FAIRCHILD SEMICONDUCTOR™

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# RC5031

## Adjustable Switching Regulator

### Features

- High power switched-mode DC-DC controller can source in excess of 13A
- Output voltage adjustable from 1.5V to 3.6V
- 85% efficiency
- Cumulative accuracy < 3% over line, load, temperature and transient variations
- Overvoltage and short circuit protection
- Built-in soft start

### Applications

- Precision 2.xV CPU core regulator for Intel Pentium® MMX™ processors
- Precision 2.xV or 3.xV CPU core regulator for AMD-K6™ MMX and Cyrix 6x86MX™ (M2) processors

### Description

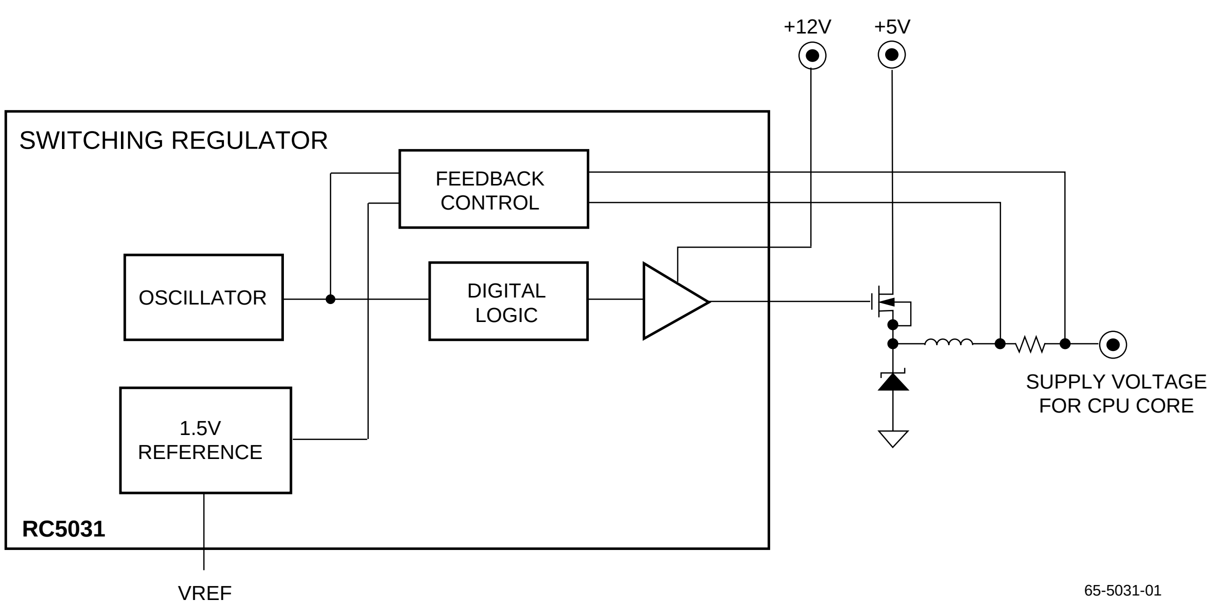
The RC5031 is a high power, switch-mode DC-DC controller that provides an accurate, adjustable output for high-end microprocessors requiring unique supply voltages. The RC5031 has built-in Soft Start feature which offers system protection during power-up by reducing both inrush current and output overshoot. When combined with the appropriate external circuitry, the RC5031 can deliver load currents as high as 13A at efficiencies as high as 88%. Through the use of external resistors, the RC5031 can generate output voltages from 1.5V up to 3.6V.

The RC5031 is designed to operate in a "constant on-time" (patent pending) control mode under all load conditions. Its accurate low TC reference eliminates the need for precision external components in order to achieve the tight tolerance voltage regulation required by most CPU-based applications. Short circuit current protection is provided through the use of a current sense resistor, while overvoltage protection is provided internally.

The RC5031 is a highly efficient switched-mode DC-DC converter that can select a 3.5V or user-adjustable output. With the appropriate external components, the RC5031 can be configured to implement a switchable power supply system for Pentium and K6 processors.

Preliminary Information

### Block Diagram

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6x86MX is a trademark of Cyrix Corporation.

Rev. 0.9.3

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# Functional Description

The RC5031 contains a precision trimmed zero TC voltage reference, a constant-on-time architecture controller, a high current switcher output driver, a low offset op-amp, and switches for selecting various output modes. The block diagram in Figure 1 shows how the RC5031 in combination with the external components achieves a switchable power supply.

## Switch-Mode Control Loop

The main control loop for the switch-mode converter consists of a current conditioning amplifier and one of the two voltage conditioning amplifiers that take the raw voltage and current information from the regulator output, compare them against the precision reference and present the error signal to the input of the constant-on-time oscillator. The two voltage conditioning amplifiers act as an analog switch to select between the internal resistor divider network (set for 3.5V) or an external resistor divider network (adjustable for 1.5V to 3.6V.) The switch-mode select pin determines which of the two amplifiers is selected. The current feedback signals come across the Iout sense resistor to the IFBH and IFBL inputs of the RC5031. The error signals from both the current feedback loop and the voltage feedback loop are summed together and used to control the off-time duration of the oscillator. The current feedback error signal is also used as part of the RC5031 short-circuit protection.

## High Current Output Drivers

The RC5031 switching high current output driver (SDRV) contains high speed bipolar power transistors configured in a push-pull configuration. The output driver is capable of supplying 0.5A of current in less than 100ns. The driver's power and ground are separated from the overall chip power and ground for added switching noise immunity.

## Internal Reference

The reference in the RC5031 is a precision band-gap type reference. Its temperature coefficient is trimmed to provide a near zero TC. For guaranteed stable operation under all loading conditions, a 0.1μF capacitor is recommended on the VREF output pin.

