Micromega Corporation

Using the uM-FPU64 DEVIO Instruction

Release 407

Introduction

The `DEVIO` instruction provides support for local peripheral devices connected to the uM-FPU64. The devices include: RAM, FIFO buffers, 1-wire bus, I²C bus, SPI bus, asynchronous serial connection (with hardware flow control), counters (with debounce and auto repeat), servo controllers, LCD display and VDrive2 USB storage. Local peripheral devices are connected to the uM-FPU64 using the digital I/O pins, which are assigned at run-time. This allows the user to configure the hardware connections as required.

The uM-FPU64 IDE has pre-defined symbols for all of the `DEVIO` actions and modifiers. They are supported by both the compiler and assembler. Detailed descriptions of the `DEVIO` instructions, including the IDE symbols that are supported, can be found in the *uM-FPU64 Instruction Set* document. This document adds some additional information and shows examples of using the `DEVIO` instructions.

Pin Assignment

Local devices are connected to the uM-FPU64 using the digital I/O pins. Pins D0-D8 (on the 28-pin chip) and D0-D18 (on the 44-pin device) can be used with any `DEVIO` device, while pins D19-D22 (on the 44-pin chip) can only be assigned to certain devices. If a device requires more than one pin, the pins are assigned sequentially. The pin assignments are described in the *uM-FPU64 Instruction Set* document. The uM-FPU64 operates at 3.3V, but some digital I/O pins are 5V tolerant, which facilitates connecting to 5V peripheral devices. See the *uM-FPU64 Datasheet* for a list of the 5V tolerant pins. If required, the digital I/O pins can also be configured as open-drain outputs.

The 28-pin and 44-pin uM-FPU64 chips have the same functionality, but the 44-pin chip provides additional pins for digital I/O and analog input.

Device Initialization

All devices must be initialized before use to assign the digital I/O pins and configure the device. This is done with the `ENABLE` action.

```
DEVIO, device, ENABLE, pin, config
```

The *pin* specifies the first digital I/O pin used by the device. If additional pins are required, they are assigned sequentially. The *config* byte specifies device specific configuration options. Details regarding the *config* byte can be found in the individual device descriptions.

Common Actions Supported by all Devices

The following actions are supported by all devices. See the description of the DEVIO instruction in the *uM-FPU64 Instruction Set* document for more details.

```
DEVIO, device, WRITE_REG8{+MSB}{+LSB}, register
DEVIO, device, WRITE_REG16{+MSB}{+LSB}, register
DEVIO, device, WRITE_REG32{+MSB}+LSB}, register
DEVIO, device, WRITE_REG64{+MSB}{+LSB}, register
DEVIO, device, WRITE_BYTE, byte
DEVIO, device, WRITE_WORD, byte, byte
DEVIO, device, WRITE_NBYTE, count, byte...byte
DEVIO, device, WRITE_REP, count, byte
DEVIO, device, WRITE_STR, string
DEVIO, device, WRITE_SBUF
DEVIO, device, WRITE_SSEL
DEVIO, device, WRITE_MEM, count
DEVIO, device, WRITE_MEMA, address, count
DEVIO, device, WRITE_MEMR, regAddr, regCount

DEVIO, device, READ_REG8{+MSB}{+LSB}{+ZE}{+SE}, register
DEVIO, device, READ_REG16{+MSB}{+LSB}{+ZE}{+SE}, register
DEVIO, device, READ_REG32{+MSB}{+LSB}{+ZE}{+SE}, register
DEVIO, device, READ_REG64{+MSB}{+LSB}{+ZE}{+SE}, register
DEVIO, device, READ_SKIP, count
DEVIO, device, READ_SBUF
DEVIO, device, READ_SSEL
DEVIO, device, READ_MEM, count
DEVIO, device, READ_MEMA, address, count
DEVIO, device, READ_MEMR, regAddr, regCount
```

Using Local Memory

The DEVIO,MEM instruction is used to configure the 2304 bytes of RAM memory that is available to the user, and to allow the use of DEVIO common for memory access. Memory can also be accessed by other FPU instructions using indirect pointers, these include: ADDIND, WRIND, RDIND, COPYIND, LOADIND, SAVEIND, and SETIND.

By default, the memory as allocated as follows:

General Foreground	1024 bytes
General Background	1024 bytes
FIFO1	64 bytes
FIFO2	64 bytes
FIFO3	64 bytes
FIFO4	64 bytes

The allocation can be changed with the DEVIO,MEM,ALLOCATE action described below.

