AN816

A CAN System Using Multiple MCP25050 I/O Expanders

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INTRODUCTION

The MCP25050 I/O Expander is an effective device that is used in a Controller Area Network (CAN) which operates without the use of a microcontroller. It supports CAN V2.0B with bit rates up to 1Mb/s. Since the I/O Expander is a stand-alone device, it can be configured to user defaults using a software template. These defaults are stored in non-volatile EPROM. A network protocol must be chosen that supports a Master Node. The Master Node is required for peer to peer communications between I/O Expander Nodes and therefore handles communication to and from all I/O Expander Nodes. For this design we have chosen the CAN-NET protocol which provides a generic framework for communication that natively supports I/O Expander Nodes. The CAN-NET framework allows users to develop a proprietary protocol for use by their own products.

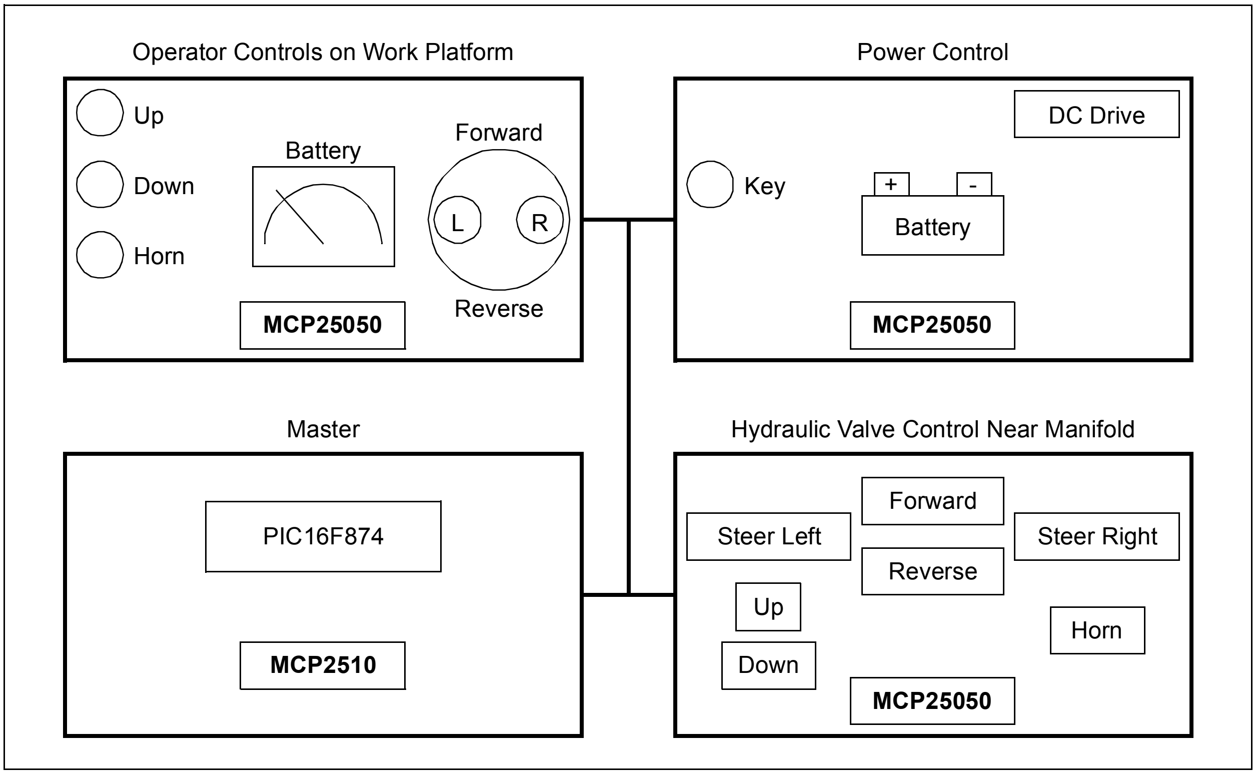
This Application Note describes a control system for a scissors lift that handles all of the operations and movements using one Master Node and three I/O Expander Nodes. The nodes are distributed throughout the vehicle and are connected together utilizing the 2-wire CAN interface. The master Node consists of a PIC16F874 working with an MCP2510 CAN controller.

