

# Microcontroller Development/Training Module

## Qik Start PICmicro Education Board Plus CAN (P/N 905172/905174)

Instruction Manual



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## 1 Overview

The ***Qik Start PIC Education Board plus CAN*** is designed to assist students with the hands-on portion of learning Microcontrollers. The Board is designed around the *Microchip Technologies Inc. PIC16F874/PIC18F442 Microcontroller*. Its features include the following:

- On-board power supply, a 40 pin Zero Insertion Force (ZIF) socket for the PIC Microcontroller
- 7.3728 MHz crystal for its clock
- All non dedicated PIC ports brought out to connecting pads
- CAN2.0B Port
- 16 momentary push buttons
- Two potentiometers
- Eight LEDs with limiting resistors
- 2 x16 LCD display
- An encoder emulator (with up/down buttons)
- Temperature sensor
- RS-232 interface
- In-Circuit Debugger (ICD) interface

All microcontroller pins are easily accessible.

Used as a stand-alone unit or as a part of larger projects, this module provides development systems/components to support experiments and the total lab environment.

## 2 Power Sources

The ***Qik Start PIC Education Board plus CAN*** operates on a DC supply that can deliver 7 to 12 VDC at 100 ma. Input power is regulated down to +5VDC for all supplies to the on-board circuits.

### 2.1 AC Power Pak

A Power Pak (DE option # 905530) is available for connection into J1 to provide continuous power to the module. Output is 9–12 VDC at 200 ma. The center pin of J1 is positive (+) and the outer shell is negative (-).

### 2.2 Battery Power Source

A 9V Panasonic #006PNX battery (or equivalent) installed in the BAT1 connector can be used to power the board.

### 2.3 DC Power Source

Between 7 and 12 VDC can be supplied to the board by connecting power to J1. The center pin of the connector is positive (+) and the outer shell is negative (-)



### 3 Microcontroller

This board supports either the PIC16F874 or PIC18F442. These are 8-bit CMOS Flash microcontrollers manufactured by Microchip Technology Inc. For information about writing software for, loading programs into and erasing this device, please refer to the Microchip data sheets and support documents which can be obtained directly from Microchip at [www.microchip.com](http://www.microchip.com). A complete programming development environment (MPLAB IDE) can be downloaded at no charge from the Microchip web site.

**\*\*\*\*WARNING\*\*\*\***

**Power Switch S17 must be in the OFF position before you raise the lever on the microcontroller socket (U3) or you may damage the part.**

#### 3.1 Removing the Microcontroller

To remove the microcontroller (U3) turn off Power Switch S17 and lift the lever located near pin 1 of the microcontroller to the vertical position. Lift the microcontroller out of the socket, keeping it level to the surface of the board until all pins have cleared the socket. The microcontroller should lift out with no resistance. If you encounter resistance, reset the lever to horizontal and then back to the vertical position. You should never need a tool to lift out the microcontroller!

#### 3.2 Installing the Microcontroller

To install the microcontroller turn off Power Switch S17 and lift the lever on microcontroller socket in the vertical position. Insert the microcontroller into the socket (U3). Verify that Pin 1 is located in the correct hole and that all pins are placed into all the appropriate holes. Lower the lever 90 degrees into the horizontal position. You should never have to force the microcontroller into the socket!

**\*\*\*\*WARNING\*\*\*\***

**Never apply power unless the lever on U3 is in the horizontal position or you will damage the microcontroller.**

### 4 Oscillator (OSC)

The OSC signal, as supplied by Diversified Engineering, is developed from an on-board crystal (X1) running at 7.3728MHz.

### 5 MCLR (Reset) Push Button

The MCLR or Master Clear Reset (S14) button is available on the module to manually reset the Microcontroller. The MCLR button is interconnected to VDD (+5V) via a 47K resistor.

