

# MC3PHAC Monolithic Intelligent Motor Controller

---

## Overview

The MC3PHAC is a high-performance monolithic intelligent motor controller designed specifically to meet the requirements for low-cost, variable-speed, 3-phase ac motor control systems. The device is adaptable and configurable, based on its environment. It contains all of the active functions required to implement the control portion of an open loop, 3-phase ac motor drive.

One of the unique aspects of this device is that although it is adaptable and configurable based on its environment, it does not require any software development. This makes the MC3PHAC a perfect fit for customer applications requiring ac motor control but with limited or no software resources available.

The device features are:

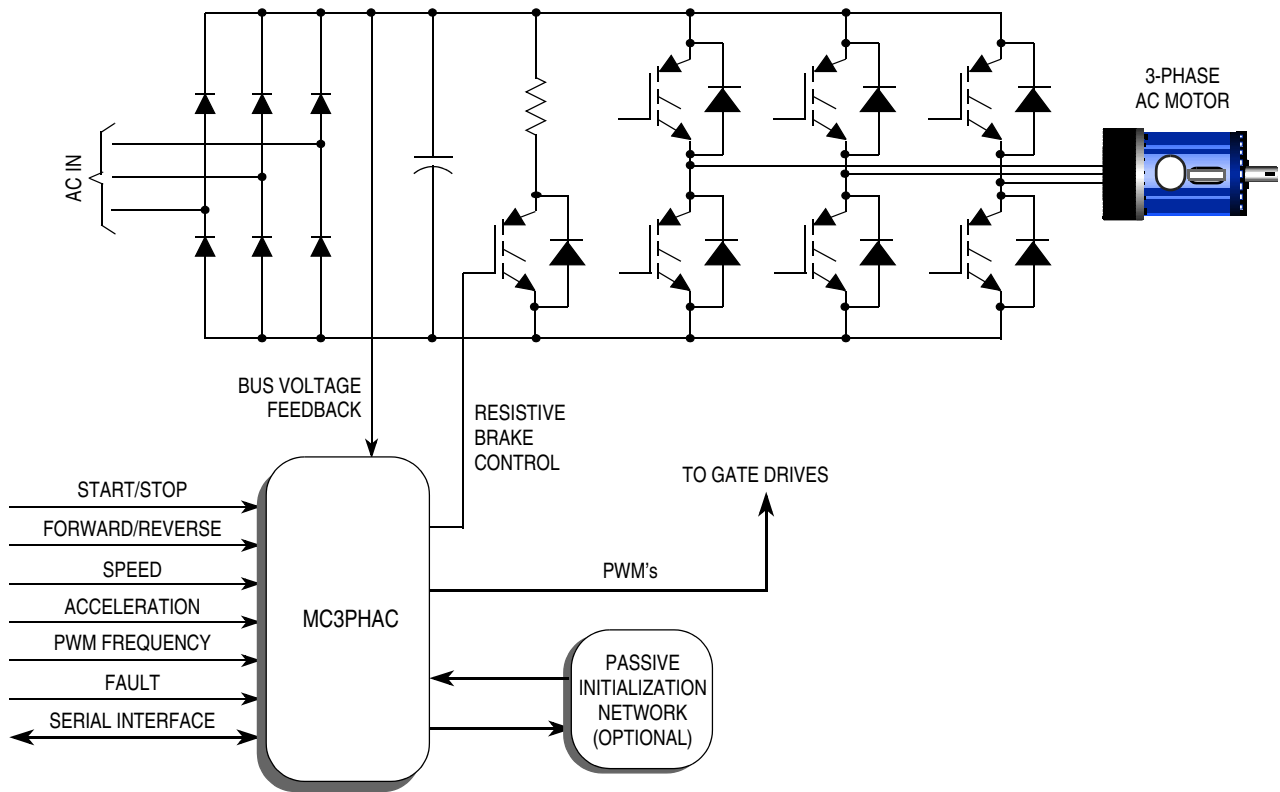
- Volts-per-Hertz speed control
- Digital signal processing (DSP) filtering to enhance speed stability
- 32-bit calculations for high-precision operation
- Internet enabled
- No user software development required for operation
- 6-output pulse-width modulator (PWM)
- 3-phase waveform generation
- 4-channel analog-to-digital converter (ADC)
- User configurable for standalone or hosted operation
- Dynamic bus ripple cancellation
- Selectable PWM polarity and frequency
- Selectable 50/60 Hz base frequency
- Phase-lock loop (PLL) based system oscillator
- Serial communications interface (SCI)
- Low-power supply voltage detection circuit

Included in the MC3PHAC are protective features consisting of dc bus voltage monitoring and a system fault input that will immediately disable the PWM module upon detection of a system fault.

## Overview

Some target applications for the MC3PHAC include:

- Low horsepower HVAC motors
- Home appliances
- Commercial laundry and dishwashers
- Process control
- Pumps and fans



**Figure 1. MC3PHAC-Based Motor Control System**

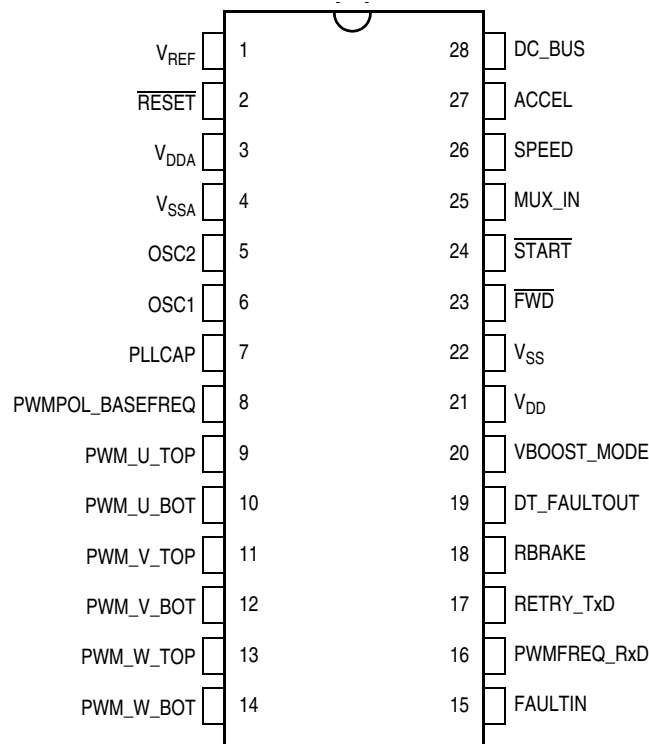
As shown in [Table 1](#), the MC3PHAC is offered in these packages:

- Plastic 28-pin dual in-line package (DIP)
- Plastic 28-pin small outline integrated circuit (SOIC)
- Plastic 32-pin quad flat pack (QFP)

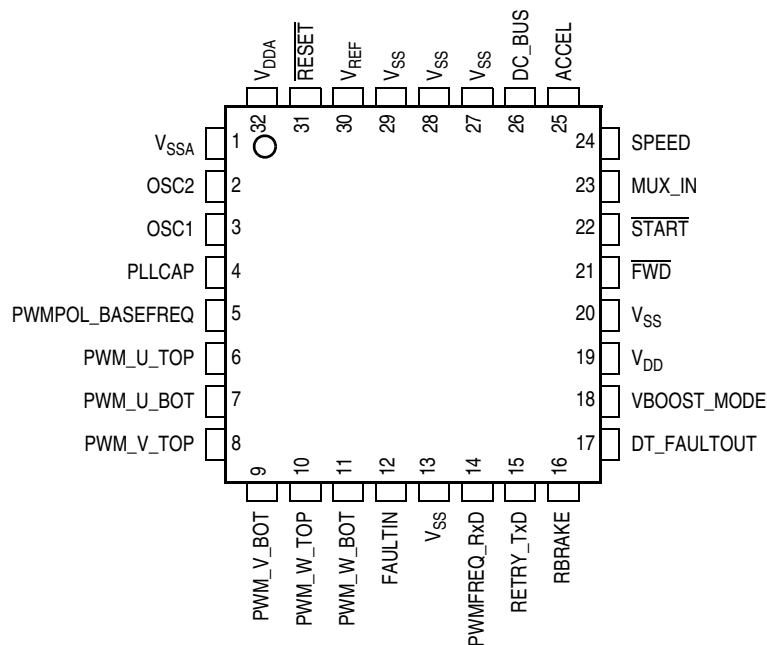
**Table 1. Ordering Information**

Device	Operating Temperature Range	Package
MC3PHACVFP	-40°C to +105°C	Plastic 28-pin DIP
MC3PHACVDW	-40°C to +105°C	Plastic 28-pin SOIC
MC3PHACVFA	-40°C to +105°C	Plastic 32-pin QFP

See [Figure 2](#) and [Figure 3](#) for the pin connections.



