RθJC</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Operating Junction Temperature</td>
<td>T_J</td>
<td>+150</td>
<td>°C</td>
</tr>
<tr>
<td>Operating Ambient Temperature Range</td>
<td>T_A</td>
<td>–40 to +85</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>T_stg</td>
<td>–65 to +150</td>
<td>°C</td>
</tr>
</tbody>
</table>

NOTES: 1. The upper voltage level is clamped by the forward drop, V_F, of the brake diode.
2. These values are for continuous DC current. Maximum package power dissipation limits must be observed.

ELECTRICAL CHARACTERISTICS (V_CC = 14 V, T_A = 25°C, unless otherwise noted.)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERROR AMP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Offset Voltage (–40°C ≤ T_A ≤ 85°C)</td>
<td>V_IO</td>
<td>–</td>
<td>1.5</td>
<td>10</td>
<td>mV</td>
</tr>
<tr>
<td>V_PIN = 7.0 V, R_L = 100 k</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Offset Current (V_PIN = 1.0 V, R_L = 100 k)</td>
<td>I_IO</td>
<td>–</td>
<td>0.7</td>
<td>–</td>
<td>nA</td>
</tr>
<tr>
<td>Input Bias Current (V_PIN = 7.0 V, R_L = 100 k)</td>
<td>I_IB</td>
<td>–</td>
<td>7.0</td>
<td>–</td>
<td>nA</td>
</tr>
<tr>
<td>Input Common–Mode Voltage Range</td>
<td>V_ICR</td>
<td>–</td>
<td>0 to (V_CC – 1.2)</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td>ΔV_IO = 20 mV, R_L = 100 k</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slew Rate, Open Loop (V_ID = 0.5 V, C_L = 15 pF)</td>
<td>SR</td>
<td>–</td>
<td>0.40</td>
<td>–</td>
<td>V/μs</td>
</tr>
<tr>
<td>Unity–Gain Crossover Frequency</td>
<td>f_c</td>
<td>–</td>
<td>550</td>
<td>–</td>
<td>kHz</td>
</tr>
<tr>
<td>Unity–Gain Phase Margin</td>
<td>φ_m</td>
<td>–</td>
<td>63</td>
<td>–</td>
<td>deg.</td>
</tr>
<tr>
<td>Common–Mode Rejection Ratio (V_PIN = 7.0 V, R_L = 100 k)</td>
<td>CMRR</td>
<td>50</td>
<td>82</td>
<td>–</td>
<td>dB</td>
</tr>
<tr>
<td>Power Supply Rejection Ratio</td>
<td>PSRR</td>
<td>–</td>
<td>89</td>
<td>–</td>
<td>dB</td>
</tr>
<tr>
<td>V_CC = 9.0 to 16 V, V_PIN = 7.0 V, R_L = 100 k</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Source Current (V_PIN = 6.0 V)</td>
<td>I_O+</td>
<td>–</td>
<td>1.8</td>
<td>–</td>
<td>mA</td>
</tr>
<tr>
<td>Output Sink Current (V_PIN = 1.0 V)</td>
<td>I_O−</td>
<td>–</td>
<td>250</td>
<td>–</td>
<td>μA</td>
</tr>
<tr>
<td>Output Voltage Swing (R_L = 17 k to Ground)</td>
<td>V_OH</td>
<td>12.5</td>
<td>13.1</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td>V_OH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| NOTES: 3. The upper or lower hysteresis will be lost when operating the Input, Pin 3, close to the respective rail. Refer to Figure 4.
4. Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient temperature as possible.
## MC33030