With the substantial I/O capability of the expanders, all of the scissors lift control signals are able to seamlessly communicate with each other. The MCP25050 has many peripherals such as digital I/O, four 10-bit A/D channels, and two PWM outputs with up to 10-bits of resolution. Utilizing the I/O Expanders reduces the size of each node along with having the ability to control a large system with a few wires rather than using complex wiring harnesses.

SYSTEM OVERVIEW

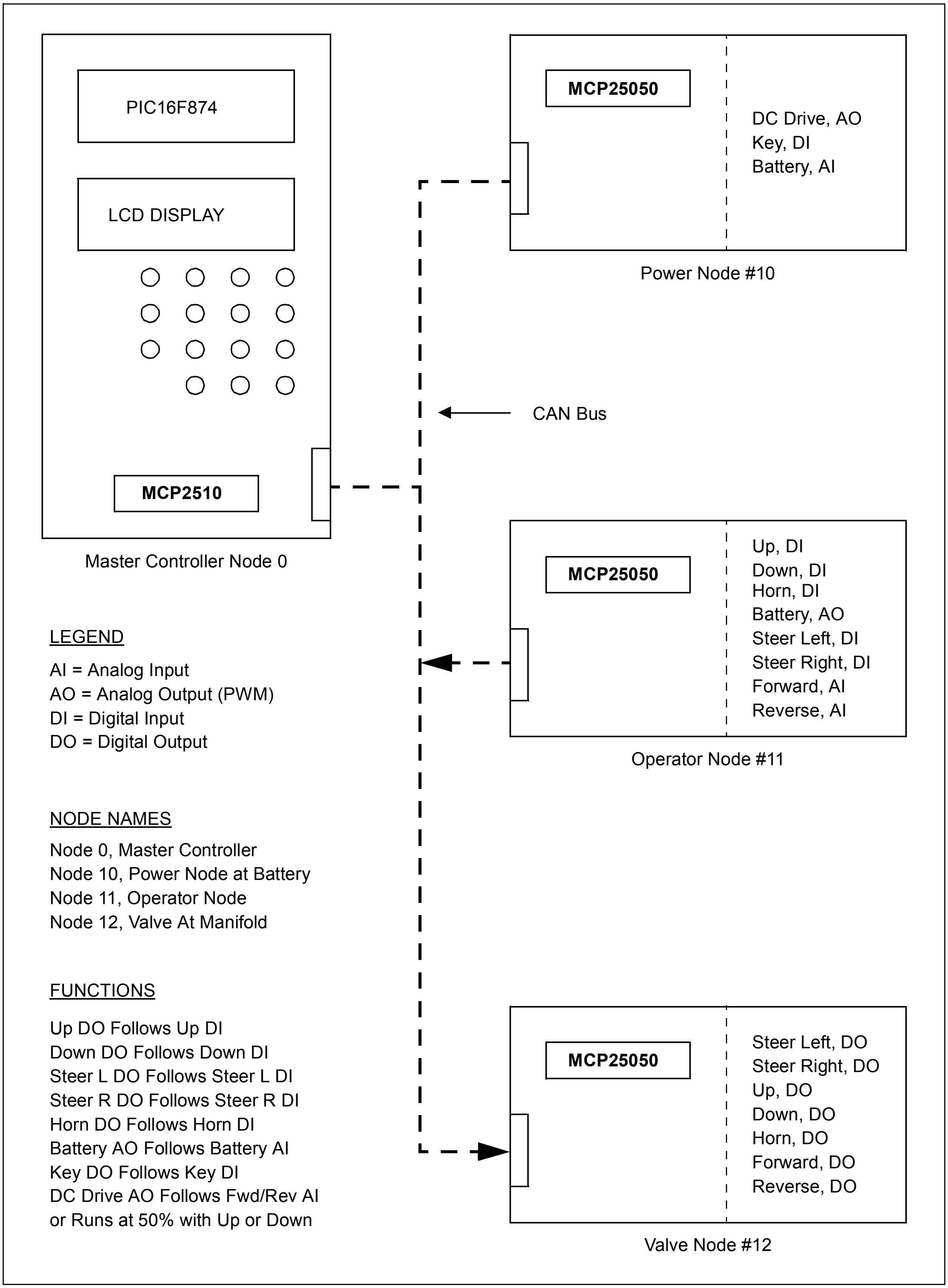
A scissors lift is essentially a mobile work platform enabling the user to reach relatively high places. The concept behind this vehicle is to have versatile maneuverability along with the ability to control the height. The basic block diagram is shown in Figure 1. All the actuators in the system are hydraulically based including the traction motors. A single DC motor drives a hydraulic pump and electro-hydraulic valves route the fluid to the appropriate actuator. The operator has complete control of the system from an operator panel located on the work platform. A single axis joystick controls forward and reverse motion while left and right steering is activated by a thumb controlled rocker switch on the top of the joystick. Raising and lowering of the platform is accomplished with UP and DOWN push buttons. A battery indicator and horn button are also located on the panel.

