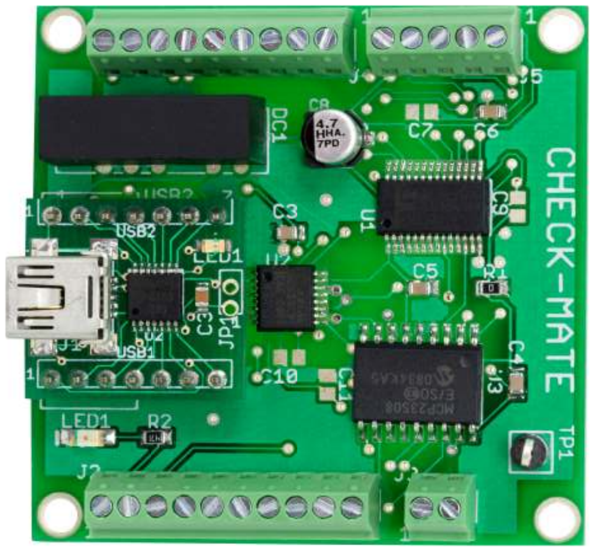
EMBEDDED TEST SOLUTIONS

CHECK-MATE

Multifunction DAQ Module



USER'S MANAUAL

overton INSTRUMENTS

Overton Instruments, Inc
5431 Auburn Blvd. #196
Sacramento, CA 95841
www.microATE.net

NOTICE

The information contained in this document is subject to change without notice. To the extent allowed by local law, Overton Instruments (OI), shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material. No part of this document may be photocopied, reproduced, or translated to another language without the prior written consent of OI.

WARNING

The instrument you have purchased and are about to use may NOT be an ISOLATED product. This means that it may be susceptible to common mode voltages that could cause damage to the instrument. SUCH DAMAGE IS NOT COVERED BY THE PRODUCT'S WARRANTY. Please read the following carefully before deploying the product. Contact OI for all questions.

WARRENTY

OI warrants that this instrument will be free from defects in materials and workmanship under normal use and service for a period of 90 days from the date of shipment. OI obligations under this warranty shall not arise until the defective material is shipped freight prepaid to OI. The only responsibility of OI under this warranty is to repair or replace, at it's discretion and on a free of charge basis, the defective material. This warranty does not extend to products that have been repaired or altered by persons other than OI employees, or products that have been subjected to misuse, neglect, improper installation, or accident. OVERTON INSTRUMENTS SHALL HAVE NO LIABILITY FOR INCIDENTAL OR CONSEQUENTIAL DEMAGES OF ANY KIND ARISING OUT OF THE SALE, INSTALLATION, OR USE OF ITS PRODUCTS.

SERVICE POLICY

1. All products returned to OI for service, regardless of warranty status, must be on a freight-prepaid basis.
2. OI will repair or replace any defective product within 10 days of its receipt.
3. For in-warranty repairs, OI will return repaired items to buyer freight prepaid. Out of warranty repairs will be returned with freight prepaid and added to the service invoice.

Table Of Contents

1.0 INTRODUCTION 4

1.1 Overview 4

1.2 Highlights 5

1.3 Specifications 6

2.0 DESCRIPTION 7

2.1 Board Layout 7

2.2 Connections 8

2.3 J6 Consolidated 9

3.0 OPERATION 10

3.1 Embedded Control 10

3.1.1 Embedded Configuration 11

3.1.2 Embedded Programming 12

3.1.3 Embedded Program Example 13

3.2 PC Control 14

3.2.1 PC Programming 15

3.2.1.1 HyperTerminal 15

3.2.1.2 Virtual Instrument Panel 16

3.2.1.3 PC Programming Example 17

APPENDIX A. SERIAL COMMAND SET 18

APPENDIX B. SCHEMATIC 20

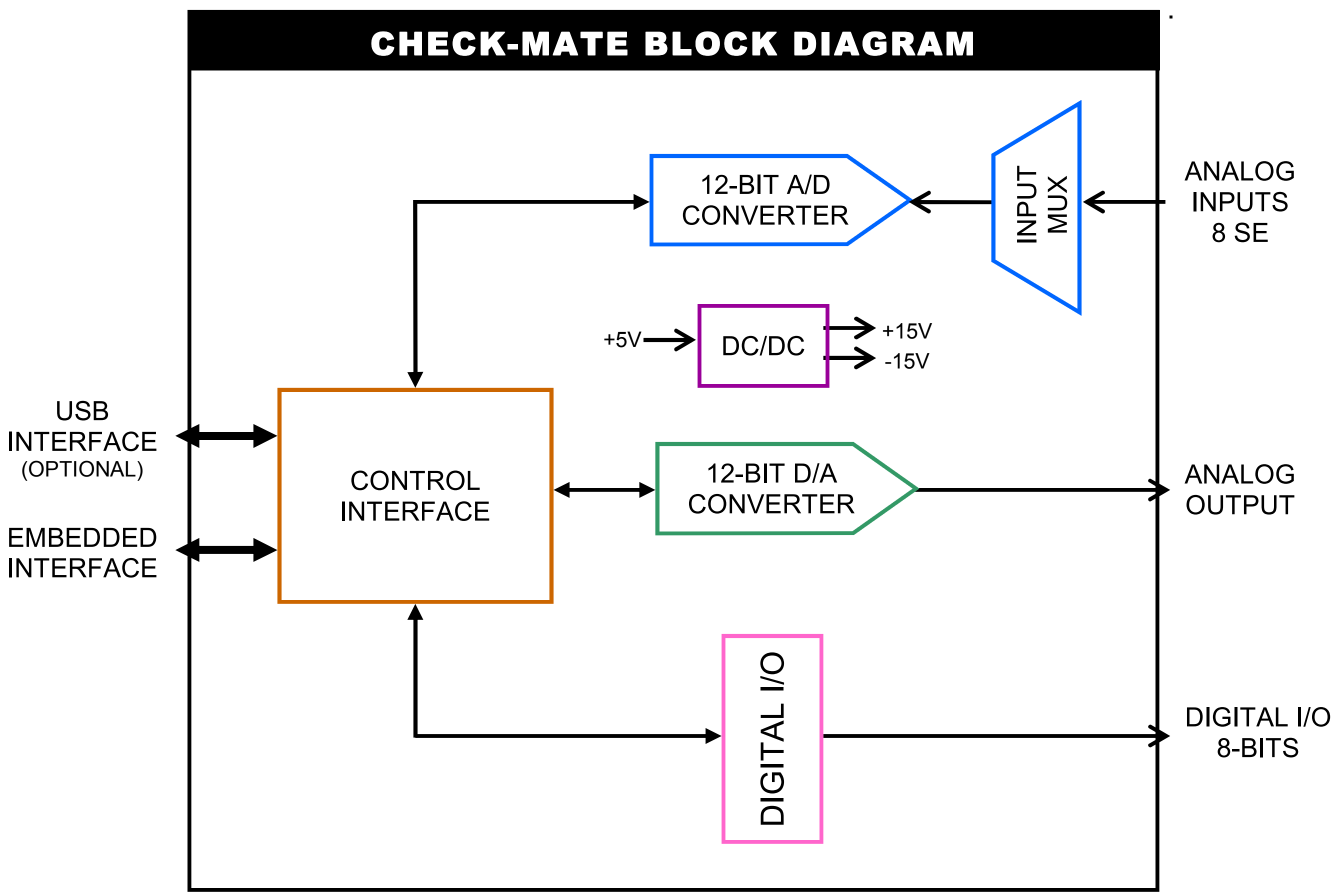
APPENDIX C. MECHANICAL DIMENSIONS 21

1. Introduction

1.1 Overview

The Check-MATE has all the primary features you expect in a general purpose data acquisition board, but for a fraction of the cost. It offers 8 single-ended analog inputs with 12-bit resolution (and a sampling rate of 110KHz). Each of the analog inputs can be programmed for unipolar or bipolar operation. Likewise, the analog output uses a 12-bit DAC (and operates in unipolar or bipolar modes). In addition, there are 8 digital input/output lines (which are independently programmable).

