
MF 624
MULTIFUNCTION I/O CARD

USER'S MANUAL

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1. Introduction

1.1. General Description

The MF 624 multifunction I/O card is designed for the need of connecting PC compatible computers to real world signals. The MF 624 contains 8 channel fast 14 bit A/D converter with simultaneous sample/hold circuit, 8 independent 14 bit D/A converters, 8 bit digital input port and 8 bit digital output port, 4 quadrature encoder inputs with single-ended or differential interface and 5 timers/counters. The card is designed for standard data acquisition and control applications and optimized for use with Real Time Toolbox for Simulink®. MF 624 features fully 32 bit architecture for fast throughput.

1.2. Features List

The MF 624 offers following features:

- 32-bit architecture
- 14 bit A/D converter with simultaneous sample & hold circuit
- Conversion time 1.6 μ s for single channel or 3.7 μ s for 8 channels
- 8 channel single ended fault protected input multiplexer
- Input range ± 10 V
- Internal clock & voltage reference
- 8 D/A converters with 14 bit resolution and ± 10 V output range
- 4 quadrature encoder inputs with single-ended or differential interface

- Software selectable digital input noise filter (0.3 μ s)
- Quadrature input frequency up to 2.5 MHz
- Software selectable index pulse operation
- 4 channel 32-bit timer/counter with 20 ns resolution
- 8 bit TTL compatible digital input port
- 8 bit TTL compatible digital output port
- Interrupt
- Requires one PCI 2.3 slot and optional second slot for second connector
- Can be used in 5V or 3.3V slot
- Power consumption 500 mA@+5V, 150 mA@+12V, 150 mA@-12V
- Operating temperature 0°C to +70°C

1.3. Specifications

1.3.1. A/D Converter

Resolution:	14 bits
Number of channels:	8 single ended
Sample/hold circuit:	simultaneous sampling of all channels
Conversion time:	1.6 μ s single channel 1.9 μ s 2 channels 2.5 μ s 4 channels 3.7 μ s 8 channels
FIFO:	8 entries/one conversion cycle
Input ranges:	\pm 10V
Input protection:	\pm 18V
Input impedance:	> 10 ¹⁰ Ohm

1.3.2. D/A Converter

Resolution:	14 bit
Number of channels:	8
Settling time:	max. 31 μ s (full scale swing, 1/2 LSB)
Slew Rate:	10 V/ μ s
Output current:	min. \pm 10 mA
Short circuit current:	\pm 15 mA
DC output impedance:	max. 0.5 Ohm
Load capacitance:	max. 50 pF
Differential nonlinearity:	\pm 1 LSB

1.3.3. Digital Inputs

Number of bits:	8
Input signal levels:	TTL
Logic 0:	0.8 V max.
Logic 1:	2.0 V min.

1.3.4. Digital Outputs

Number of bits:	8
Output signal levels:	TTL
Logic 0:	0.5 V max. @ 24 mA (sink)
Logic 1:	2.0 V min. @ 15 mA (source)

1.3.5. Quadrature Encoder Inputs

Number of axes:	4 independent
Resolution:	32 bits

Counter modes:	quadrature X4 or up/down counter
Index input:	programmable
Inputs:	differential with Schmitt triggers
Input noise filter:	digital, programmable (0.3 μ s)
Input frequency:	max. 2.5 MHz

1.3.6. Counters/Timers

Counter chip:	custom
Number of channels:	5, 4 of them available on I/O connector, one used for A/D triggering and interrupt
Resolution:	32 bits
Clock frequency:	50 MHz
Counter modes:	up, down, binary
Triggering:	software, external
Clock source:	internal, prescalers, external
Inputs:	TTL, Schmitt triggers
Outputs:	TTL

2. Installation

2.1. Board Installation

MF 624 has no switches or jumpers and you can install it in any free PCI expansion slot of your computer. Follow the steps outlined below:

