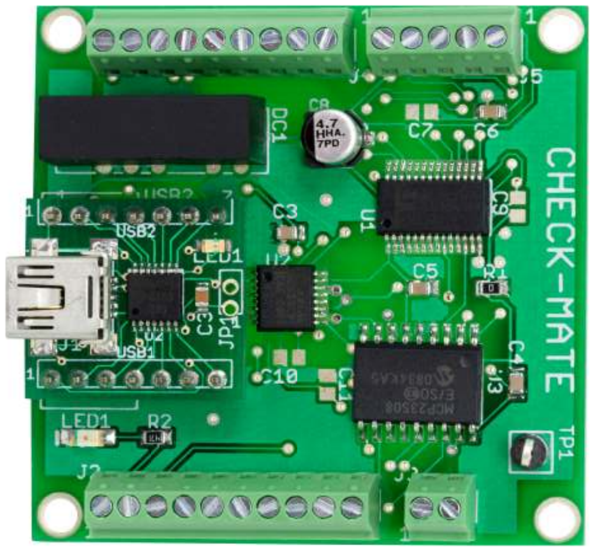
EMBEDDED TEST SOLUTIONS

CHECK-MATE

Multifunction DAQ Module



UNIVERSAL SERIAL BUS

USER'S MANAUAL

Overton Instruments, Inc
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Sacramento, CA 95841
www.microATE.net

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.

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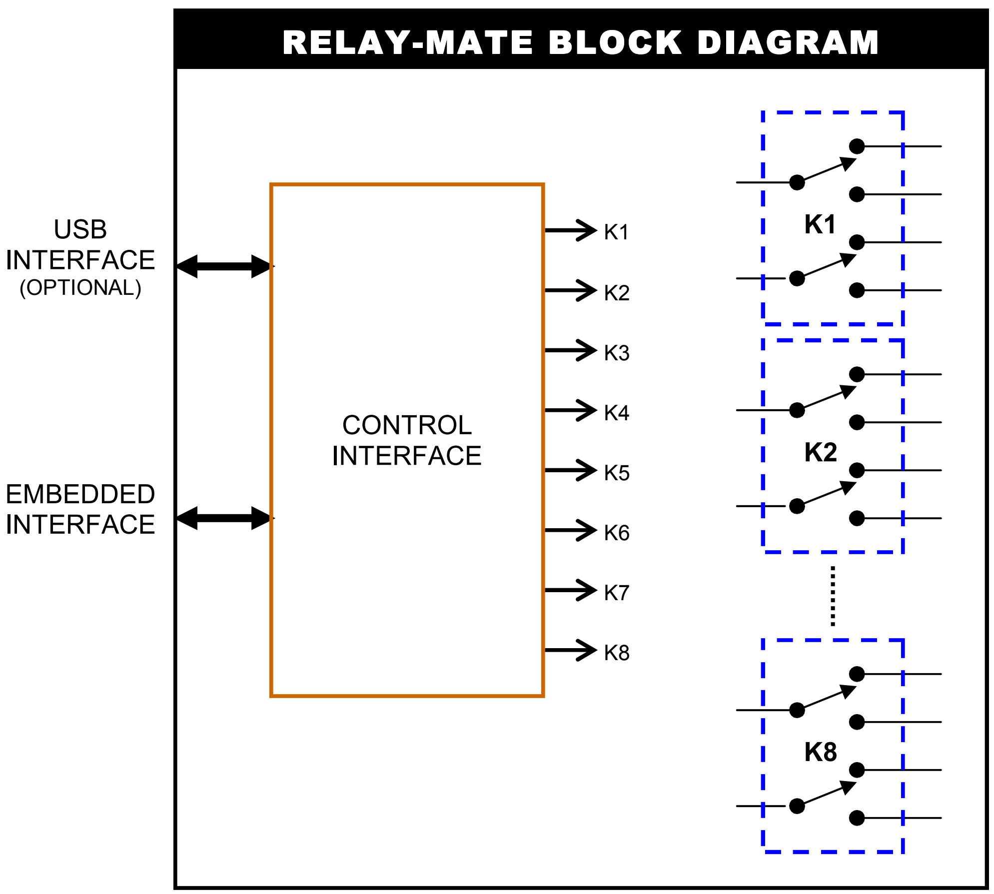
1. Introduction

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 or 4 differential analog inputs with 12-bit resolution (and a sampling rate of 100ksps). 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 Oi-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 (Single/Differential), 12-bit Resolution, 100ksps 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/differential
Input Ranges	0-5V, 0-10V, ±5V, ±10V
Max Sample Rate	100ksps
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. Description

2.1 Hardware Details

Access to Check-MATE hardware is made possible through a convenient set of screw terminal connections (J2 - J5), and J6 (which consolidates all signals into a single 40-pin header).