The Check-MATE is made available is two versions, a standard model or with a USB option. The standard model is designed for embedded applications and provides a simple SPI-bus interface for control by a external microcontroller. With the USB option, many test solutions can be quickly built by connecting the Check-MATE to a PC laptop or desktop, and then running our GUI software. No external power source is required, since power is supplied through the USB interface. Any either case, easy access to the hardware is made available through a convenient collection of screw terminal connectors.



1.2 Highlights

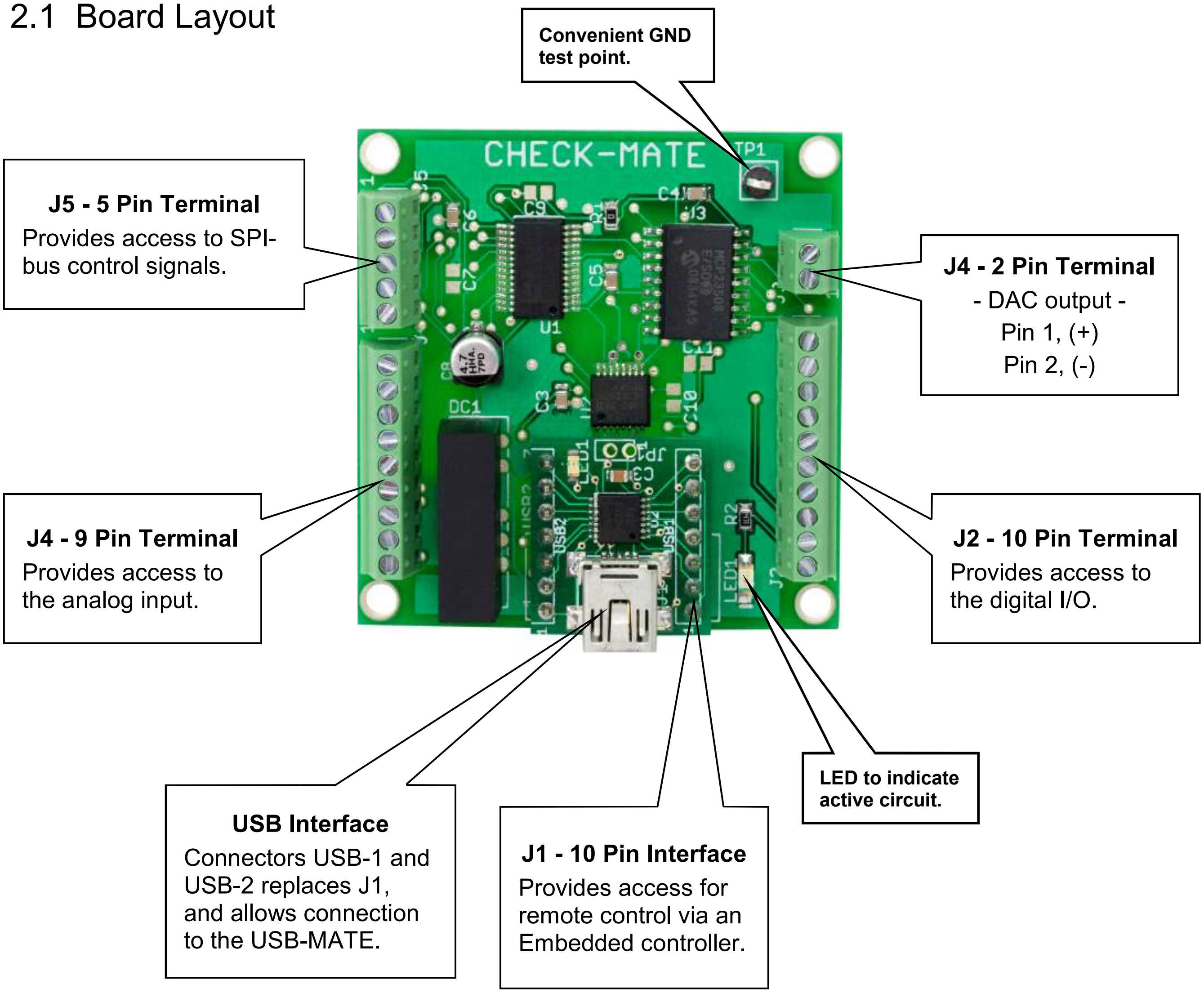
BENEFITS	APPLICATIONS	FEATURES
• A flexible, low-cost alternative to expensive PC-based DAQ cards • Supports a wide-array of mix-signal test applications • Great for embedded solutions - place inside mechanical test fixtures, instrument boxes or rack-mount enclosures	• Burn-In • Engineering • Depot Repair • Production Test • QA/QC Quality Control • OEM Test Instruments	• 8-Analog Input Channels (SE), 12-bit Resolution, 110Khz sample rate • 1-Channel, Digital-to-Analog converter, 12-bit Resolution, Unipolar/Bipolar modes • 8 Digital Input/Output Bits, Independently programmable • USB or embedded control interface • Low Cost • Compact size, a 2.5" x 2.5" PCB, with four #4 mounting holes in each corner (spacers and hardware included)

1.3 Specifications

Analog Inputs	
Number of inputs	8 12-bit, single-ended
Input Ranges	0-5V, 0-10V, ±5V, ±10V
Max Sample Rate	110KHz
Nonlinearity	±1LSB, no missing codes
Analog Output	
Resolution	12-bit
Range	0-10V, ±10V
Current	±5mA max
Settling Time	4uS max to ±1/2 LSB
Relative Accuracy	±1 LSB
Digital I/O	
Number of lines	8 bits, bidirectional
Logic Levels	TTL compatible
Input Control	
Embedded	SPI-bus & control logic
USB Interface	Optional USB module
General	
Power Supply	+5VDC±10%@3mA
Operating Temp	0-50ºC
Dimensions	1.5" x 1.5"

2. I/O Description

2.1 Board Layout



2.2 Connections

J1			
Pin	**Name**	**Dir.**	**Description**
1	VCC	→	A regulated +5Vdc input . Current should be limited to roughly 100mA.
2	SCLK	→	Part of a 3-wire SPI-Bus, SCLK synchronizes the serial data transfer for the DIN and DOUT signals.
3	ADC_CS\	→	A TTL active-low "input' signal that provides a chip-select for the ADC.
4	DIN	→	Part of a 3-wire SPI-Bus, DIN is serial command and control data for the, ADC, DAC and DIO cir-cuits.
5	DAC_CS\	→	A TTL active-low "input' signal that provides a chip-select for the DAC..
6	DOUT	←	Part of a 3-wire SPI-Bus, DIN is serial command and control data for the, ADC, DAC and DIO cir-cuits.
7	DIO_CS\	→	A TTL active-low "input' signal that provides a chip-select for the DIO.
8	UNI/BIP\	→	A TTL active-low "input' signal that determines unipolar (1), bipolar (0).
9	DGND	→	Digital Ground
10	INT	←	A TTL active-high "input' signal that indicates a interrupt from the DIO.