**ELECTRICAL CHARACTERISTICS** (continued) \((V_{CC} = 14 \text{ V}, T_A = 25{^\circ}\text{C}, \text{unless otherwise noted.})\)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WINDOW DETECTOR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Hysteresis Voltage ((V_1 - V_4, V_2 - V_3, \text{Figure 18}))</td>
<td>(V_H)</td>
<td>25</td>
<td>35</td>
<td>45</td>
<td>mV</td>
</tr>
<tr>
<td>Input Dead Zone Range ((V_2 - V_4, \text{Figure 18}))</td>
<td>(V_{IDZ})</td>
<td>166</td>
<td>210</td>
<td>254</td>
<td>mV</td>
</tr>
<tr>
<td>Input Offset Voltage (\left(\left</td>
<td>V_2 - V_{Pin 2}\right</td>
<td>- \left</td>
<td>V_{Pin 2} - V_4\right</td>
<td>\right)) (\text{Figure 18})</td>
<td>(V_{IO})</td>
</tr>
<tr>
<td>Input Functional Common–Mode Range (\text{Note 3})</td>
<td>(V_{TH})</td>
<td>(V_{IL})</td>
<td>(V_{TH} = (V_{CC} - 1.05))</td>
<td>(V_{IL} = 0.24)</td>
<td>V</td>
</tr>
<tr>
<td>Reference Input Self Centering Voltage (\text{Pins 1 and 2 Open})</td>
<td>(V_{RSC})</td>
<td>–</td>
<td>(1/2) (V_{CC})</td>
<td>–</td>
<td>V</td>
</tr>
<tr>
<td>Window Detector Propagation Delay (\text{Comparator Input, Pin 3, to Drive Outputs}) (V_{ID} = 0.5 \text{ V}, R_{L(DRV)} = 390 \Omega)</td>
<td>(t_{p(IN/DRV)})</td>
<td>–</td>
<td>2.0</td>
<td>–</td>
<td>(\mu\text{s})</td>
</tr>
<tr>
<td><strong>OVER–CURRENT MONITOR</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over–Current Reference Resistor Voltage (\text{Pin 15})</td>
<td>(R_{OC})</td>
<td>3.9</td>
<td>4.3</td>
<td>4.7</td>
<td>V</td>
</tr>
<tr>
<td>Delay Pin Source Current (V_{DLY} = 0 \text{ V}, R_{OC} = 27 \Omega, I_{DRV} = 0 \text{ mA})</td>
<td>(I_{DLY(source)})</td>
<td>–</td>
<td>5.5</td>
<td>6.9</td>
<td>(\mu\text{A})</td>
</tr>
<tr>
<td>Delay Pin Sink Current (R_{OC} = 27 \Omega, I_{DRV} = 0 \text{ mA}) (V_{DLY} = 5.0 \text{ V}) (V_{DLY} = 8.3 \text{ V}) (V_{DLY} = 14 \text{ V})</td>
<td>(I_{DLY(sink)})</td>
<td>–</td>
<td>0.1</td>
<td>–</td>
<td>mA</td>
</tr>
<tr>
<td>Delay Pin Voltage, Low State (I_{DLY} = 0 \text{ mA}) (V_{OL(DLY)})</td>
<td>–</td>
<td>0.3</td>
<td>0.4</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Over–Current Shutdown Threshold (V_{CC} = 14 \text{ V}) (V_{CC} = 8.0 \text{ V})</td>
<td>(V_{th(OC)})</td>
<td>6.8</td>
<td>7.5</td>
<td>8.2</td>
<td>V</td>
</tr>
<tr>
<td>Over–Current Shutdown Propagation Delay (\text{Delay Capacitor Input, Pin 16, to Drive Outputs, } V_{ID} = 0.5 \text{ V})</td>
<td>(t_{p(DLY/DRV)})</td>
<td>–</td>
<td>1.8</td>
<td>–</td>
<td>(\mu\text{s})</td>
</tr>
<tr>
<td><strong>POWER H–SWITCH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive–Output Saturation (\text{–}40{^\circ}\text{C} \leq T_A \leq +85{^\circ}\text{C}, \text{Note 4}) (I_{source} = 100 \text{ mA}) (I_{sink} = 100 \text{ mA}) (V_{OL(DRIV)}) (V_{OH(DRIV)}) ((V_{CC} - 2)) ((V_{CC} - 0.85))</td>
<td>(V_{TF})</td>
<td>–</td>
<td>200</td>
<td>–</td>
<td>ns</td>
</tr>
<tr>
<td>Drive–Output Voltage Switching Time (C_L = 15 \text{ pF}) (V_{TF}) (I_{F})</td>
<td>(t_{F})</td>
<td>–</td>
<td>200</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Brake Diode Forward Voltage Drop (I_F = 200 \text{ mA}, \text{Note 4})</td>
<td>(V_F)</td>
<td>–</td>
<td>1.04</td>
<td>2.5</td>
<td>V</td>
</tr>
<tr>
<td><strong>TOTAL DEVICE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standby Supply Current</td>
<td>(I_{CC})</td>
<td>–</td>
<td>14</td>
<td>25</td>
<td>mA</td>
</tr>
<tr>
<td>Over–Voltage Shutdown Threshold (\text{–}40{^\circ}\text{C} \leq T_A \leq +85{^\circ}\text{C}) (V_{th(OV)})</td>
<td>–</td>
<td>16.5</td>
<td>18</td>
<td>20.5</td>
<td>V</td>
</tr>
<tr>
<td>Over–Voltage Shutdown Hysteresis (\text{Device “off” to “on”}) (V_{CC} = 14 \text{ V}, T_A = +85{^\circ}\text{C})</td>
<td>(V_{H(OV)})</td>
<td>–</td>
<td>0.3</td>
<td>0.6</td>
<td>1.0</td>
</tr>
</tbody>
</table>

