PIC16C54-TO-Z86E02 UPGRADE

THE Z86E02 OFFERS MANY ADVANCED FEATURES COMPARED TO ITS PIC COUNTERPART, AND A PIC16C54-TO-Z86E02 UPGRADE CAN BE DONE—WITHOUT A NEW BOARD LAYOUT! HERE ARE THE "HOW-TO'S" AND ELECTRICAL CHARACTERISTIC CONSIDERATIONS.

INTRODUCTION

Customers frequently want to upgrade from a Microchip PIC16C54 microcontroller to a Zilog Z86E02 microcontroller for their application. The reasons for the switch to the Z86E02 include:

- Superior Architectural Features
- Richer Peripheral Set
- More Attractive Price Structure

The PIC16C54-to-Z86E02 upgrade can be accomplished—*without a new board layout*. Although this application note deals specifically with the "how to's" of upgrading from PIC16C54 to Z86E02, our discussion here is not limited to upgrading from PIC16C54 to Z86E02 alone. This application note also applies to upgrading all of Microchip's OTP PIC16C54/56/58 and mask ROM PIC16CR54/58 devices in the 18-pin DIP and SOIC packages to Zilog's Z86X02/04/08 (where X = E, C, or L) microcontrollers in the 18-pin DIP and SOIC packages. The Z86E02/04/08 are OTP versions of the mask ROM Z86C02/04/08 and low-voltage mask ROM Z86L02/04/08 microcontrollers. The final portion of this application note discusses the electrical characteristic considerations in converting PIC OTP and mask ROM devices to Z8 OTP, mask ROM, and low-voltage mask ROM microcontrollers.

MAPPING PIC16C54 PINS TO Z86E02 PINS

The PIC16C54-to-Z86E02 upgrade begins by mapping all of the E02 pins to the PIC. Table 1 shows a pin-for-pin functional best-fit correspondence between the PIC16C54 and the Z86E02.

Table 1. PIC16C54-to-Z86E02 Functional Best-Fit Pin Correspondence

PIC16C54 Pin	Z86E02 Pin	Description
V_{DD}	V_{CC}	Power supply
V_{SS}	GND	Ground reference
OSC1	XTAL1	Crystal oscillator/external clock input
OSC2	XTAL2	Crystal oscillator output
RB0–RB7	P20–P27	Bit-selectable, bi-directional I/Os
RA0–RA1	P00–P01	PIC: Bit-selectable, bi-directional I/Os Z8: Nibble-selectable, bi-directional I/Os
RA2–RA3	P32–P33	PIC: Bit-selectable, bi-directional I/Os Z8: Dedicated input I/Os
T0CKI	P31 (T_{in})	PIC: WDT/Timer0 clock input Z8: Timer/Counter input or dedicated input I/O
/MCLR	P02	PIC: Master clear/reset Z8: E02 has built-in Power On Reset (POR) circuit; hence, an external reset pin is not required. P02 is a nibble-select, bi-directional I/O pin.

Figure 1 shows pictorially how the Z86E02 pins maps to the PIC16C54 pinout per Table 1.

E86E02 Pin Mapping	PIC16C54	Pin	Pin	PIC16C54	Z86E02 Pin Mapping
P32 (Pin 9, Input)	RA2	1	18	RA1	P01 (Pin 12, I/O)
P33 (Pin 10, Input)	RA3	2	17	RAØ	P00 (Pin 11, I/O)
Pin 31 (Pin 8, Input)	TØCKI	3	16	OSC1	XTAL1 (Pin 7)
P02 (Pin 13, I/O)	/MCLR	4	15	OSC2	XTAL2 (Pin 6)
GND (Pin 14)	V_{SS}	5	14	V_{DD}	V_{CC} (Pin 5)
Pin 20 (Pin 15, I/O)	RBØ	6	13	RB7	P27 (Pin 4, I/O)
Pin 21 (Pin 16, I/O)	RB1	7	12	RB6	P26 (Pin 3, I/O)
Pin 22 (Pin 17, I/O)	RB2	8	11	RB5	P25 (Pin 2, I/O)
Pin 23 (Pin 18, I/O)	RB3	9	10	RB4	P24 (Pin 1, I/O)