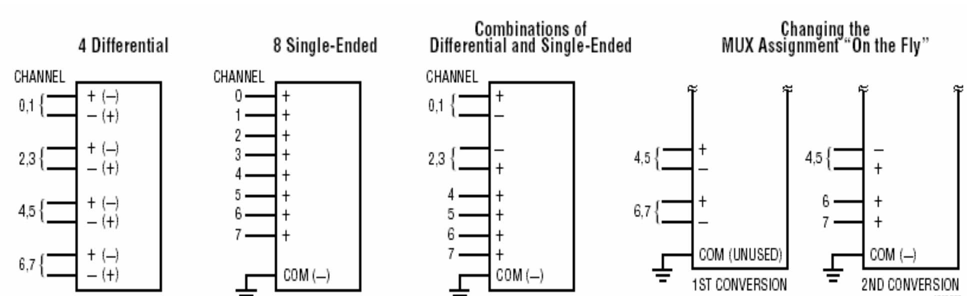
The analog inputs (or channels) can be programmed for any combination of single-ended or differential operation. The diagram below shows examples of various configurations. You will also note the polarity of connections related to differential operation can be transposed as well. Each channel can be programmed for anyone of 4 different range modes (i.e., 0-5V, ±5, 0-10V and ±10V). Keep in mind, the circuit provides ±25V protection on each channel.

The single analog output channel can be programmed for either unipolar (0-10V), or bipolar (±10V) operation.

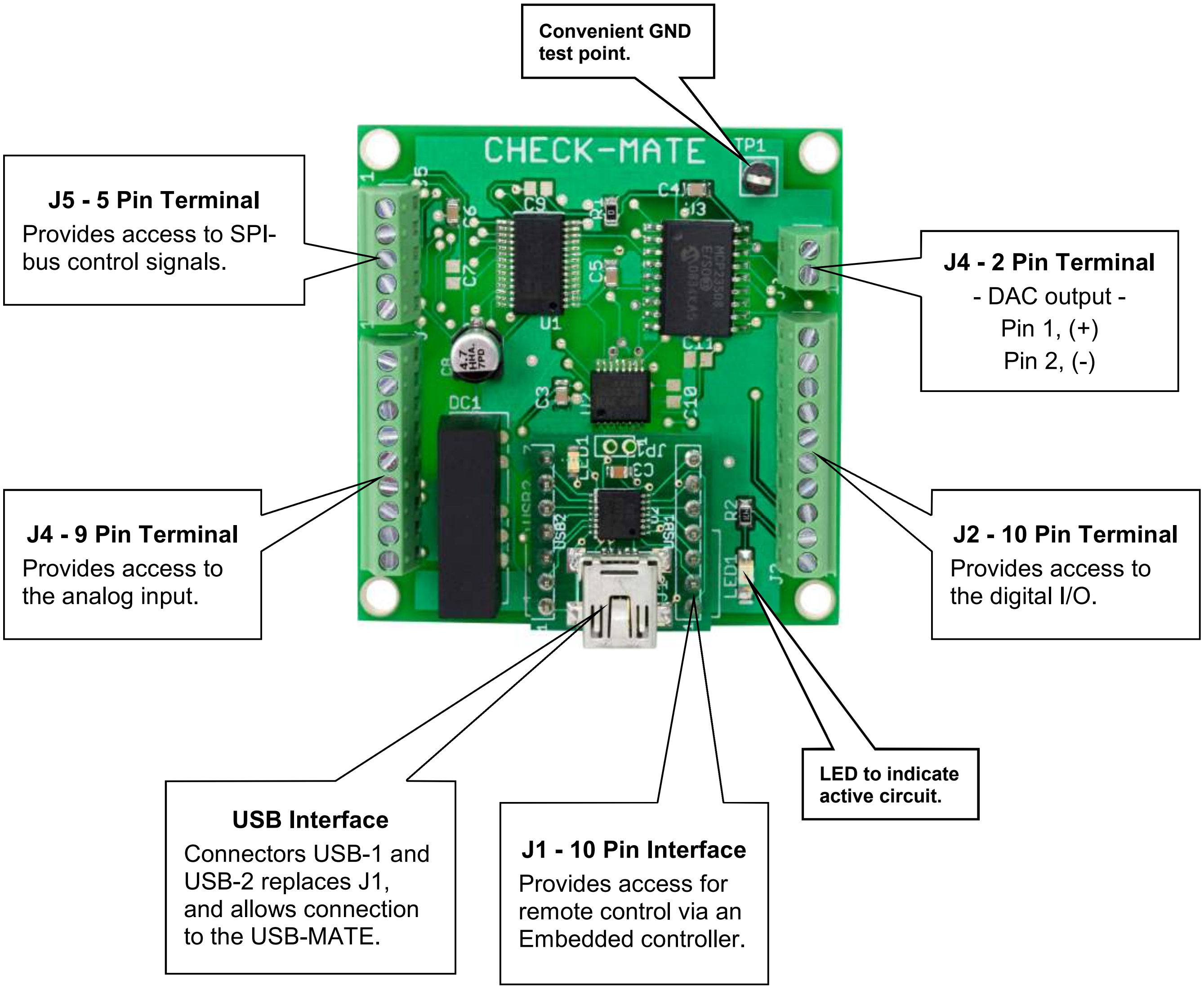
The digital circuit includes 8 independent I/O bits. Each bit can be programmed for either input or output. While in the input mode, a bit can be programmed to provide a weak pull-up (~10K). Each bit provides a TTL logic level and can source/sink 25mA.