- Turn off the power of the computer system and unplug the power cord.
- Disconnect all cables connected to the computer system.
- Using a screwdriver, remove the cover-mounting screws. These screws are at the rear side of the PC.
- Remove the computer system's cover.
- Find an empty expansion slot in your computer for MF 624 card. If the slot still has the metal expansion-slot cover attached, remove the cover with a screwdriver. Save the screw to install the MF 624.
- Hold the MF 624 firmly at the top of the board, and press the gold edge connector into an empty PCI expansion slot.
- Using a screwdriver, screw the retaining bracket tightly against the rear plate of the computer system.
- In case of using also quadrature encoder inputs or timer/counters install also the additional connector with metal slot cover to the neighbouring slot. Otherwise you can disconnect the additional connector from the board and save it for future use.
- Replace the cover of the computer, and plug in the power cord.
- Reconnect all cables that were previously attached to the rear of the

computer.

2.2. Driver Installation

Once you have installed MF 624 to PCI slot you can install Windows driver. Follow the steps outlined below:

Turn on the computer, boot Microsoft Windows. MF 624 is detected by system automatically. In Add Hardware Wizzard window click Next.

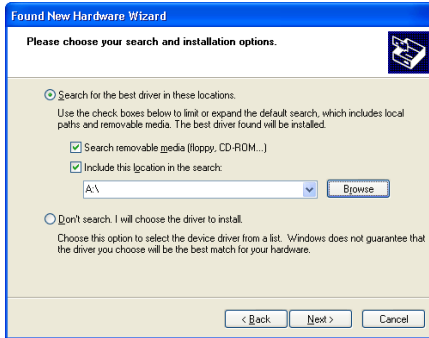


Insert installation floppy into drive a. In Found New Hardware Wizzard select Install the software automatically and click Next.



Hardware Installation

When prompted for driver location type a:\ and click Next. Click Finish to complete installation.



3. Programming Guide

3.1. Register Map

MF 624 uses PCI Vendor ID 0x186C and Device ID 0x0624. Registers of MF 624 card are located in 3 memory mapped regions:

Region	Function	Size (bytes)	Width (bits)
BADR0 (memory mapped)	PCI chipset, interrupts, status bits, special functions	32	32
BADR1 (memory mapped)	A/D, D/A, digital I/O	128	16/32
BADR2 (memory mapped)	Counter/timer chip	128	32

Table 1. Base Address Regions

PCI chipset (PCI 9030) and counter/timer chip are located in 32-bit regions and should be accessed by 32-bit instructions. BADR1 containing analog I/O has 16-bit architecture and registers are naturally 16-bit wide, but 32-bit access to this area is allowed as well under certain conditions. 32-bit access is broken by PCI chipset into two 16-bit cycles on the MF 624 internal bus. This allows increasing throughput by accessing two consecutive internal 16-bit registers by single PCI cycle. Therefore two D/A channels can be written or two A/D channels can be read at once which increases speed of data transfers almost twice. Do not use 32-bit access to other registers than ADDATA and DA0 - DA7.

Address	Read	Write
BADR0+0x4C	INTCSR	INTCSR
BADR0+0x54	GPIOC	GPIOC

Table 2. BADR0 Memory Map

Address	Read	Write
BADR1+0x00	ADDATA - A/D data	ADCTRL - A/D control
BADR1+0x02	ADDATA - A/D data mirror	
BADR1+0x04	ADDATA - A/D data mirror	
BADR1+0x06	ADDATA - A/D data mirror	
BADR1+0x08	ADDATA - A/D data mirror	
BADR1+0x0A	ADDATA - A/D data mirror	
BADR1+0x0C	ADDATA - A/D data mirror	
BADR1+0x0E	ADDATA - A/D data mirror	
BADR1+0x10	DIN - Digital input	DOUT - Digital output
BADR1+0x20	ADSTART - A/D SW trigger	DA0 - D/A 0 data
BADR1+0x22		DA1 - D/A 1 data
BADR1+0x24		DA2 - D/A 2 data
BADR1+0x26		DA3 - D/A 3 data
BADR1+0x28		DA4 - D/A 4 data
BADR1+0x2A		DA5 - D/A 5 data
BADR1+0x2C		DA6 - D/A 6 data
BADR1+0x2E		DA7 - D/A 7 data