Device Initialization

There is no initialization required for the memory device.

Device Specific Actions

DEVIO, MEM, ALLOCATE, *memSize, fifoSize*

The ALLOCATE action is used to change the memory allocation.

Sample Code

```
DEVIO, MEM, ALLOCATE, 0x99, 0x9900      ; set FG, BG, FIFO1, FIFO2 to 512 bytes
                                        ; set FIFO3, FIFO4 to 0 bytes
                                        ; extra 512 bytes allocated to FG

DEVIO, MEM, ALLOCATE, 0xFF, 0xFFFF      ; restore allocation to default setting
```

Using FIFO Buffers

Device Initialization

```
DEVIO, FIFO1, ENABLE, pin, config
DEVIO, FIFO2, ENABLE, pin, config
DEVIO, FIFO3, ENABLE, pin, config
DEVIO, FIFO4, ENABLE, pin, config
```

The *pin* number is ignored. The *config* byte is used to specify an event flag that can associated with the FIFO.

Device Specific Actions

```
DEVIO, FIFOn, CLEAR
DEVIO, FIFOn, USED
DEVIO, FIFOn, FREE
DEVIO, FIFOn, STATUS
DEVIO, FIFOn, CLEAR_OVERFLOW
```

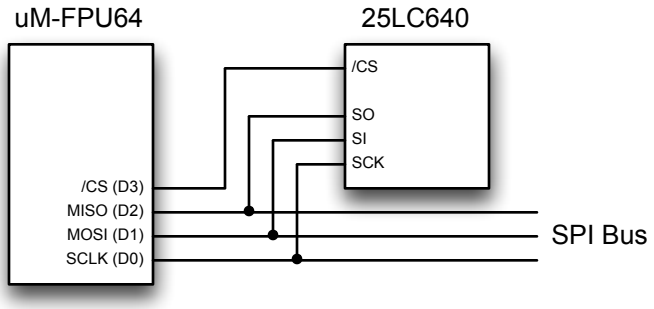
The device specific actions are used to clear the FIFO, get information about the FIFO, and to clear any overflow condition.

Sample Code

```
DEVIO, FIFO1, ENABLE, 0, 0              ; enable FIFO1

DEVIO, FIFO1, WRITE_REG32, 1            ; write register 1 value to FIFO
DEVIO, FIFO1, WRITE_REG32, 2            ; write register 2 value to FIFO

; some other process

DEVIO, FIFO1, READ_REG32, 1             ; read FIFO value to register 1
DEVIO, FIFO1, READ_REG32, 2             ; read FIFO value from register 2
```

Using the SPI Local Bus

The DEVIO,SPI instruction is used to communicate with SPI devices connected directly to the FPU. The pins used for the SPI bus are selected when the device is initialized with the ENABLE action. Device 0 is used to define the bus connections for SCLK, MOSI, and MISO that are common to all SPI devices, and devices 1 to 15 are used to specify the chip select pin (/CS) for a particular device. A maximum of 15 devices can be connected to the local bus. Each device requires a separate chip select (/CS) signal. If only one SPI device is used, the chip select pin on the device can be grounded and DEVIO,SPI+0 can be used to communicate with the device. The following diagram shows a typical connection.



Device Initialization

```
DEVIO, SPI+n, ENABLE, pin, config
```

If device 0, the *pin* number specifies the digital I/O pins used for SCLK, MOSI, and MISO. For all other devices, the *pin* number specifies the chip select (/CS) pin for that device. The *config* byte is used to specify the transfer type and speed of the SPI transaction.

Device Specific Actions

```
DEVIO, SPI+n, CS_LOW
DEVIO, SPI+n, CS_HIGH
```

The device specific actions are used to select and deselect an individual SPI device.

