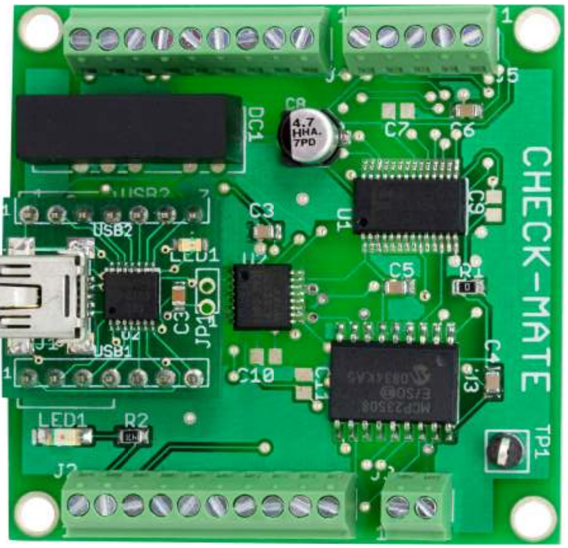
# CHECK-MATE

## Multifunction DAQ Module




# USER'S MANAUAL

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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 in 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.

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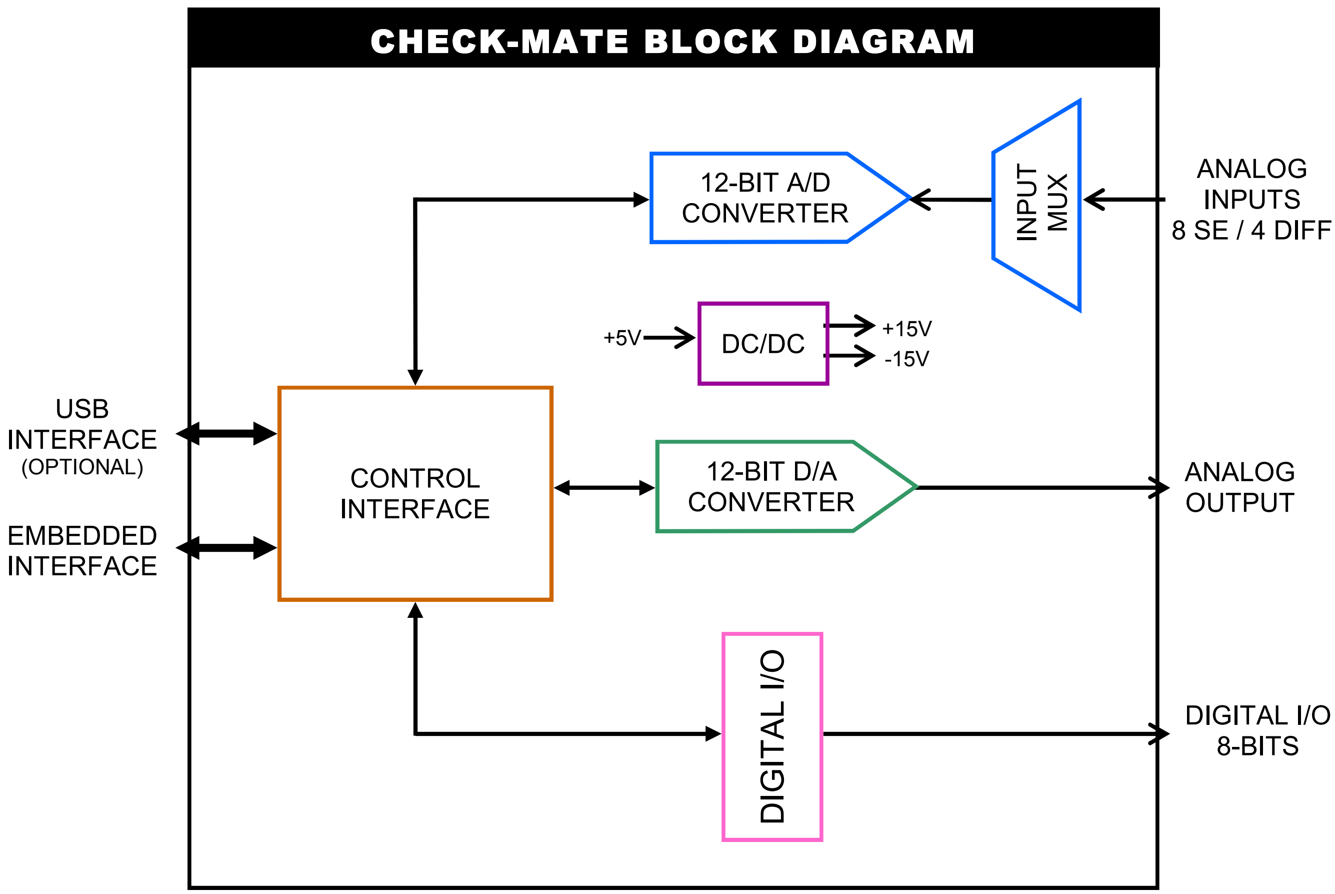