Figure 1. PIC16C54 to Z86E02 Pin Mapping per Table 1

Table 1 demonstrates a direct one-to-one correspondence for PIC16C54 functions V_{DD}, V_{SS}, OSC1, OSC2, RB0-RB7, and T0CK1 to Z86E02 signals V_{CC}, GND, XTAL1, XTAL2, P20-P27, and P31 (T_{in}) respectively. However, an exact functional correspondence for PIC16C54 signals /MCLR and RA0-RA3 does not exist.

As for mapping the PIC /MCLR reset pin to the Z86E02, the E02 has built-in POR circuitry, which obviates the need for an external reset pin on the E02. Thus, the E02 has no corresponding /MCLR pin. When converting from a PIC design, however, you may want to retain the use of an external reset signal. In that case, the E02's P02 may be programmed as an input and periodically polled for a Low state, which indicates a reset condition. When an external reset is detected, the E02 can branch to location 000CH, the program start location, and execute its initialization code as if a POR has occurred.

As for mapping the four PIC RA0-RA3 I/O pins to the Z86E02, you should first attempt to map them to the E02's P00, P01, P32, and P33 I/O pins. P32 and P33 are dedicated input pins and should be mapped to two RA0-RA3 pins that were configured as input I/Os when possible. P00 and P01 are nibble-selectable I/Os, which in conjunction with P02, must be all configured as input or output pins. P00-P02 are not individually configurable as inputs or outputs. Depending on the need, P00 and P01 will be configured as both outputs or both inputs.

If by necessity P00 and P01 are configured as outputs, then P02 has also become an output. Therefore, P02 cannot be used as a polled input for the /MCLR function as previously discussed. In this case, P02 can be used elsewhere as an output I/O and another input I/O can be used for /MCLR. Under less ideal conditions, more trade-offs may be necessary, which include swapping with some of the E02's P20-P27 I/O pins to satisfy the input and output I/O requirement for this conversion.

UPGRADING WITHOUT ADDITIONAL LAYOUT

Under ideal conditions, upgrading to an E02 from a PIC16C54 can be performed without requiring a new board layout. In the case that the application does not require the counter for external event counting and RA0-RA3 of the PIC were used as inputs, the conversion is done by simply rotating the Z86E02 by 180° to fit into a PIC16C54 socket. See Table 2 for the PIC16C54-to-Z86E02 pin correspondence for this ideal fit.

Table 2. PIC16C54 to Z86E02 Ideal Mapping

PIC16C54 Pin	Z86E02 Pin	Description
V_{DD}	V_{CC}	Power supply
V_{SS}	GND	Ground reference
OSC1	XTAL1	Crystal oscillator/external clock input
OSC2	XTAL2	Crystal oscillator output
RB0 - RB7	P20 - P27	Bit-selectable, bi-directional I/Os
RA0 - RA2	P31 - P33	PIC: Bit-selectable, bi-directional I/Os configured as inputs Z8: Dedicated input I/Os
RA3	P00	PIC: Bit-selectable, bi-directional I/O configured as an input Z8: Nibble-selectable, bi-directional I/O configured as an input
T0CKI	P01	PIC: WDT/Timer0 clock input (not used) Z8: Nibble-selectable, bi-directional I/O configured as an input
/MCLR	P02	PIC: Master clear/reset Z8: Nibble-selectable, bi-directional I/O configured as an input

Figure 2 shows pictorially how the Z86E02 pins map to the PIC16C54 pinout under the ideal situation per Table 2. You can see that the E02 can indeed be rotated upside-down 180° to fit in the PIC16C54 DIP or SOIC socket.