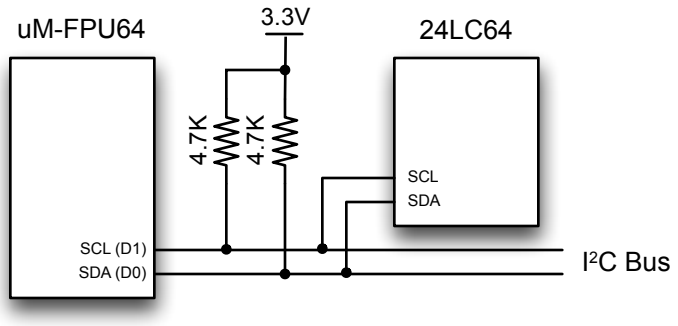
Sample Code

```
DEV_25LC640_WRSR    con    1                    ; 25LC640 64K EEPROM commands
DEV_25LC640_WRITE   con    2
DEV_25LC640_READ    con    3
DEV_25LC640_WRDI    con    4
DEV_25LC640_RDSR    con    5
DEV_25LC640_WREN    con    6

      DEVIO, SPI+0, ENABLE, 0, MODE0+5        ; Initialize SPI, use D0-D2
      DEVIO, SPI+1, ENABLE, 3, MODE0+5        ; Use D3 for /CS

      DEVIO, SPI+1, CS_LOW                    ; enable write
      DEVIO, SPI+1, WRITE_BYTE, DEV_25LC640_WREN
      DEVIO, SPI+1, CS_HIGH

      DEVIO, SPI+1, CS_LOW                    ; write three register values
      DEVIO, SPI+1, WRITE_BYTE, DEV_25LC640_WRITE
      DEVIO, SPI+1, WRITE_WORD, 0
      DEVIO, SPI+1, WRITE_REG32, 10
```

```
      DEVIO, SPI+1, WRITE_REG32, 11
      DEVIO, SPI+1, WRITE_REG32, 12
      DEVIO, SPI+1, CS_HIGH

_wait:
      DEVIO, SPI+1, CS_LOW                    ; wait for write to complete
      DEVIO, SPI+1, WRITE_BYTE, DEV_25LC640_RDSR
      DEVIO, SPI+1, READ_REG8, L0
      DEVIO, SPI+1, CS_HIGH
      SELECTA, 0
      LANDI, 1
      BRA, NZ, _wait

      DEVIO, SPI+1, CS_LOW                    ; disable write
      DEVIO, SPI+1, WRITE_BYTE, DEV_25LC640_WRDI
      DEVIO, SPI+1, CS_HIGH

      DEVIO, SPI+1, CS_LOW                    ; read values to 3 different registers
      DEVIO, SPI+1, WRITE_BYTE, DEV_25LC640_READ
      DEVIO, SPI+1, WRITE_WORD, 0
      DEVIO, SPI+1, READ_REG32, 20
      DEVIO, SPI+1, READ_REG32, 21
      DEVIO, SPI+1, READ_REG32, 22
      DEVIO, SPI+1, CS_HIGH
```

Using the I²C Local Bus

The DEVIO,I2C instruction is used to communicate with I²C devices connected directly to the FPU. The pins used for the I²C bus are selected when the device is initialized with the ENABLE action. Pull-up resistors are required for the SDA and SCL signals. Multiple I²C devices can be connected to the bus. The following diagram shows a typical connection.



Device Initialization

```
DEVIO, I2C, ENABLE, pin, config
```

The *pin* number specifies the digital I/O pins used for SDA and SCL. The *config* byte specifies the speed of the I²C bus.

Device Specific Actions

```
DEVIO, I2C, START_WRITE
DEVIO, I2C, STOP
```

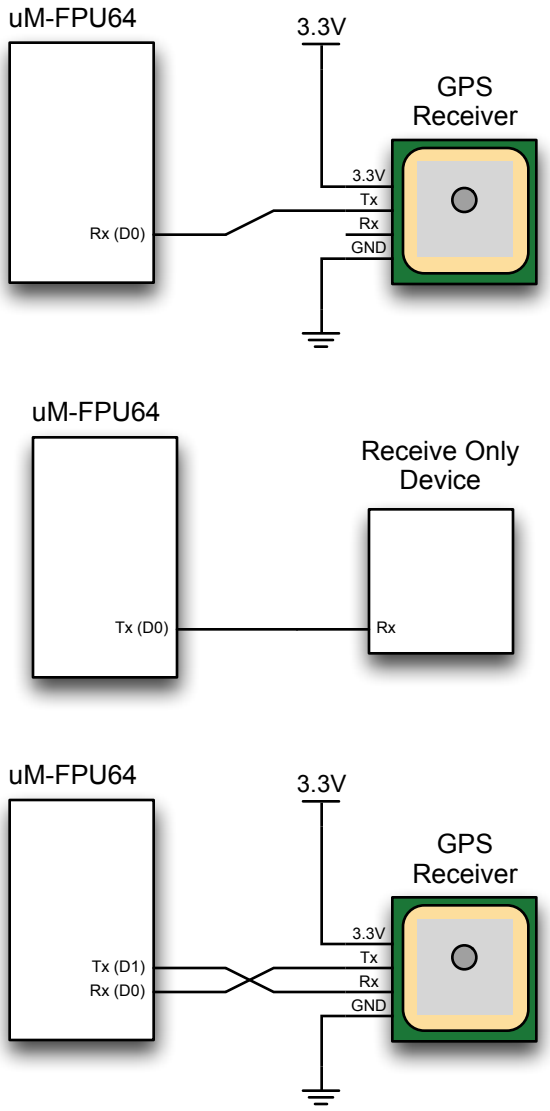
The device specific actions are used to start and stop an I²C write transfer. The I²C device address used by the START_WRITE action is specified as an 8-bit value (the 7-bit I²C device address is left justified and the least significant bit is zero). The restart required for read transfers is done automatically when a DEVIO read action is used.