Table 3. BADR1 Memory Map

Address	Read	Write
BADR2+0x00	CTR0STATUS	CTR0MODE
BADR2+0x04	CTR0	CTR0A
BADR2+0x08		CTR0B
BADR2+0x10	CTR1STATUS	CTR1MODE
BADR2+0x14	CTR1	CTR1A
BADR2+0x18		CTR1B
BADR2+0x20	CTR2STATUS	CTR2MODE
BADR2+0x24	CTR2	CTR2A
BADR2+0x28		CTR2B
BADR2+0x30	CTR3STATUS	CTR3MODE
BADR2+0x34	CTR3	CTR3A
BADR2+0x38		CTR3B
BADR2+0x40	CTR4STATUS	CTR4MODE
BADR2+0x44	CTR4	CTR4A
BADR2+0x48		
BADR2+0x60		CTRXCTRL
BADR2+0x6C	IRCSTATUS	IRCCTRL
BADR2+0x70	IRC0	
BADR2+0x74	IRC1	
BADR2+0x78	IRC2	
BADR2+0x7C	IRC3	

Table 4. BADR2 Memory Map

3.2. Register Description

INTCSR	BADR0+0x4C	Interrupt Control/Status	R/W
Bit	Description		Default
0	ADINT Enable. 1 enables A/D interrupt, 0 disables A/D interrupt.		0
1	ADINT Polarity. 1 active high, 0 active low. Connected to EOLC of A/D converter, should be set to active low for normal operation.		0
2	ADINT Status. 1 indicates interrupt active, 0 indicates interrupt not active.		0
3	CTR4INT Enable. 1 enables counter 4 (or external trigger) interrupt, 0 disables counter 4 interrupt.		0
4	CTR4INT Polarity. 1 active high, 0 active low. Connected to counter 4 output (or external trigger input).		0
5	CTR4INT Status. 1 indicates interrupt active, 0 indicates interrupt not active.		0
6	PCI Interrupt Enable. 1 enables PCI interrupt.		0
7	Software Interrupt. 1 generates PCI interrupt (INTA#) if PCI Interrupt Enable bit is set (bit [6]=1).		0
8	ADINT Select Enable. 1 indicates edge triggered, 0 indicates level triggered interrupt. <i>Note: Operates only in High-Polarity mode (bit [1]=1)</i>		0
9	CTR4INT Select Enable. 1 indicates edge triggered, 0 indicates level triggered interrupt. <i>Note: Operates only in High-Polarity mode (bit [4]=1)</i>		0
10	ADINT Clear. Writing 1 to this bit clears ADINT in edge mode.		0
11	CTR4INT Clear. Writing 1 to this bit clears CTR4INT in edge mode.		0
31:12	Reserved		0x000300

Table 5. INTCSR - Interrupt Control/Status Register Format

GPIOC		BADR0+0x54	General Purpose I/O Control	R/W
Bit	Description			Default
16:0	Reserved.			0x006C0
17	EOLC . Reads EOLC (end of last conversion) bit of A/D converter. Active low, 0 when all channels converted, 1 during A/D conversion.			0
21:18	Reserved.			0x10
23	LDAC . Load D/A converters, active low. Writing 0 makes D/A latches transparent, 1 holds D/A outputs. Can be used for simultaneous update of analog outputs.			0
25:24	Reserved.			10
26	DACEN . 1 enables D/A outputs. 0 forces 0V to all D/A outputs.			0
31:27	Reserved.			0

Table 6. GPIOC - General Purpose I/O Control Register Format

ADCTRL		BADR1+0x00	A/D Control	W
Bit	Description			Default
0	CH0 select . 1 enables chanel 0 in channel scan list.			0
1	CH1 select . 1 enables chanel 1 in channel scan list.			0
2	CH2 select . 1 enables chanel 2 in channel scan list.			0
3	CH3 select . 1 enables chanel 3 in channel scan list.			0
4	CH4 select . 1 enables chanel 4 in channel scan list.			0
5	CH5 select . 1 enables chanel 5 in channel scan list.			0
6	CH6 select . 1 enables chanel 6 in channel scan list.			0
7	CH7 select . 1 enables chanel 7 in channel scan list.			0
15:8	Reserved.			0x00