J3			
Pin	**Name**	**Dir.**	**Description**
1	DAC-OUT	←	Voltage Output
2	AGND	←	Analog Ground

J2			
Pin	**Name**	**Dir.**	**Description**
1	VCC	←	+5V Power
2	DIO-0	←→	Bit 0
3	DIO-1	←→	Bit 1
4	DIO-2	←→	Bit 2
5	DIO-3	←→	Bit 3
6	DIO-4	←→	Bit 4
7	DIO-5	←→	Bit 5
8	DIO-6	←→	Bit 6
9	DIO-7	←→	Bit 7
10	DGND	←	Digital Ground

J4			
Pin	**Name**	**Dir.**	**Description**
1	AI-0	→	Input CH 0
2	AI-1	→	Input CH 1
3	AI-2	→	Input CH 2
4	AI-2	→	Input CH 3
5	AI-4	→	Input CH 4
6	AI-5	→	Input CH 5
7	AI-6	→	Input CH 6
8	AI-7	→	Input CH 7
9	AGND	→	Analog Ground

J5			
Pin	**Name**	**Dir.**	**Description**
1	VCC	←	+5V Power
2	SCLK	→	Part of a 3-wire SPI-Bus. Use with DIO for possible external control
7	DIN	→	Part of a 3-wire SPI-Bus. Use with DIO for possible external control
9	DOUT	←	Part of a 3-wire SPI-Bus. Use with DIO for possible external control
10	DGND	→	Digital Ground

2.3 J6 Consolidated

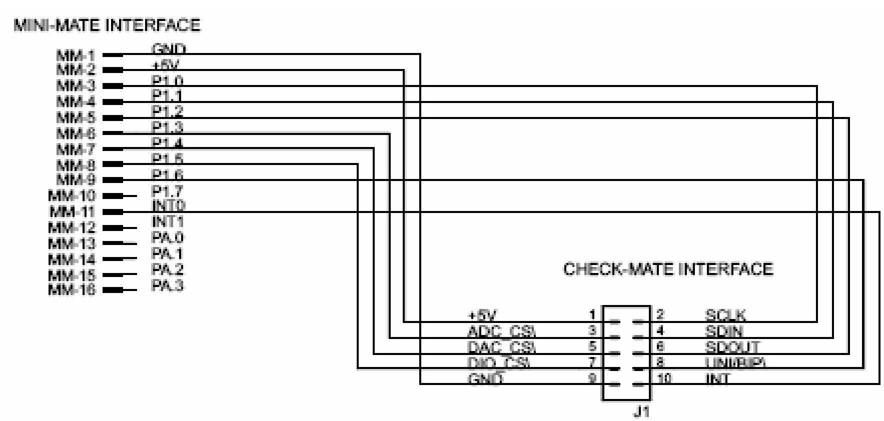
J6			
Pin	**Name**	**Dir.**	**Description**
1	VCC	←	+5V Power
2	DIO-0	←→	Bit 0
3	DIO-1	←→	Bit 1
4	DIO-2	←→	Bit 2
5	DIO-3	←→	Bit 3
6	DIO-4	←→	Bit 4
7	DIO-5	←→	Bit 5
8	DIO-6	←→	Bit 6
9	DIO-7	←→	Bit 7
10	DGND	←	Digital Ground
11	DAC-OUT	←	Voltage Output
12	AGND	←	Analog Ground
13	AI-0	→	Input CH 0
14	AI-1	→	Input CH 1
15	AI-2	→	Input CH 2
16	AI-2	→	Input CH 3
17	AI-4	→	Input CH 4
18	AI-5	→	Input CH 5
19	AI-6	→	Input CH 6
20	AI-7	→	Input CH 7