External control of the Check-MATE can be provided by a embedded controller (such as the Micro-MATE), or with a PC. Embedded control is supported by J1 (Oi-BUS interface), which is a 10-pin header that includes a 3-wire SPI-bus, chip select logic, power and ground. In PC applications, connector J1 is replaced with the USB--MATE. The USB-MATE contains a USB connector (for the PC), and a dual set of 7-pin headers that mount to the Check-MATE. The USB-MATE is designed to interpret a set of ASCII commands sent from the PC, and then perform various Check-MATE functions. For more information for the Check-MATE command set, go to Appendix A. To support embedded applications, a complete driver for the Check-MATE is provided in TES-MATE (or Test Executive Suite).

After power is applied to the Check-MATE, the analog inputs are configured for single-ended (0-5V range), the analog output is set to zero (range is 0-10V), and the digital I/O circuit is cleared (all bits inputs).



2.2 Board Layout



2.3 Connections

J1

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

J3

Pin	Name	Dir.	Description
1	DAC-OUT	O	Voltage Output
2	AGND		Analog Ground

J2

Pin	Name	Dir.	Description
1	VCC		+5V Power
2	DIO-0	I/O	Bit 0
3	DIO-1	I/O	Bit 1
4	DIO-2	I/O	Bit 2
5	DIO-3	I/O	Bit 3
6	DIO-4	I/O	Bit 4
7	DIO-5	I/O	Bit 5
8	DIO-6	I/O	Bit 6
9	DIO-7	I/O	Bit 7
10	DGND		Digital Ground

J4

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

J5

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

2.4 J6 Consolidated

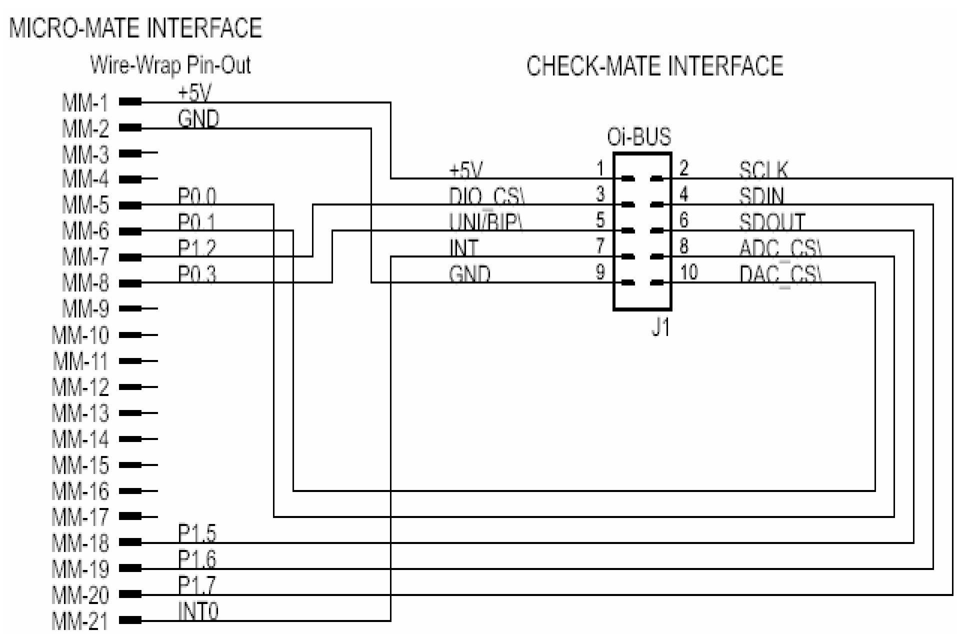
J6			
Pin	**Name**	**Dir.**	**Description**
1	VCC		+5V Power
2	DIO-0	I/O	Bit 0
3	DIO-1	I/O	Bit 1
4	DIO-2	I/O	Bit 2
5	DIO-3	I/O	Bit 3
6	DIO-4	I/O	Bit 4
7	DIO-5	I/O	Bit 5
8	DIO-6	I/O	Bit 6
9	DIO-7	I/O	Bit 7
10	DGND		Digital Ground
11	DAC-OUT	O	Voltage Output
12	AGND		Analog Ground
13	AI-1	I	Input CH 1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