## 1.2 Highlights

| BENEFITS | APPLICATIONS | FEATURES |
|---|---|---|
| • A flexible, low-cost alternative to expensive PC-based DAQ cards<br>• Supports a wide-array of mix-signal test applications<br>• Great for embedded solutions - place inside mechanical test fixtures, instrument boxes or rack-mount enclosures | • Burn-In<br>• Engineering<br>• Depot Repair<br>• Production Test<br>• QA/QC Quality Control<br>• OEM Test Instruments | • 8 SE /4 DIFF Analog Input Channels, 12-bit Resolution, 100ksps sample rate<br>• 1-Channel, Digital-to-Analog converter, 12-bit Resolution, Unipolar/Bipolar modes<br>• 8 Digital Input/Output Bits, Independently programmable<br>• USB or embedded control interface<br>• Low Cost<br>• 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 SE / 4 DIFF, programmable |
| Input Ranges | 0-5V, 0-10V, ±5V, ±10V |
| Resolution / Sample Rate | 12-bit / 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, ±25mA (source/sink) |
| **Input Control** | |
| Embedded | Oi-Bus interface |
| USB Interface | Optional USB module |
| **General** | |
| Power Supply | +5VDC±10%@3mA |
| Operating Temp | 0-50ºC |
| Dimensions | 2.5" x 2.5" |

# 2. I/O 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).

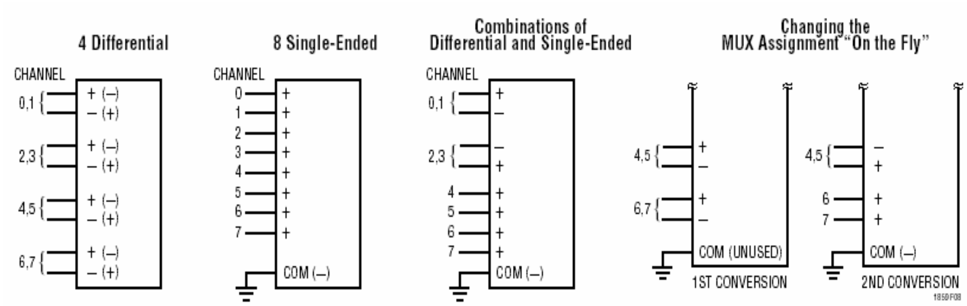
The analog inputs (or channels) can be programmed for any combination of single-ended or differential operation. The diagram below shows examples of various configurations. You will also note the polarity of connections related to differential operation can be transposed as well. Each channel can be 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.