3. Operation

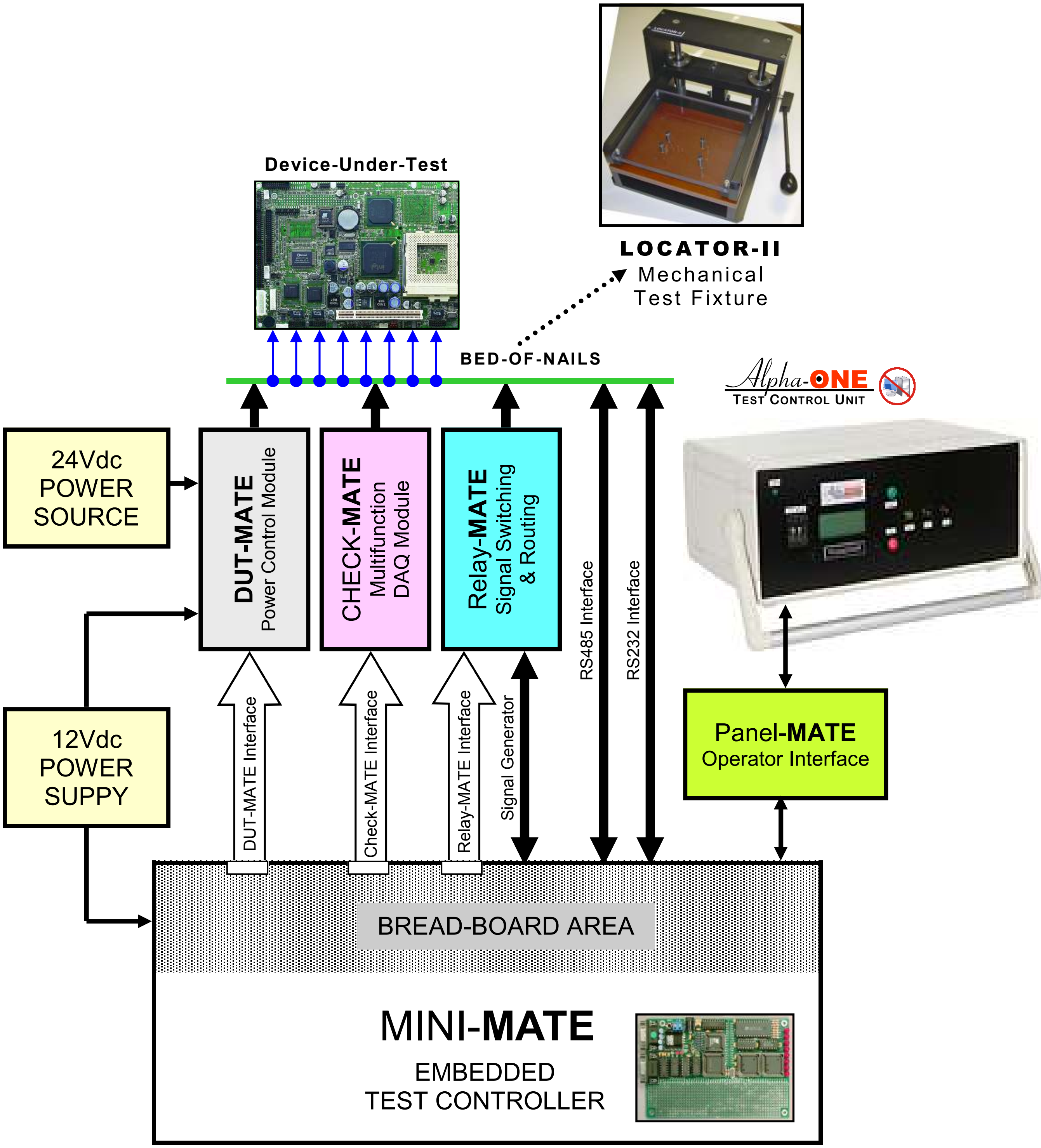
3.1 Embedded Control

In section 3.1.1 (on the next page), the Check-MATE is shown integrated with other ETS Series components that collectively form a complete Embedded Test Solution. The diagram shows the Check-MATE being driven by the Mini-MATE. The Mini-MATE is a low-cost "Embedded Test Controller", which stores a special program that is designed to exercise the device-under-test and generate Go/No-Go test results. The Mini-MATE also provides a sizable breadboard area to support the development of custom circuits. Adjacent to the breadboard area is a series of wire-wrap pins that comprise a goodly amount of general purpose Digital I/O. The schematic below shows the wire-wrap connections which create the interface between the Mini-MATE and the Check-MATE (J1, 10-pin header connector).

Actually the Check-MATE can be easily driven by most microcontrollers (including an ARM, AVR, PIC or even a STAMP). When developing an interface for the Check-MATE, it is recommended the designer start-by reviewing the interface requirements as outlined in the J1 Table (which is provided in the I/O Description section). The next step is to review the Check-MATE schematic, which is provided in Appendix A. What could be the most challenging aspect of the design effort is controlling the SPI-bus devices. The Check-MATE contains 3 SPI-bus devices which include an ADC, DAC and DIO circuits. The ADC is a 12-bit 8-channel data acquisition chip from Maxim (part number MAX1270). The DAC is a 12-bit digit-to-analog converter from Maxim (part number MAX5312). The DIO is an 8-bit device from MicroCHIP (part number MCP230S08). Details for specific device performance and SPI-bus operation can be found in their respective data sheets. Go to the manufacturers website to download said documents.



3.1.1 Embedded Configuration



3.1.2 Embedded Programming

To build-on the PCB board test example (shown in section 3.1.1), we have constructed a demo program using BASCOM. BASCOM is a BASIC language compiler that includes a powerful Windows IDE (Integrated Development Environment), and a full suite of "QuickBASIC" like commands and statements. The demo program (which is outlined in section 3.2.3), illustrates the ease of controlling the Check-MATE via the Mini-MATE microcontroller.

The program starts by initialing the Mini-MATE for proper operation. You will note that the BASCOM software provides excellent bit-manipulation capabilities, as evident by the use of the ALIAS statement. The Mini-MATE (P1 port bits) are assigned unique label names (i.e., SCLK, DOUT), which are used to support various Check-MATE functions. In the "Main" program section, the Mini-MATE receives "high level" serial commands from a host PC, parses them and then executes accordingly. When (for example), the "CK_CS4" command is entered, the program selects analog channel number 4. And then when command "CK_AR1" is entered, the program selects the analog channel range (which is ±5Vdc). Finally, when the command "CK_RA?" is entered, the program call's subroutine "Chk_rd_adc(chk_adc_val , Chk_ch , Chk_adc_range)". This causes the Check-MATE to take an analog measurement and return the results in a 4 character hexadecimal "ASCII" string.

Independent of the microcontroller hardware or programming language you choose, the program sequence described above will likely resemble the way you implement your Check-MATE application. For this reason, we suggest that you go to our website and download the "Check-MATE.zip" file. In the Documents folder will contain more extensive examples of routines to control the Check-MATE.