## Constant-On-Time Oscillator

The RC5031 switch-mode oscillator is designed as a fixed on-time, variable off-time oscillator. The constant-on-time oscillator consists of a comparator, an external capacitor, a fixed current source, a variable current source, and an analog switch that selects between two threshold voltages for the comparator. The external timing capacitor is alternately charged and discharged through the enabling and disabling of the fixed current source. The variable current source is controlled from the error inputs that are received from the current and voltage feedback signals. The oscillator off-time is controlled by the amount of current that is available from the variable current source to charge the external capacitor up to the high threshold level of the comparator. The on-time is set be the constant current source that discharges the external capacitor voltage down to the lower comparator threshold.

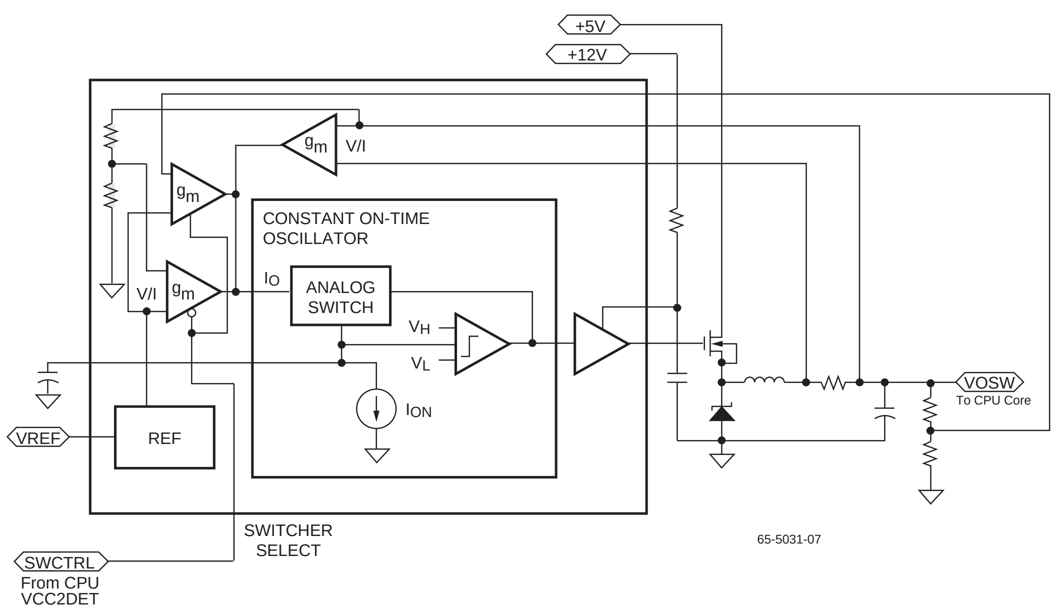
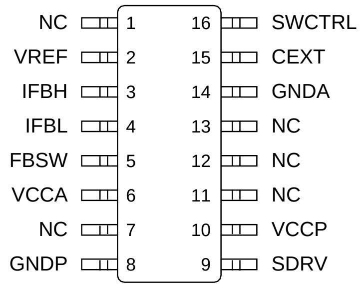



**Figure 1. RC5031 Block Diagram**

## Pin Assignments




65-5031-02

## Pin Descriptions

| Pin Name | Pin Number | Pin Function Description |
|---|---|---|
| NC | 1 | **No connection.** |
| VREF | 2 | **Voltage reference test point.** This pin provides access to the internal precision 1.5V bandgap reference and should be decoupled to ground using a 0.1μF ceramic capacitor. No load should be connected to this pin. |
| IFBH | 3 | **High side current feedback for switching regulator.** Pins 3 and 4 are used as the inputs for the current feedback control loop and as the short circuit current sense points. Careful layout of the traces from these pins to the current sense resistor is critical for optimal performance of the short circuit protection scheme. See Applications Information for details. |
| IFBL | 4 | **Low side current feedback for switching regulator.** See Applications Information for details. |
| FBSW | 5 | **Voltage feedback for switching regulator.** This input is active when a logic level LOW is input on pin 16 (SWCTRL). Using two external resistors, it sets the output voltage level for the switching regulator. See Applications Information for details. |
| VCCA | 6 | **Switching Regulator $V_{CC}$.** Power supply for switching regulator control circuitry and voltage reference. Connect to system 5V supply and decouple to ground with 0.1μF ceramic capacitor. |
| NC | 7 | **No connection.** |
| GNDP | 8 | **Power Ground.** Return pin for high currents flowing in pins 9, 10 and 12 (SDRV, VCCP and LDRV). Connect to a low impedance ground. See Application Information for details. |
| SDRV | 9 | **FET driver output for switching regulator.** Connect this pin to the gate of the N-channel MOSFET M1 as shown in Figure 11. The trace from this pin to the MOSFET gate should be kept as short as possible (less than 0.5"). See Applications Information for details. |
| VCCP | 10 | **Switching regulator gate drive $V_{CC}$.** Power supply for SDRV output driver. Connect to system 12V supply with R-C filter shown in Figure 11. See Applications Information for details. |
| NC | 11–13 | **No connection.** |
| GNDA | 14 | **Analog ground.** All low power internal circuitry returns to this pin. This pin should be connected to system ground so that ground loops are avoided. See Applications Information for details. |
| CEXT | 15 | **External capacitor.** A 180pF capacitor is connected to this pin as part of the constant on-time pulse width circuit. Careful layout of this pin is critical to system performance. See Applications Information for details. |
| SWCTRL | 16 | **Switching regulator control input.** Accepts TTL/open collector input levels. A logic level HIGH on this pin presets the switching regulator output voltage at 3.5V using internal resistors. A logic level LOW on this pin will select the output voltage set by two external resistors and the voltage feedback control pin 5 (VFBSW). See Applications Information for details. |

Preliminary Information

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## Absolute Maximum Ratings

| | |
|---|---|
| Supply Voltages, VCCA, VCCP | 13V |
| Junction Temperature, $T_J$ | +150°C |
| Storage Temperature, $T_S$ | -65 to +150°C |
| Lead Soldering Temperature, 10 seconds | 300°C |

**Note:**
1. Functional operation under any of these conditions is not implied. Performance is guaranteed only if Operating Conditions are not exceeded.