FIGURE 1: BASIC BLOCK DIAGRAM



The system uses CAN to bring all of the controls together utilizing the CAN bus shown in Figure 2. The CAN bus replaces large wiring harness and the controls are combined into a node. Each node handles the inputs and outputs along with transmitting and receiving information utilizing the bus. The bus consists of four wires. Two power wires and two CAN wires. The master controller supplies the main power and the nodes accept this power from the bus. Each node is regulated at 5V.

FIGURE 2: SYSTEM DIAGRAM



POWER NODE

The operation of Power Node is shown in Table 1. The battery input is scaled down from 12V and applied to one of the analog inputs on the MCP25050. The DC Drive is controlled by one of the PWM outputs of the MCP25050. The output signal is actually a PWM signal which is filtered into a DC voltage and run into the speed input of the DC Drive. The forward and reverse movement of the joystick determines the duty cycle while moving. When one of the up or down buttons are pressed the duty cycle will run at 50%. A key-switch in the base unit is connected to a digital input on the MCP25050.

TABLE 1: OPERATION OF POWER NODE

Operation	Type	Direction	Port Pin Description
Battery	Analog	Input	AN0
Key	Digital	Input	GP1
DC Drive	PWM	Output	PWM1

OPERATOR NODE

The operation of Operator Control Node is shown in Table 2. Operator Control Node controls all operations of the system from the work platform. The up and down momentary buttons are digital inputs which control their corresponding hydraulic valves and run the DC Drive at 50% speed. The joystick has a thumb operated momentary rocker switch for left and right steering. Forward and reverse motion of the lift is controlled by 2 potentiometers in the joystick, which are applied to two of the analog inputs on the MCP25050. These operations also control their corresponding hydraulic valves. The horn is a momentary button that is connected to a digital input and controls the horn relay. The battery voltage is displayed on an analog panel meter which is driven from one of the PWM outputs on the MCP25050.

TABLE 2: OPERATION OF OPERATOR CONTROL NODE

Operation	Type	Direction	Port Pin Description
Forward	Analog	Input	AN0
Reverse	Analog	Input	AN1
Battery	PWM	Output	PWM1
Horn	Digital	Input	GP3
Steer Left	Digital	Input	GP4
Steer Right	Digital	Input	GP5
Up	Digital	Input	GP6
Down	Digital	Input	GP7

VALVE NODE

The operation of Valve Control Node is shown in Table 3. Valve Control Node controls the hydraulic valves located at the manifold. All signals come from digital outputs on the MCP25050.

TABLE 3: OPERATION OF VALVE CONTROL NODE

Operation	Type	Direction	Port Pin Description
Up	Digital	Output	GP0
Down	Digital	Output	GP1
Horn	Digital	Output	GP2
Steer Left	Digital	Output	GP3
Steer Right	Digital	Output	GP4
Forward	Digital	Output	GP5
Reverse	Digital	Output	GP6

HARDWARE OVERVIEW

This reference design was implemented using CAN-NET development boards from Diversified Engineering. The CAN-NET Education board was used for the master control node and the CAN-NET I/O Expander Node was used for all satellite nodes. The CAN-NET I/O Expander Node is a versatile development platform for the MCP25050. Any combination of inputs and outputs can be realized by selecting the proper connections on the I/O header. Schematics for these boards are included in the appendix.

