TB027

Simplifying External Memory Connections of PIC17CXXX PICmicro® Microcontrollers

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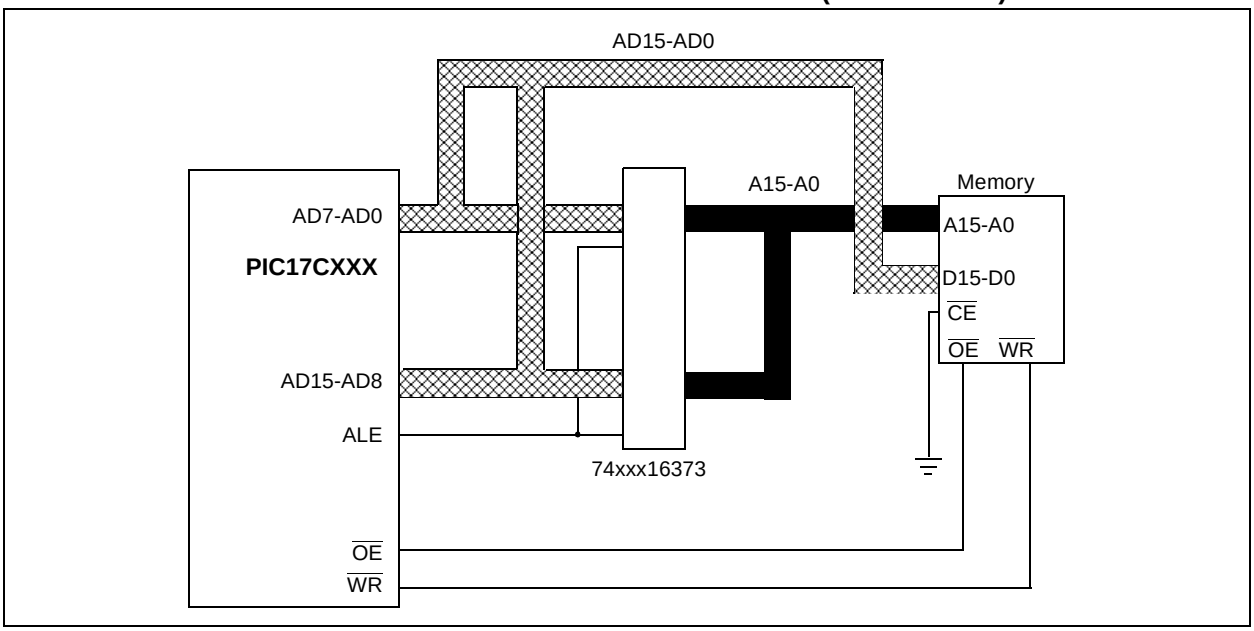
INTRODUCTION

The PIC17CXXX family of PICmicro® microcontrollers has an external program memory interface. Since the PIC17CXXX devices implement a 16-bit instruction word, the external memory must be 16-bits wide. The addressing space of these devices is 64K x 16, which requires 16-bits of address as well. Until a few years ago, the designer had to use two 8-bit latches for addressing and two 8-bit wide memories. Now, many manufacturers of logic and memory devices have developed 16-bit wide devices. These new 16-bit wide devices can simplify the layout, reduce part count and cost as shown in Figure 1.

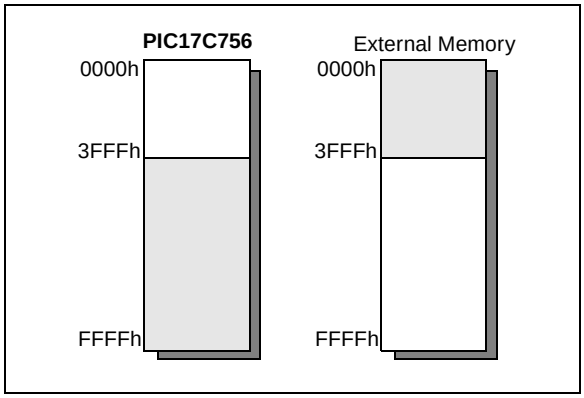
FIGURE 1: EXTERNAL MEMORY INTERFACE BLOCK DIAGRAM (x16 DEVICES)