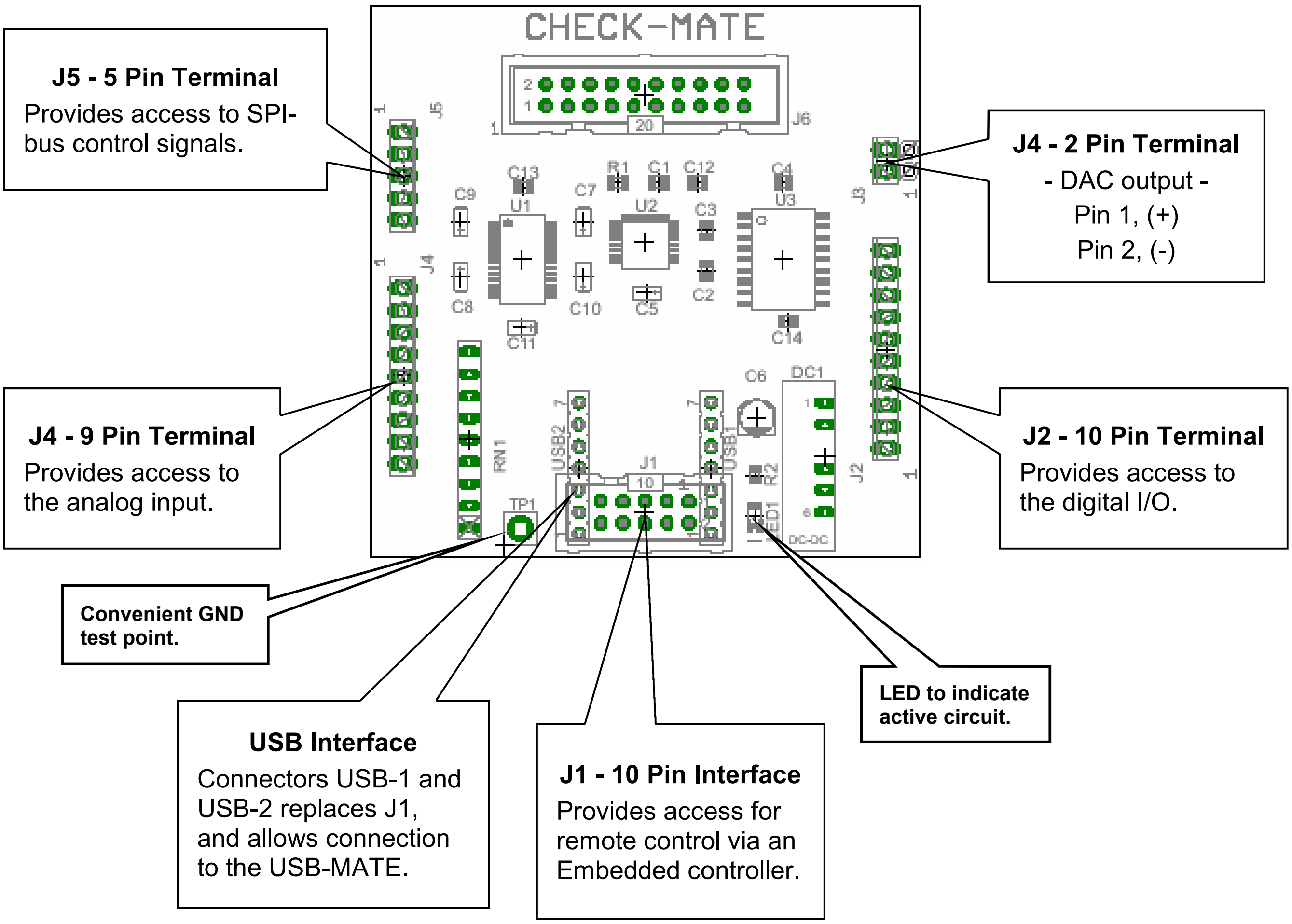
The digital circuit includes 8 independent I/O bits. Each bit can be programmed for either input or output. While in the input mode, a bit can be programmed to provide a weak pull-up (~10K). Each bit provides a TTL logic level and can source/sink 25mA.

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 on 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 provides input com-mand and control data for the, ADC, DAC and DIO circuits. |
| 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, DOUT provides output data from the ADC and DIO circuits. |
| 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) for the DAC. |
| 9 | DGND | | Digital Ground |
| 10 | BUSY\ | O | A TTL active-low "output' signal that indicates the ADC is busy converting a measurement. |

**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

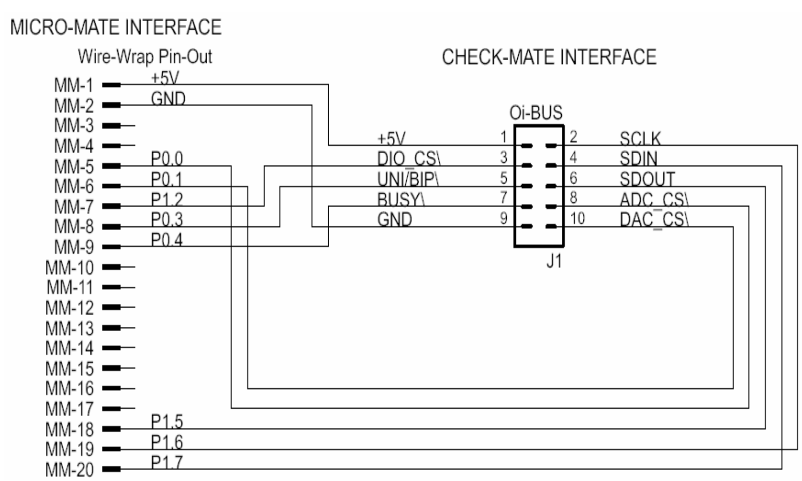
| J6 | | | |
|---|---|---|---|
| **Pin** | **Name** | **Dir.** | **Description** |
| 1 | VCC | | +5V Power |
| 2 | DIO-0 | I/O | Bit 0 |
| 3 | DIO-1 | I/O | Bit 1 |
| 4 | DIO-2 | I/O | Bit 2 |
| 5 | DIO-3 | I/O | Bit 3 |
| 6 | DIO-4 | I/O | Bit 4 |
| 7 | DIO-5 | I/O | Bit 5 |
| 8 | DIO-6 | I/O | Bit 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