**Figure 2. Pin Connections for PDIP and SOIC**



**Figure 3. Pin Connections for QFP**

## Electrical Characteristics

### Maximum Ratings

Characteristic <sup>(1)</sup>	Symbol	Value	Unit
Supply voltage	$V_{DD}$	-0.3 to +6.0	V
Input voltage	$V_{In}$	-0.3 to $V_{DD} + 0.3$	V
Input high voltage	$V_{Hi}$	$V_{DD} + 0.3$	V
Maximum current per pin excluding $V_{DD}$ and $V_{SS}$	I	± 25	mA
Storage temperature	$T_{stg}$	-55 to +150	°C
Maximum current out of $V_{SS}$	$IMV_{SS}$	100	mA
Maximum current into $V_{DD}$	$IMV_{DD}$	100	mA

1. Voltages referenced to  $V_{SS}$

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum-rated voltages to this high-impedance circuit. For proper operation, it is recommended that  $V_{In}$  and  $V_{Out}$  be constrained to the range  $V_{SS} \leq (V_{In} \text{ or } V_{Out}) \leq V_{DD}$ . Reliability of operation is enhanced if unused inputs are connected to an appropriate logic voltage level (for example, either  $V_{SS}$  or  $V_{DD}$ ).

### Functional Operating Range

Characteristic	Symbol	Value	Unit
Operating temperature range (see <a href="#">Table 1</a> )	$T_A$	-40°C to +105°C	°C
Operating voltage range	$V_{DD}$	$5.0 \pm 10\%$	V

### Control Timing

Characteristic	Symbol	Value	Unit
Oscillator frequency <sup>(1)</sup>	$F_{osc}$	$4.00 \pm 1\%$	MHz

1. Follow the crystal/resonator manufacturer's recommendations, as the crystal/resonator parameters determine the external component values required for maximum stability and reliable starting. The load capacitance values used in the oscillator circuit design should include all stray capacitances.





