**NOTES:**
3. The upper or lower hysteresis will be lost when operating the Input, Pin 3, close to the respective rail. Refer to Figure 4.
4. Low duty cycle pulse techniques are used during test to maintain junction temperature as close to ambient temperature as possible.
Figure 7. Brake Diode Forward Current versus Forward Voltage

Figure 8. Output Source Current–Limit versus Over–Current Reference Resistance

Figure 9. Output Source Current–Limit versus Temperature

Figure 10. Normalized Delay Pin Source Current versus Temperature

Figure 11. Normalized Over–Current Delay Threshold Voltage versus Temperature

Figure 12. Supply Current versus Supply Voltage
Figure 13. Normalized Over-Voltage Shutdown Threshold versus Temperature

Figure 14. Normalized Over-Voltage Shutdown Hysteresis versus Temperature

Figure 15. P Suffix (DIP–16) Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length

Figure 16. DW Suffix (SOP–16L) Thermal Resistance and Maximum Power Dissipation versus P.C.B. Copper Length
The MC33030 was designed to drive fractional horsepower DC motors and sense actuator position by voltage feedback. A typical servo application and representative internal block diagram are shown in Figure 17. The system operates by setting a voltage on the reference input of the Window Detector (Pin 1) which appears on (Pin 2). A DC motor then drives a position sensor, usually a potentiometer driven by a gear box, in a corrective fashion so that a voltage proportional to position is present at Pin 3. The servo motor will continue to run until the voltage at Pin 3 falls within the dead zone, which is centered about the reference voltage.

The Window Detector is composed of two comparators, A and B, each containing hysteresis. The reference input, common to both comparators, is pre-biased at 1/2 VCC for simple two position servo systems and can easily be overriden by an external voltage divider. The feedback voltage present at Pin 3 is connected to the center of two resistors that are driven by an equal magnitude current source and sink. This generates an offset voltage at the input of each comparator which is centered about Pin 3 that can float virtually from VCC to ground. The sum of the upper and lower offset voltages is defined as the window detector input dead zone range.

To increase system flexibility, an on-chip Error Amp is provided. It can be used to buffer and/or gain-up the actuator position voltage which has the effect of narrowing the dead zone range. A PNP differential input stage is provided so that position voltage which has the effect of narrowing the dead zone range.

A timing diagram that depicts the operation of the Drive/Brake Logic section is shown in Figure 18. The waveforms grouped in [1] show a reference voltage that was preset, appearing on Pin 2, which corresponds to the desired actuator position. The true actuator position is represented by the voltage on Pin 3. The points V1 through V4 represent the input voltage thresholds of comparators A and B that cause a change in their respective output state. They are defined as follows:

- \( V_1 \) = Comparator B turn-off threshold
- \( V_2 \) = Comparator A turn-on threshold
- \( V_3 \) = Comparator A turn-off threshold
- \( V_4 \) = Comparator B turn-on threshold
- \( V_1 - V_4 \) = Comparator B input hysteresis voltage
- \( V_2 - V_3 \) = Comparator A input hysteresis voltage
- \( V_2 - V_4 \) = Window detector input dead zone range

\[ |(V_2 - V_{Pin2}) - (V_{Pin2} - V_4)| = \text{Window detector input voltage} \]