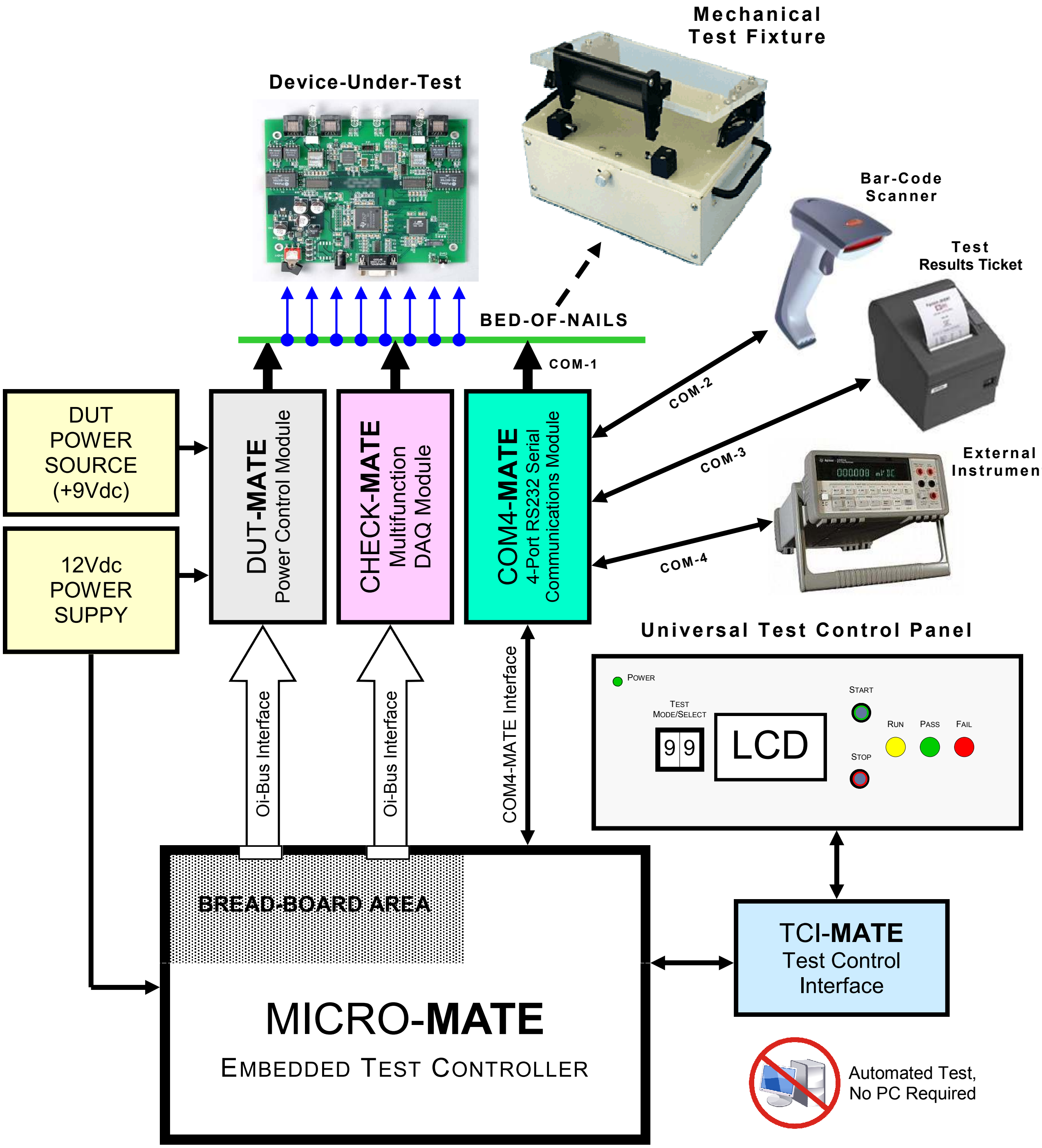
## 3.1 Embedded Control

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 B. 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 (P1.7 & P1.6 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_RC?4S01" command is entered, the program selects analog channel number 4 ('S' for single-ended, '0' for +/- polarity, '1' for 5V range) and returns the results in a 3 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 A_word, Chk_word, Chk_val As Word
Dim A_num, A_byte, A_cnt, A_ch, Chk_cntl_byte, Chk_loop, Chk_m_cnts As Byte
Dim Chk_ch, Chk_range, Chk_pol, Chk_mode, Chk_num, Chk_cnt, Chk_cntl_byte As Byte
Dim S As String * 10, A_resp AS String * 10, A_str AS String * 10, A_char AS String*1
Dim Chk_long as Long
Dim True As Const 1
Dim False As Const 0
Dim Err_trap As Bit

Sclk Alias P1.6                    ' SPI-bus serial clock
Dout Alias P1.7                    ' 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
Adc_busy Alias P0.4                'ADC busy flag

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_val As Word , Chk_ch As Byte , Chk_mode As Byte ,
Chk_pol As Byte , Chk_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 one command example is shown.