The CAN data rate selected for this system is 125 kbps.

CAN-NET GENERAL PURPOSE PROTOCOL

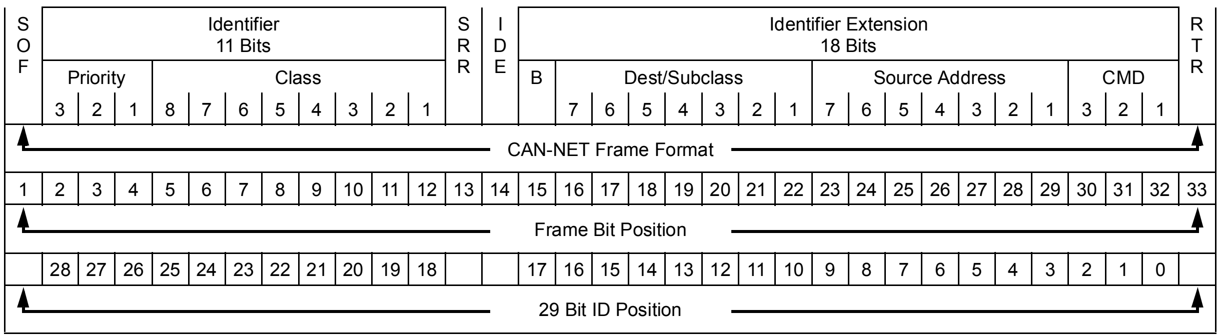
General Structure

The Application Note uses a flexible, general-purpose protocol structure that is designed to provide a basic framework for development of specialized proprietary protocols. The goal is simplicity rather than sophistication. We first present the general structure and then customize it to the reference design problem.

The general structure divides the 29 bit extended message identifier into two types of messages: Broadcast and Directed. Broadcast messages have no specific destination. Directed messages are sent with one or more specific destinations intended. Most of the fields of the message identifier are the same for both message types.

The general structure is designed for systems with a maximum of 128 nodes with each node having a unique address. This restriction can be relaxed by rearranging the number of bits allocated to each field or by adjusting the meaning of the Source and Dest/Subclass fields.

FIGURE 3: I/O PROTOCOL



The message identifier is structured by breaking it into six fields as indicated in the following table:

Field Name	Sym	# Bits	Description
Priority	I	3	Priority: a 0 has priority over a 1
Class	C	8	Type of information
Broadcast	B	1	0->Directed, 1->Broadcast
Destination/Subclass	D	7	Destination or Class dependent modifier.
Source Address	S	7	Source address
Cmd	C	3	Reserved for hardware restrictions of node

These fields are mapped onto the 29-bit message ID in the Microchip parts through the use of four one-byte registers. This mapping is common for the 2510 parts and the I/O Expander parts.

Register Name	7	6	5	4	3	2	1	0	Message ID mapping
SIDH	I2	I1	I0	C7	C6	C5	C4	C3	SID10-SID3
SIDL	C2	C1	C0	—	1	—	B	D6	SID2-SID0,x,1,x,EID17,EID16
EID8	D5	D4	D3	D2	D1	D0	S6	S5	EID15-EID8
EID0	S4	S3	S2	S1	S0	C3	C1	C0	EID7-EID0

Priority - The Priority bits are the upper three bits in the identifier and are used to resolve priority conflicts if two nodes want to transmit at the same time. A 0 has priority over a 1.

Class - The Class categorizes the type of information carried by the message. Eight bits support 256 classes or types of information. As will be discussed below, Broadcast type messages have a Subclass field that further expands the number of categories supported.

Broadcast - The Broadcast bit is a flag that identifies the message as a Directed message (0) or as a Broadcast message (1).

Dest/Subclass - The Dest/Subclass field is a seven-bit field. Its definition depends on the preceding Broadcast flag.

If the message is a Directed message then this is a Destination field and contains the address of the node or nodes to which the message is directed. A maximum of 128 node addresses is allowed.

If the message is a Broadcast message then this is a Subclass field that further categorizes the Class of information carried by the message. The meaning of the Subclass field depends on the specific Class.

Source - The Source field identifies the node that produced the message. A maximum of 128 node addresses are allowed.