Table 7. ADCTRL - A/D Control Register Format

ADDATA		BADR1+0x00	A/D Data	R
Bit	Description			Default
13:0	A/D Data. Reads data from A/D. Data is valid after EOLC bit in GPIOC goes low. Data from channels selected in ADCTRL register are available in FIFO, lower number channels first.			N/A
15:14	Reserved			N/A

Table 8. ADDATA - A/D DATA Register Format

Note: ADDATA register has 7 mirror registers located from BADR1+0x02 to BADR1+0x0E. This arrangement remaps FIFO to linear address space and allows reading consecutive values from A/D FIFO by 32-bit instructions.

DIN		BADR1+0x10	Digital Input	R
Bit	Description			Default
7:0	Digital input 7:0. Reads digital input port.			1
15:8	Reserved			N/A

Table 9. DIN - Digital Input Register Format

DOUT		BADR1+0x10	Digital Output	W
Bit	Description			Default
7:0	Digital output 7:0. Writes to digital output port.			0
15:8	Reserved			N/A

Table 10. DOUT - Digital Output Register Format

ADSTART		BADR1+0x20	A/D Conversion Start	R
Bit	Description			Default
15:0	A/D Conversion Start. Reading this register triggers A/D conversion for all channels selected in ADCTRL.			N/A

Table 11. ADSTART - A/D Conversion Start Register Format

DA0	BADR1+0x20	D/A Converter 0	W
DA1	BADR1+0x22	D/A Converter 1	W
DA2	BADR1+0x24	D/A Converter 2	W
DA3	BADR1+0x26	D/A Converter 3	W
DA4	BADR1+0x28	D/A Converter 4	W
DA5	BADR1+0x2A	D/A Converter 5	W
DA6	BADR1+0x2C	D/A Converter 6	W
DA7	BADR1+0x2E	D/A Converter 7	W

Bit	Description	Default
13:0	DAx . D/A converter channel n data.	0x3FFF
15:14	Reserved.	N/A

Table 12. DAX - D/A Converter Data Register Format

Note: D/A converter outputs are updated only if LDAC bit in GPIOC register is set low (bit [23] at BADR0+0x54 =0). Otherwise D/A outputs are keeping old values and data written to DAn registers are kept until LDAC goes low. LDAC bit can be used for simultaneous update of D/A outputs.

CTR0STATUS	BADR2+0x00	Counter 0 Status	R
CTR1STATUS	BADR2+0x10	Counter 1 Status	R
CTR2STATUS	BADR2+0x20	Counter 2 Status	R
CTR3STATUS	BADR2+0x30	Counter 3 Status	R
CTR4STATUS	BADR2+0x40	Counter 4 Status	R

Bit	Description	Default
0	Counter Running . 1 if counter is running, 0 if stopped.	0
1	Counter Output . Reads counter toggle output.	0
31:2	Reserved.	N/A

Table 13. CTRxSTATUS - Counter Status Register Format

CTR0MODE	BADR2+0x00	Counter 0 Mode	W
CTR1MODE	BADR2+0x10	Counter 1 Mode	W
CTR2MODE	BADR2+0x20	Counter 2 Mode	W
CTR3MODE	BADR2+0x30	Counter 3 Mode	W
CTR4MODE	BADR2+0x40	Counter 4 Mode	W

Bit	Description	Default
0	Count Direction. 1 counts up, 0 counts down.	0
1	Repetition. If 0, counter stops after terminal count. If 1, counter reloads after terminal count and starts new cycle.	0
2	Load Toggle. If 0, counter always reloads from register A on terminal count. If 1, counter reloads alternately from A register or from B register depending on output toggle status.	0
3	Output Toggle. If 0, counter output pin is connected to terminal count. If 1 counter output is connected to output toggle which is inverted on every terminal count.	0
5:4	Output Control. Controls output value and polarity. 00: direct output 01: inverted output 10: force output low 11: force output high	10
7:6	Trigger source. Controls counter hardware trigger source. 00: trigger disabled 01: trigger by counter input (TxIN) 10: trigger by counter n-1 output 11: trigger by counter n+1 output	0
9:8	Trigger type. Controls counter hardware trigger edge. 00: trigger disabled 01: trigger by rising edge of trigger signal 10: trigger by falling edge of trigger signal 11: trigger by either edge of trigger signal	0
10	Retrigger. If 0, retrigger is disabled and counter can be triggered only when stopped. If 1, counter can be retriggered when running.	0

