



*Micromega Corporation*

# Using the uM-FPU64 DEVIO Instruction

## Introduction

The DEVIO instruction provides support for local peripheral devices connected to the uM-FPU64. The devices include: RAM, FIFO buffers, 1-wire bus, I<sup>2</sup>C 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 is 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 be 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

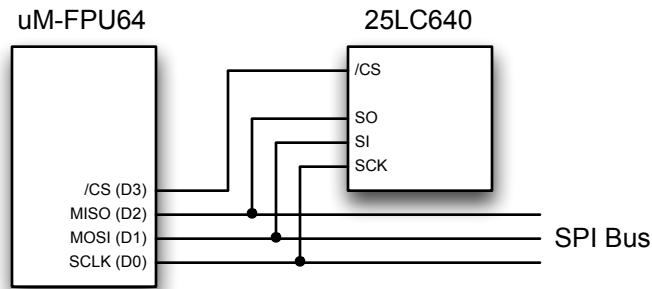
DEVIO, FIFO1, WRITE_REG32, 1         ; write register 1 value to FIFO
DEVIO, FIFO1, WRITE_REG32, 2         ; write register 2 value to FIFO

; 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

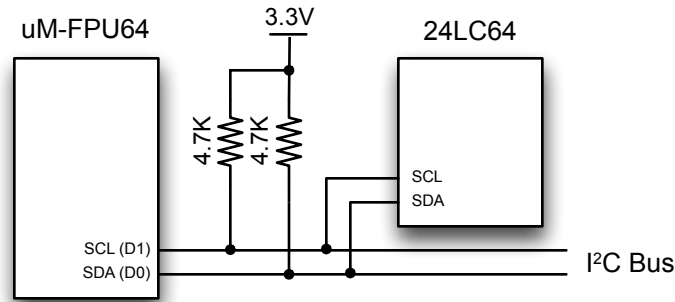
DEVIO, SPI+1, CS_LOW                ; disable write
DEVIO, SPI+1, WRITE_BYTE, DEV_25LC640_WRDI
DEVIO, SPI+1, CS_HIGH

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 I<sup>2</sup>C Local Bus

The `DEVIO, I2C` instruction is used to communicate with I<sup>2</sup>C devices connected directly to the FPU. The pins used for the I<sup>2</sup>C bus are selected when the device is initialized with the `ENABLE` action. Pull-up resistors are required for the SDA and SCL signals. Multiple I<sup>2</sup>C 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 I<sup>2</sup>C bus.

### Device Specific Actions

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

The device specific actions are used to start and stop an I<sup>2</sup>C write transfer. 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

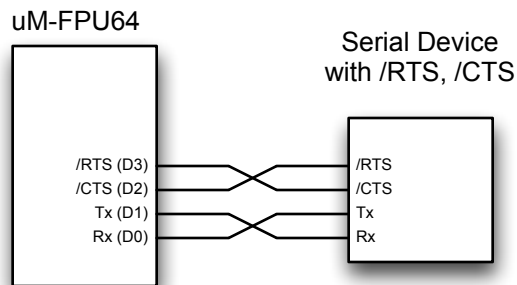
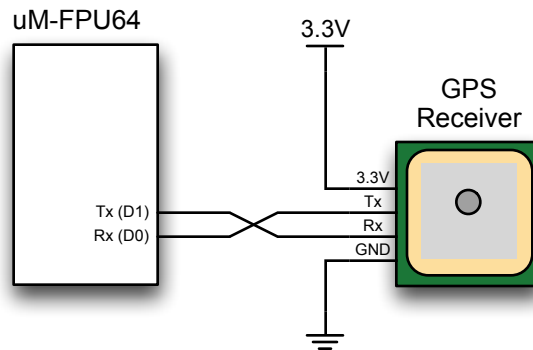
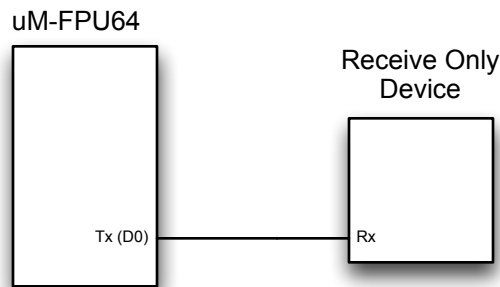
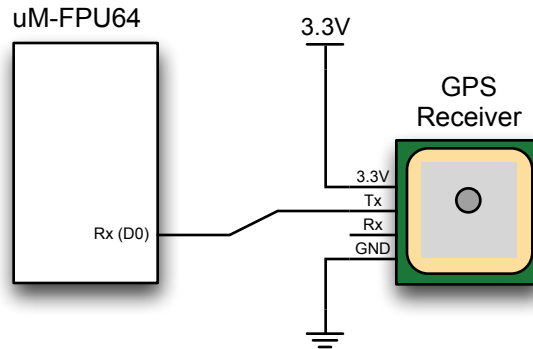
    DEVIO, I2C, START_WRITE, I2C_24LC64    ; write test string to address 20
    DEVIO, I2C, WRITE_WORD, 20
    DEVIO, I2C, WRITE_STR, "Test String"
    DEVIO, I2C, WRITE_BYTE, 0
    DEVIO, I2C, STOP

    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.