3. Operation

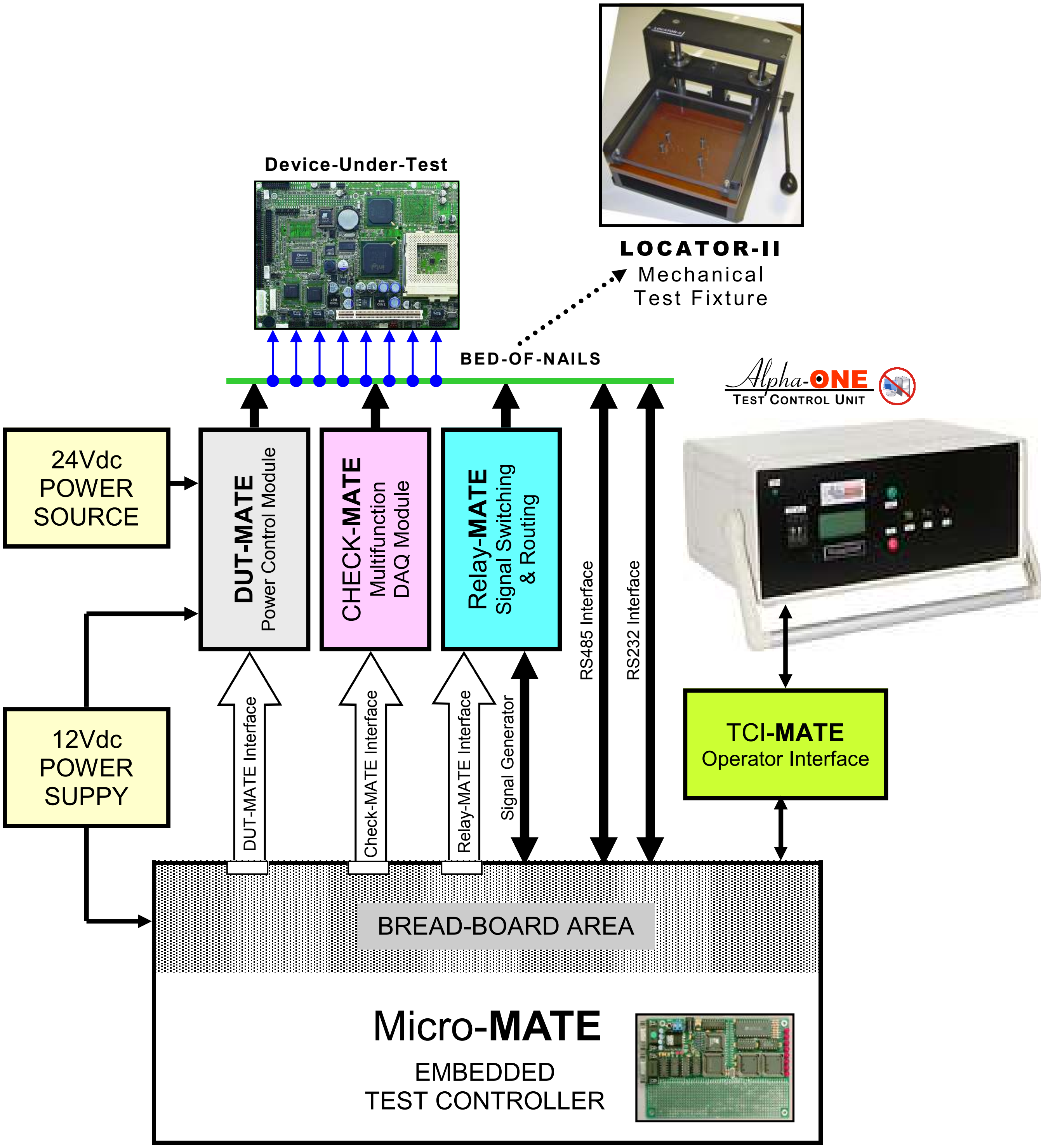
3.1 Embedded Control

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 Micro-MATE. The Micro-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 Micro-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 Micro-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 Linear Technology (part number LTC1857). 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 Micro-MATE microcontroller.