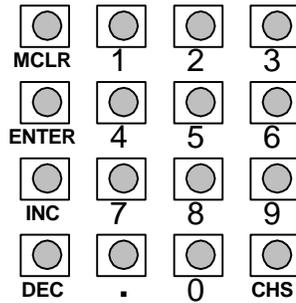
### 6 Enter Push Button

The *Enter* button (S13) is connected across GND and Pin RE2 of the microcontroller and has a 10K resistor to +5VDC. Pressing the *Enter* button brings RE2 to GND. See Schematic.



## 7 Push-button Switches (S1 – S12)

There are 12 momentary N.O. push-button switches (S1-S12) available to the designer. These switches are arranged in keyboard fashion and wired in a matrix of three columns and four rows. (See Schematic for details.) Microcontroller pins RA2, RA4, and RA5 are the driven multiplex output lines (low is a select) to each of the four rows of switches.



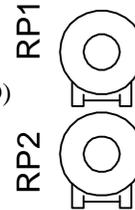
RB1, RB2, RB3 and RB4 are the input lines (pulled high via internal pull-up resistor) of the three columns. Pressing a switch produces a multiplexed output causing the input to go low on its corresponding line.

### \*\*\*\*NOTE\*\*\*\*

**Since RB1, RB2, RB3 and RB4 can also be used to drive the LCD display, the software should disable the keyboard inputs when writing to the LCD.**

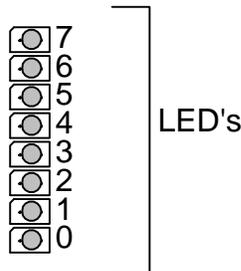
## 8 Potentiometers (RP1-RP2)

There are two adjustable potentiometers available on the board for control. Each generates an analog 0-5 V signal directly into the microcontroller A/D ports RA0 and RA1. The potentiometers are 5K ohm. Their ends are tied to the +5VDC (VDD) and GND (circuit common). Rotating the potentiometer clockwise increases the voltage at its wiper from approximately 0 to 5 VDC.



## 9 LED Indicators (LED0 – LED7)

There are eight LED indicators available on the board. The cathodes are tied to GND (circuit common) and the anodes are connected through a 1K resistor to PORT D pins 0 - 7 respectively.





## 10 LCD Display (LCD1)

There is a single 2- x 16-character LCD display on the board, with each character a 5x7 dot matrix (FEMA # CG1621-SGR1). The LCD is bus-driven with two 4-bit words output on the microcontroller pins RB1, RB2, RB3, and RB4. RE0 is used for Data/Command select and RE1 is used for Signal enable.

RP1= 0	RP1= 126
temp= 78	key=

Chart 2 gives a brief description of each of the controlling pins. Please refer to the schematic located in the Appendix for further clarification of the hardware interface.

**Chart 2**

Signal	I/O	Function
RS	I	L: Instructs register (for Write), Busy flag/Address counter (for Read) H: Data Register (for Read & Write)
E	I	Starts Data for Read or Write
DB4	I/O	Bi Directional tristate data bus pin (lsb)
DB5	I/O	Bi Directional tristate data bus pin.
DB6	I/O	Bi Directional tristate data bus pin.
DB7	I/O	Bi Directional tristate data bus pin (msb).

To assist in programming and displaying information, extracts of the data sheet for the LCD display are available in the Appendix. This display uses a Fujitsu FCS2314AK LCD controller and is comparable to the Hitachi HD44780U LCD controller. For an extensive data sheet on this controller, visit

[www.diversifiedengineering.net /Standard Products/Embedded Controller/Education Board/Support Info](http://www.diversifiedengineering.net/Standard%20Products/Embedded%20Controller/Education%20Board/Support%20Info) and look for the appropriate PDF file.

You can reach FEMA, the manufacturer of the LCD, by phone at 800-292-3362 or by e-mail at [fema@femacorp.com](mailto:fema@femacorp.com).