3.1.3 Embedded Program Example

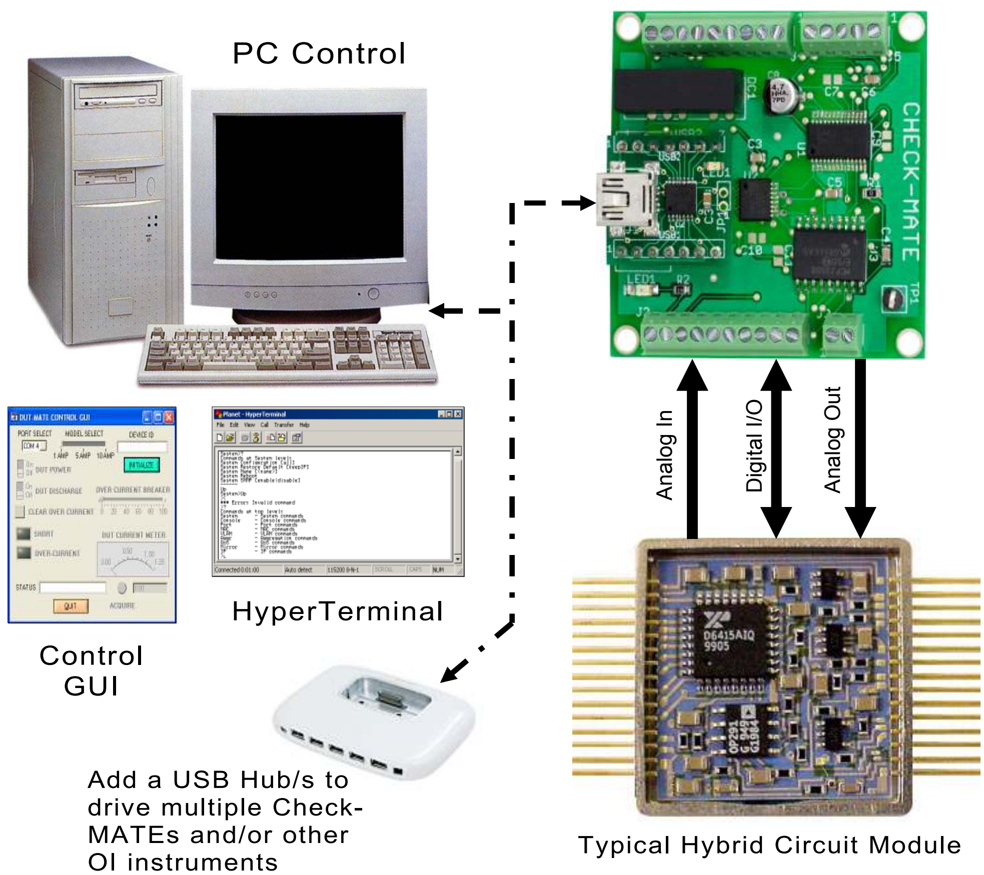
```
' Program: CHECK-MATE Demo
'
---[ Initialization ]----------------------------------------------------------
'
$large
$romstart = &H2000
$default Xram

Dim Chk_adc_word As Word
Dim Chk_adc_val As Single
Dim A_num, A_byte, A_cnt As Byte
Dim Chk_ch, Chk_adc_range, Chk_num, Chk_cnt, Chk_cntl-byte As Byte
Dim S As String * 10, A_resp AS String * 10, A_str AS String * 10
Dim Sf_str As String * 1, Sf_str AS String * 10
Dim A_word as Word
Dim A_val as Single
Dim True As Const 1
Dim False As Const 0

Sclk Alias P1.0                       ' SPI-bus serial clock
Dout Alias P1.1                       ' SPI-bus serial data output
Din Alias P1.2                        ' SPI-bus serial data input
Adc_cs Alias P1.3                     ' ADC chip select
Dac_cs Alias P1.4                     ' DAC chip select
Dio_cs Alias P1.5                     ' DIO chip select
Dac_mode Alias P1.6                   ' DAC mode, (1) unipolar, (0) bipolar

Declare Sub Print_ic                  ' print invalid command
Declare Sub Print_orr                 ' print out-of-range
Declare Sub Print_ur                  ' print under range
Declare Sub Print_ok                  ' print command is OK
Declare Sub Chk_rd_adc(chk_adc_val As Single , Chk_ch As Byte , Chk_adc_range As
Byte)

---[ Main ]----------------------------------------------------------
' In the Main the Operator or Host, is prompted to enter a command.  The command is
parsed and then executed if valid.  Only two command examples are  ' shown.

Set Sclk, Dout, Adc_cs, Dac_cs, Dio_cs, Dac_mode   ' Set to logic '1'

Do
  Input "Enter command " , S
  S = Ucase(s)
  A_resp = Left(s , 3)
  If A_resp = "CK_" Then
    A_resp = Mid(s , 4 , 2)
    Select Case A_resp

      Case "AR":                'Set ADC Range

        A_resp = Mid(s , 6 , 1)
        If A_resp = "?" Then
          If Chk_adc_range = Chk_adc_5v Then A_str = "0"
          If Chk_adc_range = Chk_adc_10v Then A_str = "1"
          If Chk_adc_range = Chk_adc_5v5v Then A_str = "2"
          If Chk_adc_range = Chk_adc_10v10v Then A_str = "3"
          Print "<" ; A_str ; ">"
          Print
        Else
          A_num = Val(a_resp)
          If A_num < 0 Or A_num > 3 Then
            Call Print_oor                    ' out-of-range
          Else
            If A_num = 0 Then Chk_adc_range = Chk_adc_5v
            If A_num = 1 Then Chk_adc_range = Chk_adc_10v
            If A_num = 2 Then Chk_adc_range = Chk_adc_5v5v
            If A_num = 3 Then Chk_adc_range = Chk_adc_10v10v
          End If
        End If

   Case "SC":                'Set ADC channel

        A_resp = Mid(s , 6 , 1)
        If A_resp = "?" Then
          A_str = Str(chk_ch)
          Print "<" ; A_str ; ">"
          Print
        Else
          A_num = Val(a_resp)
          If A_num < 0 Or A_num > 7 Then
            Call Print_oor                    ' out-of-range
          Else
            Chk_ch = A_num
          End If
        End If

      Case "RV":                ' read voltage

        A_resp = Mid(s , 6 , 1)
        If A_resp = "?" Then
          Call Chk_rd_adc(chk_adc_val , Chk_ch , Chk_adc_range)
          A_str = Str(chk_adc_val)
          Print "<" ; A_str ; ">"
          Print
        Else
          Call Print_ic         ' invalid command
        End If

      Case Else
          Call Print_ic             ' invalid command
        End Select
    Else
      Call Print_ic             ' invalid command
    End If
  Loop
End

'---[ Sub-Routines]----------------------------------------------------------
'
Sub Print_ic                  ' print invalid command
  Print "><"
End Sub

Sub Print_oor                 ' print out-of-range
  Print ">>"
End Sub

Sub Print_ur                  ' print under range
  Print "<<"
End Sub

Sub Print_ok' print command is OK
  Print "<>"
End Sub

Sub Chk_rd_adc(chk_adc_val As Single , Chk_ch As Byte , Chk_adc_range As Byte)
   Chk_adc_val = &H0000
         ' Select range
   If Chk_adc_range = Chk_adc_5v Then Chk_cntl_byte = Chk_adc_5v
   If Chk_adc_range = Chk_adc_10v Then Chk_cntl_byte = Chk_adc_10v
   If Chk_adc_range = Chk_adc_5v5v Then Chk_cntl_byte = Chk_adc_5v5v
   If Chk_adc_range = Chk_adc_10v10v Then Chk_cntl_byte = Chk_adc_10v10v
         ' Select analog channel
   Chk_cntl_byte = Chk_cntl_byte || Chk_ch
   Reset Sclk
         ' take X measurements
   For Chk_cnt = 1 To Chk_m_cnts
    Chk_adc_word = &H0000
    Chk_num = 7
    Chk_num_2 = 11
          ' Select device
    Reset Adc_cs
    For Chk_cnt_2 = 1 To 24
      If Chk_cnt_2 < 9 Then
          ' Send control byte
        Dout = Chk_cntl_byte.chk_num
        Set Sclk
        Reset Sclk
        Decr Chk_num
      Elseif Chk_cnt_2 > 12 Then
          ' Get ADC value
        Set Sclk
        Reset Sclk
        Chk_adc_word.chk_num_2 = Din
        Decr Chk_num_2
      Else
          ' dummy clocks
        Set Sclk
        Reset Sclk
      End If
    Next Chk_num
          ' disable device
    Set Adc_cs
          ' collect results
    Chk_adc_val = Chk_adc_val + Chk_adc_word
    Waitms 1
  Next Chk_cnt
          ' compute average
   Chk_adc_val = Chk_adc_val / Chk_m_cnts

End Sub
```

3.2 PC Control

For those who are more comfortable building traditional PC-based "Automated Test Equipment" (ATE), the Check-MATE offers many features that are well suited for that environment as well.

Controlling the Check-MATE from a PC, requires that it be equipped with an optional USB-MATE module. The USB-MATE module contains a USB bridge-chip and a PIC microcontroller. On the PC side, the USB bridge-chip receives a special set of serial commands. On the Check-MATE side, the PIC controller processes the serial commands and then drives the Check-MATE accordingly. In order to be recognized by the PC, the USB-MATE module requires a set of Windows' drivers be installed. To do so, go to "www.Check-MATE.com", click "Download", select the "OI VCP Interface" file and follow the prompts. The letters VCP stands for "Virtual COM Port", and is a method by-which the USB interface can appear to the PC as a standard serial COM port. With the drivers installed and the USB-MATE connected to the PC, go to the Device Manager (click on Ports) and verify "OI Serial Interface (COM#)" is included.

The diagram below provides a basic illustration of a PC-driven configuration. As shown, the Check-MATE is used to stimulate a hybrid module in a test & measurement application. The hybrid module is a mix-signal device that requires Analog I/O, as well as Digital I/O to function properly.