12:11	<p>Gate source. Controls counter hardware gate source.</p> <p>00: gate set high</p> <p>01: counter gated by counter input (TxIN)</p> <p>10: counter gated by counter n-1 output</p> <p>11: counter gated by counter n+1 output</p>	0
13	<p>Gate polarity. Selects value of gate input which disables counting. If set to 0, low level of gate signal disables counting. If set to 1, high level of gate signal disables counting.</p>	0
17:14	<p>Clock source. Selects counter clock source.</p> <p>0000: 50 MHz internal clock</p> <p>0001: 10 MHz internal clock</p> <p>0010: 1 MHz internal clock</p> <p>0011: 100 kHz internal clock</p> <p>0100: reserved</p> <p>0101: counter input (TxIN) rising edge</p> <p>0110: counter input (TxIN) falling edge</p> <p>0111: counter input (TxIN) either edge</p> <p>1000: reserved</p> <p>1001: counter n-1 output rising edge</p> <p>1010: counter n-1 output falling edge</p> <p>1011: counter n-1 output either edge</p> <p>1100: reserved</p> <p>1101: counter n+1 output rising edge</p> <p>1110: counter n+1 output falling edge</p> <p>1111: counter n+1 output either edge</p>	0
29:18	Reserved	0
30	<p>ADTRIGSRC. A/D trigger source. 0 triggers by falling edge of external trigger input. 1 triggers by falling edge of counter 4 output. Implemented in CTR4MODE register only.</p>	0
31	<p>CTR4INTSRC. Interrupt signal source. 0 interrupts by falling edge of external trigger input. 1 interrupts by falling edge of counter 4 output. Implemented in CTR4MODE register only.</p>	0

Table 14. CTRxMODE - Counter Mode Register Format

CTR0	BADR2+0x04	Counter 0 Data	R
CTR1	BADR2+0x14	Counter 1 Data	R
CTR2	BADR2+0x24	Counter 2 Data	R
CTR3	BADR2+0x34	Counter 3 Data	R
CTR4	BADR2+0x44	Counter 4 Data	R

Bit	Description	Default
31:0	Counter Data. Reads current contents of counter.	0

Table 15. CTRx - Counter Data Register Format

CTR0A	BADR2+0x04	Counter 0 Load A	W
CTR1A	BADR2+0x14	Counter 1 Load A	W
CTR2A	BADR2+0x24	Counter 2 Load A	W
CTR3A	BADR2+0x34	Counter 3 Load A	W
CTR4A	BADR2+0x44	Counter 4 Load A	W

Bit	Description	Default
31:0	Counter Load A. Counter load register A	0

Table 16. CTRxA - Counter Load A Register Format

CTR0B	BADR2+0x08	Counter 0 Load B	W
CTR1B	BADR2+0x18	Counter 1 Load B	W
CTR2B	BADR2+0x28	Counter 2 Load B	W
CTR3B	BADR2+0x38	Counter 3 Load B	W

Bit	Description	Default
31:0	Counter Load B. Counter load register B	0

Table 17. CTRxB - Counter Load B Register Format

Note: Counter 4 does not have Load B register and is always being loaded from Load A register.