The program starts by initialing the Micro-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 Micro-MATE (P0 & 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 Micro-MATE receives "high level" serial commands from a host PC, parses them and then executes accordingly. When (for example), the "CK_CC4S01" command is entered, the program selects analog channel number 4 ('S' for single-ended, '0' for +/- polarity, '1' for 5V range). Finally, when the command "CK_RV?" 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

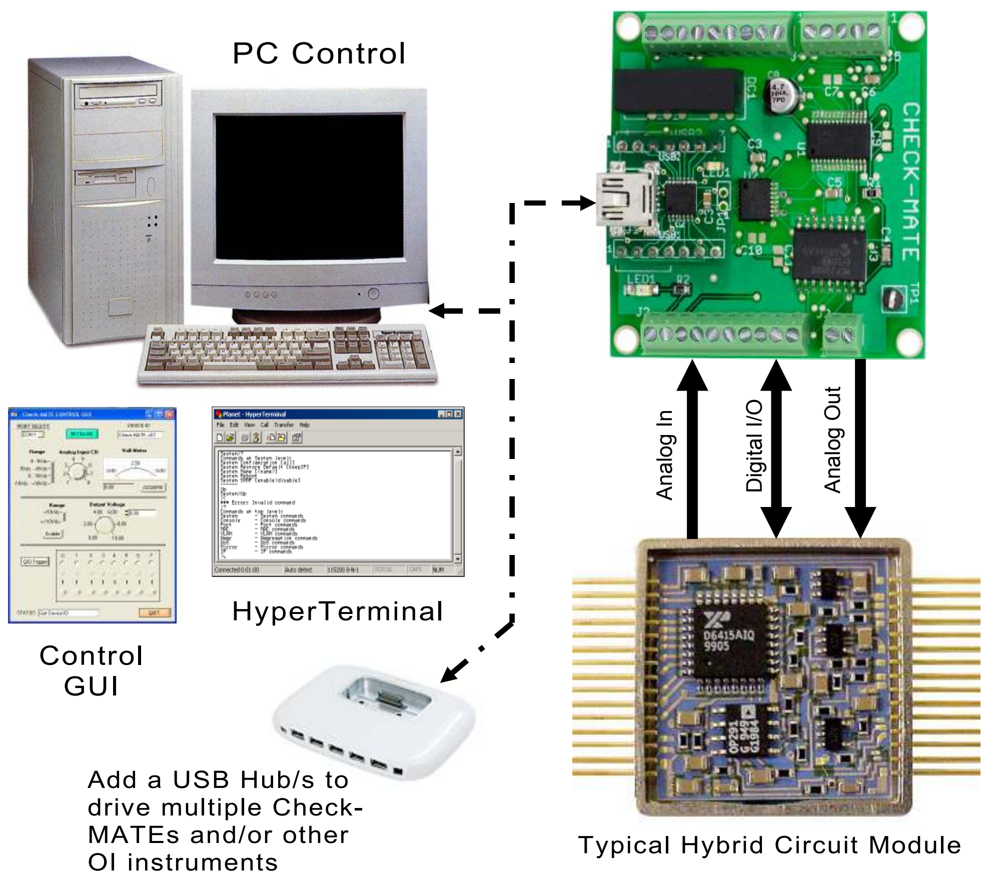
```
' Program: CHECK-MATE Demo
'
---[ Initialization ]---------------------------------------------------------
'
$large
$romstart = &H2000
$default Xram

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 P1.7                    ' SPI-bus serial clock
Dout Alias P1.6                    ' SPI-bus serial data output
Din Alias P1.5                     ' SPI-bus serial data input
Adc_cs Alias P0.0                  ' ADC chip select
Dac_cs Alias P0.1                  ' DAC chip select
Dio_cs Alias P0.2                  ' DIO chip select
Dac_mode Alias P0.3                ' 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, Daq _adc_3cs ' Set to logic '1'
Do
  Print
  Err_trap = False
  Input "-> " , S Noecho
  S = Ucase(s)
  A_num = Len(s)
  If A_num > 0 Then
    A_resp = Left(s , 3)
    If A_resp = "CK_" Then
      A_resp = Mid(s , 4 , 2)
      Select Case A_resp
        Case "CC":              'Configure ADC channel
          A_resp = Mid(s , 6 , 1)
          If A_resp = "?" Then
            Print "<" ; Chk_conf_code ; ">"
          Else
            A_resp = Mid(s , 6 , 2)
            A_ch = Val(a_resp)
            If A_ch > 32 Then Err_trap = True
            A_char = Mid(s , 8 , 1)
            If A_char <> "D" And A_char <> "S" Then
              Err_trap = True
            Else
              If A_char = "D" Then Chk_mux_mode = 0
              If A_char = "S" Then Chk_mux_mode = 1
            End If
            A_char = Mid(s , 9 , 1)
            If A_char <> "0" And A_char <> "1" Then
              Err_trap = True
            Else
              If A_char = "0" Then Chk_mux_pol = 0