## Operating Conditions

| Parameter | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| Switching Regulator $V_{CC}$, VCCA | | 4.75 | 5 | 5.25 | V |
| Logic Inputs, SWCTRL | Logic HIGH<br>Logic LOW | 2.4 | | <br>0.8 | V<br>V |
| Ambient Operating Temperature, $T_A$ | | 0 | | 70 | °C |
| Drive Gate Supply, VCCP | | 9 | 12 | 13 | V |

## Electrical Characteristics

(VCCA = 5V, VCCP = 12V, $T_A$ = 25°C using circuit of Figure 11, unless otherwise noted)

The • denotes specifications which apply over the full ambient operating temperature range.

| Parameter | Conditions | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| Output Voltage, $V_{OUT}$ | SWCTRL = High | • | | 3.5 | | V |
| Output Voltage, $V_{OUT}$[1] | SWCTRL = Low<br>Set by external resistors | • | 1.5 | | 3.6 | V |
| Setpoint Accuracy[2] | $I_{SW}$ = 5A, using 0.1% resistors | | -1.2 | | +1.2 | % |
| Output Temperature Drift | | | | 40 | | ppm |
| Output Current, $I_{SW}$ | | • | | | 13 | A |
| Line Regulation | VCCA = 4.75 to 5.25V, $I_{SW}$= 5A | | | 0.10 | 0.15 | %Vo |
| Load Regulation | $I_{SW}$ = 0 to 5A or 5A to 10A | | | ±0.9 | ±1.3 | %Vo |
| Output Ripple, peak-peak | 20MHz BW, $I_{SW}$ = 5A | | | 15 | | mV |
| Cumulative DC Accuracy[3] | | • | | ±55 | ±100 | mV |
| Efficiency | $I_{SW}$ = 5A, VOSW[1] = 2.8V | • | 80 | 85 | | % |
| Output Driver Current | Open Loop | • | 0.5 | | | A |
| Short Circuit Threshold Voltage | | • | 80 | 90 | 100 | mV |
| On Time Pulse Width[4] | $C_{EXT}$ = 180pF | | | 3.5 | | µs |
| Reference Voltage, VREF | | | 1.485 | 1.5 | 1.515 | V |
| VREF PSRR | | | 60 | | | dB |
| Thermal Impedance, $\theta_{JA}$ | | • | | 150 | | °C/W |
| VCCA Supply Current | Independent of load | • | | 5 | 10 | mA |

| Parameter | Conditions | | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|---|
| VCCP Supply Current | $I_{SW}$ = 5A | • | | 20 | 25 | mA |
| Internal Power Dissipation | $I_{SW}$ = 5A, using Figure 11 | • | | 125 | | mW |

**Notes:**

1. When the SWCTRL pin is HIGH or left open, the switch-mode regulator output will be preset at 3.5V using internal precision resistors. When the SWCTRL pin is LOW, the output voltage may be programmed with external resistors. Please refer to the Applications Section for output voltage selection information.
2. Setpoint accuracy is the initial output voltage variability under the specified conditions. When SWCTRL is LOW, the matching of the external resistors will have a major influence on this parameter.
3. Cumulative DC accuracy includes setpoint accuracy, temperature drift, line and load regulation, and output ripple.
4. The on-time pulse width of the oscillator is preset via external capacitor $C_{EXT}$. See Typical Operating Characteristics curves.

## Typical Operating Characteristics

(VCCA = 5V, and $T_A$ = +25°C using circuit in Figure 11, unless otherwise noted)