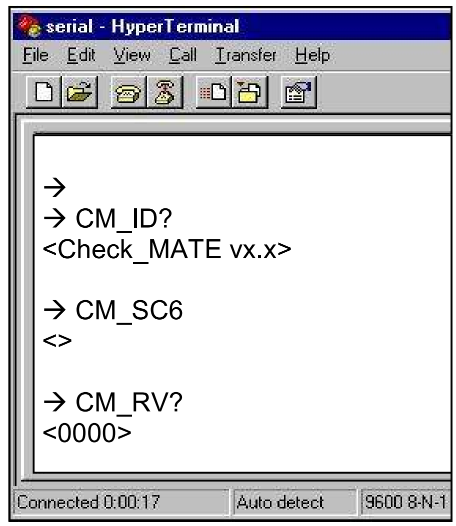


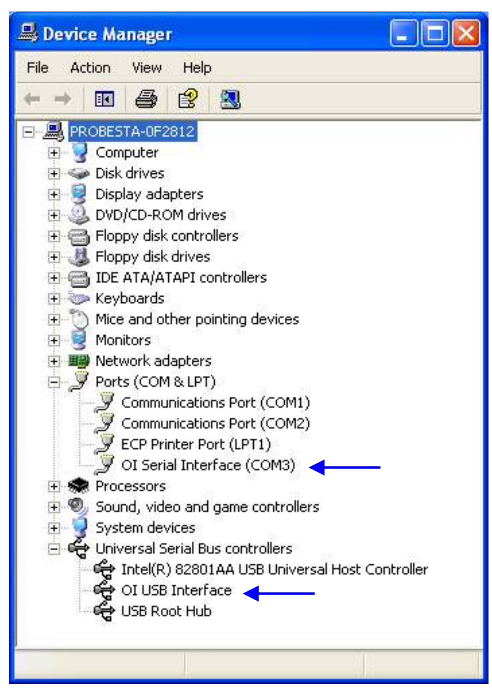
3.2.1 PC Programming

The starting point for developing code to control the Check-MATE, begins with acquainting yourself with its Serial Command Set. The serial commands are a sequence of ASCII characters that originate from the PC and are designed to instruct the Check-MATE to perform specific functions. The complete serial command set is detailed in Appendix B. There are two ways to exercise the serial commands, (1) using HyperTerminal or (2), run our Virtual Instrument Panel software (Control GUI).

3.2.1.1 HyperTerminal

HyperTerminal is a serial communications program that comes with the Windows OS and is located in the Accessories folder. Use the USB cable to connect the PC to the Check-MATE. Run HyperTerminal and configure the settings for 19200 bps, 8 data bits, no parity, 1 stop bit and no flow control. Select the COM port based on the available COM port as indicated in the Device Manager (example shown below). Press the 'Enter' key and the '→' prompt should appear on the screen (as demonstrated in the example on the right). Refer to the table in Appendix B, to begin to experiment with the serial commands.





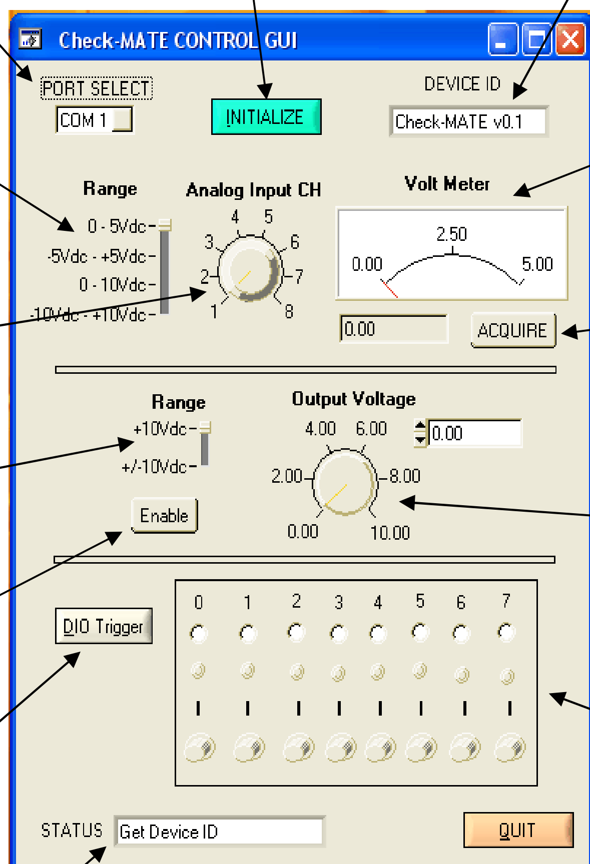
3.2.1.2 Virtual Instrument Panel

The Virtual Instrument Panel (or Control GUI), removes the hassle of "manually " typing ASCII commands and provides the User a more efficient method to interact and control the Check-MATE. Download the panel from our website at www.check-mate.com, click on downloads and select "Check-Matexxx.exe".

First Step: The User must select a COM Port. Refer to the Device Manage to identify an available COM port.

Second Step: Push the Initialize button. This will cause the module to initialize itself and attempt to establish a communications link.

Third Step: After initializing, the module should send back a unique ID code. If no response has occurred within 10 seconds, the program will time-out , and generate a No Response message.



This 'Range' function selects (1 of 4) specific analog input modes. Each 'Analog Input CH' can be set to a different range setting.

The 'Analog Input CH' function selects an individual analog channel (1 to 8).

This 'Range' function selects either Unipolar or Bipolar operation.

The 'Enable' function updates the analog output settings.

The 'DIO Trigger' function updates the DIO configuration settings.

The 'Volt Meter', displays a voltage measurement based the current analog channel and range setting.

The 'ACQUIRE' function updates the analog configuration settings, and displays a measurement every 100msec.

The 'Output Voltage' function updates the analog configuration settings, and displays a measurement every 100msec.

This function panel allows the User to control the DIO circuit. The top section provides a tool for setting the 'bit' direction. A blank-circle (indicates input), and a dot-circle (indicates output). The middle section includes a set of eight LED's (which indicate input status). The bottom section includes eight push-button switches (which allow the setting of output bits). When the switch is the out position (that represents a logic '0'). When the switch is in the in position (that represents a logic '1').

The 'STATUS' message box summarizes results of the serial commands.