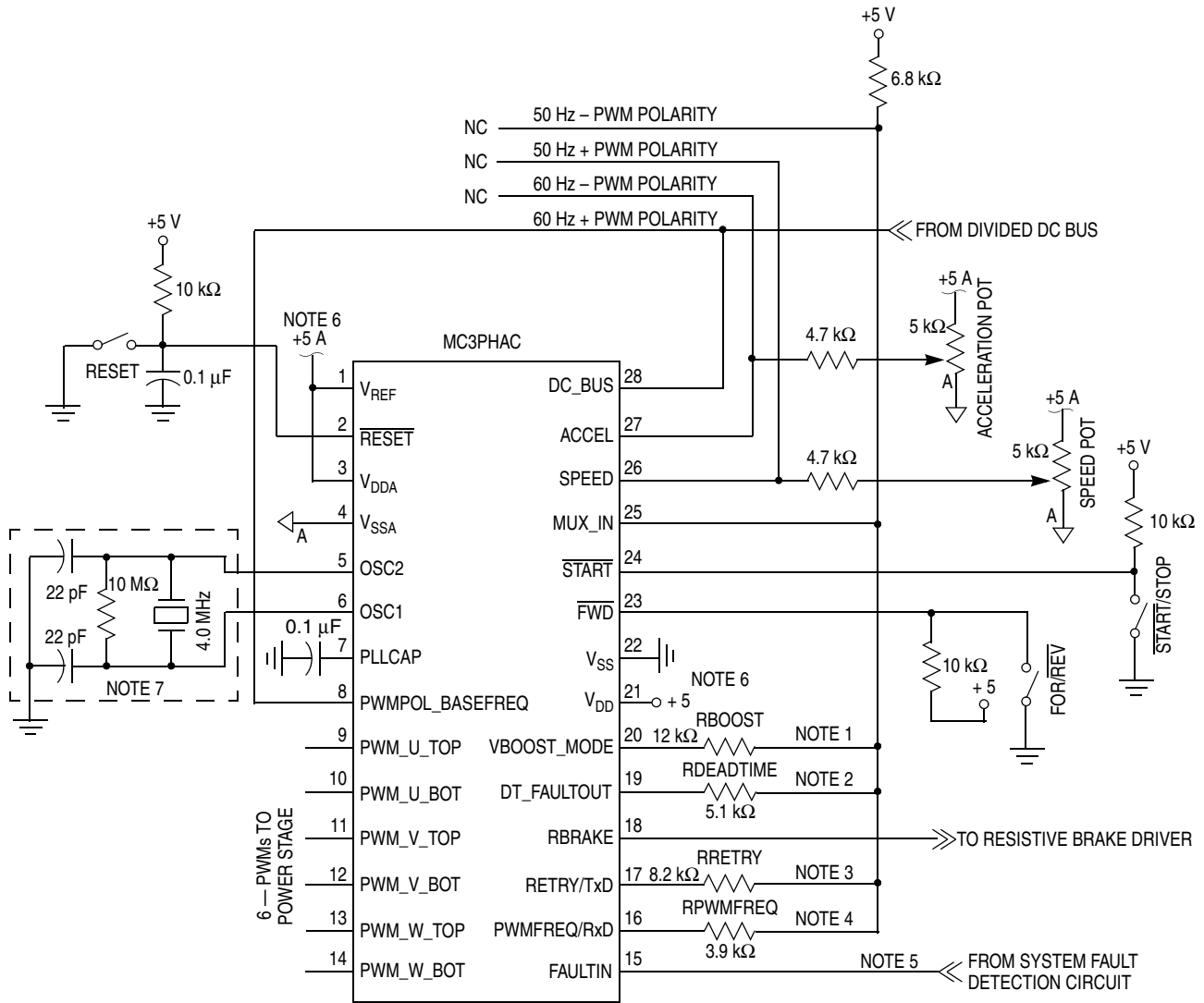






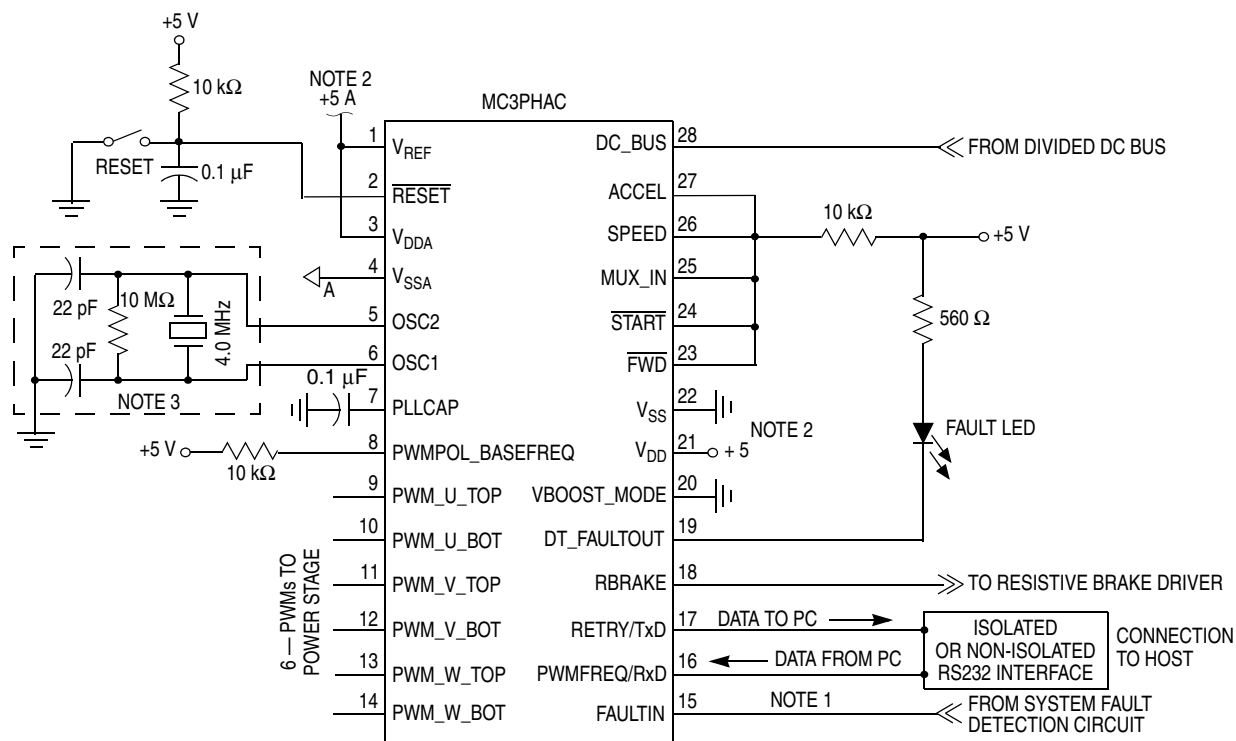






- Notes:
1. See Figure 11.
  2. See Figure 9.
  3. See Figure 10.
  4. See Table 4.
  5. If no external fault circuit is provided, connect to V<sub>SS</sub>.
  6. Use bypass capacitors placed close to the MC3PHAC.
  7. Consult crystal/resonator manufacturer for component values.

Figure 12. MC3PHAC Application Example in Standalone Mode



- Notes:
1. If no external fault circuit is provided, connect to V<sub>SS</sub>.
  2. Use bypass capacitors placed close to the MC3PHAC.
  3. Consult crystal/resonator manufacturer for component values.

**Figure 13. MC3PHAC Configuration for Using a PC as a Master**

*PC Master Software Operation with the MC3PHAC*

When power is first applied to the MC3PHAC, or if a logic low level is applied to the  $\overline{\text{RESET}}$  pin, the MC3PHAC enters PC master software mode if the VBOOST\_MODE pin is low during the initialization phase. The MC3PHAC recognizes a subset of the PC master software command set, which is listed in [Table 5](#).

**Table 5. Recognized PC Host Software Commands**

Command	Description
GETINFOBRIEF	MC3PHAC responds with brief summary of hardware setup and link configuration information
READVAR8	MC3PHAC reads an 8-bit variable at a specified address and responds with its value
READVAR16	MC3PHAC reads a 16-bit variable at a specified address and responds with its value
READVAR32	MC3PHAC reads a 32-bit variable at a specified address and responds with its value
WRITEVAR8	MC3PHAC writes an 8-bit variable at a specified address
WRITEVAR16	MC3PHAC writes a 16-bit variable at a specified address

With the READVARx commands, the addresses are checked for validity, and the command is executed only if the address is within proper limits. In general, a read command with an address value below \$0060 or above \$EE03 will not execute properly, but instead will return an invalid operation response. An

## Operation

exception to this rule is that PC master software allows reading locations \$0001, \$0036 and \$FE01, which are PORTB data register, Dead Time register and SIM Reset Status registers respectively. The addresses for the WRITEVARx commands are checked for validity, and the data field is also limited to a valid range for each variable. See [Table 6](#) for a list of valid data values and valid write addresses.

User interface variables and their associated PC master software addresses within the MC3PHAC are listed in [Table 6](#).

**Table 6. User Interface Variables for Use with PC Master Software**

Name	Address	Read/Write	Size (Bytes)	Description	Valid Data
Commanded direction	\$1000	W	1	Determines whether the motor should go forward, reverse, or stop	Forward — \$10 Reverse — \$11 Stop — \$20
Command reset	\$1000	W	1	Forces the MC3PHAC to perform an immediate reset	\$30
Commanded PWM frequency <sup>(1)</sup>	\$1000	W	1	Specifies the frequency of the MC3PHAC PWM frequency	5.3 kHz — \$41 10.6 kHz — \$42 15.9 kHz — \$44 21.1 kHz — \$48
Measured PWM period	\$00A8	R	2	The modulus value supplied to the PWM generator used by the MC3PHAC — value is multiplied by 250 ns to obtain PWM period	\$00BD–\$05E8
Commanded PWM polarity <sup>(2), (3), (4)</sup>	\$1000	W	1	Specifies the polarity of the MC3PHAC PWM outputs. This is a write once parameter after reset. Example: \$50 = Bottom and top PWM outputs are positive polarity.	B + T + \$50 B + T – \$54 B – T + \$58 B – T – \$5C
Dead time <sup>(2), (3), (4)</sup>	\$0036	R/W	1	Specifies the dead time used by the PWM generator. Dead time = Value * 125 ns. This is a write-once parameter.	\$00–\$FF
Base frequency <sup>(3)</sup>	\$1000	W	1	Specifies the motor frequency at which full voltage is applied	60 Hz — \$60 50 Hz — \$61
Acceleration <sup>(3)</sup>	\$0060	R/W	2	Acceleration in Hz/sec (7.9 format) <sup>(8)</sup>	\$0000–\$7FFF
Commanded motor frequency <sup>(3)</sup>	\$0062	R/W	2	Commanded frequency in Hz. (8.8 format) <sup>(9)</sup>	\$0000–\$7FFF
Actual frequency	\$0085	R	2	Actual frequency in Hz. (8.8 format) <sup>(9)</sup>	\$0000–\$7FFF
Status <sup>(7)</sup>	\$00C8	R	1	Status byte	\$00–\$FF
Voltage boost	\$006C	R/W	1	0 Hz voltage. %Voltage boost = Value/\$FF	\$00–\$FF
Modulation index	\$0091	R	1	Voltage level (motor waveform amplitude percent assuming no bus ripple compensation) Modulation index = value/\$FF	\$00–\$FF