Set Sclk, Dout, Adc_cs, Dac_cs, Dio_cs, Dac_mode ' 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 "RC":             ' Configure & Read single channel
            A_char = Mid(s , 6 , 1)
            If A_char = "?" Then
              A_char = Mid(s , 7 , 1)
              Chk_ch = Val(a_char)
              If Chk_ch > 8 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_mode = 0
                If A_char = "S" Then Chk_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_pol = 0
                If A_char = "1" Then Chk_pol = 1
              End If
              If Chk_ch > 4 And Chk_mode = 0 Then Err_trap = True
              A_char = Mid(s , 10 , 1)
              Chk_range = Val(a_char)
              If Chk_range < 1 Or Chk_range > 4 Then Err_trap = True
              If Err_trap = False Then
                Call Chk_rd_adc(chk_val , Chk_ch , Chk_mode , Chk_pol , Chk_range)
                Printhex "<" ; Chk_val ; ">"
              Else
                Call Print_oor
              End If
            Else
              Call Print_ic
            End If
```

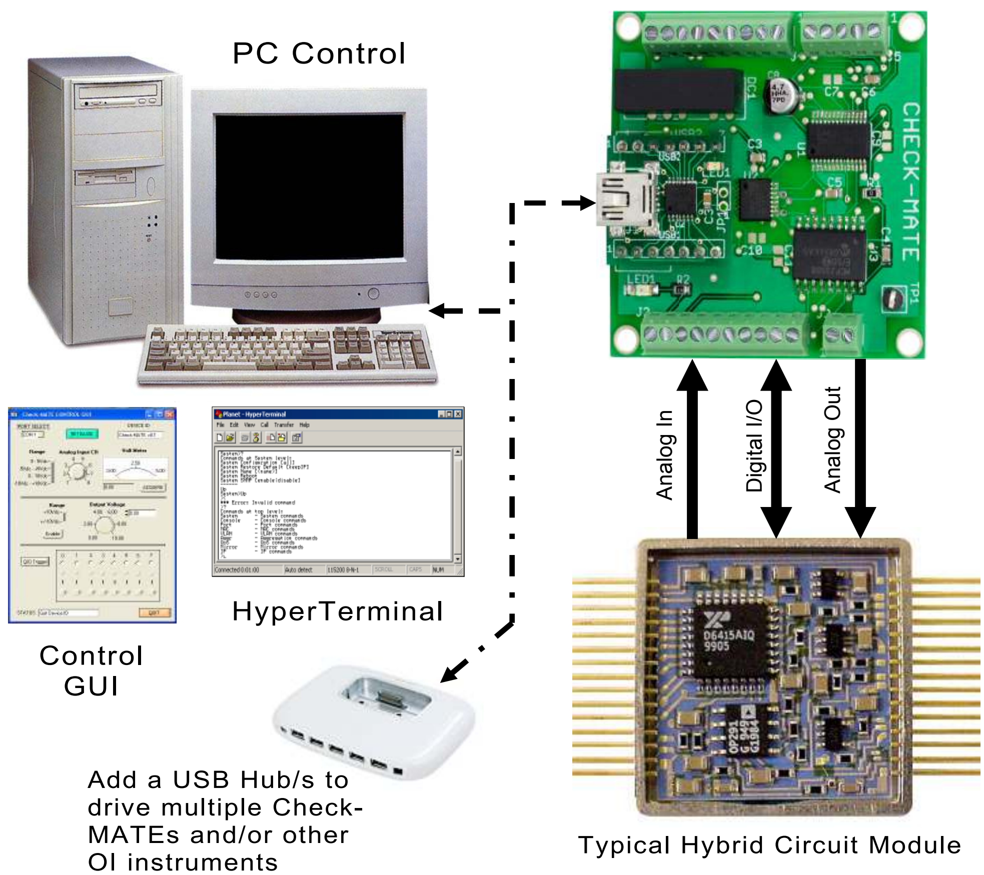
```
'===========================================================================
'                       ADC Subroutine
'===========================================================================