              If A_char = "1" Then Chk_mux_pol = 1
            End If
            If A_ch > 4 And A_ch < 9 Then
              If Chk_mux_mode = 0 Then Err_trap = True
            Elseif A_ch > 12 And A_ch < 17 Then
              If Chk_mux_mode = 0 Then Err_trap = True
            Elseif A_ch > 20 And A_ch < 25 Then
              If Chk_mux_mode = 0 Then Err_trap = True
            Elseif A_ch > 28 And A_ch < 33 Then
              If Chk_mux_mode = 0 Then Err_trap = True
            End If
            A_char = Mid(s , 10 , 1)
            A_num = Val(a_char)
            If A_num < 1 Or A_num > 4 Then Err_trap = True
            If Err_trap = False Then
              If A_num = 1 Then Chk_range = Daq_adc_5v
              If A_num = 2 Then Chk_range = Daq_adc_5v5v
               If A_num = 3 Then Chk_range = Chk_adc_10v
              If A_num = 4 Then Chk_range = Chk_adc_10v10v
              If Chk_mux_mode = 1 Then
                Chk_ch = Chk_ch_buf(a_ch)      ' set single-ended ch
              Else
                Chk_ch = Chk_ch_buf_d(a_ch)      ' set differential-ended ch
                Chk_ch.6 = Chk_mux_pol       ' set polarity (+/-)
              End If
              Chk_conf_code = Mid(s , 6 , 5)      ' set configuration code
              Call Print_ok
            Else
              Call Print_oor
            End If
          End If
        Case "RV":                    ' read voltage
          A_resp = Mid(s , 6 , 1)
          If A_resp = "?" Then
            Call Chk_rd_adc(Chk_word , Chk_ch , Chk_range)
            If Chk_word > 4095 Then
              Call Print_oor
            Else
              A_str = Str(Chk_word)
              Print "<" ; A_str ; ">"
            End If
          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
  End If
Loop
End

'---[ Sub-Routines]---------------------------------------------------------
'
Sub Chk_rd_adc(chk_adc_word As Word , Chk_adc_ch As Byte , Chk_adc_range As
Byte)
   Chk_adc_val = 0
   Chk_cntl_byte = Chk_adc_range + Chk_ch ' Select analog channel
   While Adc_busy = 0                 ' check busy flag
   Wend
   Reset Sclk
   Delay
   For Chk_loop = 0 To Chk_m_cnts      ' take X measurements
      Chk_adc_word = 0