It must be remembered that points V1 through V4 always try to follow and center about the reference voltage setting if it is within the input common-mode voltage range of Pin 3; Figures 4 and 5. Initially consider that the feedback input voltage level is somewhere on the dashed line between V2 and V4 in [1]. This is within the dead zone range as defined above and the motor will be off. Now if the reference voltage is raised so that VPin 3 is less than V4, comparator B will turn-on [3] enabling Q Drive, causing Drive Output A to sink and B to source motor current [8]. The actuator will move in Direction B until VPin 3 becomes greater than V1, Comparator B will turn-off, activating the brake enable [4] and Q Brake [6] causing Drive Output A to go high and B to go into a high impedance state. The inertia of the mechanical system will drive the motor as a generator creating a positive voltage on Pin 10 with respect to Pin 14. The servo system can be stopped quickly, so as not to over-shoot through the dead zone range, by braking. This is accomplished by shorting the motor/generator terminals together. Brake current will flow into the diode at Drive Output B, through the internal VCC rail, and out the emitter of the sourcing transistor at Drive Output A. The end of the solid line and beginning of the dashed for VPin 3 [1] indicates the possible resting position of the actuator after braking.
Figure 17. Representative Block Diagram and Typical Servo Application

If V_{pin 3} should continue to rise and become greater than V_2, the actuator will have overshot the dead zone range and cause the motor to run in direction A until V_{pin 3} is equal to V_3. The Drive/Brake behavior for direction A is identical to that of B. Overshooting the dead zone range in both directions can cause the servo system to continuously hunt or oscillate. Notice that the last motor run-direction is stored in the direction latch. This information is needed to determine whether Q or Q_{Brake} is to be enabled when V_{pin 3} enters the dead zone range. The dashed lines in [8,9] indicate the resulting waveforms of an over-current condition that has exceeded the programmed time delay. Notice that both Drive Outputs go into a high impedance state until V_{pin 2} is readjusted so that V_{pin 3} enters or crosses through the dead zone [7,4].

The inputs of the Error Amp and Window Detector can be susceptible to the noise created by the brushes of the DC motor and cause the servo to hunt. Therefore, each of these inputs are provided with an internal series resistor and are pinned out for an external bypass capacitor. It has been found that placing a capacitor with short leads directly across the brushes will significantly reduce noise problems. Good quality RF bypass capacitors in the range of 0.001 to 0.1 µF may be required. Many of the more economical motors will generate significant levels of RF energy over a spectrum that extends from DC to beyond 200 MHz. The capacitance value and method of noise filtering must be determined on a system by system basis.

Thus far, the operating description has been limited to servo systems in which the motor mechanically drives a potentiometer for position sensing. Figures 19, 20, 27, and 31 show examples that use light, magnetic flux, temperature, and pressure as a means to drive the feedback element. Figures 21, 22 and 23 are examples of two position, open loop servo systems. In these systems, the motor runs the actuator to each end of its travel limit where the Over–Current Monitor detects a locked rotor condition and shuts down the drive. Figures 32 and 33 show two possible methods of using the MC33030 as a switching motor controller. In each example a fixed reference voltage is applied to Pin 2. This causes V_{pin 3} to be less than V_4 and Drive Output A, Pin 14, to be in a low state saturating the TIP42 transistor. In Figure 32, the motor drives a tachometer that generates an ac voltage proportional to RPM. This voltage is rectified, filtered, divided down by the speed set potentiometer, and applied to Pin 8. The motor will accelerate until V_{pin 3} is equal to V_1 at which time Pin 14 will go to a high state and terminate the motor drive. The motor will now coast until V_{pin 3} is less than V_4 whereupon drive is then reapplied. The system operation of Figure 31 is identical to that of 32 except the signal at Pin 3 is an amplified average of the motors drive and back EMF voltages. Both systems exhibit excellent control of RPM with variations of V_{CC}; however, Figure 32 has somewhat better torque characteristics at low RPM.
Figure 18. Timing Diagram