**Table 6. User Interface Variables for Use with PC Master Software (Continued)**

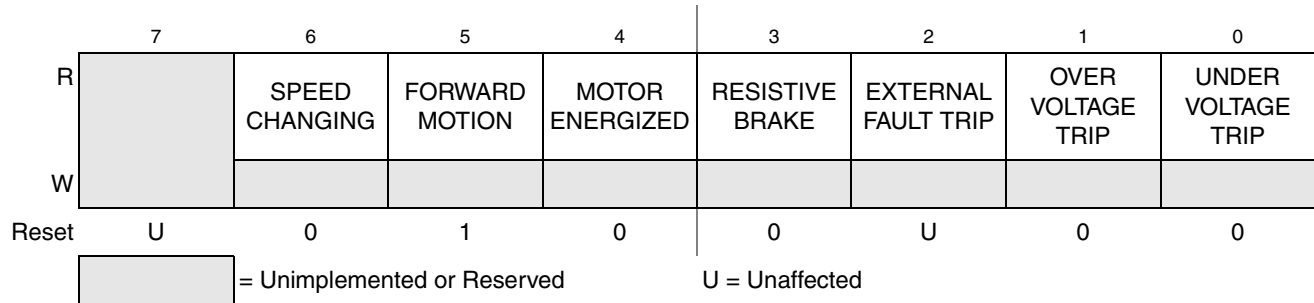
Name	Address	Read/Write	Size (Bytes)	Description	Valid Data
Maximum voltage	\$0075	R/W	1	Maximum allowable modulation index value %Maximum voltage = value/\$FF	\$00-\$FF
V <sub>Bus</sub> voltage <sup>(5), (10)</sup>	\$0079	R	2	DC bus voltage reading	\$000-\$3FF
Fault timeout	\$006A	R/W	2	Specifies the delay time after a fault condition before re-enabling the motor. Fault timeout = value * 0.262 sec	\$0000-\$FFFF
Fault timer	\$006D	R	2	Real-time display of the fault timer Elapsed fault time = value * 0.262 sec	\$0000-\$FFFF
V <sub>Bus</sub> decel value <sup>(10)</sup>	\$00C9	R/W	2	V <sub>Bus</sub> readings above this value result in reduced deceleration.	\$0000-\$03FF
V <sub>Bus</sub> RBRAKE value <sup>(10)</sup>	\$0064	R/W	2	V <sub>Bus</sub> readings above this value result in the RBRAKE pin being asserted.	\$0000-\$03FF
V <sub>Bus</sub> brownout value <sup>(10)</sup>	\$0066	R/W	2	V <sub>Bus</sub> readings below this value result in an under voltage fault.	\$0000-\$03FF
V <sub>Bus</sub> over voltage value <sup>(10)</sup>	\$0068	R/W	2	V <sub>Bus</sub> readings above this value result in an over voltage fault.	\$0000-\$03FF
Speed in ADC value <sup>(5)</sup>	\$0095	R	2	Left justified 10-bit ADC reading of the SPEED input pin.	\$0000-\$FFC0
Setup <sup>(7)</sup>	\$00AE	R	1	Bit field indicating which setup parameters have been initialized before motion is permitted	\$E0-\$FF
Switch in <sup>(7)</sup>	\$0001	R	1	Bit field indicating the current state of the start/stop and forward/reverse switches	\$00-\$FF
Reset status <sup>(6), (7)</sup>	\$FE01	R	1	Indicates cause of the last reset	\$00-\$FF
Version	\$EE00	R	4	MC3PHAC version	ASCII field

1. The commanded PWM frequency cannot be written until the PWM outputs exit the high-impedance state. The default PWM frequency is 15.873 kHz.
2. The PWM output pins remain in a high-impedance state until this parameter is specified.
3. This parameter must be specified before motor motion can be initiated by the MC3PHAC.
4. This is a write-once parameter. The first write to this address will execute normally. Further attempts at writing this parameter will result in an illegal operation response from the MC3PHAC.
5. The value of this parameter is not valid until the PWM outputs exit the high-impedance state.
6. The data in this field is only valid for one read. Further reads will return a value of \$00.
7. See register bit descriptions following this table.
8. Acceleration is an unsigned value with the upper seven bits range of \$00 to \$7F = acceleration value of 0 to 127 Hertz/second. The lower nine bits constitute the fractional portion of the acceleration parameter. Its range is \$000 to \$1FF which equals 0 to ~1. Therefore, the range of acceleration is 0 to 127.99 Hertz/second.
9. Commanded motor frequency and actual frequency are signed values with the upper byte range of \$00 to \$7F = frequency of 0 to 127 Hz. The lower byte is the fractional portion of the frequency. Its range is \$00 to \$FF which equals 0 to ~1.
10. V<sub>Bus</sub> is the voltage value applied to the DC\_BUS analog input pin. The analog-to-digital converter is a 10-bit converter with a 5 volt full scale input. The value is equal to the voltage applied to the DC\_BUS input pin/V<sub>REF</sub> \* \$03FF.

## Operation

Each bit variable listed in Table 6 is defined in Figure 14, Figure 15, Figure 16, and Figure 17.

Address: \$00C8

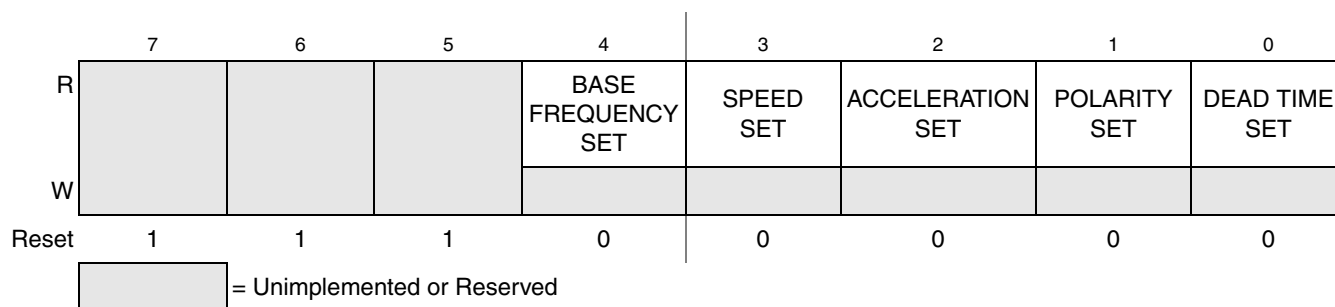


**Figure 14. Status Register**

**Table 7. Status Register Field Descriptions**

Field	Description
6 SPEED CHANGING	<b>SPEED CHANGING Bit</b> — This read-only bit indicates if the motor is at a steady speed or if it is accelerating or decelerating. 0 Motor is at a steady speed. 1 Motor is accelerating or decelerating.
5 FORWARD MOTION	<b>FORWARD MOTION Bit</b> — This read-only bit indicates the direction of the motor. It also indicates if the motor is stopped. 0 Motor is rotating in the reverse direction. 1 Motor is rotating in the forward direction. If this bit is a logic 1 and the actual frequency (location \$0085 and \$0086) is 0, the motor is stopped.
4 MOTOR ENERGIZED	<b>MOTOR ENERGIZED Bit</b> — This read-only bit indicates PWM output activity 0 The PWM outputs are inactive or the bottom PWM outputs are in the pre-charge cycle. 1 All PWM outputs are active.
3 RESISTIVE BRAKE	<b>RESISTIVE BREAK Bit</b> — This read-only bit indicates the state of the RBRAKE output pin 0 The RBRAKE output pin is inactive and no braking is in progress. 1 The RBRAKE output pin is active. Braking is in progress.
2 EXTERNAL FAULT TRIP	<b>EXTERNAL FAULT TRIP Bit</b> — This read-only bit indicates a FAULT has occurred resulting from a logic 1 applied to the FAULTIN pin. 0 A logic 0 is applied to the FAULTIN pin and no FAULT timeout is in progress. 1 A logic 1 was applied to the FAULTIN pin and a FAULT timeout is still in progress.
1 OVER VOLTAGE TRIP	<b>OVER-VOLTAGE TRIP Bit</b> — This read-only bit indicates if the voltage at the DC_BUS pin exceeds the preset value of $V_{BUS}$ over voltage located at address \$0068 and \$0069. 0 The voltage applied to the DC_BUS pin is less than the preset value of $V_{BUS}$ over voltage and a FAULT timeout is not in progress. 1 The voltage applied to the DC_BUS pin has exceeded the preset value of $V_{BUS}$ over voltage and a FAULT timeout is still in progress.
0 UNDER VOLTAGE TRIP	<b>UNDER-VOLTAGE Bit</b> — This read-only bit indicates if the voltage at the DC_BUS pin is less than the present value of $V_{BUS}$ brownout located at address \$0066 and \$0067. 0 The voltage applied to the DC-BUS pin is greater than the preset value of $V_{BUS}$ under voltage and a FAULT timeout is not in progress. 1 The voltage applied to the DC_BUS pin is less than the present value of $V_{BUS}$ under voltage and a FAULT timeout is still in progress.