## 11 Temperature Sensor (U4)

A temperature-sensing integrated circuit (U4) is located on the board for experimental use. It is a Microchip device TC1047A and it outputs an analog signal proportional to temperature. After amplification the temperature is input into the microcontroller on pin AN3. See Schematic.



## 12 Encoder Emulator (U1)

When the CAN<-> ENCODER jumper is in the ENCODER position, pin 3 of U8 is connected to RC0 and pin 4 of U8 is connected to RB0. U8 is used to simulate an encoder whose output is two square waves with a 90-degree phase shift. Pressing button INC (S16) causes the signal on Pin 4 to lead the signal on Pin 3 of U8. (See Schematic) Pressing button DEC (S15) causes the signal on Pin 4 to lag the signal on Pin 3 of U8.

## 13 Bread-Boarding Area

There is an area near the power supply that has a series of holes providing a space for bread boarding custom circuits. These holes are .040" plated through on a 0.1" x 0.1" matrix. Within this area are holes tied to +5 VDC (Vdd) . Another set of holes is tied to GND (circuit common) . For ease of instrument connection, a ground (GND) terminal post is located to the left center of the board .

### 13.1 Connecting Pads

You can connect the microcontroller to various other circuits easily by interconnecting to its pins using J5 and J6, which are available for soldering wires. You can also install a standard connector (2x10, 0.1" center), available from Samtec (SSW-110-01-T-D) and other manufacturers. (See Schematic for details of pin configuration.)

## 14 Source Code Utility

A source code utility for the PIC16F874 or the PIC18F442 is available to help support experiments with the Qik Start PIC Education Board plus CAN. This can be downloaded from our web site at [www.diversifiedengineering.net](http://www.diversifiedengineering.net).

Routines for interfacing with Serial port, LCD display, 4x4 matrix keypad, A/D and others are included in the utility code. Please feel free to download and use this code for *Qik Start*-ing your project.

## 15 Serial Port

The RS-232 signal connects through the DB-9 connector (J3) and is converted through the MAX 232 integrated circuit. The signal is then received on RC7 and transmitted on RC6 of the microcontroller. (See Schematic) The DB-9 pin-out configuration is shown in Chart 3.

The microprocessor Universal Asynchronous Receiver Transmitter (UART) can be configured to interface with either RS232 or RS422 driver/receiver.

### 15.1 13.2 Serial control options:

Position	Option
1	PIC UART to RS-232 Driver (DB9 J3)
2	PIC UART to RS-422 Driver (J4)
3	RS-232 (DB9, J3) to RS-422 (J4)



UART  
JUMPERS



## 15.2 13.3 RS232 / RS422 Connections:

### RS-232 (J3)

Pin	Function
1	Open
2	Transmit
3	Receive
4	Connected to 6
5	Circuit Common
6	Connected to 4
7	Connected to 8
8	Connected to 7

### RS-422

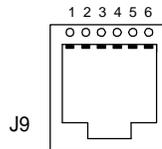
Pin	Function
1	GND
2	A
3	B
4	Z
5	Y
6	Connection

## 16 In-circuit Debugger (ICD) Interface

Each *Qik Start PIC Education Board plus CAN* has circuitry for built in access to connector ICD that permits interfacing the ICD Module for emulation capability to a PC. The wiring configuration of J2 is shown in Chart 4.

Chart 4

Pin (RJ)	Connection Point
6	Nc
5	RB6
4	RB7
3	Gnd
2	+5V
1	MCLR



Programming, reprogramming and in-circuit debugging require the use of an In-Circuit-Debugger Module (ICD). This must be purchased separately. (905502) A complete programming development environment (MPLAB IDE) can be downloaded at no charge from the Microchip web site. [www.microchip.com](http://www.microchip.com)



## 17 CAN Port

CAN-NET (Controller Area Network) is a two-wire serial communication protocol that supports distributed real time control.