      Reset Adc_cs                     ' Select device
      Delay
      For Chk_cnt = 15 Downto 0
        If Chk_cnt >= 8 Then           ' transceive serial data
          Chk_num = Chk_cnt - 8
          Dout = Chk_cntl_byte.chk_num
        End If
        Set Sclk
        Delay
        Chk_adc_word = Din
        Delay
        Reset Sclk
      Next Chk_cnt
      Set Adc_cs          ' disable device
      If Chk_loop > 0 Then Chk_adc_val = Chk_adc_val + Chk_adc_word
   Next Chk_loop
   Chk_adc_val = Chk_adc_val / Chk_m_cnts                ' compute average
   Chk_adc_word = Loww(chk_adc_val)
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.info", 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.

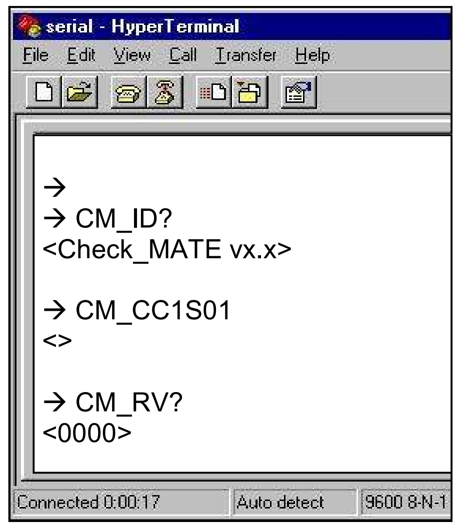


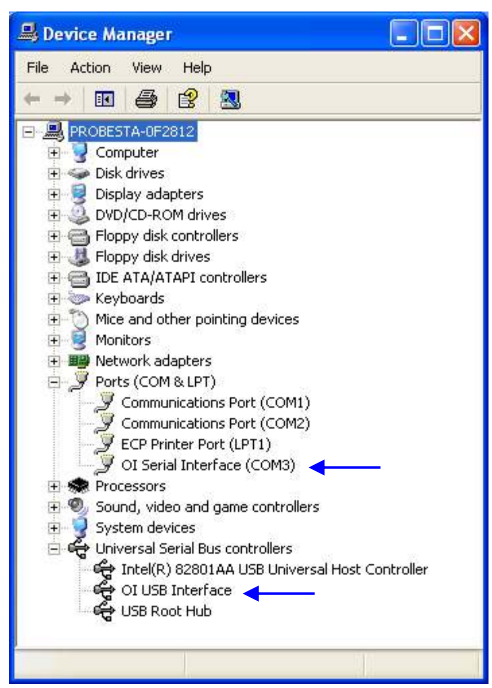
3.2.1 PC Programming

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.





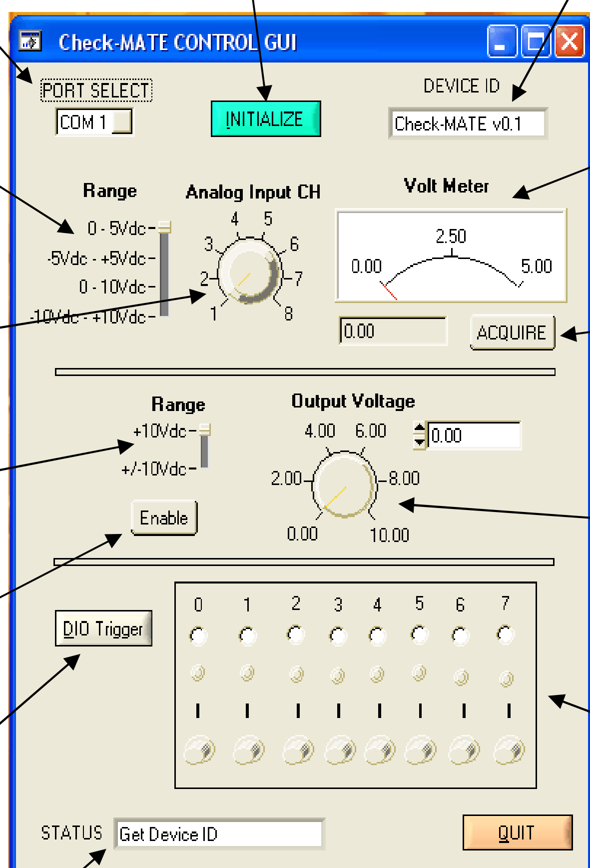
3.2.1.2 Virtual Instrument Panel

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 input (which indicates the DUT is ready).  The outputs
//  for the DUT amplifiers are connected to the inputs of the Check-MATE
// analog 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 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.  The Check-MATE is
//  controlled by a remote PC, via a USB interface.

#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_ch[]      = "CK_CC";      // configure 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 configuration

        sprintf (send_data, "%s%d%s\r", set_adc_ch, dut_ch, "S03");
        PutString(port,send_data)  // send CK_CC

                    // 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

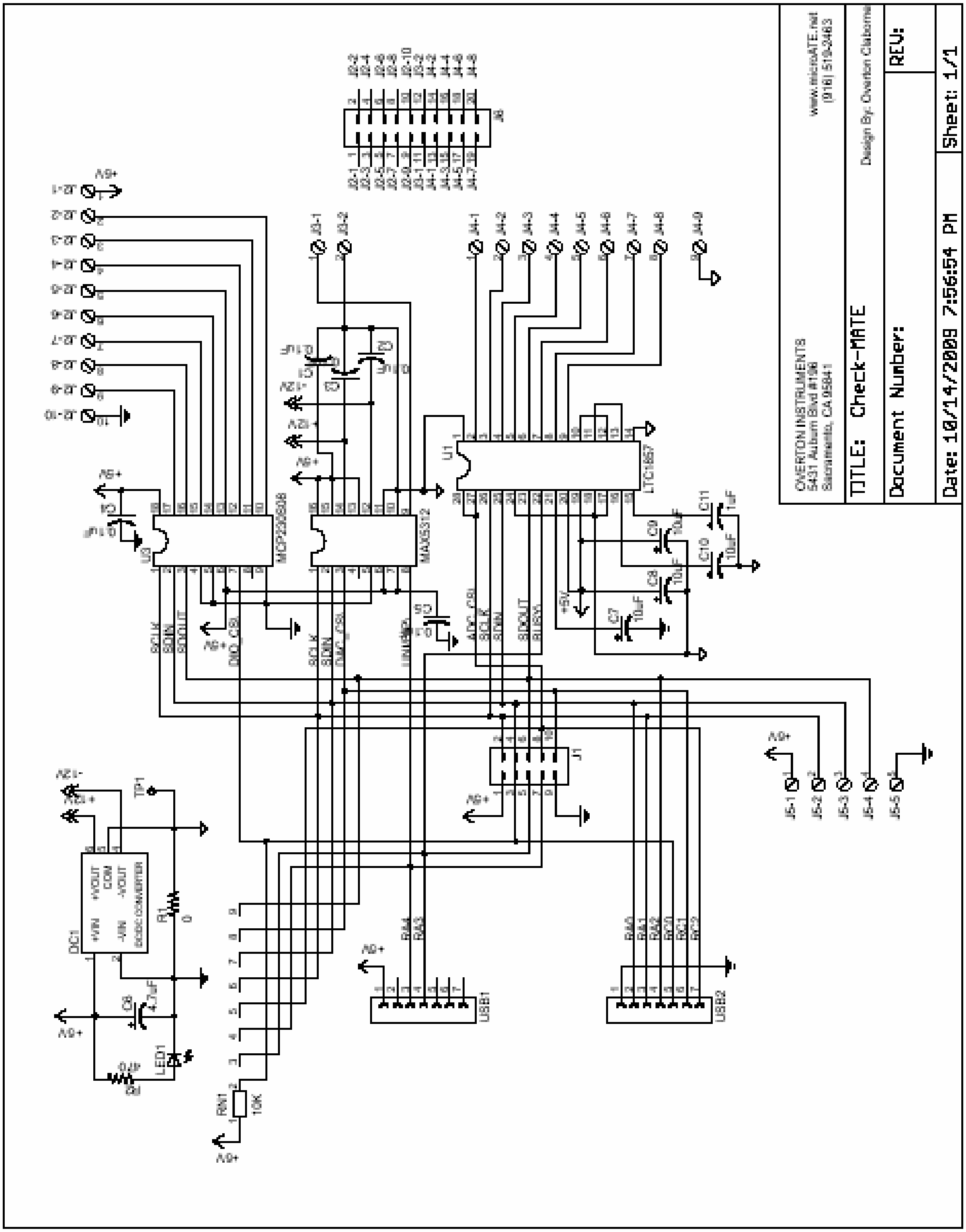
To facilitate remote control for the Check-MATE, a USB interface is required. When connected to a host PC, the USB connection appears as a “Virtual Com Port”, which establishes a serial data communications link between the two. The default protocol is 19200 baud rate, no parity, 1 stop bit and no flow 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 **‘CK_’,** 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
CK_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).