Address: \$00AE



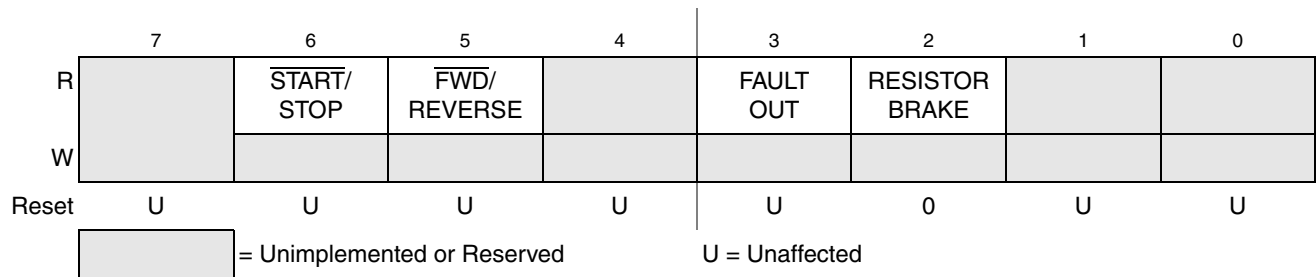
**Figure 15. Setup Register**

**Table 8. Setup Register Field Descriptions**

Field	Description
4 BASE FREQUENCY SET	<b>BASE FREQUENCY SET Bit</b> — This read-only bit indicates if the base frequency parameter has been set. 0 Base frequency parameter has not been set. 1 Base frequency parameter has been set.
3 SPEED SET	<b>SPEED SET Bit</b> — This read-only bit indicates if the speed parameter has been set. 0 Speed parameter has not been set. 1 Speed parameter has been set.
2 ACCELE- RATION SET	<b>ACCELERATION SET Bit</b> — This read-only bit indicates if the acceleration rate parameter has been set. 0 Acceleration rate parameter has not been set. 1 Acceleration rate parameter has been set.
1 POLARITY SET	<b>POLARITY SET Bit</b> — This read-only bit indicates if the PWM polarity parameters has been set. 0 PWM polarity parameters has not been set. 1 PWM polarity parameters has been set.
0 DEAD TIME SET	<b>DEAD TIME SET Bit</b> — This read-only bit indicates if the dead time parameter has been set. 0 Dead time parameter has not been set. 1 Dead time parameter has been set.

## Operation

Address: \$0001



**Figure 16. Switch In Register**

**Table 9. Switch In Register Field Descriptions**

Field	Description
6 $\overline{\text{START/STOP}}$	<b><math>\overline{\text{START/STOP}}</math> Bit</b> — This read-only bit indicates the state of the $\overline{\text{START}}$ input pin. 0 The $\overline{\text{START}}$ input pin is at a logic 0. 1 The $\overline{\text{START}}$ input pin is at a logic 1.
5 $\overline{\text{FWD/REVERSE}}$	<b><math>\overline{\text{FWD/REVERSE}}</math> Bit</b> — This read-only bit indicates the state of the $\overline{\text{FWD}}$ input pin. 0 The $\overline{\text{FWD}}$ input pin is at a logic 0 1 The $\overline{\text{FWD}}$ input pin is at a logic 1
3 FAULT OUT	<b>FAULT OUT Bit</b> — This read-only bit indicates the state of the DT_FAULTOUT output pin. 0 The DT_FAULTOUT output pin is indicating a fault condition. 1 The DT_FAULTOUT output pin is indicating no fault condition.
2 RESISTOR BRAKE	<b>RESISTIVE BRAKE Bit</b> — This read-only bit indicates the state of resistive brake pin (RBRAKE). 0 The RBRAKE output pin is inactive and no braking is in progress. 1 The RBRAKE output pin is active. Braking is in progress.

Address: \$FE01

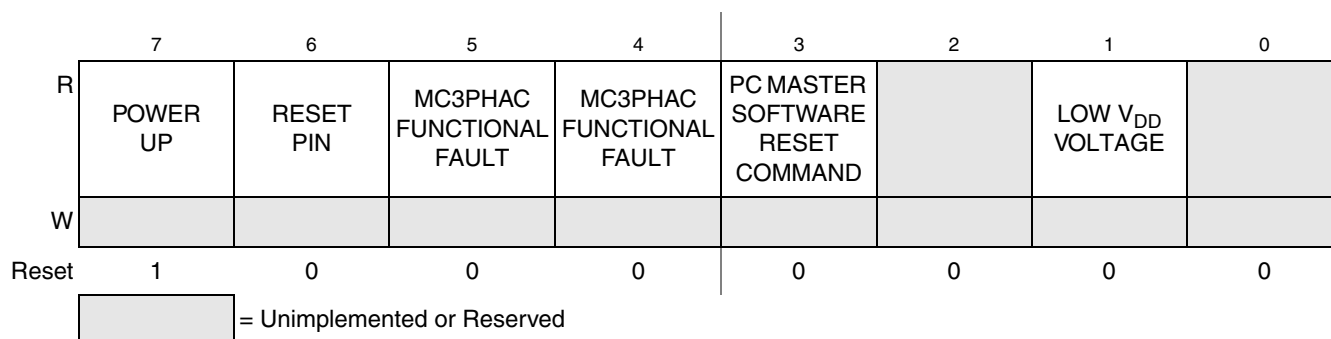


Figure 17. Reset Status Register

Table 10. Reset Status Register Field Descriptions

Field	Description
7 POWER UP	<b>POWER UP Bit</b> — This read-only bit indicates the last system reset was caused by the power-up reset detection circuit. 0 Power-up reset was not the source of the reset or a read of the reset status register after the first read. 1 The last reset was caused by an initial power-up of the MC3PHAC.
6 RESET PIN	<b>RESET PIN Bit</b> — This read-only bit indicates the last system reset was caused from the $\overline{\text{RESET}}$ input pin. 0 The $\overline{\text{RESET}}$ pin was not the source of the reset or a read of the reset status register after the first read. 1 Last reset was caused by an external reset applied to the $\overline{\text{RESET}}$ input pin.
5–4 MC3PHAC FUNCTIONAL FAULT BITS	<b>MC3PHAC FUNCTIONAL FAULT Bits</b> — This read-only bit indicates if the last system reset was the result of an internal system error. 0 The FUNCTIONAL FAULT was not the source of the reset or a read of the reset status register after the first read. 1 MC3PHAC internal system error
PC MASTER SOFTWARE RESET COMMAND	<b>PC MASTER SOFTWARE RESET COMMAND Bit</b> — This read-only bit indicates the last system reset was the result of a PC master software reset command. 0 The PC master software RESET COMMAND was not the source of the reset or a read of the reset status register after the first read. 1 The MC3PHAC was reset by the PC master software command reset as the result of a write of \$30 to location \$1000
1 LOW V <sub>DD</sub> VOLTAGE	<b>LOW V<sub>DD</sub> VOLTAGE Bit</b> — This read-only bit indicates if the last reset was the result of low V <sub>DD</sub> applied to the MC3PHAC. 0 The LOW V <sub>DD</sub> was not the source of the reset or a read of the reset status register after the first read. 1 The last reset was caused by the low power supply detection circuit.

### Command State Machine

When using the PC master software mode of operation, the command state machine governs behavior of the device depending upon its current state, system parameters, any new commands received via the communications link, and the prevailing conditions of the system. The command state diagram is in [Figure 18](#). It illustrates the sequence of commands which are necessary to bring the device from the reset condition to running the motor in a steady state and depicts the permissible state transitions. The device will remain within a given state unless the conditions shown for a transition are met.

Some commands only cause a temporary state change to occur. While they are being executed, the state machine will automatically return to the state which existed prior to the command being received. For example, the motor speed may be changed from within any state by using the WRITEVAR16 command to write to the "Speed In" variable. This will cause the "Set Speed" state to be momentarily entered, the "Speed In" variable will be updated and then the original state will be re-entered. This allows the motor speed, acceleration or base frequency to be modified whether the motor is already accelerating, decelerating, or in a steady state.

Each state is described here in more detail.

