

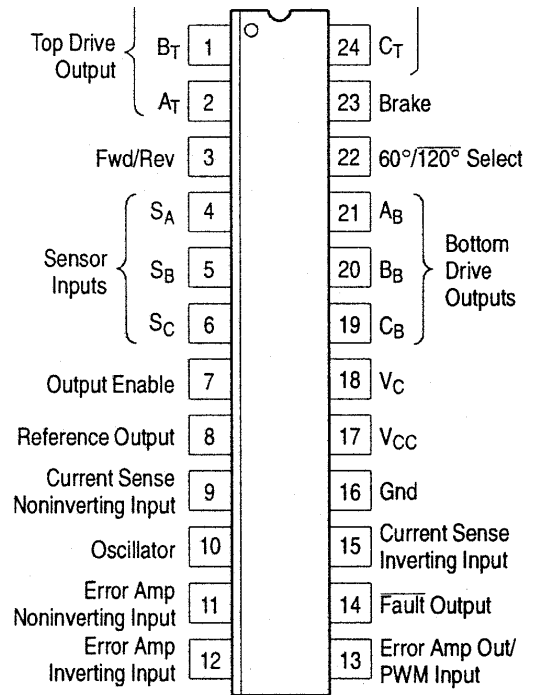
**BRUSHLESS DC MOTOR CONTROLLER**

**IL33035**

The IL33035 is a high performance second generation monolithic brushless DC motor controller containing all of the active functions required to implement a full featured open loop, three or four phase motor control system. This device consists of a rotor position decoder for proper commutation sequencing, temperature compensated reference capable of supplying sensor power, frequency programmable sawtooth oscillator, three open collector top drivers, and three high current totem pole bottom drivers ideally suited for driving power MOSFETs.

Also included are protective features consisting of undervoltage lockout, cycle-by-cycle current limiting with a selectable time delayed latched shutdown mode, internal thermal shutdown, and a unique fault output that can be interfaced into microprocessor controlled systems.

Typical motor control functions include open loop speed, forward or reverse direction, run enable, and dynamic braking. The MC33035 is designed to operate with electrical sensor phasings of 60°/300° or 120°/240°, and can also efficiently control brush DC motors



**FEATURES**

- 10 to 30 V Operation
- Undervoltage Lockout
- 6.25V Reference Capable of Supplying Sensor Power
- Fully Accessible Error Amplifier for Closed Loop Servo Applications
- High Current Drivers Can Control External 3-Phase MOSFET Bridge
- Cycle-By-Cycle Current Limiting
- Pinned-Out Current Sense Reference
- Internal Thermal Shutdown
- Selectable 60°/300° or 120°/240° Sensor Phasings
- Can Efficiently Control Brush DC Motors with External MOSFET H-Bridge

**Absolute maximum ratings**

| Parameter   | Symbol                             | Value                    | Unit       |
|---|------------------------------------|--------------------------|------------|
| Power Supply Voltage  | V <sub>CC</sub>                    | 40                       | V          |
| Digital Inputs (Pins 3, 4, 5, 6, 22, 23)  | -                                  | V <sub>ref</sub>         | V          |
| Oscillator Input Current (Source or Sink)   | I <sub>osc</sub>                   | 30                       | mA         |
| Error Amp Input Voltage Range (Pins 11, 12, Note 1)   | V <sub>IR</sub>                    | -0.3 to V <sub>ref</sub> | V          |
| Error Amp Output Current (Source or Sink, Note 2)   | I <sub>Out</sub>                   | 10                       | mA         |
| Current Sense Input Voltage Range (Pins 9, 15)  | V <sub>Sense</sub>                 | -0.3 to 5.0              | V          |
| Fault Output Voltage  | V <sub>CE(Fault)</sub>             | 20                       | V          |
| Fault Output Sink Current   | I <sub>Sink(Fault)</sub>           | 20                       | mA         |
| Top Drive Voltage (Pins 1, 2, 24)   | V <sub>CE(top)</sub>               | 40                       | V          |
| Top Drive Sink Current (Pins 1, 2, 24)  | I <sub>Sink(top)</sub>             | 50                       | mA         |
| Bottom Drive Supply Voltage (Pin 18)  | V <sub>C</sub>                     | 30                       | V          |
| Bottom Drive Output Current (Source or Sink, Pins 19, 20, 21)                                   | I <sub>DRV</sub>                   | 100                      | mA         |
| Power Dissipation and Thermal Characteristics   |                                    |                          |            |
| DIP package Maximum Power Dissipation T <sub>A</sub> = 85°C Thermal Resistance, Junction-to-Air | P <sub>D</sub><br>R <sub>θJA</sub> | 860<br>75                | mW<br>°C/W |
| SO Package Maximum Power Dissipation T <sub>A</sub> = 85°C Thermal Resistance, Junction-to-Air  | P <sub>D</sub><br>R <sub>θJA</sub> | 650<br>100               | mW<br>°C/W |
| Operating Junction Temperature  | T <sub>J</sub>                     | 150                      | °C         |
| Operating Ambient Temperature Range   | T <sub>A</sub>                     | -40 to +85               | °C         |
| Storage Temperature Range   | T <sub>stg</sub>                   | -65 to +150              | °C         |

\* Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

**ELECTRICAL CHARACTERISTICS**

(V<sub>CC</sub> = V<sub>C</sub> = 20 V, R<sub>τ</sub> = 4.7 k, C<sub>τ</sub> = 10 nF, T<sub>A</sub> = 25°C, unless otherwise noted.)

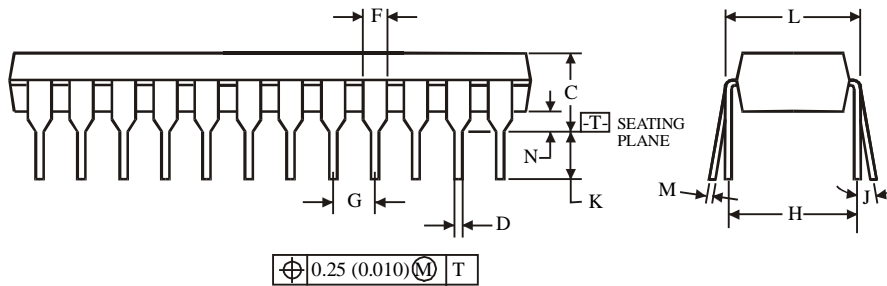
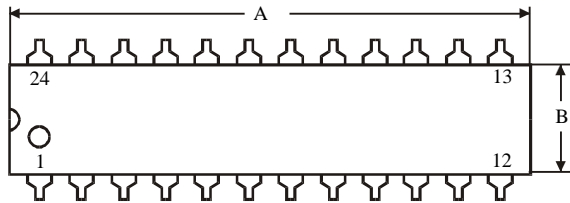
| Characteristic   | Symbol              | Min                     | Typ       | Max         | Unit |
|--|---------------------|-------------------------|-----------|-------------|------|
| Reference Output Voltage (I <sub>ref</sub> = 1.0 mA)<br>T <sub>A</sub> = 25°C<br>T <sub>A</sub> = -40°C to +85°C | V <sub>ref</sub>    | 5.9<br>5.82             | 6.24<br>- | 6.5<br>6.57 | V    |
| Line Regulation (V <sub>CC</sub> = 10 to 30 V, I <sub>ref</sub> = 1.0 mA)  | Reg <sub>line</sub> | -                       | 1.5       | 30          | mV   |
| Load Regulation (I <sub>ref</sub> = 1.0 to 20 mA)  | Reg <sub>load</sub> | -                       | 16        | 30          | mV   |
| Output Short Circuit Current (Note 3)  | I <sub>SC</sub>     | 40                      | 75        | -           | mA   |
| Reference Under Voltage Lockout Threshold  | V <sub>th</sub>     | 4.0                     | 4.5       | 5.0         | V    |
| Input Offset Voltage (T <sub>A</sub> = -40°C to +85°C)   | V <sub>IO</sub>     | -                       | 0.4       | 10          | mV   |
| Input Offset Current (T <sub>A</sub> = -40°C to +85°C)   | I <sub>IO</sub>     | -                       | 8.9       | 500         | nA   |
| Input Bias Current (T <sub>A</sub> = -40°C to +85°C)   | I <sub>IB</sub>     | -                       | -46       | -1000       | nA   |
| Input Common Mode Voltage Range  | V <sub>ICR</sub>    | (OV to V <sup>+</sup> ) |           |             | V    |
| Open Loop Voltage Gain (V <sub>O</sub> = 3.0 V, R <sub>L</sub> = 15 k)   | A <sub>VOL</sub>    | 70                      | 80        | -           | dB   |
| Input Common Mode Rejection Ratio  | CMRR                | 55                      | 86        | -           | dB   |
| Power Supply Rejection Ratio (V <sub>CC</sub> = V <sub>C</sub> = 10 to 30 V)                                     | PSRR                | 65                      | 105       | -           | dB   |