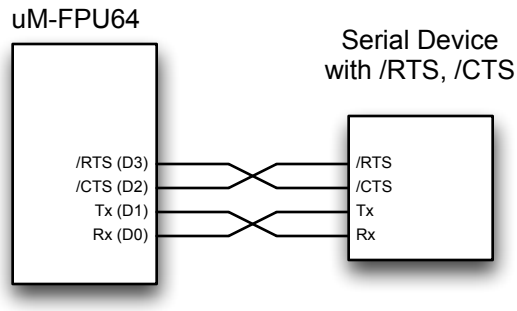
Sample Code

```
I2C_24LC64    con   $A0    ; device address for 24LC640

      DEVIO, I2C, ENABLE, D0, 0              ; initialize I2C, use D0-D1

      DEVIO, I2C, START_WRITE, I2C_24LC64    ; write test string to address 20
      DEVIO, I2C, WRITE_WORD, 20
      DEVIO, I2C, WRITE_STR, "Test String"
      DEVIO, I2C, WRITE_BYTE, 0
      DEVIO, I2C, STOP

      DELAY, 10                              ; wait for write to finish

      STRSET, 0                              ; read test string from address 20
      DEVIO, I2C, START_WRITE, I2C_24LC64    ;   and store in string buffer
      DEVIO, I2C, WRITE_WORD, 20
      DEVIO, I2C, READ_SBUF
```

Using the Asynchronous Serial Connection

The `DEVIO,ASYNC` instruction is used to configure a second serial port on the FPU. The pins used for the serial port are selected when the device is initialized with the `ENABLE` action.The serial port uses from one to four digital pins depending on the configuration. The `SEROUT` and `SERIN` instructions can also be used with the second serial port. The following diagram shows typical connections for receive-only, transmit-only, receive and transmit, and receive and transmit with hardware handshaking.





Device Initialization

```
DEVIO, ASYNC, ENABLE, pin, config
```

The *pin* number specifies the digital I/O pins to use for the second serial port. The serial port can be configured a receive, transmit, receive and transmit, and receive and transmit with hardware handshake. From one to four digital I/O pins are used for the serial port. The *config* byte is used to specify the type of connection and the baud rate.

Device Specific Actions

```
SEROUT, ASYNC+SET_BAUD, mode
SEROUT, ASYNC+WRITE_STR, string
SEROUT, ASYNC+WRITE_SBUF
SEROUT, ASYNC+WRITE_SSEL
SEROUT, ASYNC+WRITE_CHAR
SEROUT, ASYNC+WRITE_STRZ, string

SERIN, ASYNC+DISABLE
SERIN, ASYNC+ENABLE_CHAR
SERIN, ASYNC+STATUS_CHAR
SERIN, ASYNC+READ_CHAR
SERIN, ASYNC+ENABLE_NMEA
SERIN, ASYNC+STATUS_NMEA
SERIN, ASYNC+READ_NMEA
```

There are no device specific actions for `DEVIO,ASYNC` but the `SERIN` and `SEROUT` instructions can be used with the second serial port.