CTRCTRL BADR2+0x60 Counter Control Register W

Bit	Description	Default
0	CTR0START. Writing 1 starts counter 0.	0
1	CTR0STOP. Writing 1 stops counter 0.	0
2	CTR0LOAD. Writing 1 loads counter 0 from Load A or Load B register.	0
3	CTR0RESET. Writing 1 resets counter 0.	0
4	CTR0TSET. Writing 1 sets counter 0 output toggle register.	0
5	CTR0TRESET. Writing 1 resets counter 0 output toggle register.	0
6	CTR1START. Writing 1 starts counter 1.	0
7	CTR1STOP. Writing 1 stops counter 1.	0
8	CTR1LOAD. Writing 1 loads counter 1 from Load A or Load B register.	0
9	CTR1RESET. Writing 1 resets counter 1.	0
10	CTR1TSET. Writing 1 sets counter 1 output toggle register.	0
11	CTR1TRESET. Writing 1 resets counter 1 output toggle register.	0
12	CTR2START. Writing 1 starts counter 2.	0
13	CTR2STOP. Writing 1 stops counter 2.	0
14	CTR2LOAD. Writing 1 loads counter 2 from Load A or Load B register.	0
15	CTR2RESET. Writing 1 resets counter 2.	0
16	CTR2TSET. Writing 1 sets counter 2 output toggle register.	0
17	CTR2TRESET. Writing 1 resets counter 2 output toggle register.	0
18	CTR3START. Writing 1 starts counter 3.	0
19	CTR3STOP. Writing 1 stops counter 3.	0
20	CTR3LOAD. Writing 1 loads counter 3 from Load A or Load B register.	0
21	CTR3RESET. Writing 1 resets counter 3.	0

22	CTR3TSET . Writing 1 sets counter 3 output toggle register.	0
23	CTR3TRESET . Writing 1 resets counter 3 output toggle register.	0
24	CTR4START . Writing 1 starts counter 4.	0
25	CTR4STOP . Writing 1 stops counter 4.	0
26	CTR4LOAD . Writing 1 loads counter 4 from Load A or Load B register.	0
27	CTR4RESET . Writing 1 resets counter 4.	0
28	CTR4TSET . Writing 1 sets counter 4 output toggle register.	0
29	CTR4TRESET . Writing 1 resets counter 4 output toggle register.	0
31:30	Reserved.	0

Table 18. CTRXCTRL - Common Counter Control Register Format

Note: Bits 29:0 are active by writing 1. Writing 0 to these bits is not necessary and has no action assigned.

IRCCTRL BADR2+0x6C IRC Control Register W

Bit	Description	Default
1:0	IRC0MODE. Selects IRC0 counter operation. 00: IRC, 4 edge detection 01: bidirectional counter, rising edge 10: bidirectional counter, falling edge 11: bidirectional counter, either edge	0
3:2	IRC0COUNT. IRC0 count control. 00: IRC0 count enabled 01: IRC0 count disabled 10: IRC0 count enabled if I0 input is 0 11: IRC0 count enabled if I0 input is 1	0
6:4	IRC0RESET. IRC0 reset control. 000: IRC0 reset disabled 001: IRC0 reset 010: IRC0 reset if I0 is 0 011: IRC0 reset if I0 is 1 100: IRC0 reset by rising edge of I0 101: IRC0 reset by falling edge of I0 110: IRC0 reset by either edge of I0 111: Reserved	0
7	IRC0FILTER. IRC0 digital filter control. 1 enables digital filter on IRC0 inputs. 0 disables filtering.	0
9:8	IRC1MODE. Selects IRC1 counter operation. See IRC0MODE	0
11:10	IRC1COUNT. IRC1 count control. See IRC0COUNT	0
14:12	IRC1RESET. IRC1 reset control. See IRC0RESET	0
15	IRC1FILTER. IRC1 digital filter control. 1 enables digital filter on IRC1 inputs. 0 disables filtering.	0
17:16	IRC2MODE. Selects IRC2 counter operation. See IRC0MODE	0
19:18	IRC2COUNT. IRC2 count control. See IRC0COUNT	0
22:20	IRC2RESET. IRC2 reset control. See IRC0RESET	0

23	IRC2FILTER. IRC2 digital filter control. 1 enables digital filter on IRC2 inputs. 0 disables filtering.	0
25:24	IRC3MODE. Selects IRC3 counter operation. See IRC0MODE	0
27:26	IRC3COUNT. IRC3 count control. See IRC0COUNT	0
30:28	IRC3RESET. IRC3 reset control. See IRC0RESET	0
31	IRC3FILTER. IRC3 digital filter control. 1 enables digital filter on IRC3 inputs. 0 disables filtering.	0

Table 19. IRCCTRL - IRC Control Register Format

Note: Digital filter on IRC inputs is a low-pass filter improving noise immunity. The filter also decreases maximum input frequency and signal changes shorter than 320 ns are ignored.