Sub Chk_rd_adc(chk_val As Word , Chk_ch As Byte , Chk_mode As Byte , Chk_pol As
Byte , Chk_range As Byte)

                     ' Select analog channel
   Chk_long = 0
   If Chk_mode = 1 Then
      Chk_ch = Chk_ch_buf(chk_ch)         ' configure SE
   Else
      Chk_ch = Chk_ch_buf_d(chk_ch)       ' configure Differential
      If Chk_pol = 0 Then Chk_num.6 = 0   ' configure Polarity +/-
      If Chk_pol = 1 Then Chk_num.6 = 1   ' configure Polarity -/+
   End If
   Chk_range = Chk_range_buf(chk_range)   ' configure Range
   Chk_cntl_byte = Chk_range Or Chk_ch    ' configure Control Byte
   Reset Sclk
                  ' take X measurements
   For Chk_loop = 0 To Chk_m_cnts
     Chk_word = 0
     While Adc_busy = 0 ' check busy flag
     Wend
     Reset Adc_cs          ' Select device
     For Chk_cnt = 15 Downto 0
       If Chk_cnt >= 8 Then
         Chk_num = Chk_cnt - 8
         Dout = Chk_cntl_byte.chk_num      ' transmit serial data
       End If
       Set Sclk
       Reset Sclk
     Next Chk_cnt
     Set Adc_cs                 ' disable device
     While Adc_busy = 0         ' check busy flag
     Wend
     Reset Adc_cs               ' Select device
     For Chk_cnt = 15 Downto 0
       If Chk_cnt >= 8 Then
         Chk_num = Chk_cnt - 8
         Dout = Chk_cntl_byte.chk_num
       End If
       Set Sclk
       Chk_word = Din           ' receive serial data
       Reset Sclk
     Next Chk_cnt
     Set Adc_cs            ' disable device
     If Chk_loop > 0 Then Chk_long = Chk_long + Chk_word
   Next Chk_loop
                     ' compute average
   Chk_long = Chk_long / Chk_m_cnts
   Chk_val = Loww(chk_long)
End Sub

Sub Print_ic

  Err_trap = True
  Print "><"

End Sub

Sub Print_oor

  Err_trap = True
  Print ">>"

End Sub

Sub Print_ok

  Print "<>"

End Sub

Sub Print_ur

  Err_trap = True
  Print "<<"