Sample Code

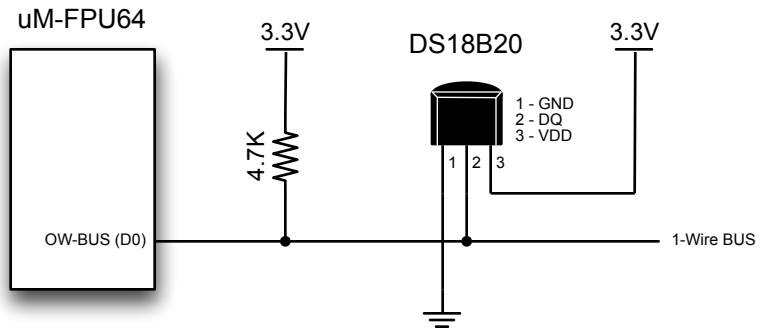
```
DEVIO, ASYNC, ENABLE, D8, RX+BAUD_4800  ; set GPS input on D8

SERIN, ASYNC+ENABLE_NMEA                ; enable NMEA input

SERIN, ASYNC+READ_NMEA                  ; read next NMEA sentence
```

```
DEVIO, ASYNC, ENABLE, D7, TX+BAUD_57600 ; set async output on D7

DEVIO, ASYNC, WRITE_STR, “test”         ; send test string

STRSET, 0                               ; send the value of e as string
SELECTA, 0
```

```
    LOADE
    FTOA, 0
    DEVIO, ASYNC, WRITE_SBUF
```

Using the 1-wire Local Bus

The DEVIO,OWIRE instruction is used to communicate with 1-Wire devices connected directly to the FPU. The pin used for the 1-wire bus is selected when the device is initialized with the ENABLE action. Multiple devices can be connected to the FPU using a single digital pin. The following diagram shows a typical connection.



Device Initialization

```
DEVIO, OWIRE, ENABLE, pin, config
```

The *pin* number specifies the digital I/O pin to use for the 1-wire bus. The *config* byte is not used.

Device Specific Actions

```
DEVIO, OWIRE, RESET
DEVIO, OWIRE, SELECT, regAddr
DEVIO, OWIRE, VERIFY, regAddr
DEVIO, OWIRE, SEARCH, count, regAddr
DEVIO, OWIRE, ALARM, count, regAddr
DEVIO, OWIRE, FAMILY_SEARCH, count, regAddr
DEVIO, OWIRE, FAMILY_ALARM, count, regAddr
```

The device specific actions are used to send a reset pulse prior to a 1-wire transmission, to select or verify a device, and to search for devices on the 1-wire bus. The SEARCH, ALARM, FAMILY_SEARCH, and FAMILY_ALARM actions implement the 1-wire search protocol to identify multiple devices on the 1-wire bus. The address of each device found in the search is stored in the specified 64-bit registers.

The following example searches the 1-wire bus for devices and stores the addresses in register 130-139. The example assumes that register 130 contains the address of the DS18B20 temperature sensor. The temperature is then read to register 1, and converted to floating point.

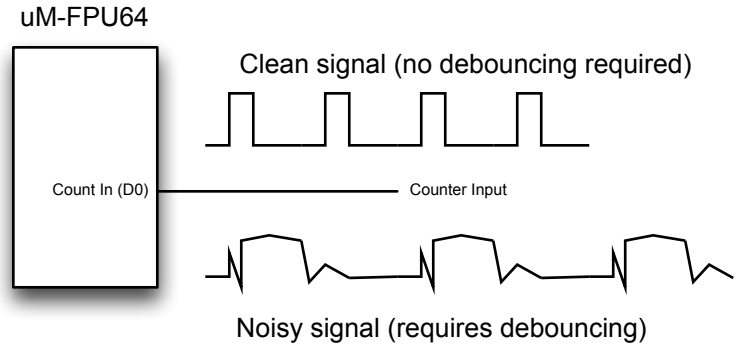
Sample Code

```
CONVERT_T           con    0x44                ; DS18B20 commands
READ_SCRATCHPAD     con    0xBE

      DEVIO, OWIRE, ENABLE, D5, 0              ; initialize 1-wire bus, use D5

      DEVIO, OWIRE, RESET                      ; search for devices
      DEVIO, OWIRE, SEARCH, 10, 130

      DEVIO, OWIRE, RESET                      ; start temperature conversion
      DEVIO, OWIRE, SELECT, 130
      DEVIO, OWIRE, WRITE_BYTE, CONVERT_T
```

```
DELAY, 1000                             ; wait for conversion

DEVIO, OWIRE, RESET                     ; read temperature
DEVIO, OWIRE, SELECT, 130
DEVIO, OWIRE, WRITE_BYTE, READ_SCRATCHPAD
DEVIO, OWIRE, READ_REG16+LSB+SE, 1

SELECTA, 1                              ; convert to floating point
FLOAT
FDIVI, 16
```

Using Counters

The DEVIO,COUNTER instruction is used count input pulses or to interface to switches. The pin used for the counter input is selected when the device is initialized with the ENABLE action. When used for connecting to a switch, switch debouncing and auto-repeat are available. The following diagram shows a typical connection.