- **Reset** — This state is entered when a device power-on reset (POR), pin reset, loss of crystal, internally detected error, or reset command occurs from within any state. In this state, the device is initialized and the PWM outputs are configured to high impedance. This state is then automatically exited.
- **PWMHighZ** — This state is entered from the reset state. This state is also re-entered after one and only one of the PWM dead-time or polarity parameters have been initialized. In this state the PWM outputs are configured to a high-impedance state as the device waits for both the PWM dead time and polarity to be initialized.
- **SetDeadTime** (write once) — This state is entered from the PWMHighZ state the first time that a write to the PWM dead-time variable occurs. In this state, the PWM dead time is initialized and the state is then automatically exited. This state cannot be re-entered, and hence the dead time cannot be modified, unless the reset state is first re-entered.
- **SetPolarity** (write once) — This state is entered from the PWMHighZ state the first time that the PWM polarity command is received. In this state, the PWM polarity is initialized and the state is then automatically exited. This state cannot be re-entered, and hence the polarity cannot be modified, unless the reset state is first re-entered.
- **PWMOFF** — This state is entered from the PWMHighZ state if both the PWM dead time *and* polarity have been configured. In this state, the PWM is activated and all the PWM outputs are driven off for the chosen polarity. The device then waits for the PWM base frequency, motor speed, and acceleration to be initialized.
- **PWMORPM** — This state is entered from the PWMOFF state when the PWM base frequency, motor speed, and acceleration have been initialized. This state can also be entered from the FwdDecel or RevDecel states if a CmdStop command has been received, and the actual motor speed has decelerated to 0 r.p.m. In this state, the PWM pins are driven to the off state for the chosen polarity. The only exit of this state is to the PWMPump state, which occurs when a CmdFwd or CmdRev command is received.

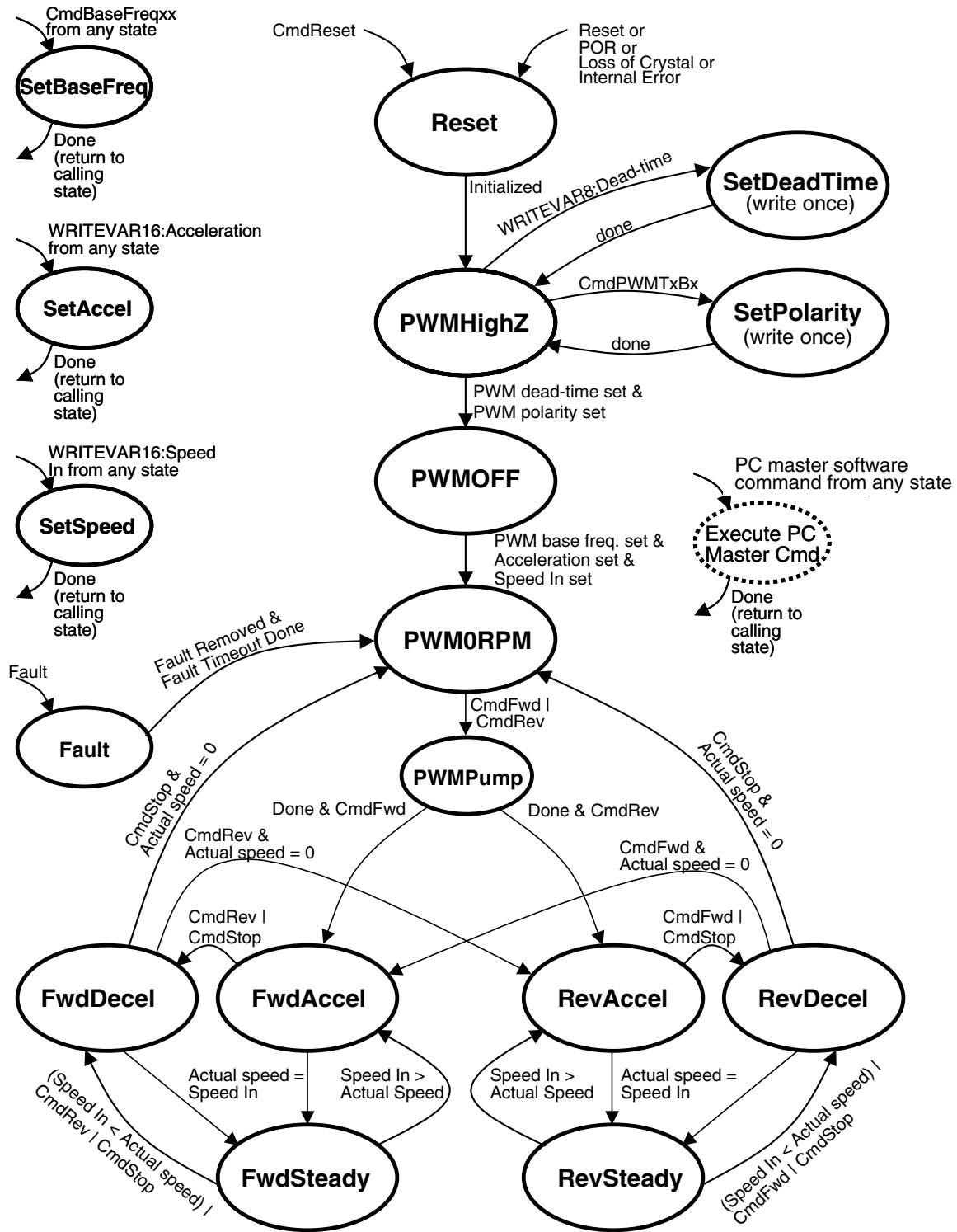


Figure 18. PC Host Software Command State Diagram

## Operation

- **PWMPump** — This state is entered from the PWMORPM state when a CmdFwd or CmdRev command is received. In this state the top PWM outputs are driven off while the bottom PWM outputs are driven with a 50 percent duty cycle. This allows high side transistor gate drive circuits which require charge pumping from the lower transistors to be charged up prior to applying full PWMs to energize the motor. This state is automatically exited after the defined amount of time  $t_{Pump}$  (see [Electrical Characteristics](#)).
- **FwdAccel** — This state is entered from the PWMPump state after a CmdFwd command is received and the timeout interval from the PWMPump state is completed. This state can also be entered from the FwdSteady state if the Speed In variable is increased above the actual current speed and the RevDecel state if the actual motor speed equals 0 r.p.m. when a CmdFwd command has been received. In this state the motor is accelerated forward according to the chosen parameters.
- **FwdSteady** — This state is entered from the FwdAccel state after the actual motor speed has reached the requested speed defined by the Speed In variable. In this state, the motor is held at a constant forward speed.
- **FwdDecel** — This state is entered from the FwdAccel or FwdSteady states whenever a CmdStop or CmdRev command is received. This state can also be entered from the FwdSteady state if the Speed In variable is decreased below the actual current speed. In this state, the motor is decelerated forward according to the chosen parameters.
- **RevAccel** — This state is entered from the PWMPump state. After a CmdRev command is received and the timeout interval from the PWMPump state is completed. This state can also be entered from the RevSteady state if the Speed In variable is increased above the actual current speed and the FwdDecel state if the actual motor speed equals 0 r.p.m. when a CmdRev command has been received. In this state, the motor is accelerated in reverse according to the chosen parameters.
- **RevSteady** — This state is entered from the RevAccel state after the actual motor speed has reached the requested speed defined by the Speed In variable. In this state, the motor is held at a constant reverse speed.
- **RevDecel** — This state is entered from the RevAccel or RevSteady states whenever a CmdStop or CmdFwd command is received. This state can also be entered from the RevSteady state if the Speed In variable is decreased below the actual current speed. In this state, the motor is decelerated in reverse according to the chosen parameters.
- **SetBaseFreq** — This state is entered from any state whenever a CmdBaseFreqxx command is received. In this state, the motor frequency at which full voltage is applied is configured and the state is then automatically exited and the original state is re-entered.
- **SetAccel** — This state is entered from any state whenever a write to the Acceleration variable occurs. In this state, the motor acceleration is configured and the state is then automatically exited and the original state is re-entered.
- **SetSpeed** — This state is entered from any state whenever a write to the Speed In variable occurs. In this state, the requested motor speed is configured and the state is then automatically exited and the original state is re-entered.
- **Fault** — This state is entered from any state whenever a fault condition occurs (see [Fault Protection](#) on page 13). In this state, the PWM outputs are driven off (unless the fault state was entered from the PWMHighZ state, in which case, the PWM outputs remain in the High Z state). When the problem causing the fault condition is removed, a timer is started which will wait a specified amount of time (which is user programmable) before exiting this state. Under normal

operating conditions, this timeout will cause the Fault state to be automatically exited to the PWM0RPM state, where motion will once again be initiated if a CmdFwd or CmdRev has been received. The exceptions to this rule are the cases when the Fault state was entered from the PWMHighZ or PWMOFF states, in which case, exiting from the Fault state will return back to these states.