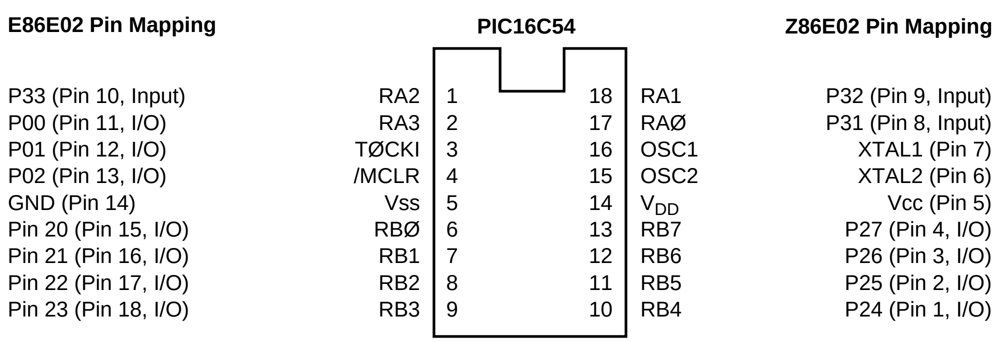

Figure 2. PIC16C54 to Z86E02 Ideal Pin Mapping per Table 2

ELECTRICAL CHARACTERISTIC CONSIDERATIONS

When migrating to the Z86E02 from PIC16C54, you must carefully consider some electrical characteristic differences between the devices. One consideration is the difference in the operational supply voltage ranges of the two devices. The second consideration is the difference in the buffer type of the two devices.

Operational Voltage Range Differences

The PIC family of devices and Z8 family of devices have very different supply voltage operation ranges. These differences are important design considerations in upgrading to the Z8 from PIC, especially in hand-held type of applications where batteries are used. See Table 3 for a listing of Microchip's PIC16C54 types of devices and their supply voltage (V_{DD}) ranges. The PIC16C54 and the low-voltage PIC16LC54 with all their varying oscillator types are OTP microcontrollers, while the PIC16CR54s are mask ROM devices. Microchip's PIC supply voltage ranges vary both by device type and oscillator option.

Table 3. PIC16C54 Devices Supply Voltage Ranges

OSC. Option	PIC16C54 V_{DD} Range	PIC16LC5 V_{DD} Range	PIC16CR54 V_{DD} Range
RC	3.0V–6.25V	2.5V–6.25V	2.0V–6.25V
LP	3.0V–6.25V	2.5V–6.25V	2.0V–6.25V
XT	3.0V–6.25V	2.5V–6.25V	2.0V–6.25V
HS	4.5V–5.5V	N/A	4.5V–5.5V

Contrast and compare Table 3 with Table 4 where the Z86E02 OTP, mask ROM Z86C02, and low-voltage mask ROM Z86L02 supply voltage (V_{CC}) ranges are tabulated.

Table 4. Z86E02/C02/L02 Supply Voltage Ranges

Z86E02 V_{CC} Range	Z86C02 V_{CC} Range	Z86L02 V_{CC} Range
4.5V–5.5V	3.0V–5.5V	2.0V–3.9V

The designer must ensure that the target Z8 device of the PIC-to-Z8 conversion has an acceptable operating voltage range for the application. (For the sake of preserving each manufacturer's nomenclature, we will continue to use V_{DD} to refer to the operational supply voltage range for a PIC device and V_{CC} to refer to the operational supply voltage range for a Z8 device.)

Buffer Type Differences

Another difference between PIC and Z8 microcontrollers is the difference in buffer types. The PIC has a TTL buffer type, while the Z8 has a CMOS buffer type. If a Z86E02 were to replace a PIC16C54, the buffer type of the surrounding logic may have to be changed to compatible CMOS logic from TTL logic.