CK_BR?	Get baud rate code	<n>	Get current baud rate code (-n- is the return code 0 to 3).
CK_ID?	Get module ID	<CHECK-MATE vx.x>	Get current identification and version number.
CK_MR	Maser Reset	<>	Reset & initialize the module
CK_WC	Write configuration	<>	Store current instrument settings in EEPROM. Save settings related to the ADC, DAC and DIO hardware.
CK_RC	Recall configuration	<>	Retrieve stored instrument settings
CK_CC?	Get ADC Channel Configuration	<cmpr>	Get current channel configuration. c = ADC channel number (1 to 8) m = ADC mode (“D” = Differential, “S” = Single) p = ADC polarity (0 = +, 1 = -) r = ADC range (1 = +5V, 2 = ±5V, 3 = 10V, 4 = ±10V)
CK_CCcmpr	Configure ADC Channel	<>	Set channel configuration with following codes. c = ADC channel number (1 to 8) m = ADC mode (“D” = Differential, “S” = Single) p = ADC polarity (0 = +, 1 = -) r = ADC range (1 = +5V, 2 = ±5V, 3 = 10V, 4 = ±10V)
CK_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).

Appendix A. Serial Command Set cont.

Command	Function	Response	Description
CK_MS?	Get current measurement sample count	<nnn>	Get a three byte ASCII string that represents the number of measurement samples the ADC performs. The range is 1 to 255.
CK_MSnnn	Set measurement sample count	<>	Set a three byte ASCII string that represents the number of measurement samples the ADC performs. The range is 1 to 255.
CK_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), 0000 to 4095. In bipolar mode 0000 = -10Vdc.
CK_SA?	Get voltage output	<nnnn>	Get the current DAC output voltage.
CK_DMn	Set DAC mode	<n>	Set the DAC range mode (-n- is 1 = 0-10Vdc and 0 = ±10Vdc).
CK_DM?	Get DAC mode	<n>	Get the current DAC range mode.
CK_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.
CK_PD?	Get DIO direction	<bbbbbbbb>	Get (or read) the current DIO port direction setting.
CK_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.
CK_PU?	Get weak pull-ups	<bbbbbbbb>	Get (or read) the current DIO port pull-up status.
CK_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'.
CK_PB?	Get DIO port	<bbbbbbbb>	Get (or read) the current DIO port status.

Appendix B. Schematic



Appendix C. Mechanical Dimensions