**ELECTRICAL CHARACTERISTICS**

(V<sub>cc</sub> = V<sub>c</sub> = 20 V, R<sub>τ</sub> = 4.7 k, C<sub>τ</sub> = 10 nF, T<sub>A</sub> = 25°C, unless otherwise noted.)

| Characteristic  | Symbol                                | Min                         | Typ                           | Max      | Unit |
|---|---------------------------------------|-----------------------------|-------------------------------|----------|------|
| Output Voltage Swing  |                                       |                             |                               |          |      |
| High State (R <sub>L</sub> = 15k to Gnd)  | V <sub>OH</sub>                       | 4.6                         | 5.3                           | -        | V    |
| Low State (R <sub>L</sub> =15k to V <sub>ref</sub> )  | V <sub>OL</sub>                       | -                           | 0.5                           | 1.0      |      |
| Oscillator Frequency  | f <sub>osc</sub>                      | 22                          | 25                            | 28       | kHz  |
| Frequency Change with Voltage (V <sub>cc</sub> = 10 to 30 V)  | Δfosc/ΔV                              | -                           | 0.01                          | 5.0      | %    |
| Sawtooth Peak Voltage   | V <sub>OSC(P)</sub>                   | -                           | 4.1                           | 4.5      | V    |
| Sawtooth Valley Voltage   | V <sub>OSC(V)</sub>                   | 1.2                         | 1.5                           | -        | V    |
| Input Threshold Voltage (Pins 3, 4, 5, 6, 7, 22, 23) High State   | V <sub>IH</sub>                       | 3.0                         | 2.2                           | -        | V    |
| Low State   | V <sub>IL</sub>                       | -                           | 1.7                           | 0.8      |      |
| Sensor Inputs (Pins 4, 5, 6)  |                                       |                             |                               |          |      |
| High State Input Current (V <sub>IH</sub> = 5.0 V)  | I <sub>IL</sub>                       | -150                        | -70                           | -20      | nA   |
| Low State Input Current (V <sub>IL</sub> = 0 V)   | I <sub>IL</sub>                       | -600                        | -337                          | -150     |      |
| Forward/Reverse, 60°/120° Select (Pins 3, 22, 23) High State Input Current (V <sub>IH</sub> = 5.0 V)  | I <sub>IL</sub>                       | -75                         | -36                           | -10      | nA   |
| Low State Input Current (V <sub>IL</sub> = 0 V)   | I <sub>IL</sub>                       | -300                        | -175                          | -75      |      |
| Output Enable High State Input Current (V <sub>IH</sub> = 5.0 V)  | I <sub>IH</sub>                       | -60                         | -29                           | -10      | μA   |
| Low State Input Current (V <sub>IL</sub> = 0 V)   | I <sub>IL</sub>                       | -60                         | -29                           | -10      |      |
| Threshold Voltage   | V <sub>th</sub>                       | 85                          | 101                           | 115      | mV   |
| Input Common Mode Voltage Range   | V <sub>ICR</sub>                      | -                           | 3.0                           | -        | V    |
| Input Bias Current  | I <sub>IB</sub>                       | -                           | -0.9                          | -5.0     | nA   |
| Top Drive Output Sink Saturation (I <sub>Sink</sub> = 25 mA)  | V <sub>CE(SAT)</sub>                  | -                           | 0.5                           | 1.5      | V    |
| Top Drive Output Off-State Leakage (V <sub>CE</sub> = 30 V)   | I <sub>DRV(leak)</sub>                | -                           | 0.06                          | 100      | nA   |
| Top Drive Output Switching Time (C <sub>L</sub> = 47 pF, R <sub>L</sub> = 1.0 k)  |                                       |                             |                               |          |      |
| Rise Time   | t <sub>r</sub>                        |                             | 107                           | 300      | ns   |
| Fall Time   | t <sub>f</sub>                        |                             | 26                            | 300      |      |
| Bottom Drive Output Voltage   |                                       |                             |                               |          |      |
| High State (V <sub>cc</sub> =20V, V <sub>c</sub> = 30 V, I <sub>source</sub> = 50 mA) Low State (V <sub>cc</sub> = 20 V, V <sub>c</sub> = 30 V, I <sub>sink</sub> =50 mA) | V <sub>OH</sub><br>V <sub>OL</sub>    | (V <sub>cc</sub> -2.0)<br>- | (V <sub>cc</sub> -1.1)<br>1.5 | -<br>2.0 | V    |
| Bottom Drive Output Switching Time (C <sub>L</sub> = 1000 pF) Rise Time   | t <sub>r</sub>                        | -                           | 38                            | 200      | ns   |
| Fall Time   | t <sub>f</sub>                        |                             | 30                            | 200      |      |
| Fault Output Sink Saturation (I <sub>sink</sub> = 16 mA)  | V <sub>CE(sat)</sub>                  | -                           | 225                           | 500      | mV   |
| Fault Output Off-State Leakage (V <sub>CE</sub> = 20 V)   | I <sub>FLT(leak)</sub>                | -                           | 1.0                           | 100      | nA   |
| Under Voltage Lockout   |                                       |                             |                               | 10 0.3   | V    |
| Drive Output Enabled (V <sub>cc</sub> or V <sub>c</sub> Increasing) Hysteresis  | V <sub>th(on)</sub><br>V <sub>H</sub> | 8.2<br>0.1                  | 8.9<br>0.2                    |          |      |
| Power Supply Current  |                                       |                             |                               |          |      |
| Pin 17 (V <sub>cc</sub> = V <sub>c</sub> = 20 V)  | I <sub>CC</sub>                       | „                           | 12                            | 16       | mA   |
| Pin 17 (V <sub>cc</sub> = 20V, V <sub>c</sub> = 30V)  |                                       |                             | 14                            | 20       |      |
| Pin 18 (V <sub>cc</sub> = V <sub>c</sub> = 20V)   | I <sub>C</sub>                        |                             | 3.5                           | 6.0      |      |
| Pin 18 (V <sub>cc</sub> = 20 V, V <sub>c</sub> = 30V)   |                                       |                             | 5.0                           | 10       |      |