Examine, compare, and contrast some of the electrical characteristics to see why it may be necessary to change the buffer types of the surrounding logic. See Table 5, which lists the Input Low-Voltage Maximum (V_{IL} Max) and Input High-Voltage Minimum (V_{IH} Min) for the PIC16C54 device types and Z86X02 device types. In the case of the PIC devices, the electrical characteristic values for the I/O ports are used, whereas, the Z8 electrical characteristic values apply to any and all input pins.

Table 5. PIC versus Z8 Input Voltage Requirements

PIC Device	V_{IL} Max	V_{IH} Min	Z8 Device	V_{IL} Max	V_{IH} Min
PIC16C54	0.2 V_{CC}	0.45 V_{CC}	Z86E02	0.2 V_{CC}	0.7 V_{CC}
PIC16LC54	0.2 V_{CC}	0.45 V_{CC}	Z86C02	0.2 V_{CC}	0.7 V_{CC}
PIC16CR54	0.2 V_{CC}	0.45 V_{CC}	Z86L02	0.1 V_{CC}	0.9 V_{CC}

It appears that the V_{IL} Max values for both Z8 and PIC are the same except for the Z86L02. The main difference between PIC and Z8 is the V_{IH} Min value. The nominal difference is 25 percent of V_{CC} and in the extreme case of the Z86L02 versus PIC, it is 45 percent of V_{CC}. The minimum input voltage level required for a logic "1" High is much greater with the Zilog Z86X02s. Next, examine, compare, and contrast the Output Low-Voltage Maximum (V_{OL} Max) and the Output High-Voltage Minimum (V_{OH} Min) for PIC and Z8 (see Table 6). As before, the electrical characteristic values for the PIC I/O ports are used, whereas, the Z8 electrical characteristic values apply to any and all output pins.

Table 6. PIC versus Z8 Output Voltage Requirements.

PIC Device	V_{OL} Max	V_{OH} Min	Z8 Device	V_{OL} Max	V_{OH} Min
PIC16C54	0.6V @ 4.5V V_{DD}	V_{DD}–0.7V	Z86E02	0.4V @ 4.5V V_{CC}	V_{CC}–0.4V
PIC16LC54	0.6V @ 4.5V V_{DD}	V_{DD}–0.7V	Z86C02	0.4V @ 5.5V V_{CC}	V_{CC}–0.4V
PIC16CR54	0.5V @ 6.0VV_{DD}	V_{DD}–0.5V	Z86L02	0.4V @ 3.9V V_{CC}	V_{CC}–0.4V

In Table 6, the Z8 V_{OH} values are 0.1V to 0.3V higher than PIC V_{OH} values due to the Z8's CMOS output buffers. Also note that the Z8 V_{OL} values are approximately 0.1V to 0.2V lower than PIC V_{OL} values.

In general, the required Z8 input voltages and output voltages will be "closer" to its positive supply voltage and negative supply/ground voltage than PIC microcontrollers due its CMOS buffers. The required PIC input voltages and output voltages are "farther away" from its positive supply voltage and negative supply/ground voltage than a Z8 microcontroller due to its TTL buffers. Again, if a Z86E02 were to replace a PIC16C54, the buffer type of the surrounding logic may have to be changed to compatible CMOS logic from previous TTL-type logic. In some cases, choice placement of pull-up resistors maybe all that is required, while in other cases the type of logic surrounding the microcontroller will have to be completely changed.

SUMMARY

If you choose to upgrade from a PIC16C54 to a Z86E02, first carefully map PIC16C54 pins to Z86E02 pins. Under the right circumstances, the Z86E02 could be rotated 180° relative to the PIC16C54 chip orientation and placed right into the PIC socket. Accomplishing the 180° rotation will mean that a new board layout will not be required to upgrade. You should also consider the two main electrical characteristic differences:

- Operational Supply Voltage V_{DD}/V_{CC} Ranges
- TTL/CMOS Buffer Types

Understanding the difference in operational voltage ranges will help you pick the best Z86X02 target device for the application. Understanding the difference in buffer type between a PIC and a Z8 will ensure that the application will function electrically after the upgrade is performed.