IRCSTATUS BADR2+0x6C IRC Status Register R

Bit	Description	Default
0	IRC0INDEX. Reads I0 input.	1
7:1	Reserved.	N/A
8	IRC1INDEX. Reads I1 input.	1
15:9	Reserved.	N/A
16	IRC2INDEX. Reads I3 input.	1
23:17	Reserved.	N/A
24	IRC3INDEX. Reads I3 input.	1
31:25	Reserved.	N/A

Table 20. IRCSTATUS - IRC Status Register Format

IRC0	BADR2+0x70	IRC0 Data Register	
IRC1	BADR2+0x74	IRC1 Data Register	
IRC2	BADR2+0x78	IRC2 Data Register	
IRC3	BADR2+0x7C	IRC3 Data Register	R

Bit	Description	Default
31:0	IRCx . Reads data from IRC counter.	0

Table 21. IRCx - IRCx Data Register Format

3.3. A/D Converter

A/D converter is controlled through ADDATA, ADCTRL, ADSTART and GPIOC registers.

Before starting a conversion it is necessary to configure channels which will be converted by ADCTRL register. Each A/D channel has one bit in ADCTRL. Setting this bit includes the channel in conversion scan list. Conversion can be initiated by a read operation from ADSTART register, by timer/counter T4 or by external trigger. Once the conversion is started, selected channels are simultaneously sampled and converted. When the conversion of all selected channels is complete, EOLC (bit 17 in GPIOC register) is set low which means that converted data is available in output FIFO and can be read from ADDATA register. EOLC remains low until next conversion is started. Starting new conversion resets FIFO.

A/D conversion can be triggered also by timer 4 output or by external trigger input according to setting of ADTRIGSRC (bit 30 in CTR4MODE register). These signals can also generate interrupt according to setting of CTR4INTSRC (bit 31 in CTR4MODE register).

A/D converter has fixed input range $\pm 10V$ and uses two's complement binary coding. A/D converter zero offset can be adjusted by R23. A/D gain can be

adjusted by R25.

Digital Value	Analog Voltage
0x3FFF	-0.0012 V
0x2000	-10.0000 V
0x1FFF	9.9988 V
0x0000	0.0000 V

Table 22. A/D Inputs Coding

3.4. D/A Converters

D/A converters are accessed through eight data input latch registers DA0 - DA7. D/A converter outputs are initially connected to ground until DACEN (bit 26 in GPIOC register) is set to 1. This bit can be used to disconnecting all analog outputs from D/A converters. Data from D/A input latch registers are passed to D/A converters only if LDAC (bit 23 in GPIOC register) is 0. If this bit is set to 1, data remains just in input latches without being written to D/A converters. Then if LDAC is set to 0, all D/A outputs are updated simultaneously from input latch registers.

Output voltage ranges of D/A converters are $\pm 10V$ and straight binary coding is used. After power-on or hardware reset the output voltage is set to 0V. D/A converter positive range can be adjusted by R5 while negative range can be adjusted by R8.

Digital Value	Analog Voltage
0x3FFF	9.9988 V
0x2000	0.0000 V
0x1FFF	-0.0012 V
0x0000	-10.0000 V

Table 23. D/A Outputs Coding

3.5. Digital I/O

MF 624 contains one 8-bit digital input port and one 8-bit digital output port. Digital input port can be accessed directly by read from DIN register. Inputs are TTL compatible. Digital output port can be accessed by byte or word write to DOUT register. Outputs are TTL compatible. After power-on or hardware reset digital outputs are set to 0.

3.6. Quadrature Encoder Inputs

MF 624 contains four quadrature encoder inputs with single-ended or differential interface and index inputs. Inputs are differential TTL compatible with Schmitt triggers.