## Optoisolated RS232 Interface Application Example

Some motor control systems have the control electronics operating at the same potential as the high voltage bus. Connecting a PC to that system could present safety issues, due to the high voltage potential between the motor control system and the PC. Figure 19 is an example of a simple circuit that can be used with the MC3PHAC to isolate the serial port of the PC from the motor control system.

The circuit in Figure 19 is the schematic of a half-duplex optoisolated RS232 interface. This isolated terminal interface provides a margin of safety between the motor control system and a personal computer. The EIA RS232 specification states the signal levels can range from  $\pm 3$  to  $\pm 25$  volts. A Mark is defined by the EIA RS232 specification as a signal that ranges from  $-3$  to  $-25$  volts. A Space is defined as a signal that ranges from  $+3$  to  $+25$  volts. Therefore, to meet the RS232 specification, signals to and from a terminal must transition through 0 volts as it changes from a Mark to a Space. Breaking the circuit down into an input and output section simplifies the explanation of the circuit.

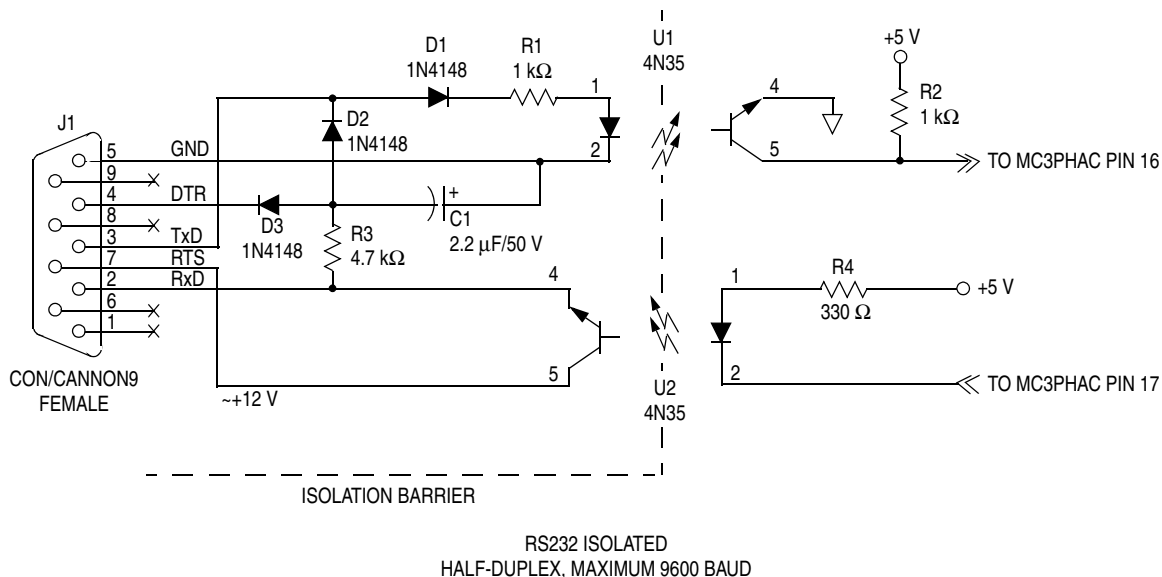


Figure 19. Optoisolated RS232 Circuit

To send data from a PC to the MC3PHAC, it is necessary to satisfy the serial input of the MC3PHAC. In the idle condition, the serial input of the MC3PHAC must be at a logic 1. To accomplish that, the transistor in U1 must be turned off. The idle state of the transmit data line (TxD) from the PC serial port is a Mark ( $-3$  to  $-25$  volts). Therefore, the diode in U1 is off and the transistor in U1 is off, yielding a logic 1 to the MC3PHAC's serial input. When the start bit is sent to the MC3PHAC from the PC's serial port, the PC's TxD transitions from a Mark to a Space ( $+3$  to  $+25$  volts), thus forward biasing the diode in U1. Forward biasing the diode in D1 turns on the transistor in U1, providing a logic 0 to the serial input of the MC3PHAC. Simply stated, the input half of the circuit provides input isolation, signal inversion, and level

## Optoisolated RS232 Interface Application Example

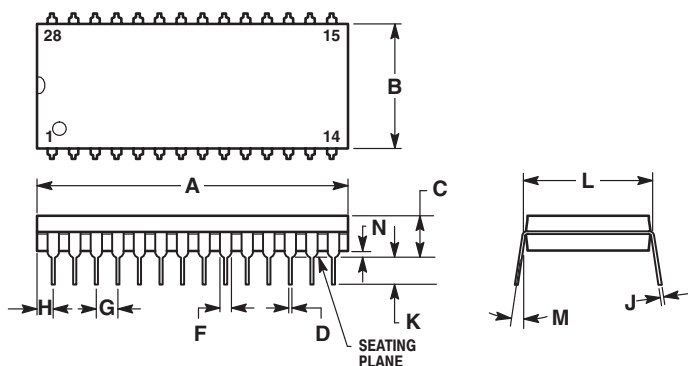
shifting from the PC to the MC3PHAC's serial port. An RS-232 line receiver, such as an MC1489, serves the same purpose without the optoisolation function.

To send data from the MC3PHAC to the PC's serial port input, it is necessary to satisfy the PC's receive data (RxD) input requirements. In an idle condition, the RxD input to the PC must be at Mark (-3 to -25 volts). The data terminal ready output (DTR) on the PC outputs a Mark when the port is initialized. The request to send (RTS) output is set to a Space (+3 to +25 volts) when the PC's serial port is initialized. Because the interface is half-duplex, the PC's TxD output is also at a Mark, as it is idle. The idle state of the MC3PHAC's serial port output is a logic 1. The logic 1 out of the MC3PHAC's serial port output port forces the diode in U2 to be turned off. With the diode in U2 turned off, the transistor in U2 is also turned off. The junction of D2 and D3 are at a Mark (-3 to -25 volts). With the transistor in U2 turned off, the input is pulled to a Mark through current limiting resistor R3, satisfying the PC's serial input in an idle condition. When a start bit is sent from the MC3PHAC's serial port, it transitions to a logic 0. That logic 0 turns on the diode in U2, thus turning on the transistor in U2. The conducting transistor in U2 passes the voltage output from the PC's RTS output, that is now at a Space (+3 to +25 volts), to the PC's receive data (RxD) input. Capacitor C1 is a bypass capacitor used to stiffen the Mark signal. The output half of the circuit provides output isolation, signal inversion, and level shifting from the MC3PHAC's serial output port to the PC's serial port. An RS-232 line driver, such as a MC1488, serves the same purpose without the optoisolation function.