Cmd - This three-bit field is set aside as an additional extension to the Class field to further identify the contents of the message. It is suggested that it be used to distinguish between multiple message types contained within the same node. This is how the I/O Expander devices use it and it is the only part of the message ID that is hardware determined (in the case of I/O Expander devices) and not adjustable by the user.

CAN-NET PROTOCOL IMPLEMENTATION FOR REFERENCE DESIGN

Class Definition

The CAN communication for the reference design consists only of messages being exchanged between the Controller board and I/O Expander nodes, (i.e I/O Expanders cannot generate messages that can be decoded by other I/O Expanders).

Class	Description
1	I/O Expander Data Packet containing GPIO digital inputs and A/D values
2	I/O Expander PWM output values
3	I/O Expander Digital outputs
4	All other I/O Expander messages (ignored by Master Controller)

All of the classes have associated data that is formatted in a specific manner that is fixed for an I/O Expander. Detailed information is available in the I/O Expander data sheet.

Class 1

These messages are generated by the I/O Expander for consumption by the Controller board.

The associated data is an eight-byte data group that contains all the measured data values measured by the MCP25050:

	Bit Name
8 bits	IOINTFL
8 bits	GPIO
4 bytes	AN0H
4 bytes	AN1H
2 bytes	AN10L
4 bytes	AN2H
4 bytes	AN3H
2 bytes	AN23L

- The eight bits of IOINTFL indicate which inputs have changed since the last message.
- The eight bits of GPIO give the state of each of the inputs.
- The four bytes, AN0H, AN1H, AN2H, AN3H, give the upper 8 bits of the 10 bit A/D measurement from each activated A/D input.
- The two bytes, AN10L and AN32L, give the lower 2 bits of the 10-bit A/D measurement from each activated A/D input. The bits are left justified in the four nibbles that make up the two bytes as follows:
  - AN10L = (AN1:1,AN1:0,0,0 AN0:1,AN0:0,0,0)
  - AN32L = (AN3:1, AN3:0,0,0, AN2:1,AN2:0,0,0)

Class 2 and 3

These messages are generated by the Controller board for consumption by the MCP25050 devices.

The data group used by these Classes is the "Write Register" command of the MCP25050 devices that allows the writing of a data value directly into a register of the 2505x. In Class 2 the PWM registers are addressed and for Class 3 it is the GPLAT register that sets the digital output levels.

Node Addresses

Each node in the system is assigned a unique node address for use in the Source and Dest/Subclass fields.

Address	Node
0	MasterController Node
10	Power Node
11	Operator Control Node
12	Valve Control Node

Master Controller Node

	Direction	
	Send	Receive
Priority	0	0
Class	2 or 3	1
Broadcast	No	Yes
Dest/Subclass	10,11,12	0
Source	0	10,11,12
Cmd	0	0

Power Node

	Direction	
	Send	Receive
Priority	0	0
Class	1,4	2,3
Broadcast	Yes	No
Dest/Subclass	0	10
Source	10	0
Cmd	0	0

Operator Control Node

	Direction	
	Send	Receive
Priority	0	0
Class	1,4	2,3
Broadcast	Yes	No
Dest/Subclass	0	11

Operator Control Node

	Direction	
	Send	**Receive**
Source	11	0
Cmd	0	0

Valve Control Node

	Direction	
	Send	**Receive**
Priority	0	0
Class	1,4	2,3
Broadcast	Yes	No
Dest/Subclass	0	12
Source	12	0
Cmd	0	0

SOFTWARE OVERVIEW

Configuring the MCP25050 devices consists of providing arguments to a set of macros that generate a data table for MASM. In this sense, I/O Expander devices are configured rather than programmed.

The Controller board is programmed in the normal fashion but the specific details of the programming are not particularly important for the reference design since the primary purpose of the Controller board is to receive messages from the I/O Expanders and repackage the data to be sent to the other I/O Expanders.

I/O EXPANDER CONFIGURATION

For I/O Expander configurations that are static, (i.e. the configuration is not changed dynamically over the network), the important configuration parameters fall into two categories: network related items and I/O functions.