MF 624 can be used either with single-ended or differential encoder outputs. In case of single-ended encoder outputs use + signal inputs and leave - inputs disconnected. If differential encoder outputs are used connect both + and - inputs of MF 624 to encoder outputs. In both cases connect encoder signal ground to GND on X2 connector of MF 624.

Each IRC channel has one 32 bit data register IRC0 - IRC3. Control and status

registers IRCCTRL and IRCSTATUS are common for all IRC channels. Each IRC counter can be switched to bidirectional counter mode. In such case A is clock input and B controls direction (1 up, 0 down). In IRC and counter modes counter reset can be controlled by I input.

3.7. Timer/Counter

MF 624 contains 5 timers/counters with 50 MHz clock. The first four timers are accessible through external connector X2 while the fifth timer can generate system interrupt or trigger A/D conversion, or can be used as a clock source for other timers or for similar internal functions. TxIN pin on I/O connector can serve either as clock, gate or trigger input depending on configuration. Inputs and outputs are TTL compatible, Schmitt triggers are at all inputs to improve noise immunity.

Counters are implemented in programmable gate array chip offering wide range of operation modes allowing:

- up/down, binary counting
- internal or external clock and gate sources
- prescaling
- one shot/continuous outputs
- software/external triggering
- programmable gate and output polarities
- pulse counting
- frequency measurement
- pulse generation including PWM
- programmable clock source

4. I/O Signals

4.1. Output Connector Signal Description

The MF 624 multifunction I/O card is equipped with an on-board 37 pin D-type female connector X1 and with an additional 37 pin D-type female connector X2 on cable extender. For pin assignment refer to Tables 24 and 25. TB 620 Terminal Board can be connected to both connectors.

AD0-AD7	Analog inputs
DA0-DA7	Analog outputs
DIN0-DIN7	TTL compatible digital inputs
DOUT0-DOUT7	TTL compatible digital outputs
IRC0-IRC3	Quadrature encoder A, B and Index inputs
T0IN-T3IN	Timer/counter gate and clock inputs
T0OUT-T3OUT	Timer/counter outputs
TRIG	A/D converter external trigger input
+12V	+12V power supply
-12V	-12V power supply
+5V	+5V power supply
AGND	Analog ground
GND	Digital ground

I/O Signals

AD0	1	20	DA0
AD1	2		
AD2	3	21	DA1
AD3	4	22	DA2
AD4	5	23	DA3
AD5	6	24	DA4
AD6	7	25	DA5
AD7	8	26	-12V
AGND	9	27	+12V
DA6	10	28	+5V
DA7	11	29	GND
DIN0	12	30	DOUT0
DIN1	13	31	DOUT1
DIN2	14	32	DOUT2
DIN3	15	33	DOUT3
DIN4	16	34	DOUT4
DIN5	17	35	DOUT5
DIN6	18	36	DOUT6
DIN7	19	37	DOUT7

Table 24. X1 Connector Pin Assignment

IRC0A+	1	20	IRC3A+
IRC0A-	2		
IRC0B+	3	21	IRC3A-
IRC0B-	4	22	IRC3B+
IRC0I+	5	23	IRC3B-
IRC0I-	6	24	IRC3I+
IRC1A+	7	25	IRC3I-
IRC1A-	8	26	TRIG
IRC1B+	9	27	
IRC1B-	10	28	+5V
IRC1I+	11	29	GND
IRC1I-	12	30	T0IN
IRC2A+	13	31	T0OUT
IRC2A-	14	32	T1IN
IRC2B+	15	33	T1OUT
IRC2B-	16	34	T2IN
IRC2I+	17	35	T2OUT
IRC2I-	18	36	T3IN
GND	19	37	T3OUT

Table 25. X2 Connector Pin Assignment

Contact Address

Contact address:

HUMUSOFT s.r.o.

Pobřežní 20

186 00 Praha 8

Czech Republic

tel.: + 420 2 84011730

tel./fax: + 420 2 84011740

E-mail: info@humusoft.com

Homepage: <http://www.humusoft.com>