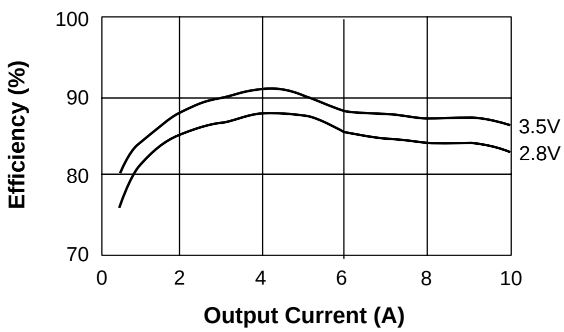


**Figure 2. Switcher Efficiency vs. Output Current**

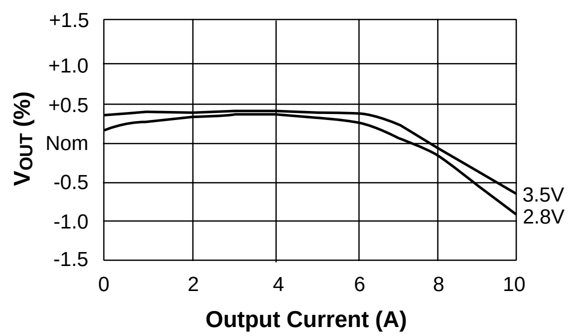


**Figure 3. Switcher Output Voltage vs. Load**

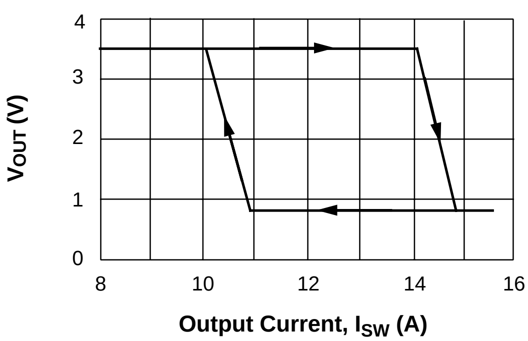


**Figure 4. Switcher Output vs Output Current**

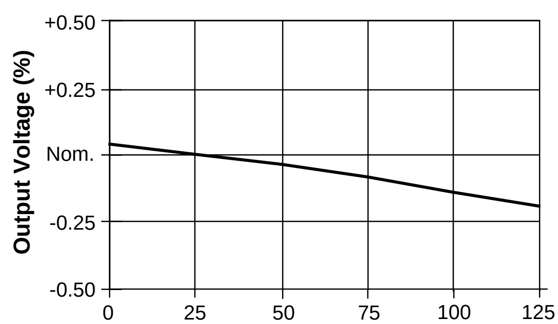


**Figure 5. Output Voltage vs. Temperature ($I_{SW}$ or $I_L$ = 5A)**

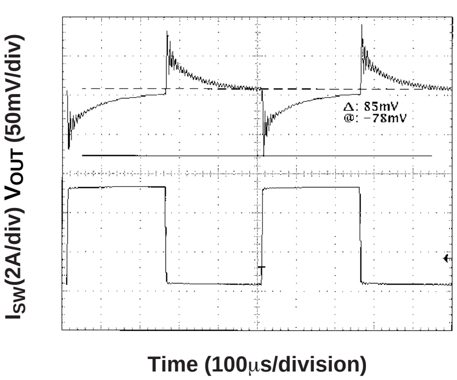


**Figure 6. Switcher Transient Response (0.5 to 5.5A Load Step)**

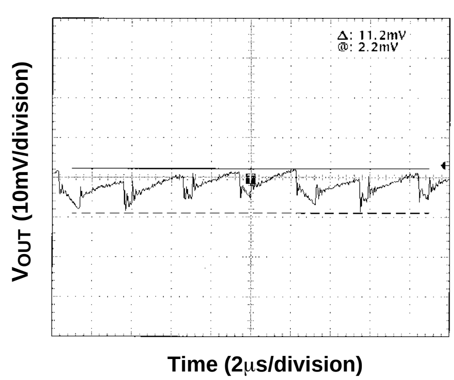


**Figure 7. Switcher Output Ripple (BW = 20MHz, $I_{SW}$ = 5A)**

## Typical Operating Characteristics (continued)

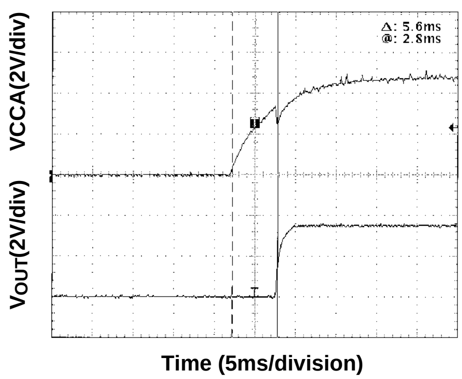


Figure 8. Switcher Turn-on Response

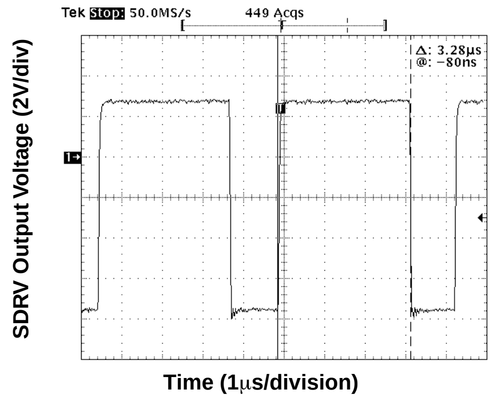


Figure 9. Pin 9 (SDRV) at a 5 Amp Load

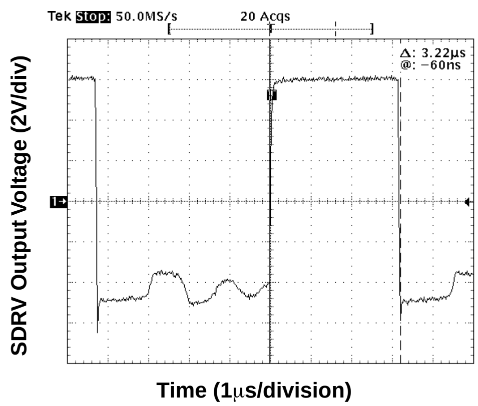


Figure 10. Pin 9 (SDRV) at a 0.1 Amp Load

## Test Circuit Configurations

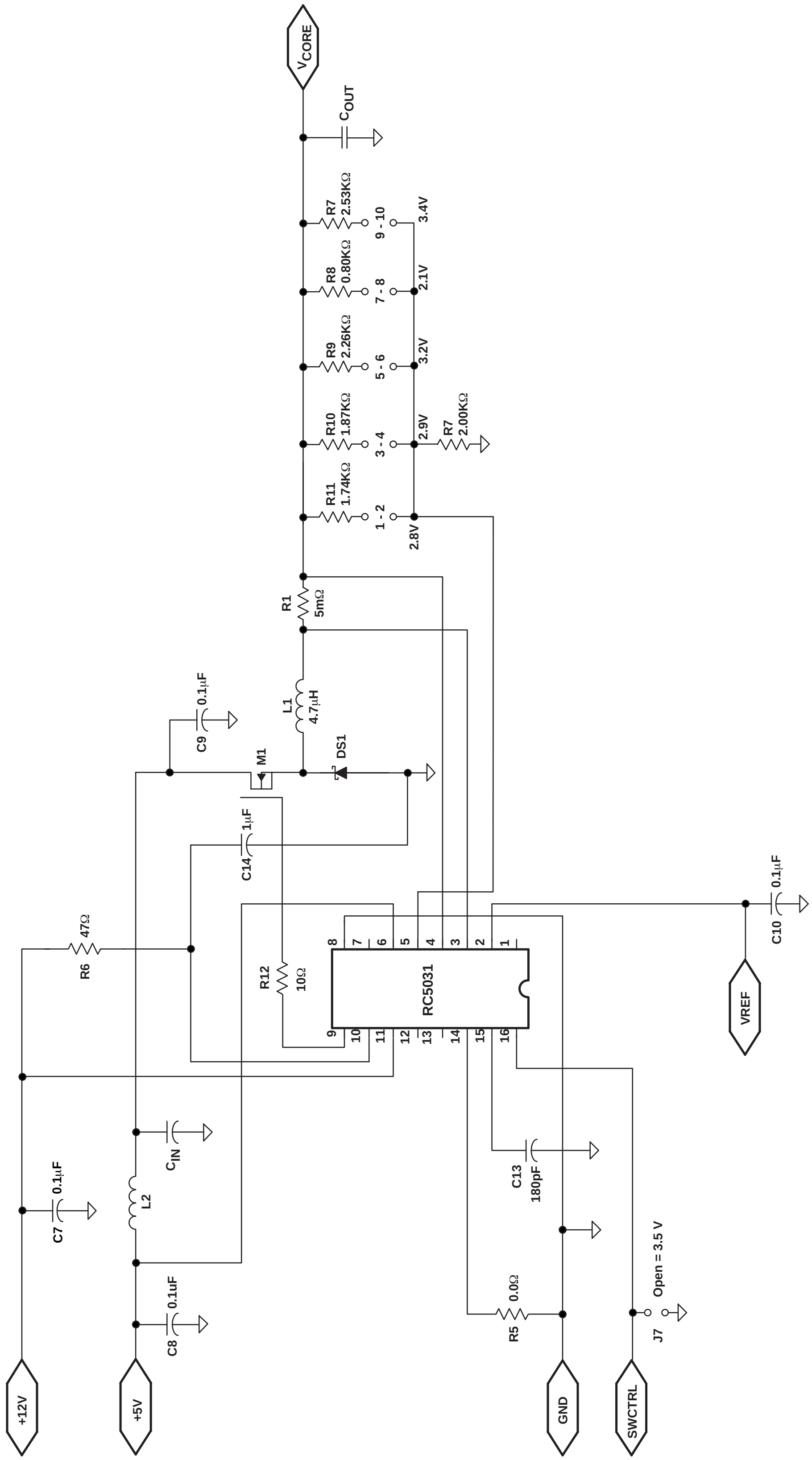


Figure 11. P54/P55C, K6, or M2 Switching Power Supply Application Schematic

Preliminary Information

**Table 1. Bill of Materials for a RC5031 P55C, K6, or M2 Application**

| Qty. | Reference | Manufacturer Part Order # | Description | Requirements and Comments |
|---|---|---|---|---|
| 4 | C7, C8, C9, C10 | Panasonic ECU-V1H104ZFX | 0.1μF 50V SMT 0805 capacitors | |
| 1 | C13 | Panasonic ECU-V1H181JCG | 180pF 50V SMT0805 capacitor | |
| 1 | C14 | Panasonic ECSH1CY105R | 1μF 16V SMT 0805 Capacitor | |
| See Table 2 | $C_{OUT}$ | Sanyo 6MV1500GX | 1500μF 6.3V electrolitic capacitor, 10mm x 20mm | ESR < 0.044Ω |
| See Table 2 | $C_{IN}$ | Sanyo 10MB1200GX | 1200μF 10 B electrolytic capacitor, 10mm x 20mm | |
| 1 | DS1 | Motorola MBR1545CT | Schottky Diode | $V_f$ < 0.57V at $I_f$ = 7.5A |
| 1 | L1 | Pulse Engineering PE-53682 | 4.7μH inductor | |