Choosing the network values other than the message ID's consist primarily in calculating the networking parameters determined by clock frequency and other physical characteristics of the network. The message ID's for transmitting and receiving messages are determined by the network protocol selected. For the reference design the message ID selection is described in detail above.

The MCP25050 can be configured to perform up to eight I/O functions. To chose from there are 8 digital inputs, 7 digital outputs, four 10-bit A/D channels, and two PWM outputs with up to 10-bits of resolution. Available with each of the I/O types are associated support functions such as message transmission triggered by a change in input. Scheduled message transmission can be used in addition to on-change messaging to insure the network is routinely informed of the current state of the inputs even if none of them have changed.

A combination of scheduled and on-change messages often is the best solution to routine updates with rapid response to change.

The data selections for the reference design are in files:

File	Description
OPERNODE.ASM	Operator board
MAINNODE.ASM	Main board
VALVNODE.ASM	Hydraulic valve board

CONTROLLER BOARD SOFTWARE

The Controller board software is written to run on the Diversified Engineering CAN-NET Education board. The code for the CAN NET board is written in the PIC instruction set to be assembled using Microchip's MPLAB environment. There is significant use of macros to make the code more readable and less error prone. In addition to the macros defined at the top of the individual files a large number of macros can be found in the MACROS16.INC file. If in reading the code you come across an unfamiliar instruction it probably is a macro. We use the macros in MACROS16.INC extensively in writing code for PICs and have found that they increase readability and greatly reduce programming errors.

To simplify the code, the code that handled the LCD display and keypad input was removed. What remains is the initialization code that sets up the ports and initializes the MCP2510 CAN controller and a main loop that checks for CAN messages from the I/O Expander nodes and sends messages to the I/O Expander nodes.

The technique used by the program is to maintain a local set of variables that fully represent the state of the system. The variables are updated by messages received from the I/O Expander nodes and the new values are sent to the appropriate I/O Expanders.

Nine digital flags that contain the current state of the associated buttons or outputs represent the binary values.

tbFlgUp	Up
tbFlgDown	Down
tbFlgHorn	Horn
tbFlgLeft	Left
tbFlgRight	Right
tbFlgForward	Forward
tbFlgReverse	Reverse
tbFlgBattery	Battery LED
tbFlgKeyLED	Key LED
tbFlgKey	Key

The four analog variables are represented by four 1-byte quantities.

bBatteryLevel	Battery level 0 -> 255
bDCDrive	DC Drive control level: 0 -> 255
bForward	Joy stick level: 0 -> 255
bReverse	Joy stick level: 0 -> 255

Each time a message is received from a MCP25050, the received data is used to update the local binary and analog variables that maintain the state of the system. If a binary or analog value is received that should be sent to another of the I/O Expanders in the system a flag is set indicating that a message should be sent to that I/O Expander.

Each time around the main loop incoming messages are parsed and messages are generated for I/O Expanders.

The only calculations done by the controller board software are for the operation of the DC drive motor. The two analog values from the forward and reverse joystick inputs on the Operator Control Board are converted to a single PWM for the DC Drive and binary forward or reverse valve positions. A dead band is imposed so that the exact center of the joystick need not be known. Other than these calculations, the input data is simply sent back out to the appropriate node.

The controller software is contained in the files:

File	Description
MCP2510.inc	Definitions and macros for 2510 support
Macros16.inc	Support macros
MainExp.asm	Main program
RefCode.asm	Code specific to the Reference Design
Ref.asm	I/O Expander Reference Design
Canlib.asm	2510 support functions
Lcd4bit.asm	LCD Handler
OperExp.asm	Operator Control Board
ValveExp.asm	Valve Control Board

CONCLUSION

The MCP25050 CAN I/O Expanders are an excellent and effective solution for new systems or simply adding them to an existing system. The advantage of the MCP25050 CAN I/O Expander is that an extra controller is not needed per node in order to utilize the CAN engine. Another advantage is that several Expanders can work off of the same CAN bus rather than using large and complicated wiring harnesses. This design demonstrates a useful way to integrate the expanders in a system using different types of inputs and outputs and also by providing a stepping stone to quickly start similar projects. From this example, several uses can be implemented simply by using the basic techniques from this design.