- Comparator A Non Inverting Input Threshold
- Reference Input Voltage (Desired Actuator Position)
- Comparator B Inverting Input Threshold
- Feedback Input (True Actuator Position)
- Direction Latch Q Output
- Direction Latch Q Output
- Brake Enable
- Drive/Break Enable
- Over-Current Latch Reset Input
- Source
- Drive Output A
- High Z
- Sink
- Source
- Drive Output B
- Over-Current Monitor CDLY
- Drive/Brake Logic
- Direction B Feedback Input less than V1
- Over-Current Monitor
- Dead Zone Feedback Input between V1 & V2
- Direction A Feedback Input greater than V2
- Dead Zone Feedback Input between V3 & V4
- Direction B Feedback Input less than V4

- Comparator A Output
- Comparator B Output
- Brake Enable
- Q Brake
- - Q Brake
- Over-Current Latch Reset Input
- Source
- Drive Output A
- High Z
- Sink
- Source
- Drive Output B
- Over-Current Monitor CDLY
- Drive/Brake Logic
- Direction B Feedback Input less than V1
- Over-Current Monitor
- Dead Zone Feedback Input between V1 & V2
- Direction A Feedback Input greater than V2
- Dead Zone Feedback Input between V3 & V4
- Direction B Feedback Input less than V4

- Comparator A Output
- Comparator B Output
- Brake Enable
- Q Brake
- - Q Brake
- Over-Current Latch Reset Input
- Source
- Drive Output A
- High Z
- Sink
- Source
- Drive Output B
- Over-Current Monitor CDLY
- Drive/Brake Logic
- Direction B Feedback Input less than V1
- Over-Current Monitor
- Dead Zone Feedback Input between V1 & V2
- Direction A Feedback Input greater than V2
- Dead Zone Feedback Input between V3 & V4
- Direction B Feedback Input less than V4

- Comparator A Output
- Comparator B Output
- Brake Enable
- Q Brake
- - Q Brake
- Over-Current Latch Reset Input
- Source
- Drive Output A
- High Z
- Sink
- Source
- Drive Output B
- Over-Current Monitor CDLY
- Drive/Brake Logic
- Direction B Feedback Input less than V1
- Over-Current Monitor
- Dead Zone Feedback Input between V1 & V2
- Direction A Feedback Input greater than V2
- Dead Zone Feedback Input between V3 & V4
- Direction B Feedback Input less than V4

- Comparator A Output
- Comparator B Output
- Brake Enable
- Q Brake
- - Q Brake
- Over-Current Latch Reset Input
- Source
- Drive Output A
- High Z
- Sink
- Source
- Drive Output B
- Over-Current Monitor CDLY
- Drive/Brake Logic
- Direction B Feedback Input less than V1
- Over-Current Monitor
- Dead Zone Feedback Input between V1 & V2
- Direction A Feedback Input greater than V2
- Dead Zone Feedback Input between V3 & V4
- Direction B Feedback Input less than V4

- Comparator A Output
- Comparator B Output
- Brake Enable
- Q Brake
- - Q Brake
- Over-Current Latch Reset Input
- Source
- Drive Output A
- High Z
- Sink
- Source
- Drive Output B
- Over-Current Monitor CDLY
- Drive/Brake Logic
- Direction B Feedback Input less than V1
- Over-Current Monitor
- Dead Zone Feedback Input between V1 & V2
- Direction A Feedback Input greater than V2
- Dead Zone Feedback Input between V3 & V4
- Direction B Feedback Input less than V4

- Comparator A Output
- Comparator B Output
- Brake Enable
- Q Brake
- - Q Brake
- Over-Current Latch Reset Input
- Source
- Drive Output A
- High Z
- Sink
- Source
- Drive Output B
- Over-Current Monitor CDLY
- Drive/Brake Logic
- Direction B Feedback Input less than V1
- Over-Current Monitor
- Dead Zone Feedback Input between V1 & V2
- Direction A Feedback Input greater than V2
- Dead Zone Feedback Input between V3 & V4
- Direction B Feedback Input less than V4

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- Sink
- Source
- Drive Output B
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- Direction A Feedback Input greater than V2
- Dead Zone Feedback Input between V3 & V4
- Direction B Feedback Input less than V4
**Figure 19. Solar Tracking Servo System**

R1, R2 – Cadmium Sulphide Photocell
SM Dark, 3.0 k light resistance
R3 – 30 k, repositions servo during darkness for next sunrise.