**\*\*\*\*NOTE\*\*\*\***

**Node boards and an array of digital and analog I/O boards are available at our web site at [www.diversifiedengineering.net](http://www.diversifiedengineering.net)**

By placing the “CAN<-> ENCODER” jumper in the CAN position the *CAN port* provides a means of communication between the Education Board plus CAN and remote nodes. The CAN Education board can control up to four nodes at one time allowing reading and writing through a CAN bus with the provided harness. A variety of node board options are available at [www.diversifiedengineering.net](http://www.diversifiedengineering.net).

### 17.1 The Node Board (905186)

**18.1.1** The Node Board is designed around the Microchip PIC16F873 microcontroller and MCP2510 CAN controller.

**18.1.2** The Node Board provides an interface between the *CAN Education Board* and the I/O board. Its features include:

- 4 Mhz crystal for controlling the PIC16F873
- 16 Mhz crystal for controlling the MCP2510
- PIC16F873 reset switch (S1 RST)
- In circuit debugger module connector (ICD)
- 15-pin connector for interfacing with the I/O (J3)
- 4-position DIP switch for selecting input and output IDs (S4)
- Two 4-pin MTA headers (J1, J2) for CAN bus interfacing with a terminating jumper (J4) for the last node in the system.

### 17.2 I/O Board (905187)

**18.2.1** The I/O board provides digital and analog inputs and outputs to the Node Board.

The form of the inputs and outputs to the Node Board is:

- two analog inputs -- 5k potentiometer (RP1) and photocell (CDS)
- one analog output (LAMP)
- one digital input (S1)
- one digital output (LED1)



### 17.3 Interconnection and Initial Power-up

The CAN-NET Education Board Kit is supplied as four separate components:

- CAN-NET Education Board
- Node Wiring Harness
- CAN-NET Node Board
- CAN-NET I/O Board

### 17.4 To interconnect the node and the I/O boards:

- Ensure that switch S17 is in the off position
- Connect one end of the harness to J2 of the CAN-Net Education Board.
- Connect the other end to J1 of the CAN-Net Node Board.
- Insure the CAN-Net I/O Board is connected to the Node board through the 15 pin connector

**\*\*\*WARNING\*\*\***

**To prevent circuit pins from shorting out, avoid placing boards on metal or conductive surfaces.**

## 18 CAN Net Software System Overview

### 18.1 CAN ID Structure

CAN messages are transmitted with an ID to identify them. They are received based on a match between the Mask/Filter settings in the 2510 chip and the message ID. In this implementation, the extended ID is not used and all IDs are assumed to be 11 bits. The code that is shipped with the CAN ED system further assumes that all IDs have the form 0xnm0 where nm is between 0x00 and 0x32 Note that the form used to specify IDs is a 12-bit representation with the ID shifted left into the msb of the 12-bit word. In other words, the lsb is always 0 and is not part of the ID.

### 18.2 Software

#### 19.2.1 Programming Style

The code for the CAN Ed and Node boards is written in the PIC instruction set to be assembled using MicroChip's MPLAB environment. There is significant use of macros to make the code more readable and less error prone. The macros are defined in three places:

- near the top of the main file
- in the CANLIB.ASM file for CAN macros
- in the MACROS16.INC file.

Any unrecognized instructions encountered in the code are probably macros. The macros in MACROS16.INC have been used extensively in writing code for PICs to increase readability and reduce programming errors.



## 18.3 Common Code

The CAN ED board and the Node board share several common software files. The routines that provide communication with the 2510 CAN chip are in the file CANLIB.ASM and definitions of 2510 registers are in MCP2510.INC. Common macros are in MACROS16.INC.

Communications with the MCP2510 chip is over the SPI bus. The PICs used on the Node board and the CAN Ed board fully support SPI in the master mode. Command strings are sent and received using a single software buffer. To send a string, the software buffer, called pSPIBufBase, is loaded with the bytes to send and the SPI interrupt is turned on. The interrupt handler exchanges bytes with the 2510. The bytes received from the 2510 replace the bytes that were sent from the software buffer so that after the string has been sent the buffer will contain the bytes received from the 2510. All communication with the 2510 is handled in this manner and is encapsulated in the routines in CANLIB.ASM.