3.2.1.3 PC Programming Example

```
//  Check-MATE programming example in 'C'
//
//  The following program provides a Go/No Go test sequence for testing
//  a hypothetical electronic module.  The electronic module is a mix-
//  signal hybrid device that contains 8 programmable amplifiers.  The
//  electronic module is controlled by a Check-MATE via the DIO lines.  DIO
//  bits 0-3 (select one of 8 DUT amplifiers).  DIO bits 4 & 5 (selects the
//  gain range).  DIO bit 6 is active-low (provides a DUT chip-select).  DIO
//  bit 7 is active-high (which indicates the DUT is ready).  The outputs of
//  the DUT amplifiers are connected to the inputs of the Check-MATE ana-
//  log channels.  The objective for the program is to verify each of the 8
//  amplifiers will perform properly at each gain setting and over a varying
//  range of input voltage levels.  During the test sequence, the program
//  first selects both the DUT amplifier and the Check-MATE ADC chan-
//  nel.  Then the DUT gain is selected and the Check-MATE updates the
//  DUT by writing the control byte (which asserts the chip-select).  The
//  Check-MATE then reads the DIO-bit-7 to determine if the DUT is
//  ready.  Once the DUT is ready, the Check-MATE will stimulate the
//  DUT amplifier input by supplying a voltage from the DAC output.  To
//  verify the DUT amplifier, the program reads the Check-MATE analog
//  channel and determines the PASS/FAIL results.

#define     MSWIN                   //  serial comm libraries from
#define     MSWINDLL                //  www.wcscnet.com

#include <comm.h>
#include <stdlib.h>
#include <stddio.h>

int stat, port=0, a_byte = 0, a_cnt = 0, int idx = 0;
int dut_ch = 0, dut_gain =0, gain_sel = 0;
int dio_bit[10] = 0;

long value = 0, limit = 0;

char dio_byte[10], dir_byte[10], results[64];
char send_data[64], read_data[64];

char set_adc_range[]  = "CK_AR";    // set ADC voltage range
char set_adc_ch[]     = "CK_SC";    // set ADC channel
char get_adc_volts[]  = "CK_RV?";   // read voltage
char set_dac_range[]  = "CK_DM";    // set DAC voltage range
char set_dac_out[]    = "CK_SA";    // set DAC output voltage
char set_dio_dir[]    = "CK_PD";    // set DIO port direction
char set_dio_pullup[] = "CK_PU";    // set DIO port pull-up
char set_dio_port[]   = "CK_PB";    // set DIO port write
char get_dio_port[]   = "CK_PB?";   // get DIO port
char get_device_id[]  = "CK_ID?";   // get module ID
char master_clear[]   = "CK_MC";    // master clear

main()
{
    port=OpenComPort(1,256,64);  // Open COM 1, rx_buff = 256 bytes, tx_buff = 64

    if ((stat = SetPortCharacteristics(port,BAUD19200,PAR_EVEN,
            LENGTH_8,STOPBIT_1,PROT_NONNON)) != RS232ERR_NONE) {
        printf("Error #%d setting characteristics\n",stat);
        exit(1);
    }
    CdrvSetTimerResolution(port,1);     // 1 msec ticks
    SetTimeout(port,2000);              // 2000 ticks = 2 sec time-out
    FlushReceiveBuffer(port);           // clear receiver buffer
    FlushTransmitBuffer(port);          // clear transmit buffer

            // Get device prompt

    sprintf (send_data, "%s\r", "");
    PutString(port,send_data);  // send CR
    if ((resp_len = GetString(port,sizeof(read_data),read_data)) == 0); {
        printf("Time-out error\n");
        exit(1);
    }
    if (strcmp("-> ", read_data)) {
        printf("Incorrect promt\n");
        exit(1);
    }
            // Master Clear

        sprintf (send_data, "%s\r", master_clear);
        PutString(port,send_data);          // send CK_MC

            // Set DIO direction & weak pull-up

    sprintf (send_data, "%s%s\r", set_dio_dir, "10000000");
    PutString(port,send_data);          // send CK_PD10000000
    sprintf (send_data, "%s%s\r", set_dio_pullup, "10000000");
    PutString(port,send_data);          // send CK_PU10000000

            // Execute test sequence

    for (dut_ch = 0; dut_ch >= 7; dut_ch++) {

            //  set check-mate ADC channel & range

        sprintf (send_data, "%s%d\r", set_adc_ch, dut_ch);
        PutString(port,send_data);                  // send CK_SC
        sprintf (send_data, "%s%d\r", set_adc_range, 1);
        PutString(port,send_data);      // send CK_AR - 0-10Vdc

                // exercise DUT gain performance

        for (gain_sel = 0;  >= 3; gain_sel++) {
            if (gain_sel == 0) dut_gain = 4095;     // x1 range
            if (gain_sel == 1) dut_gain = 409;      // x10
            if (gain_sel == 2) dut_gain = 40;       // x100
            if (gain_sel == 3) dut_gain = 4;        // x1000

                // build dio control byte

            a_byte = dut_ch + (gain_sel + 8)
            for ( idx = 0; idx <= 7; idx++ ) {
                dio_bit[idx] = a_byte % 2;
                a_byte = a_byte / 2;
                sprintf (dio_byte[idx], "%d", dio_bit[idx]);
            }

                // Select DUT, gain & amp ch

            sprintf (send_data, "%s%s\r", set_dio_port, dio_byte);
            PutString(port,send_data);  // send CK_PBxxxxxxxx

            do {        // Get DIO input - check DUT ready

                sprintf (send_data, "%s\r", get_dio_port);
                PutString(port,send_data);  // send CK_PB?
                GetString(port,sizeof(read_data),read_data);

            } while (atoi (read_data[1])); // loop while msb = '0', DUT not ready

            do {        // Set check-mate DAC output

                sprintf (send_data, "%s%04d\r", set_dac_out, dut_gain);
                PutString(port,send_data);          // send CK_SAnnnn

                // Get check-mate ADC input

                sprintf (send_data, "%s\r", get_adc_ch);
                PutString(port,send_data);          // send CK_SA?
                GetString(port,sizeof(read_data),read_data);
                for ( idx = 1; idx <= 4; idx++ ) {
                    results[idx] = read_data[idx];
                }
                // determine pass/fail results

                Value = atoi(results);
                 if (gain_sel == 1) dut_gain = dut_gain * 10;
                 if (gain_sel == 2) dut_gain = dut_gain * 100;
                 if (gain_sel == 3) dut_gain = dut_gain * 1000;
                 limit = asb(value - dut_gain);
                 if (limit > (0.001 * 4096)) {
                    printf ("Test Failed - ADC Ch:", "%d", " Gain Range:",
                        "%d", " Gain Value", "%d", dut_ch, gain_sel, dut_gain);
                        exit(1);
                 {
                dut_gain--;

            } while (dut_gain != 0);

                // De-select DUT

            sprintf (send_data, "%s%s\r", set_dio_port, "00000000");
            PutString(port,send_data);          // send CK_PB00000000
        }
    }
    printf ("Test Passed");
}
```