CONTACTING DIVERSIFIED ENGINEERING

Additional information and CAN related products may be obtained from Diversified Engineering by calling:

(203) 799-7875

or by visiting their web site:

www.DiversifiedEngineering.net

SOURCE CODE

Because of its overall size and number of files for the controller software, a complete source file is not provided. The complete source code is available as a single WinZip archive file, which may be downloaded from the Microchip corporate Web site at:

www.microchip.com

APPENDIX A: CAN-NET BOARD SCHEMATICS

FIGURE A-1: Main CAN-NET Board Schematic

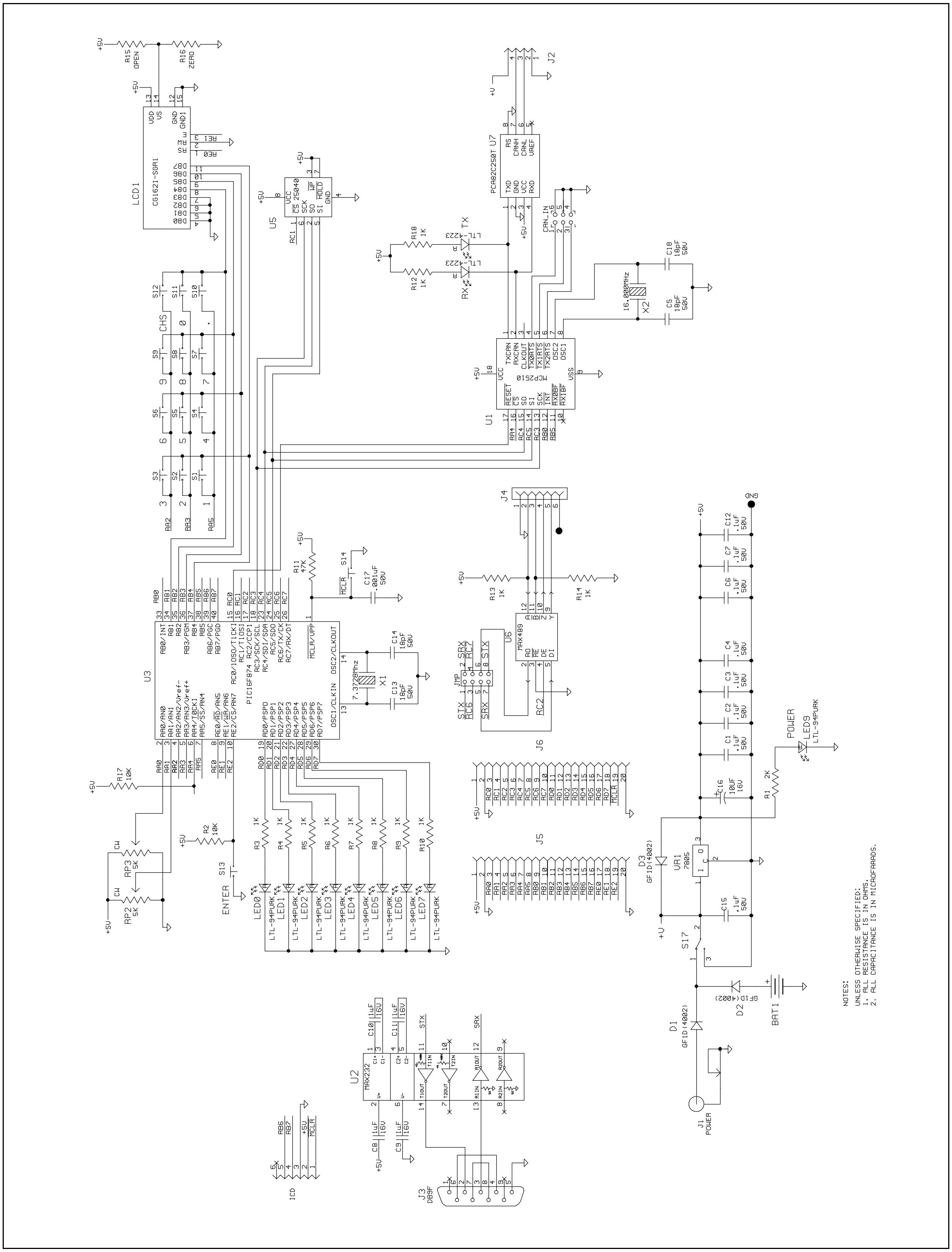


FIGURE A-2: CAN I/O Expander Schematic (1 of 2)