## 18.4 CAN-NET Education Board

### 18.4.1 Software Default ID Structure

The CAN Ed Board code uses these default settings:

RxMask0 0xFFFF	RxFilter0 0xFFF	RxFilter1 0xFFF
RxMask1 0xFFE	RxFilter2 0x000	RxFilter3 0x100
	RxFilter4 0x200	RxFilter5 0x300

The potentiometer labeled RP3 is permanently assigned an ID of 0x000. It is measured and transmitted with that ID every 300 mS as a two-byte integer in the range 0 to 4095. Note that the A/D measurement is eight bits which are then left-shifted by four bits before transmission. As a result, the actual range is 0x0000 to 0x0FF0.

### 18.4.2 General

The CAN Ed board must be connected to at least one operating Node board or it will not function. If pressing a numerical key on the keypad doesn't change the display then the CAN network is not operating. This means that the transmitted message is not being acknowledged; the CAN Ed program is hung resending the message and waiting for an acknowledgment.)

### 18.4.3 Keypad

The keypad is used to select the ID to be displayed. An ID is entered with two key strokes. The first entry selects the "n" for the ID 0xnm0 and the second selects the "m." Note that an ID is displayed and entered as a hex number but the keypad does not contain the hex digits A through F. This restricts the range of IDs that can be selected using the keypad, but the IDs assigned to the various inputs and outputs do not require these hex digits.

When a new ID is entered by the keypad it replaces the ID that is in RxFilter2 regardless of its value or the values in the other filters. This is of concern only when the CAN Ed board is connected to the PC. As described below, the PC program will display all the messages accepted by the CAN Ed board's RxFilters. As a result, changing the value in the RxFilter2 can affect which messages are displayed on the PC.

### 18.4.4 LCD

The currently selected ID is displayed along with the most recent message received. The message is assumed to be a two-byte integer with the least significant byte sent first. It is displayed as a decimal number. If no message is received with the selected ID within 1.4 seconds, the previously displayed value is replaced by blanks.



## 18.4.5 PC Communications

There is a 115,200 kbaud PC interface that uploads to the PC all messages that match the RxMask/RxFilter values. It allows the PC operator to put messages onto the CAN bus with any ID and with any number of data bytes up to the CAN limit of 8. The PC program can also be used to change the RxMask and RxFilter values of the CAN Ed board.

## 18.5 Node Board Software

### 18.5.1 General ID Structure

The ID structure used by the Node boards is determined by the DIP switch settings on power-up or after a board reset. Changing the DIP settings while running will have no effect.

### 18.5.2 Receive ID Structure

The Node board uses these settings for receiving:

RxMask0	0xFFFF	RxFilter0	0xFFFF	RxFilter1	0xFFFF
RxMask1	0xFFE	RxFilter2	0xn00	RxFilter3	0xn10
		RxFilter4	0xFFFF	RxFilter5	0xFFFF

where 0xn00 is the Base Receive ID for receiving and is derived from the DIP Swt #1 and DIP Swt #2 as follows:

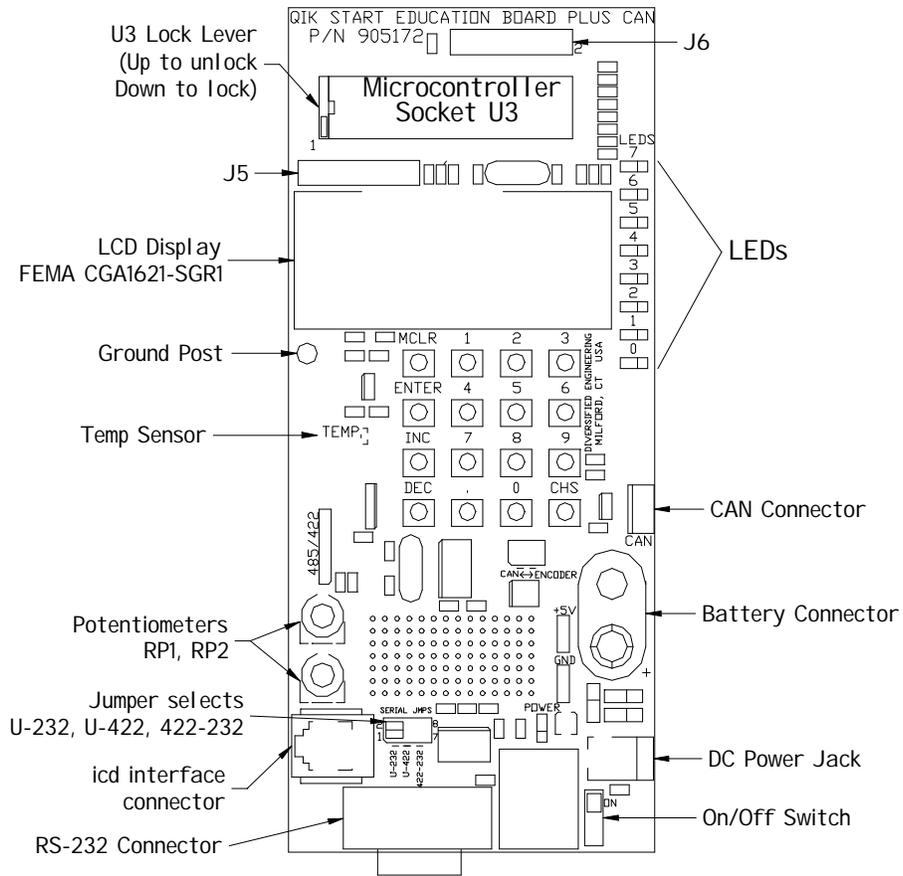
<b>Swt:</b>	<b>1</b>	<b>2</b>	<b>ID</b>
	0	0	0x000
	0	1	0x100
	1	0	0x200
	1	1	0x300

A message received for RxFilter2, the Base Receive ID, is assumed to be a two-byte integer that contains a 12-bit value, that is, a value between 0 and 4095. The 12-bit data is used to generate a PWM output where a value of 0 gives a zero duty cycle, and 0xFFF generates a 100% duty cycle. The PWM output drives the lamp whose output is proportional to the duty cycle.

The ID associated with RxFilter3, Base Receive ID + 0x010, is assumed to be a two-byte integer containing 12-bit data. The data is interpreted as a logical value where a value in the range 0 to 0x7FF is a logic 0, and a value in the range 0x800 to 0xFFFF is a logic 1. The logic value is placed on the PIC output pin RB2 which is not connected to any output device in this model.



## Appendix A Board Layout





## Appendix B LCD Character Set

Upper Lower		Lower															
		0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
0000	*1	á		0	Q	P	'	P	_	á		—	9	E	o	P	
0001	*2	À	!	1	A	Q	a	A	_	A	#	7	+	¿	á	Q	
0010	*3	\	"	2	B	R	b	r	_	火	°	4	W	Y	2	0	
0011	*4	€	#	3	C	S	c	s	_	*	¡	ó	í	E	E	*	
0100	*5	Ä	*	4	D	T	d	t	_	*	\	í	í	†	W	o	
0101	*6	ı	%	5	E	U	e	u	_	金	*	†	†	ı	ı	U	
0110	*7	*	%	6	F	V	f	v	_	上	°	°	ı	ı	ı	ı	
0111	*8	*	'	7	G	W	g	w	_	*	°	†	†	†	†	†	
1000	*1	€	(	8	H	X	h	x	_	上	°	°	ı	ı	ı	ı	
1001	*2	ø	)	9	I	Y	i	y	_	下	°	†	ı	ı	ı	ı	
1010	*3	é	*	:	J	Z	j	z	_	上	°	ı	ı	ı	ı	ı	
1011	*4	é	+	;	K	C	k	c	_	上	°	ı	ı	ı	ı	ı	
1100	*5	ù	,	<	L	*	ı	ı	_	上	°	ı	ı	ı	ı	ı	
1101	*6	ò	—	=	M	I	m	i	_	上	°	ı	ı	ı	ı	ı	
1110	*7		.	>	N	^	n	^	_	上	°	ı	ı	ı	ı	ı	
1111	*8		/	?	O	_	o	+	_	上	°	ı	ı	ı	ı	ı	