IMPLEMENTATION

Although EPROM and static RAM devices are compatible with PICmicro microcontrollers, FLASH memory was chosen to implement a reprogrammable system. Due to the operational characteristics of FLASH memory, the PIC17CXXX device must be configured in extended microcontroller mode to implement an external reprogrammable system. In this mode, the internal memory of the PICmicro microcontroller is operational, and the remainder of the 64K memory is external to the device (see Figure 2). The bootloader routine is located in the on-chip memory. This routine reads data from the outside world and programs it into the FLASH memory. The PIC17CXXX has many interfaces, which could be used for downloading new code into the external memory including: USART, SPI, or I^2C™. Since the PIC17CXXX has two USARTs, one could be used to communicate with other devices in the system and the second USART could be used for downloading new code into the FLASH.

FIGURE 2: PIC17C756 IN EXTENDED MICROCONTROLLER MODE



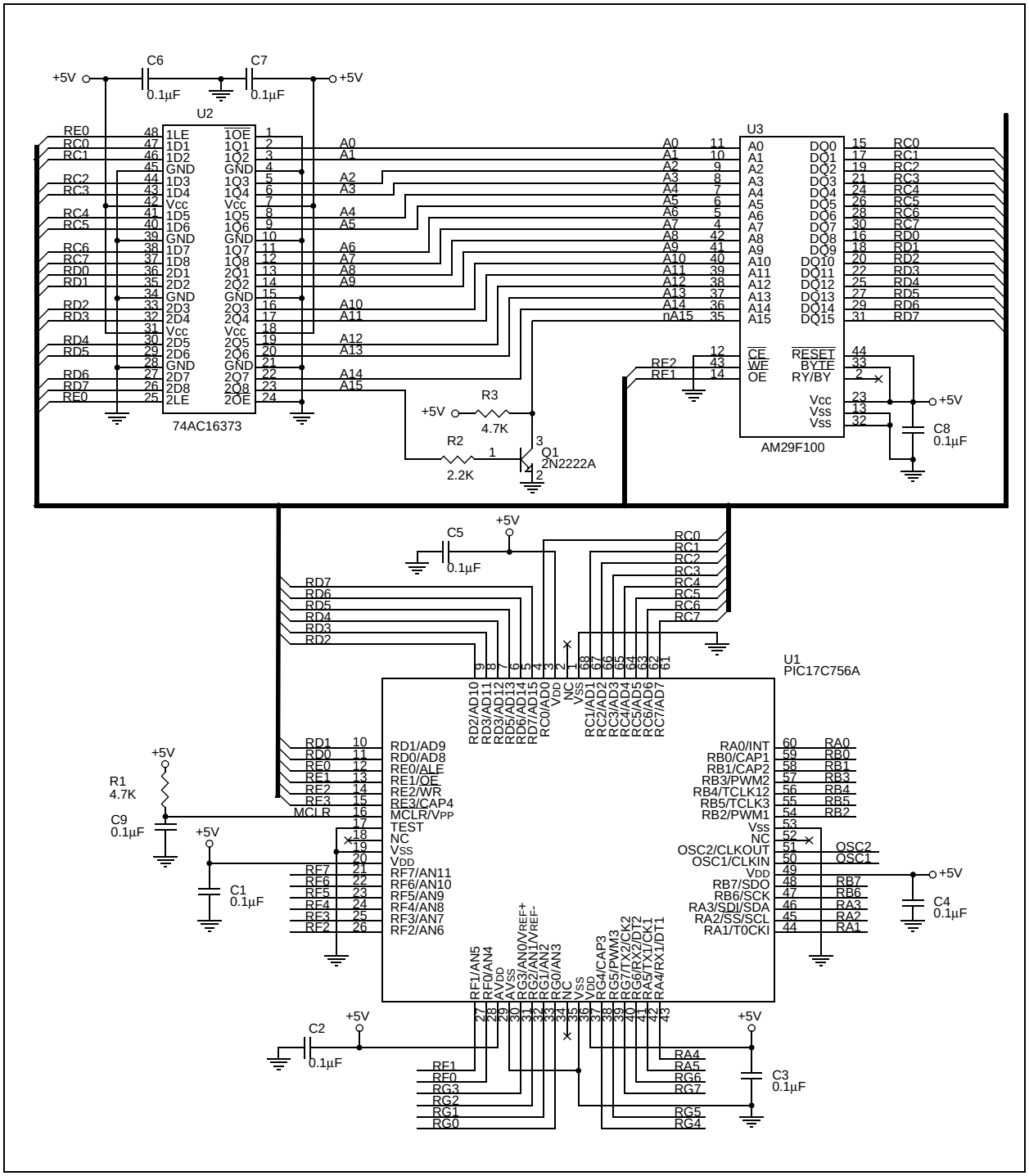
LOGIC DEVICES

In recent years, many manufacturers have developed x16 versions of the more popular 74xxx devices. These new devices use the following naming convention:

74xxx16yyy

where xxx defines the technology (HC,AC,FCT, etc.) and yyy defines the part number (244, 373, etc.). For the purposes of this design, the 74xxx16373 will be used. The technology depends on the operating frequency of the microcontroller. Appendix A lists some of the manufacturers of the x16 logic devices. All these devices have the same pinout which includes 16 inputs, 16 outputs, two latch enable (LE) pins and two output enable (OE) pins. Each set of LE/OE controls 8-bits of input/output. As shown in Figure 3, both LE pins are tied to the RE0/ALE pin of the microcontroller and the OE pins are tied to ground. These devices can be found in various packages types (DIP through TSSOP).

FIGURE 3: SCHEMATIC USING x16 DEVICES



MEMORY DEVICES

Almost all manufacturers of memory make a x16 device. Currently, the smallest x16 FLASH memories are the 1 Megabit (64K x 16) devices from AMD or Catalyst. Memory selection should address the required program voltage requirements because some manufacturers have single supply devices and others have multiple supply devices. Appendix A lists some of the manufacturers of x16 FLASH memory devices. Some of the basic features of any FLASH memory are:

- Power supply options
  - Single power supply for read, erase and program operations (desirable for 5V only systems)
  - or Dual power supply, one for read an another for program/erase operations
- Access time
- Software method of detecting end of program cycle
- Full chip erase capability
- Hardware and software data protection

The devices from AMD provide many superior features over other manufacturers of FLASH memory including:

- x8 or x16 configurable
- Low power consumption:
  - 28 mA typical active read current
  - 30 mA typical program/erase current
  - 25 μA typical standby current
- Any combination of sectors can be erased
- Embedded algorithms that automatically pre-programs and erases sectors or programs and verifies data at a specified address
- Minimum 100,000 program/erase cycles
- JEDEC compatible pinout and software commands
- Hardware pin for detecting end of program/erase cycles
- Software commands that suspend or resume an erase cycle to read data out of other sectors
- Hardware reset pin

Figure 3 shows the schematic of the PIC17C756A with the AM29F100 FLASH memory from AMD. The first thing to notice is that the address line, A15, is inverted before going to the FLASH. The reason is that commands must be issued to the lower half of the FLASH to program or erase. The commands for both program and erase are shown below.

Program

1. Send AAAAh to address 5555h
2. Send 5555h to address 2AAAh
3. Send 8080h to address 5555h
4. Send 16-bits of data to desired address

Chip Erase

1. Send AAAAh to address 5555h
2. Send 5555h to address 2AAAh
3. Send 8080h to address 5555h
4. Send AAAAh to address 5555h
5. Send 5555h to address 2AAAh
6. Send 1010h to address 5555h

Sector Erase

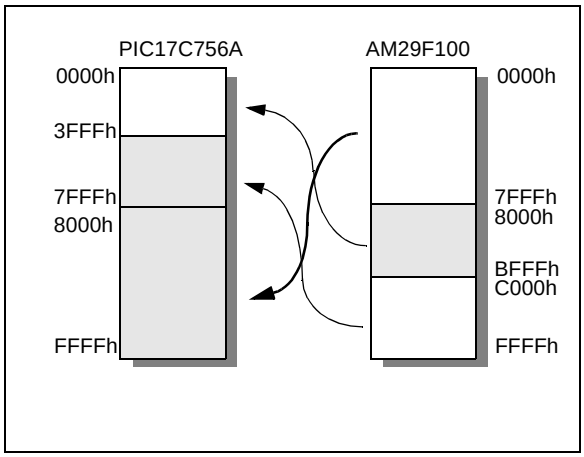
1. Send AAAAh to address 5555h
2. Send 5555h to address 2AAAh
3. Send 8080h to address 5555h
4. Send AAAAh to address 5555h
5. Send 5555h to address 2AAAh
6. Send 3030h to desired sector address