Device Initialization

```
DEVIO, COUNTER+n, ENABLE, pin, config
```

The *pin* number specifies the digital I/O pin used for the counter input. The *config* byte is used to select the active state of the counter and optionally selects an event flag.

Device Specific Actions

```
DEVIO, COUNTER+n, DEBOUNCE, period
DEVIO, COUNTER+n, REPEAT, delay, rate
DEVIO, COUNTER+n, READ_COUNT
```

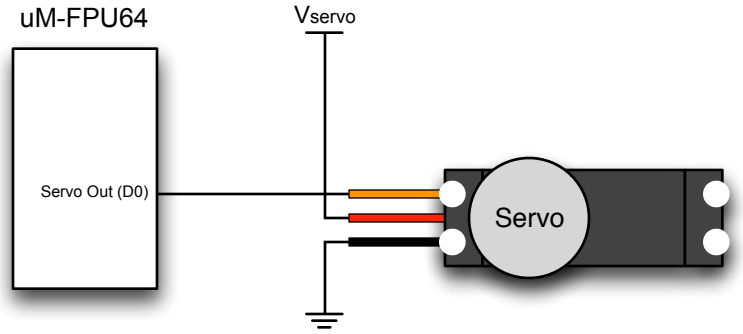
The device specific actions are used control and read the counter. The DEVIO common actions are not applicable to the DEVIO,COUNTER device.

Sample Code

```
DEVIO, COUNTER+0, ENABLE, D3, HIGH      ; counter 0 input on D3, active high

; delay for some period of time

DEVIO, COUNTER+0, READ_COUNT            ; read counter 0 value to register 0
```

Using the Servo Controller

The `DEVIO,SERVO` instruction is used control servo motors commonly used in robotics and remote-control applications. The pin used for the servo output is selected when the device is initialized with the ENABLE action. The following diagram shows a typical connection.



Device Initialization

```
DEVIO, SERVO+n, ENABLE, pin, config
```

The *pin* number specifies the digital I/O pins used for the servo output. The *config* byte specifies if normal (800 to 2200 usec) or extended (500 to 2500) pulse widths are allowed, and optionally selects an event flag.

Device Specific Actions

```
DEVIO, SERVO+n, PULSE, register
DEVIO, SERVO+n, SPEED, register
DEVIO, SERVO+n, TIME, register
DEVIO, SERVO+n, MOVE
DEVIO, SERVO+n, HOME
DEVIO, SERVO+n, READ_PULSE
DEVIO, SERVO+n, STATUS
```

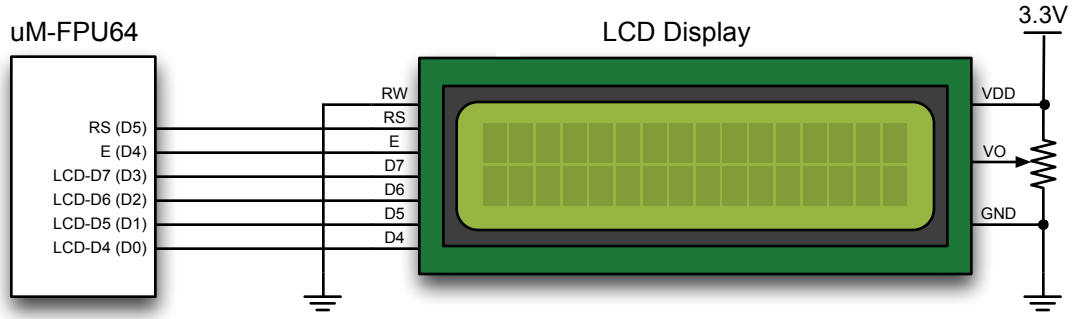
The device specific actions are used control the servo. The `DEVIO` common actions are not applicable to the `DEVIO,SERVO` device.