End Sub
```

## 3.2 PC Control

For those 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 hardware 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.

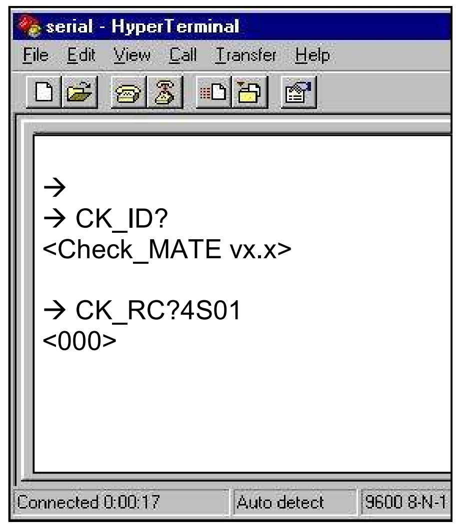


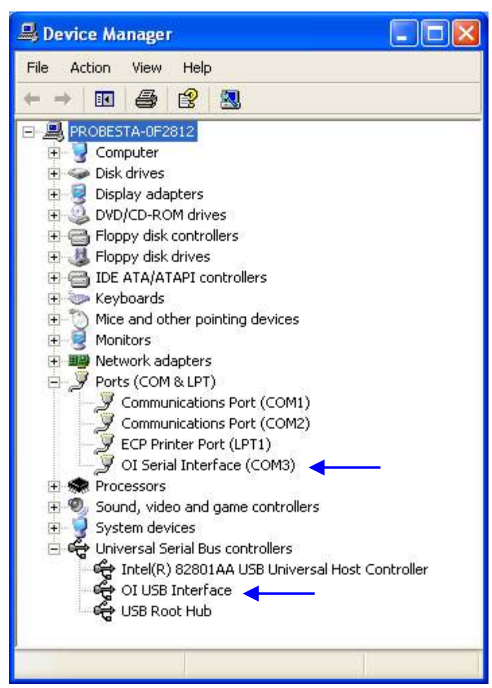
## 3.2.1 PC Programming

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 A. 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 A, 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.

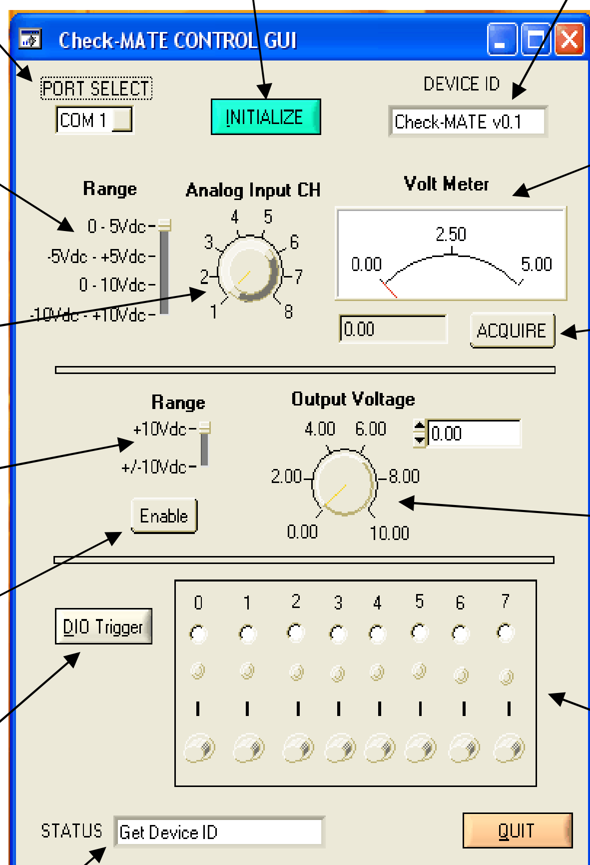
**Third Step**: After initializing, the module should send back a unique ID code. If no response has occurred within 10 seconds, the program will time-out , and generate a No Response message.

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

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

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

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




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

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

The 'Enable' function updates the analog output settings.

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

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 get_adc_volts[]   = "CK_RC?";     // configure & read a single ADC channel
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++) {

                        // 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

              A_ch++;
              sprintf (send_data, "%s%d%s\r", get_adc_ch, A_ch, "S04" );
              PutString(port,send_data);              // send 'CK_RC?' command
              GetString(port,sizeof(read_data),read_data);
              for ( idx = 1; idx <= 3; 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. **'<0F4>'**. 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_SScr** | Set single-ended configuration | <> | Set single-ended channel configuration.<br>c = ADC channel number (1 to 8)<br>r = ADC range (1 = +5V, 2 = ±5V, 3 = 10V, 4 = ±10V)<br>If c=0, then all channels are set to 'r' (same range) |
| **CK_SDcpr** | Set differential configuration | <> | Set differential channel configuration.<br>c = ADC channel number (1 to 4)<br>p = ADC polarity (0 = +, 1 = -)<br>r = ADC range (1 = +5V, 2 = ±5V, 3 = 10V, 4 = ±10V)<br>If c=0, then all channels are set to 'p' and 'r' (same polarity and range) |