| 1 | L2 | Beads Inductor | 2 Beads, 3.5 x 8mm wire, diameter = 0.6mm | Optional—Helps reduce ripple on the 5V line |
| 1 | M1 | IRL3103 | N-Channel Logic Level Enhancement Mode MOSFET | $R_{DS(ON)}$ < 20mΩ, $V_{GS}$ < 4.5V, $I_D$ > 20A |
| 1 | R1 | $R_{SENSE}$ (SW) | 5mΩ MnCu or Copel resistor | |
| 1 | R8 | Panasonic ERJ-6ENF 0.80KV | 0.80KΩ 1% resistor | 0.1% resistor desirable for accuracy |
| 1 | R9 | Panasonic ERJ-6ENF2.26KV | 2.26KΩ 1% resistor | 0.1% resistor desirable for accuracy |
| 1 | R10 | Panasonic ERJ-6ENF1.87KV | 1.87KΩ 1% resistor | 0.1% resistor desirable for accuracy |
| 1 | R11 | Panasonic ERJ-6ENF1.74KV | 1.74KΩ 1% resistor | 0.1% resistor desirable for accuracy |
| 1 | R7 | Panasonic ERJ-6ENF2.00KV | 2.00KΩ 1% resistor | 0.1% resistor desirable for accuracy |
| 1 | R5 | Panasonic ERJ-6GEY000V | 0Ω 5% resistor | Resistor raises $V_{OUT}$ 25mV/5Ω |
| 1 | R6 | Panasonic ERJ-6GEY047V | 47Ω 5% resistor | |
| 1 | U1 | Fairchild Semiconductor RC5031M | Adjustable Switching Regulator | |

**Table 2. Switching Regulator Components Selection Table**

| Output Voltage | Output Current | $C_{IN}$ Sanyo 10MV1200GX | $C_{OUT}$ Sanyo 6M1500GX | Power MOSFET (M1) |
|---|---|---|---|---|
| 3.5 | 8 | 1x | 2x | IRL3103 |
| 2.8 | 6 | 1x | 2x | IRL3103 |
| 2.9 | 6.25 | 1x | 2x | IRL3103 |
| 2.9 | 7.5 | 1x | 2x | IRL3103 |
| 3.2 | 9.5 | 2x | 4x | IRL3103 |
| 3.2 | 13 | 3x | 6x | IRL3103 |
| 2.1 | 5.6 | 1x | 2x | IRL3103 |
| 3.3 | 3 | N/A | 1x | MJE15028 |

## Applications Information

The following discussion is intended to be an abbreviated list of design considerations regarding the RC5031 as used in a typical voltage processor motherboard application.
For a more thorough discussion of applicable specifications relating to the Intel Pentium P55C processor, please refer to Application Note 48.