## Mechanical Data

This subsection provides case outline drawings for:

- Plastic 28-pin DIP, [Figure 20](#)
- Plastic 28-pin SOIC, [Figure 21](#)
- Plastic 32-pin QFP, [Figure 22](#)

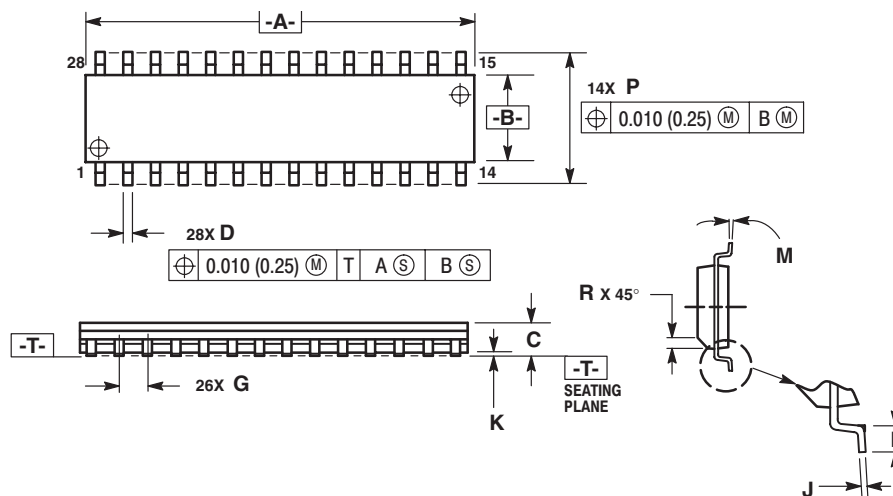


NOTES:

1. POSITIONAL TOLERANCE OF LEADS (D), SHALL BE WITHIN 0.25mm (0.010) AT MAXIMUM MATERIAL CONDITION, IN RELATION TO SEATING PLANE AND EACH OTHER.
2. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION B DOES NOT INCLUDE MOLD FLASH.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	36.45	37.21	1.435	1.465
B	13.72	14.22	0.540	0.560
C	3.94	5.08	0.155	0.200
D	0.36	0.56	0.014	0.022
F	1.02	1.52	0.040	0.060
G	2.54 BSC		0.100 BSC	
H	1.65	2.16	0.065	0.085
J	0.20	0.38	0.008	0.015
K	2.92	3.43	0.115	0.135
L	15.24 BSC		0.600 BSC	
M	0°	15°	0°	15°
N	0.51	1.02	0.020	0.040

Figure 20. Plastic 28-Pin DIP (Case 710)



NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION 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.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	17.80	18.05	0.701	0.711
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.41	0.90	0.016	0.035
G	1.27 BSC		0.050 BSC	
J	0.23	0.32	0.009	0.013
K	0.13	0.29	0.005	0.011
M	0°	8°	0°	8°
P	10.05	10.55	0.395	0.415
R	0.25	0.75	0.010	0.029

Figure 21. Plastic 28-Pin SOIC (Case 751F)

Mechanical Data

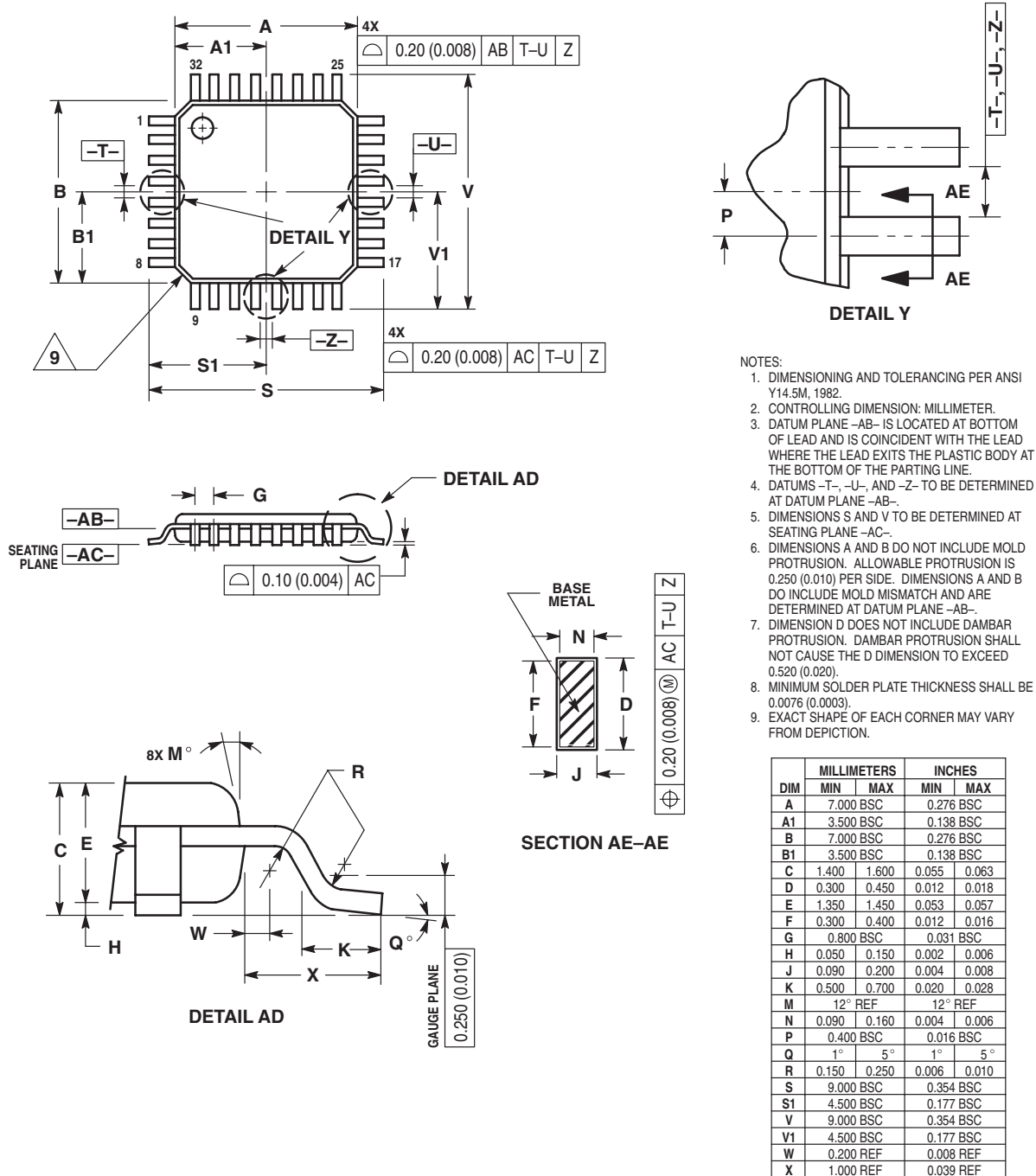


Figure 22. Plastic 32-Pin QFP (Case 873A)



## **How to Reach Us:**

### **USA/Europe/Locations not listed:**

Freescale Semiconductor Literature Distribution  
P.O. Box 5405, Denver, Colorado 80217  
1-800-521-6274 or 480-768-2130

### **Japan:**

Freescale Semiconductor Japan Ltd.  
SPS, Technical Information Center  
3-20-1, Minami-Azabu  
Minato-ku  
Tokyo 106-8573, Japan  
81-3-3440-3569

### **Asia/Pacific:**

Freescale Semiconductor H.K. Ltd.  
2 Dai King Street  
Tai Po Industrial Estate  
Tai Po, N.T. Hong Kong  
852-26668334

### **Learn More:**

For more information about Freescale Semiconductor products, please visit <http://www.freescale.com>

Information in this document is provided solely to enable system and software implementers to use Freescale Semiconductor products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits or integrated circuits based on the information in this document.

Freescale Semiconductor reserves the right to make changes without further notice to any products herein. Freescale Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters which may be provided in Freescale Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. Freescale Semiconductor does not convey any license under its patent rights nor the rights of others. Freescale Semiconductor products are not designed, intended, or authorized for use as components in systems intended for surgical implant into the body, or other applications intended to support or sustain life, or for any other application in which the failure of the Freescale Semiconductor product could create a situation where personal injury or death may occur. Should Buyer purchase or use Freescale Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold Freescale Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that Freescale Semiconductor was negligent regarding the design or manufacture of the part.

Freescale™ and the Freescale logo are trademarks of Freescale Semiconductor, Inc. All other product or service names are the property of their respective owners.  
© Freescale Semiconductor, Inc. 2004.

RoHS-compliant and/or Pb- free versions of Freescale products have the functionality and electrical characteristics of their non-RoHS-compliant and/or non-Pb- free counterparts. For further information, see <http://www.freescale.com> or contact your Freescale sales representative.

For information on Freescale's Environmental Products program, go to <http://www.freescale.com/epp>.