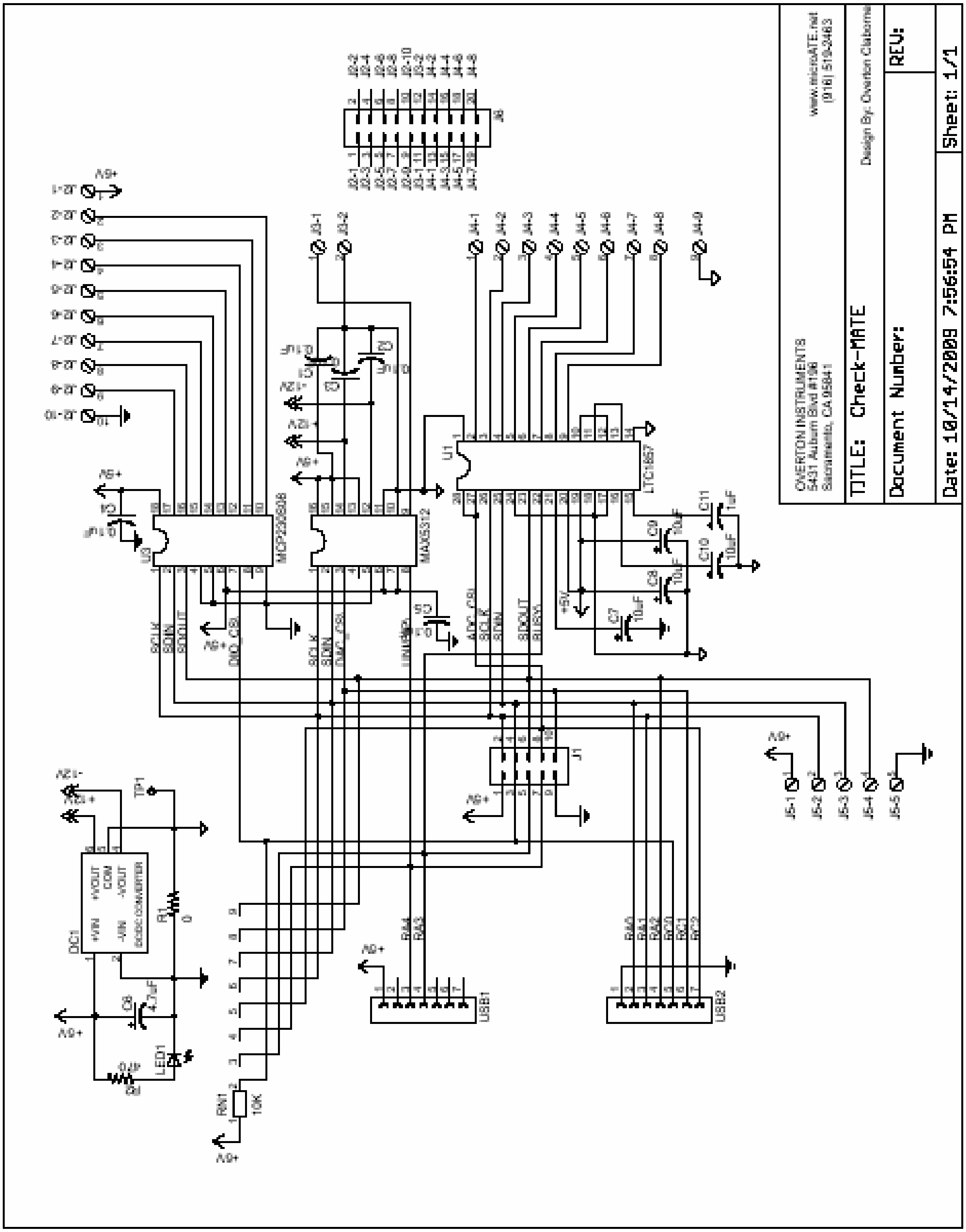
# Appendix A. Serial Command Set cont.

| Command | Function | Response | Description |
|---|---|---|---|
| **CK_RC?cmprf** | Configure channel and get voltage measurement | <n> | Configure and read a specific ADC channel.<br>c = ADC channel number (1 to 8 SE or 1 to 4 Diff)<br>m = ADC mode (“S” = Single-Ended, “D” = Differential)<br>p = ADC polarity (0 = +/-, 1 = -/+)<br>r = ADC range (1 = +5V, 2 = ±5V, 3 = 10V, 4 = ±10V)<br>f = Data format (“D” = Decimal, “H” = Hexa-decimal<br>The voltage measurement contains a series of ASCII bytes representing a 12-bit value which is expressed in counts (0-4095 or 000-FFF). |
| **CK_AS?nf** | Scan all channels and return voltage measurements | <CH1mpr=nnnn, CH2mpr=nnnn,.., CH8mpr=nnnn> | Auto scan all ADC channels and return readings based-on presets from channel configuration commands ‘CK_SS’ and ‘CK_SD’. The measured data is returned in one of two forms, Basic or Extended. In Extended each channel is identified (including the mode, polarity and range codes). The voltage measurements are a series of ASCII bytes representing a 12-bit value that is expressed in counts (0-4095 decimal or 000-FFF hex). A comma is used to separate each channel reading. In Basic mode, the measured data is provided alone. When n=0 (Basic mode is active), and n=1 (Extended mode is active).<br>When f=“D” (decimal data),<br>f=“H” (hexadecimal data). |
| **CK_MSnnn** | Set ADC measurement sample count | <> | Analog inputs can be averaged with a measurement sample count. The sample count value -nnn-, must be a 3 byte ASCII decimal from “000” to “255”. |
| **CK_MS?** | Get ADC measurement sample count | <n> | Get the current ADC sample count . |
| **CK_SAnnnn** | Set voltage output | <> | Set the DAC output voltage level. The DAC value -nnnn-, must be a 4 byte ASCII decimal number from “0000” to “4095”. In bipolar mode, “0000” = -10Vdc. |
| **CK_SA?** | Get voltage output | <n> | Get the current DAC output voltage. |
| **CK_DMn** | Set DAC mode | <> | 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. |

# Appendix A. Serial Command Set cont.

| Command | Function | Response | Description |
|---|---|---|---|
| **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