### Output Voltage Selection

#### Feedback Voltage Divider

The RC5031 precision reference is trimmed to be 1.5V nominally. When using the RC5031, the system designer has complete flexibility in choosing the output voltage for each regulator from 1.5V to 3.6V. This is done by appropriately selecting the feedback resistors. These should be 0.1% resistors to realize optimum output accuracy. The following equations determine the output voltages of the two regulators:

Switching Regulator

$$V_{OUT} = 1.5 \times \left(\frac{R2 + R3}{R3}\right)$$

where: R2 > 1.5kΩ and (R2 + R3) ≤ 25kΩ

Example:

For 2.8V,

$$V_{OUT} = 1.5 \times \left(\frac{R2 + R3}{R3}\right) = 1.5 \times \left(\frac{1.6k + 1.85k}{1.85k}\right) = 2.8V$$

### Short Circuit Considerations

The RC5031 uses a current sensing scheme to limit the load current if an output fault condition occurs. The current sense resistor carries the peak current of the inductor, which is greater than the maximum load current due to ripple currents flowing in the inductor. The RC5031 will begin to limit the output current to the load by turning off the top-side FET driver when the voltage across the current-sense resistor exceeds the short circuit comparator threshold voltage ($V_{th}$). When this happens the output voltage will temporarily go out of regulation. As the voltage across the sense resistor becomes larger, the top-side MOSFET will continue to turn off until the current limit value is reached. At this point, the RC5031 will continuously deliver the limit current at a reduced output voltage level. The short circuit comparator threshold voltage is typically 90mV, with a variability of ±10mV. The ripple current flowing through the inductor is typically 0.5A. There needs to be a 29% margin for the sense resistor when using a motherboard PC trace resistor. Refer to Application Note 48 for detailed discussions. The sense resistor value can be approximated as follows:

$$R_{SENSE} = \frac{V_{th,min}}{I_{PK}} \times (1 - TF) = \frac{V_{th,min}}{1.5A + I_{LOAD,MAX}} \times (1 - TF)$$

Where TF = Tolerance Factor for the sense resistor and 1.5A accounts for the inductor ripple current.

There are several different types of sense resistors. Table 3 describes the tolerance, size, power capability, temperature coefficient and cost of various types of sense resistors.

Based on the Tolerance in Table 3:

For an embedded PC trace resistor:

$$R_{SENSE} = \frac{V_{th,min}}{1.5 + I_{LOAD,MAX}} \times (1 - TF)$$

$$= \frac{80mV}{1.5A + 10A} \times (1 - 29\%) = 4.9m\Omega$$

For a discrete resistor:

$$R_{SENSE} = \frac{V_{th,min}}{1.5 + I_{LOAD,MAX}} \times (1 - TF)$$

$$= \frac{80mV}{1.5A + 10A} \times (1 - 5\%) = 6.6m\Omega$$

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**Table 3. Comparison of Sense Resistors**

| | Motherboard Trace Resistor | Discrete Iron Alloy resistor (IRC) | Discrete Metal Strip surface mount resistor (Dale) | Discrete MnCu Alloy wire resistor | Discrete CuNi Alloy wire resistor (Copel) |
|---|---|---|---|---|---|
| Tolerance Factor (TF) | ±29% | ±5% (±1% available) | ±1% | ±10% | ±10% |
| Size (L x W x H) | 2" x 0.2" x 0.001" (1 oz Cu trace) | 0.45" x 0.065" x 0.2" | 0.25" x 0.125" x 0.025" | 0.2" x 0.04" x 0.16" | 0.2" x 0.04" x 0.1" |
| Power capability | >50A/in | 1 watt (3 and 5 watts available) | 1 watt (3 and 5 watts available) | 1 watt | 1 watt |
| Temperature Coefficient | +4,000 ppm | +30 ppm | ±75 ppm | ±30 ppm | ±20ppm |
| Cost@10,000 piece quantity | Low; included in motherboard | $0.31 | $0.47 | $0.09 | $0.09 |

Table 4 lists recommended values for sense resistors for various load currents using an embedded PC trace resistor or a discrete resistor.

### Table 4. $R_{SENSE}$ for Various Load Currents, Switching Regulator

| $I_{LOAD, MAX}$ (A) | $R_{SENSE}$ PC Trace Resistor (mΩ) | $R_{SENSE}$ Discrete Resistor (mΩ) |
|---|---|---|
| 5 | 8.7 | 11.7 |
| 6 | 7.6 | 10.1 |
| 7 | 6.7 | 8.9 |
| 8 | 6.0 | 8.0 |
| 9 | 5.4 | 7.0 |
| 10 | 4.9 | 6.6 |

Since the value of the sense resistor is often less than 10mΩ, care should be taken in the layout of the PCB. Trace resistance can contribute significant errors. The traces to the IFBH and IFBL pins of the RC5031 should be Kelvin connected to the pads of the current-sense resistor. To minimize the influence of noise, the two traces should be run next to each other.

## Thermal Design Considerations

Good thermal management is critical in the design of high current regulators. System reliability will be degraded if the component temperatures become excessive. The following guide should serve as a reference for proper thermal management.

#### MOSFET Temperature

The maximum power dissipation of the MOSFET can be calculated by using the following formula:

$$P_D = \frac{T_{J(MAX)} - T_A}{\Theta_{JA}}$$

For IR 3103, $\Theta_{JA}$ is 42°C/W. For reliability the junction temperature of the MOSFET should not exceed 120°C. Assuming that the ambient temperature is 40°C, then the maximum power dissipation is calculated as:

$$P_D = \frac{120 - 40}{42} = 1.905\text{W}$$

The power that the MOSFET dissipates at the rated 6A load is calculated as follows:

$$P_{MOSFET} = I_{LOAD}^2 \times R_{DS(ON)} \times (\text{Duty Cycle}) + \frac{V_{IN} \times I_{LOAD}}{6} \times (t_r + t_f) \times f$$

$$\text{Duty Cycle} = \frac{V_{OUT} + V_D}{V_{IN} + V_D - (I_{LOAD} \times R_{DS(ON)})}$$

where $V_D$ is the forward voltage of the Schottky diode used.