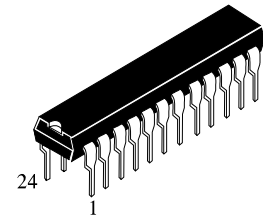
**N SUFFIX PLASTIC DIP  
(MS - 001AF)**



$\oplus 0.25 (0.010) \text{ (M) T}$

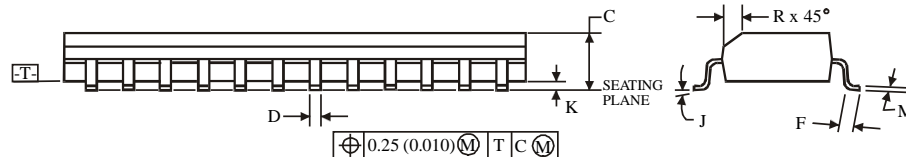
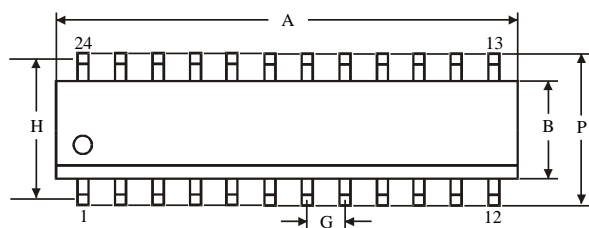
**NOTES:**

- Dimensions "A", "B" do not include mold flash or protrusions.  
Maximum mold flash or protrusions 0.25 mm (0.010) per side.



|        | Dimension, mm |       |
|--------|---------------|-------|
| Symbol | MIN           | MAX   |
| A      | 31.24         | 32.51 |
| B      | 6.1           | 7.11  |
| C      |               | 5.33  |
| D      | 0.36          | 0.56  |
| F      | 1.14          | 1.78  |
| G      | 2.54          |       |
| H      | 7.62          |       |
| J      | 0°            | 10°   |
| K      | 2.92          | 3.81  |
| L      | 7.62          | 8.26  |
| M      | 0.2           | 0.36  |
| N      | 0.38          |       |

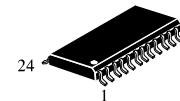
**D SUFFIX SOIC  
(MS - 013AD)**



$\oplus 0.25 (0.010) \text{ (M) T C (M)}$

**NOTES:**

- Dimensions A and B do not include mold flash or protrusion.
- Maximum mold flash or protrusion 0.15 mm (0.006) per side  
for A; for B - 0.25 mm (0.010) per side.



|        | Dimension, mm |       |
|--------|---------------|-------|
| Symbol | MIN           | MAX   |
| A      | 15.2          | 15.6  |
| B      | 7.4           | 7.6   |
| C      | 2.35          | 2.65  |
| D      | 0.33          | 0.51  |
| F      | 0.4           | 1.27  |
| G      | 1.27          |       |
| H      | 9.53          |       |
| J      | 0°            | 8°    |
| K      | 0.1           | 0.3   |
| M      | 0.23          | 0.32  |
| P      | 10            | 10.65 |
| R      | 0.25          | 0.75  |