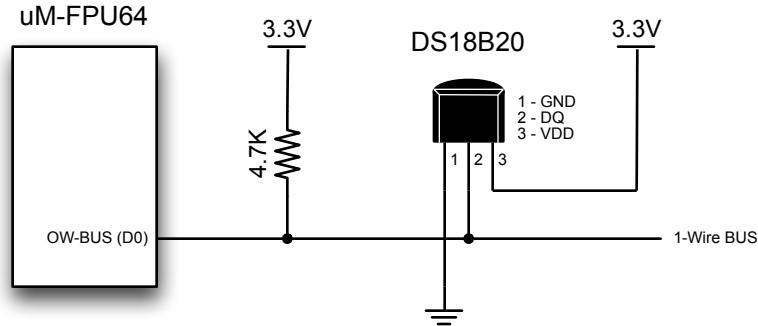
## Sample Code

```
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
```

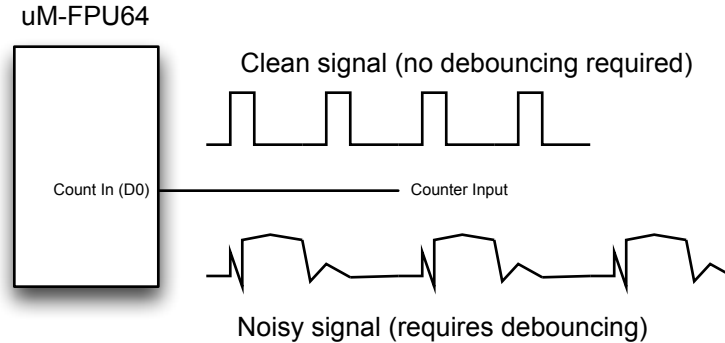
```
DELAY, 1000 ; wait for conversion

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.

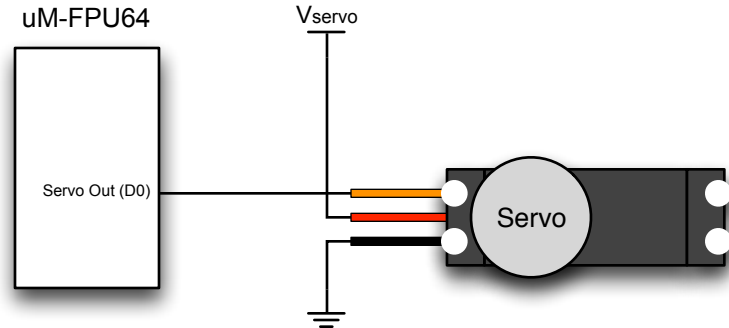
### Sample Code

```
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
```

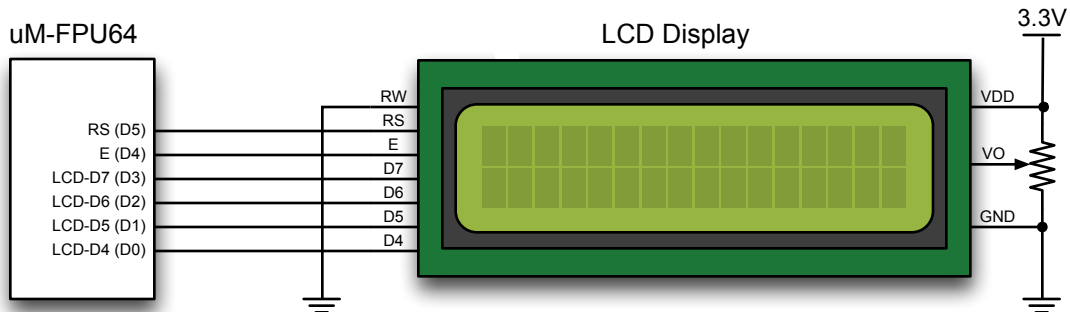
The device specific actions are used control the servo. The `DEVIO` common actions are not applicable to the `DEVIO, SERVO` device.

### 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

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 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. The 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*