Using the above formula, for $V_{out}$ = 2.8V, $I_{LOAD}$ = 6A

$$\text{Duty Cycle} = \frac{2.8 + 0.57}{2.8 + 0.57 - (6 \times 0.019)} = 61.8\%$$

$$P_{MOSFET} = 6A^2 \times 0.019\Omega \times 61.8\% + \frac{5V \times 6A}{6} \times (210\text{ns} + 54\text{ns}) \times 300\text{KHz}$$

$$P_{MOSFET} = 0.82\text{W}$$

Since the power at 6A is within the thermal guideline, a heat sink is not required other than the PCB.

## Schottky Diode

In Figure 11, MOSFET M1 and flyback diode DS1 are used as complementary switches in order to maintain a constant current through the output inductor L1. As a result, DS1 will have to carry the full current of the output load when the power MOSFET is turned off. The power in the diode is a direct function of the forward voltage at the rated load current during the off time of the FET. The following equation can be used to estimate the diode power:

$$P_{DIODE} = I_D \times V_D \times (1 - \text{DutyCycle})$$

where $I_D$ is the forward current of the diode, $V_D$ is the forward voltage of the diode, and DutyCycle is defined the same as above.

For the Motorola MBR2030CTL Rectifier in Figure 11,

$$P_{DIODE} = 10A \times 0.57 \times (1 - 64.8\%) = 2.0\text{W}$$

It is recommended that the diode T0-220 package be placed down on the motherboard to utilize the power plane as a heatsink and achieve a thermal resistance of 40°C/W.

## Board Design Considerations

#### RC5031 Placement

The RC5031 should be placed as close to the core voltage supply pins of the P55C as possible, preferably to have the PC layer directly underneath the RC5031 for ground layer. This serves as extra isolation from noisy power planes.

#### MOSFET Placement

Placement of the power MOSFET is critical in the design of the switch-mode regulator. The FET should be placed in such a way as to minimize the length of the gate drive path from the RC5031 SDRV pin. This trace should be kept under 0.5" for optimal performance. Excessive lead length on this trace will cause high frequency noise resulting from the parasitic inductance and capacitance of the trace. Since this voltage can transition nearly 12V in around 100nsec, the resultant ringing and noise will be very difficult to suppress. This trace should be routed on one layer only and kept well away from the “quiet” analog pins of the device; VREF, CEXT, FBSW, IFBH, IFBL, and VFBL. A10Ω resistor in series with the MOSFET gate can decrease this layout critically. Refer to Figure 12.

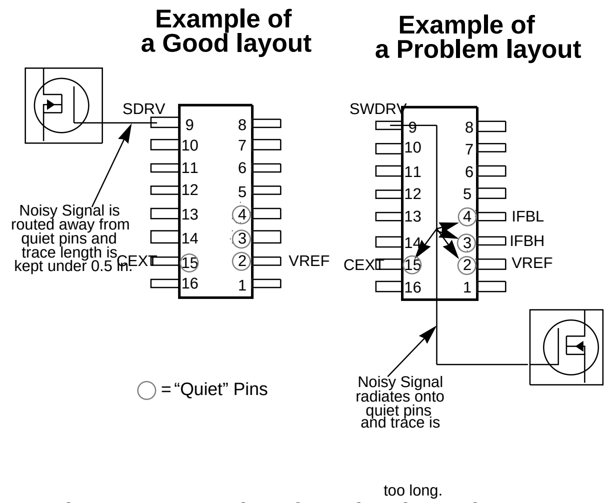



**Figure 12. Examples of good and poor layouts**

#### Inductor and Schottky Diode Placement

The inductor and fly-back Schottky diode need to be placed close to the source of the power MOSFET for the same reasons stated above. The node connecting the inductor and Schottky diode will swing between the drain voltage of the FET and the forward voltage of the Schottky diode. It is recommended that this node be converted to a plane if possible. This node will be part of the high current path in the design, and as such it is best treated as a plane in order to minimize the parasitic resistance and inductance on that node. Since most PC board manufacturers utilize 1/2 oz copper on the top and bottom signal layers of the PCB, it is not recommended to use these layers to rout the high current portions of the regulator design. Since it is more common to use 1 oz. copper on the PCB inner layers, it is recommended to use those layers to route the high current paths in the design.

#### Capacitor Placement

One of the keys to a successful switch-mode power supply design is correct placement of the low ESR capacitors. Decoupling capacitors serve two purposes; first there must be enough bulk capacitance to support the expected transient current of the CPU, and second, there must be a variety of values and capacitor types to provide noise supression over a wide range of frequencies. The low ESR capacitors on the input side (5V) of the FET must be located close to the drain of the power FET. Minimizing parasitic inductance and resistance is critical in supressing the ringing and noise spikes on the power supply. The output low ESR capacitors need to be placed close to the output sense resistor to provide good decoupling at the voltage sense point. One of the characteristics of good low ESR capacitors is that the impedance gradually increases as the frequency increases. Thus for high frequency noise supression, good quality low inductance ceramic capacitors need to be placed in parallel with the low ESR bulk capacitors. These can usually be 0.1μF 1206 surface mount capacitors.

#### Power and Ground Connections

The connection of VCCA to the 5V power supply plane should be short and bypassed with a 0.1μF directly at the VCCA pin of the RC5031. The ideal connection would be a via down to the 5V power plane. A similar arrangement should be made for the VCCL pin that connects to +12V, though this one is somewhat less critical since it powers only the linear op-amp. Each ground should have a separate via connection to the ground plane below.