Sample Code

```
DEVIO, SERVO+0, ENABLE, D6, 0           ; use D6 for servo 0, normal range
DEVIO, SERVO+1, ENABLE, D7, EXTENDED    ; use D7 for servo 1, extended range

SELECTA, 1                              ; set servo 0 pulse width to 2000
LONGWORD, 2000
DEVIO, SERVO+0, PULSE, 1
```

Using an LCD Display (direct connection)

The `DEVIO,LCD` instruction is used to control an LCD display connected directly to the FPU. The pins used for the LCD are selected when the device is initialized with the `ENABLE` action. The RW line can optionally be grounded to reduce the number of pin connections. The following diagram shows a typical connection.



Device Initialization

```
DEVIO, LCD, ENABLE, pin, config
```

The *pin* number specifies the digital I/O pins to use for the LCD connections. Either six or seven pins are required depending on whether or not the `RW` is used. The *config* byte specifies the size of the LCD, the font size, and whether or not `RW` is used.

Device Specific Actions

```
DEVIO, LCD, CLEAR
DEVIO, LCD, HOME
DEVIO, LCD, MOVE, row, column
DEVIO, LCD, MOVE_REG, rowReg, colReg
DEVIO, LCD, CMD, command
```

The device specific actions are used to clear the screen, set the text position, and to sent special commands.

The following example displays several test strings and the value of pi, on a 4x20 LCD.

Sample Code

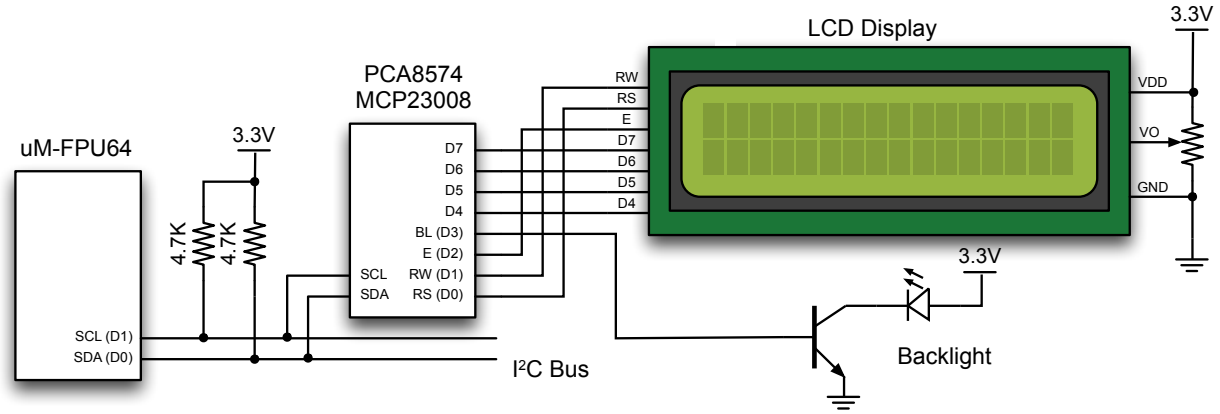
```
DEVIO, LCD, ENABLE, D3, ROWS_4+COLS_20  ; initialize 4x20 LCD, use D3-D8

DEVIO, LCD, WRITE_STR, "Test Strings"   ; write string to home position (0,0)
DEVIO, LCD, MOVE, 2, 0
DEVIO, LCD, WRITE_STR, "Line 2"         ; write string to 2, 0
DEVIO, LCD, MOVE, 1, 0
DEVIO, LCD, WRITE_STR, "Line 1"         ; write string to 1, 0
DEVIO, LCD, MOVE, 3, 0
DEVIO, LCD, WRITE_STR, "Line 3"         ; write string to 3,0

STRSET, 0                               ; display the value pi in 9.5 format
SELECTA, 0
LOADPI
FTOA, 95
DEVIO, LCD, WRITE_SBUF
```

Using an LCD Display (I²C interface)

The `DEVIO,LCD` instruction can also be used to control an LCD display connected using an I²C interface. There are three connections styles supported: ST7038i, PCF8574, and MCP23008. The I²C interface is specified using the `devio(LCD,INTERFACE,`*`type`*`)` function, where *type* selects the `ST7038`, `PCF8574`, or `MCP23008` interface and selects the I²C device address.

Some inexpensive and commonly available I²C displays have the ST7038i interface is built-in. For example the NHD-C0220BIZ-FSW-FBW-3V3M and NHD−C0220BiZ−FS(RGB)−FBW−3V3M LCD displays from Newhaven Display.

Any LCD display that is compatible with the HD44780 chipset can be interfaced with I²C using either the PCA8574 or MCP23008 I/O expander chips. The following diagram shows an example using a PCA8574 or MCP23008 I/O expander chip for the interface and the pin connections.