## Appendix C LCD Instruction Set

Instruction	Code										Description	Execution Time (max) (when $f_{cp}$ or $f_{osc}$ is 270 kHz)	
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0			
Clear display	0	0	0	0	0	0	0	0	0	0	1	Clears entire display and sets DDRAM address 0 in address counter.	
Return home	0	0	0	0	0	0	0	0	0	1	—	Sets DDRAM address 0 in address counter. Also returns display from being shifted to original position. DDRAM contents remain unchanged.	1.52 ms
Entry mode set	0	0	0	0	0	0	0	1	I/D	S		Sets cursor move direction and specifies display shift. These operations are performed during data write and read.	37 $\mu$ s
Display on/off control	0	0	0	0	0	0	1	D	C	B		Sets entire display (D) on/off, cursor on/off (C), and blinking of cursor position character (B).	37 $\mu$ s
Cursor or display shift	0	0	0	0	0	1	S/C	R/L	—	—		Moves cursor and shifts display without changing DDRAM contents.	37 $\mu$ s
Function set	0	0	0	0	1	DL	N	F	—	—		Sets interface data length (DL), number of display lines (N), and character font (F).	37 $\mu$ s
Set CGRAM address	0	0	0	1	ACG	ACG	ACG	ACG	ACG	ACG		Sets CGRAM address. CGRAM data is sent and received after this setting.	37 $\mu$ s
Set DDRAM address	0	0	1	ADD		Sets DDRAM address. DDRAM data is sent and received after this setting.	37 $\mu$ s						
Read busy flag & address	0	1	BF	AC		Reads busy flag (BF) indicating internal operation is being performed and reads address counter contents.	0 $\mu$ s						
Write data to CG or DDRAM	1	0	Write data									Writes data into DDRAM or CGRAM.	37 $\mu$ s $t_{ADD} = 4 \mu\text{s}^*$
Read data from CG or DDRAM	1	1	Read data									Reads data from DDRAM or CGRAM.	37 $\mu$ s $t_{ADD} = 4 \mu\text{s}^*$

I/D = 1: Increment  
 I/D = 0: Decrement  
 S = 1: Accompanies display shift  
 S/C = 1: Display shift  
 S/C = 0: Cursor move  
 R/L = 1: Shift to the right  
 R/L = 0: Shift to the left  
 DL = 1: 8 bits, DL = 0: 4 bits  
 N = 1: 2 lines, N = 0: 1 line  
 F = 1: 5 x 10 dots, F = 0: 5 x 8 dots  
 BF = 1: Internally operating  
 BF = 0: Instructions acceptable

DDRAM: Display data RAM  
 CGRAM: Character generator RAM  
 ACG: CGRAM address  
 ADD: DDRAM address  
 (corresponds to cursor address)  
 AC: Address counter used for both DD and CGRAM addresses

Execution time changes when frequency changes  
 Example:  
 When  $f_{cp}$  or  $f_{osc}$  is 250 kHz,  
 $37 \mu\text{s} \times \frac{270}{250} = 40 \mu\text{s}$

Note: — indicates no effect.

\* After execution of the CGRAM/DDRAM data write or read instruction, the RAM address counter is incremented or decremented by 1. The RAM address counter is updated after the busy flag turns off.



## Limited Warranty

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