**Figure 20. Magnetic Sensing Servo System**

Typical sensitivity with gain set at 3.9 k is 1.5 mV/gauss.
Servo motor controls magnetic field about sensor.

**Figure 21. Infrared Latched Two Position Servo System**

Over–current monitor (not shown) shuts down servo when end stop is reached.

**Figure 22. Digital Two Position Servo System**

Over–current monitor (not shown) shuts down servo when end stop is reached.

**Figure 23. 0.25 Hz Square–Wave Servo Agitator**

\[ f = \frac{0.72}{RC} \]

**Figure 24. Second Order Low–Pass Active Filter**

\[ f_0 = \frac{1}{2\pi R^2 C_1 C_2} \]

\[ Q = \frac{C_1}{C_2} \]
Figure 25. Notch Filter

\[ f_{notch} = \frac{1}{2\pi RC} \]

For 60 Hz, \( R = 53.6 \, k\Omega \), \( C = 0.05 \)

Figure 26. Differential Input Amplifier

\[ V_{pin6} = \frac{V_A}{(R_1 + R_2)} \left( \frac{R_3}{R_4} \right) - \left( \frac{R_2}{R_3} \right) V_B \]

Figure 27. Temperature Sensing Servo System

\[ V_{pin6} = \frac{R_4}{R_3} \left( \frac{R_1}{R_2} + 1 \right) \]

In this application the servo motor drives the heat/air conditioner modulator door in a duct system.

Figure 28. Bridge Amplifier

\[ V_A - V_B = V_{ref} \left( \frac{\Delta R}{4R + 2\Delta R} \right) \]

\[ R_1 = R_3; \quad R_2 = R_4; \quad R_1 >> R \]

\[ V_{pin6} = \frac{R_4}{R_3} (V_A - V_B) \]

Figure 29. Remote Latched Shutdown

\[ R_E = \frac{V_{F(D_1)} + V_{F(D_2)} - V_{BE(ON)}}{IMOTOR - IDRV(max)} \]

A direction change signal is required at Pins 2 or 3 to reset the over–current latch.

Figure 30. Power H–Switch Buffer

This circuit maintains the brake and over–current features of the MC33030. Set \( R_{OC} \) to 15 k for \( IDRV(max) = 0.5 \, A. \)
Figure 31. Adjustable Pressure Differential Regulator

VCC = 12 V

Gas Flow

LM324 Quad Op Amp

MPX11DP Silicon Pressure Sensor

Vacuum Port

Motor

Zero Pressure Offset Adjust

2.0 V for Zero Pressure Differential

6.0 V for 100 kPa (14.5 PSI) Pressure Differential

2.0 k

5.1 k

Gain

2.4 k

1.0 k

0.01

1.0 k

6.2 k

5.1 k

12 k

1.76 k

8.06 k

VCC = 12 V

Pressure Port

Vacuum Port

Pressure Port

1.76 k

1.0 k

0.01

200

200

4.12 k

1.0 k

S +

2.0 V for Zero Pressure Differential

6.0 V for 100 kPa (14.5 PSI) Pressure Differential

Zero Pressure Offset Adjust

Pressure Differential Reference Set

1.8 k

5.0 k

5.1 k

12 k

15 k

200

5.1 k

12 k

5.0 k

4.12 k

Gain

0.01

2.4 k

1.0 k

0.01

2.0 k

1.0 k

2.4 k

1.0 k

0.01

1.0 k

0.01

2.0 k

1.0 k

Figure 32. Switching Motor Controller With Buffered Output and Tach Feedback
Figure 33. Switching Motor Controller With Buffered Output and Back EMF Sensing
NOTES:
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 0.13 (0.005) TOTAL IN EXCESS OF D DIMENSION AT MAXIMUM MATERIAL CONDITION.

NOTES:
2. CONTROLLING DIMENSION: INCH.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.13 (0.005) TOTAL IN EXCESS OF D DIMENSION AT MAXIMUM MATERIAL CONDITION.
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