Pin Connections

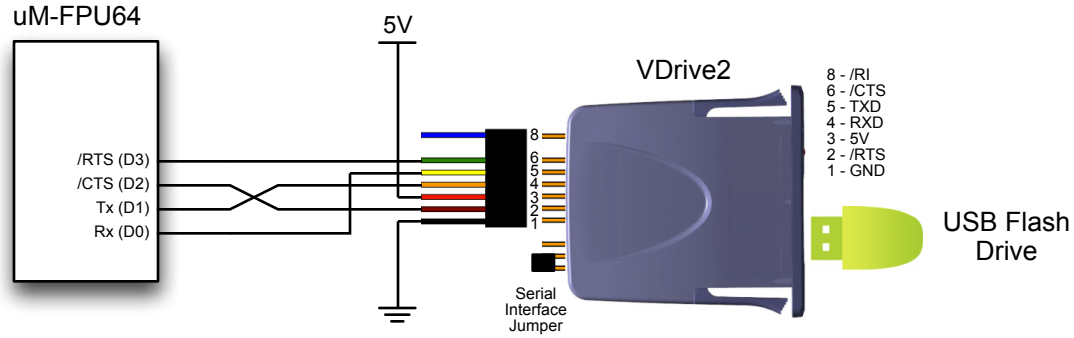
PCA8574 MCP23008	LCD Display
D7	D7
D6	D6
D5	D5
D4	D4
D3	Backlight
D2	E
D1	RW
D0	RS

Sample Code

```
devio(I2C, ENABLE, D0, FAST)        ; initialize I2C using pin D0, D1
devio(LCD, INTERFACE, PCF8574)      ; select PCF8574 interface, I2C address 40
devio(LCD, ENABLE, 0, ROWS_4+COLS_20) ; initialize 4x20 LCD

devio(LCD, WRITE_STR, "Example")    ; write string to home position (0,0)
devio(LCD, MOVE, 2, 0)
devio(LCD, WRITE_STR, "Pi: ")       ; write string to 2, 0

strset("")                          ; display the value pi in 9.5 format
ftoa(pi, 95)
devio(LCD, WRITE_SBUF)
```

Using the VDrive2 USB Storage Device

The `DEVIO,VDRIVE2` instruction is used to communicate with a VDrive2 USB Flash drive using the asynchronous serial connection with hardware flow control. The pins used for the VDrive2 are selected when the device is initialized with the `ENABLE` action. Note: The VDrive2 interface uses the second serial port, so the `DEVIO,ASYNC` device can't be used at the same time as the `DEVIO,VDRIVE2` device is being used. The following diagram shows a typical connection.



Device Initialization

```
DEVIO, VDRIVE2, ENABLE, pin, config
```

The *pin* number specifies the first of four digital I/O pins used for the 9600 baud serial interface to the VDrive2. The config byte is not used. Thee VDrive2 device using the second serial port, so `DEVIO,VDRIVE` and `DEVIO,ASYNC` can't be used at the same time.

Device Specific Actions

```
DEVIO, VDRIVE2, CHECK_INPUT
DEVIO, VDRIVE2, CHECK_DRIVE
DEVIO, VDRIVE2, READ_FILE, filename
DEVIO, VDRIVE2, WRITE_FILE, filename
DEVIO, VDRIVE2, NEW_FILE, filename
DEVIO, VDRIVE2, CLOSE
DEVIO, VDRIVE2, READ_LINE
```

The device specific actions are used to check if the USB Flash drive is inserted, check for input data, open and close files, and read a text line from an input file. The filename can include a path. If no path is specified, the top level directory is used.
e.g.

text.txt
\level2\demo2.txt

Sample Code

```
DEVIO, VDRIVE2, ENABLE, D0, 0           ; initialize VDrive2, use D0-D3

DEVIO, VDRIVE2, NEW_FILE, "test.txt"    ; open a file

DEVIO, VDRIVE2, WRITE_STR, "line1\0D"   ; write test string to file
DEVIO, VDRIVE2, WRITE_STR, "line2\0D"

DEVIO, VDRIVE2, CLOSE                   ; close the file
```

Further Information

See the Micromega website (http://www.micromegacorp.com) for additional information regarding the uM-FPU64 floating point coprocessor, including:

uM-FPU64 Datasheet
uM-FPU64 Instruction Set