Appendix A. Serial Command Set

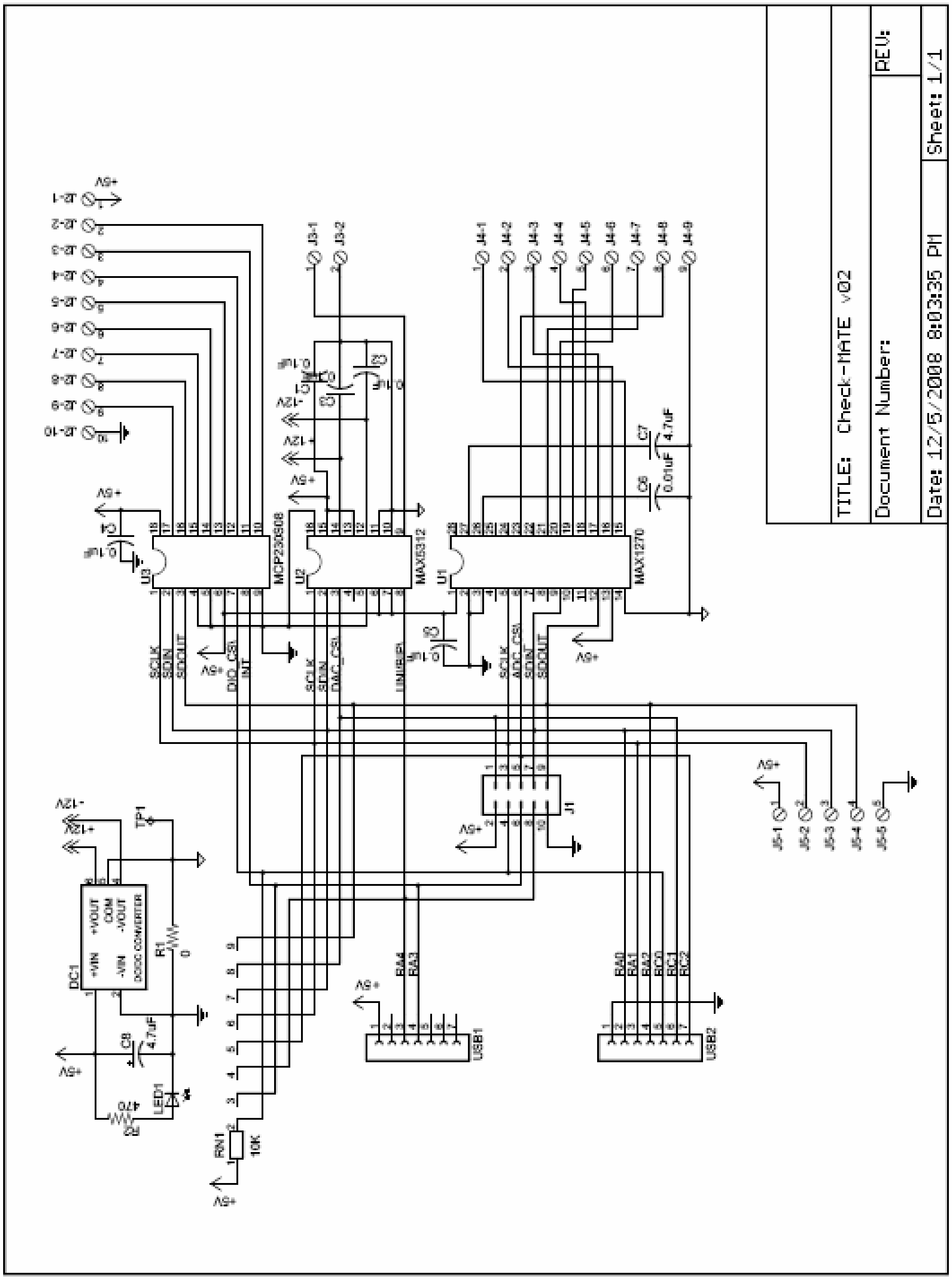
To facilitate remote control for the Check-MATE, a USB interface is required. When connected to a host PC, the USB connection appears as a "Virtual Com Port", which establishes a serial data communications link between the two. The default protocol is 19200 baud rate, no parity, 1 stop bit and no flow control. The Check-MATE will respond to a unique set of ASCII serial data commands (listed below). The first three bytes of the command string starts with the prefix **'CM_',** followed by a code that represents the actual command. All commands are upper case sensitive and are terminated with a carriage-return. If the command is valid, the Check-MATE will return either a **'<>'**, or a bracketed result (i.e. **'<2108>'**. If the Check-MATE receives a carriage-return or line-feed alone (without a command), then a **'→'** is returned (this response is a "prompt" to signal the Check-MATE is ready). If the Check-MATE detects an incorrect command then one of three error symbols will be generated, (1) invalid command then a **'><'** is returned, (2) a command that is out-of-limits then a **'>>'** is returned, and (3) a command that prematurely times-out then a **'<<'** is returned. In some cases the error symbol will include a bracketed result (i.e. '**>1<**'), which defines a specific error code.

Command	Function	Response	Description
CM_BRn	Set baud rate code	<n>	Select one of 4 different baud rates by changing -n-code. 0 = 1200, 1 = 2400, 2 = 9600 & 3 = 19200. Baud will remain set. Default code is 3 (19200).
CM_BR?	Get baud rate code	<n>	Get current baud rate code (-n- is the return code 0 to 3).
CM_ID?	Get module ID	<CHECK-MATE vx.x>	Get current identification and version number.
CM_MR	Maser Reset	<>	Reset & initialize the module
CM_WC	Write configuration	<>	Store current instrument settings in EEPROM. Save settings related to the ADC, DAC and DIO hardware.
CM_RC	Recall configuration	<>	Retrieve stored instrument settings
CM_SCn	Set ADC channel	<>	Select a ADC voltage channel. The -n- represents a channel number from 1 to 8.
CM_SC?	Get ADC channel	<n>	Get the current ADC voltage channel.
CM_ARn	Set ADC range	<>	Set the ADC range code (-n- is 0 = 0-5Vdc, 1 = 0-10Vdc, 2 = ±5Vdc, and 3 = ±10Vdc).
CM_AR?	Get ADC range	<n>	Get the current ADC range code.
CM_RV?	Get voltage measurement	<nnnn>	Get a voltage measurement based on the current ADC channel and range selection. The measurement contains 4 ASCII bytes representing a 12-bit decimal value (0-4095).
CM_CS?	Scan all ADC ch's	<ch1,ch2,...,ch8>	Measure and output 8 ADC channels. Each channel contains 4 ASCII bytes representing a 12-bit decimal value (0-4095). A comma ',' separates each channel

Appendix A. Serial Command Set cont.

Command	Function	Response	Description
CM_SAnnnn	Set voltage output	<>	Set the DAC output voltage. The DAC value is contained in -nnnn-, which comprises a 12-bit decimal, 4-byte ASCII string.
CM_SA?	Get voltage output	<nnnn>	Get the current DAC output voltage.
CM_PDbbbbbbbb	Set DIO direction	<>	Set (or write) the DIO port direction. The direction byte is represented by eight ASCII bytes starting with the most-significant-bit (-b- left most) to the least-significant-bit (-b- right most). A logic '1' is input and '0' is output.
CM_PD?	Get DIO direction	<bbbbbbbb>	Get (or read) the current DIO port direction setting.
CM_PUbbbbbbbb	Set weak pull-ups	<>	Set (or write) pull-ups on the DIO port inputs. The pull-up byte is represented by eight ASCII bytes starting with the most-significant-bit (-b- left most) to the least-significant-bit (-b- right most). A logic '1' is active and '0' is not.
CM_PU?	Get weak pull-ups	<bbbbbbbb>	Get (or read) the current DIO port pull-up status.
CM_PBbbbbbbbb	Set DIO port	<>	Set (or write) the DIO port output bits. Depending on the condition of the direction byte, the output bits are represented by eight ASCII bytes starting with the most-significant-bit (-b- left most) to the least-significant-bit (-b- right most). The -b- bit is a logic '1' or '0'.
CM_PB?	Get DIO port	<bbbbbbbb>	Get (or read) the current DIO port status.

Appendix B. Schematic



Appendix C. Mechanical Dimensions