As shown in Figure 2, the on-chip memory of the PICmicro microcontroller is located in the first part of program memory, and in some devices, this on-chip program memory overlaps the address 2AAAh in the FLASH. The length of this memory depends on the device:

- PIC17C42A from 0000h to 07FFh,
- PIC17C43 from 0000h to 0FFFh,
- PIC17C44 from 0000h to 1FFFh,
- PIC17C752 from 0000h to 1FFFh,
- PIC17C756A from 0000h to 3FFFh,
- PIC17C762 from 0000h to 1FFFh, and
- PIC17C766 from 0000h to 3FFFh

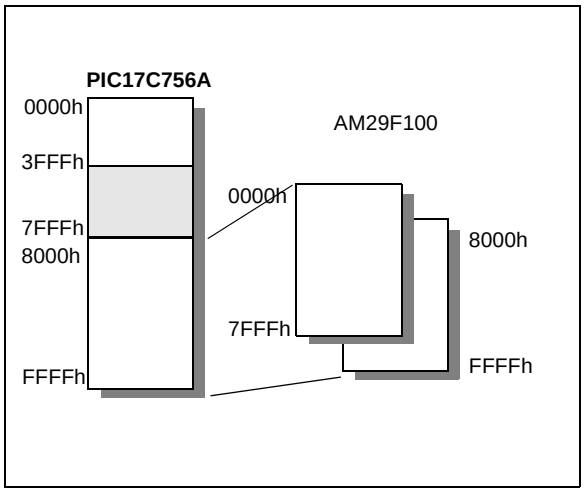
The first three devices do not require the inverter circuit, but the PIC17C756A does. When the bootloader program tries to send any data to address 2AAAh, the core thinks it is writing to the internal memory address because it is less than 3FFFh. The address/data lines from the PICmicro microcontroller assert the correct address/data, but the control lines do not allow the FLASH memory to be enabled for reading or writing. Therefore, by inverting A15, address 2AAAh of the FLASH can be accessed at location AAAAh in the program memory of the PIC17C756A. Address 5555h can be accessed at location D555h. The PIC17C756A is now able to send program and erase commands to the FLASH. The program memory address locations 4000h to 7FFFh are now located in the FLASH at locations C000h to FFFFh (See Figure 4).

FIGURE 4: OVERLAP OF FLASH



The previous method leaves part of the external FLASH unused, which can amount to 25% of program memory depending on the PICmicro microcontroller used. There is another method which completely uses all of the FLASH, but requires additional firmware support. The inverter circuit shown in Figure 3 is connected to the CE pin of the FLASH and A15 of the FLASH is connected to an I/O pin of the PICmicro microcontroller. In this case, external program memory becomes “banked”. Only addresses from 8000h to FFFFh can be used and the I/O pin controls which bank is selected (See Figure 5). The designer must now have some previous knowledge about the locations of routines in external memory. A table must be created to define the location of each routine in external memory by bank (0 or 1) and address (8000h to FFFFh). This table is located in the on-chip program memory of the PICmicro microcontroller and cannot be changed. The designer must be careful when constructing this table to take into account the growth routines of old routines and addition of new routines for bug fixes or enhancements. In most cases, the C compiler cannot correctly execute code from both banks of FLASH. One bank would be for data and the other for code.

FIGURE 5: BANKING OF FLASH



CONCLUSION

By using the new x16 logic and memory devices, a designer can lower part count, cut cost, reduce board size and simplify layout. Since most manufacturers use the standard JEDEC footprint for their devices, single source supply concerns can be eliminated.

APPENDIX A

The following list of manufacturers is provided for reference only and is not meant to be a complete listing of all companies producing x16 logic and memory products.

x16 Logic Manufacturers

- National Semiconductor www.national.com
- IDT www.idt.com
- Quality Semiconductor www.qualitysemi.com
- Pericom Semiconductor www.pericom.com
- Texas Instruments www.ti.com

x16 FLASH Manufacturers

- AMD www.amd.com
- Catalyst www.catsemi.com
- Hyundai www.hea.com
- Intel www.intel.com
- ISSI www.issiusa.com
- Micron Technology www.micron.com/flash
- Texas Instruments www.ti.com

NOTES:

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