A 12V power supply is used to bias the VCCP. A 47Ω resistor is used to limit the transient current into VCCP. A 1uF capacitor filter is used to filter the VCCP supply and source the transient current required to charge the MOSFET gate capacitance. This method provides sufficiently high gate bias voltage to the MOSFET ($V_{GS}$), and therefore reduces $R_{DS(ON)}$ of the MOSFET and its power loss.

Figure 13 provides about 5V of gate bias which works well when using typical logic-level MOSFETs, as shown in Figure 14. Non-logic-level MOSFETs should not be used because of their higher $R_{DS(ON)}$.

## MOSFET Gate Bias

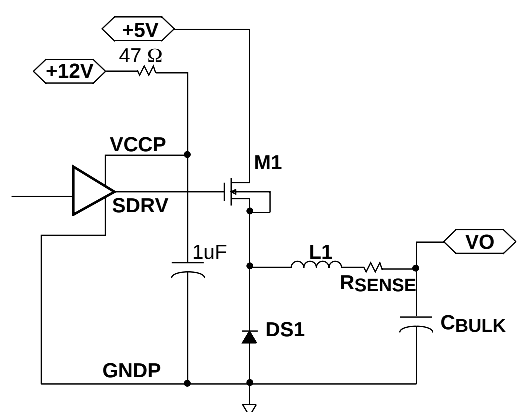



**Figure 13. 12V Gate Bias Configuration**

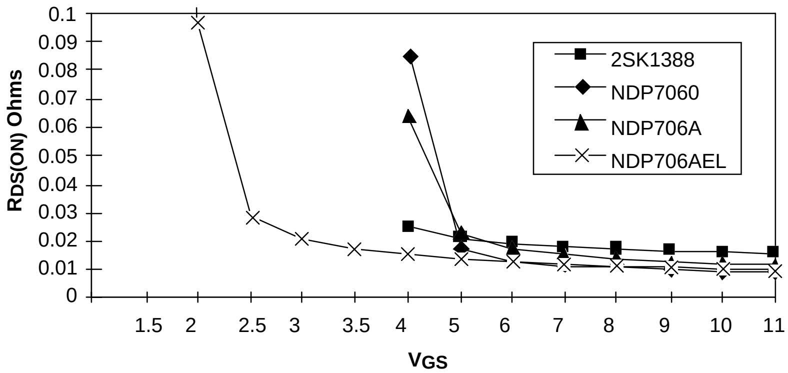



**Figure 14. $R_{DS(ON)}$ vs. $V_{GS}$ for Selected Logic-Level MOSFETs**

## Notes:

Preliminary Information

## Notes:

Preliminary Information

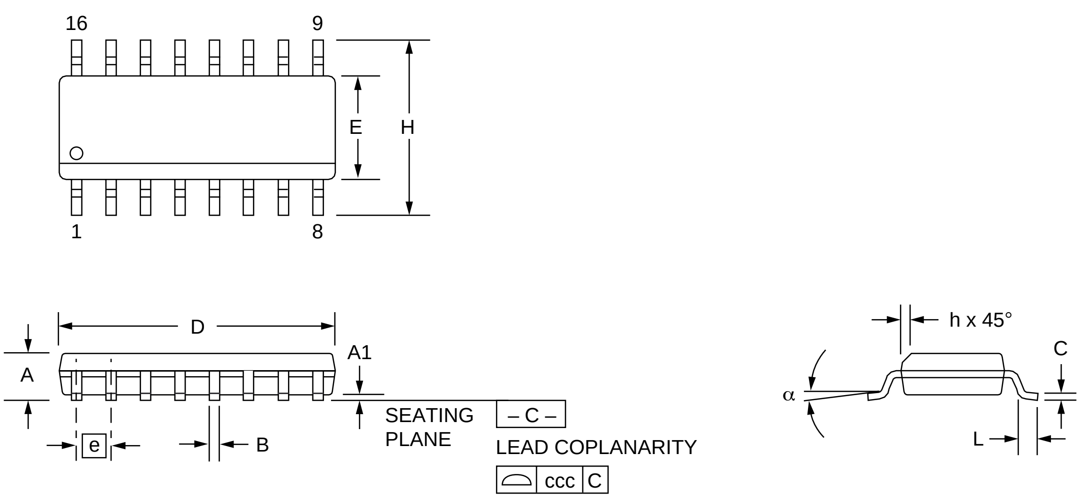
# Mechanical Dimensions

## 16-Lead SOIC Package

| Symbol | Inches | | Millimeters | | Notes |
|---|---|---|---|---|---|
| | Min. | Max. | Min. | Max. | |
| A | .053 | .069 | 1.35 | 1.75 | |
| A1 | .004 | .010 | 0.10 | 0.25 | |
| B | .013 | .020 | 0.33 | 0.51 | |
| C | .008 | .010 | 0.19 | 0.25 | 5 |
| D | .386 | .394 | 9.80 | 10.00 | 2 |
| E | .150 | .158 | 3.81 | 4.00 | 2 |
| e | .050 BSC | | 1.27 BSC | | |
| H | .228 | .244 | 5.80 | 6.20 | |
| h | .010 | .020 | 0.25 | 0.50 | |
| L | .016 | .050 | 0.40 | 1.27 | 3 |
| N | 16 | | 16 | | 6 |
| $\alpha$ | 0° | 8° | 0° | 8° | |
| ccc | — | .004 | — | 0.10 | |

**Notes:**

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E" do not include mold flash. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. "L" is the length of terminal for soldering to a substrate.
4. Terminal numbers are shown for reference only.
5. "C" dimension does not include solder finish thickness.
6. Symbol "N" is the maximum number of terminals.



## Ordering Information

| Product Number | Package |
|---|---|
| RC5031M | 16 pin SOIC |

Preliminary Information





5/20/98 0.0m 001
Stock#DS30005031