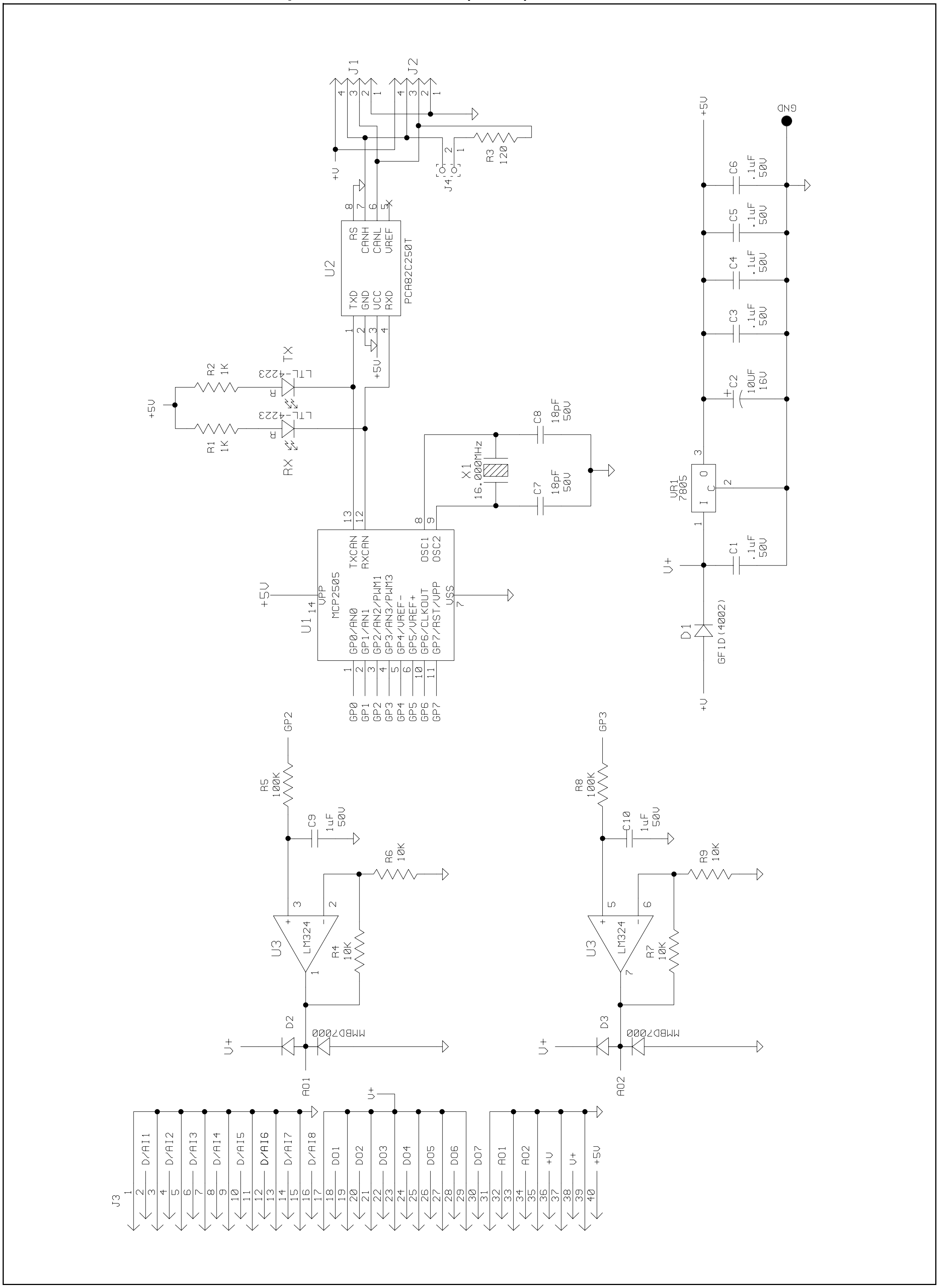
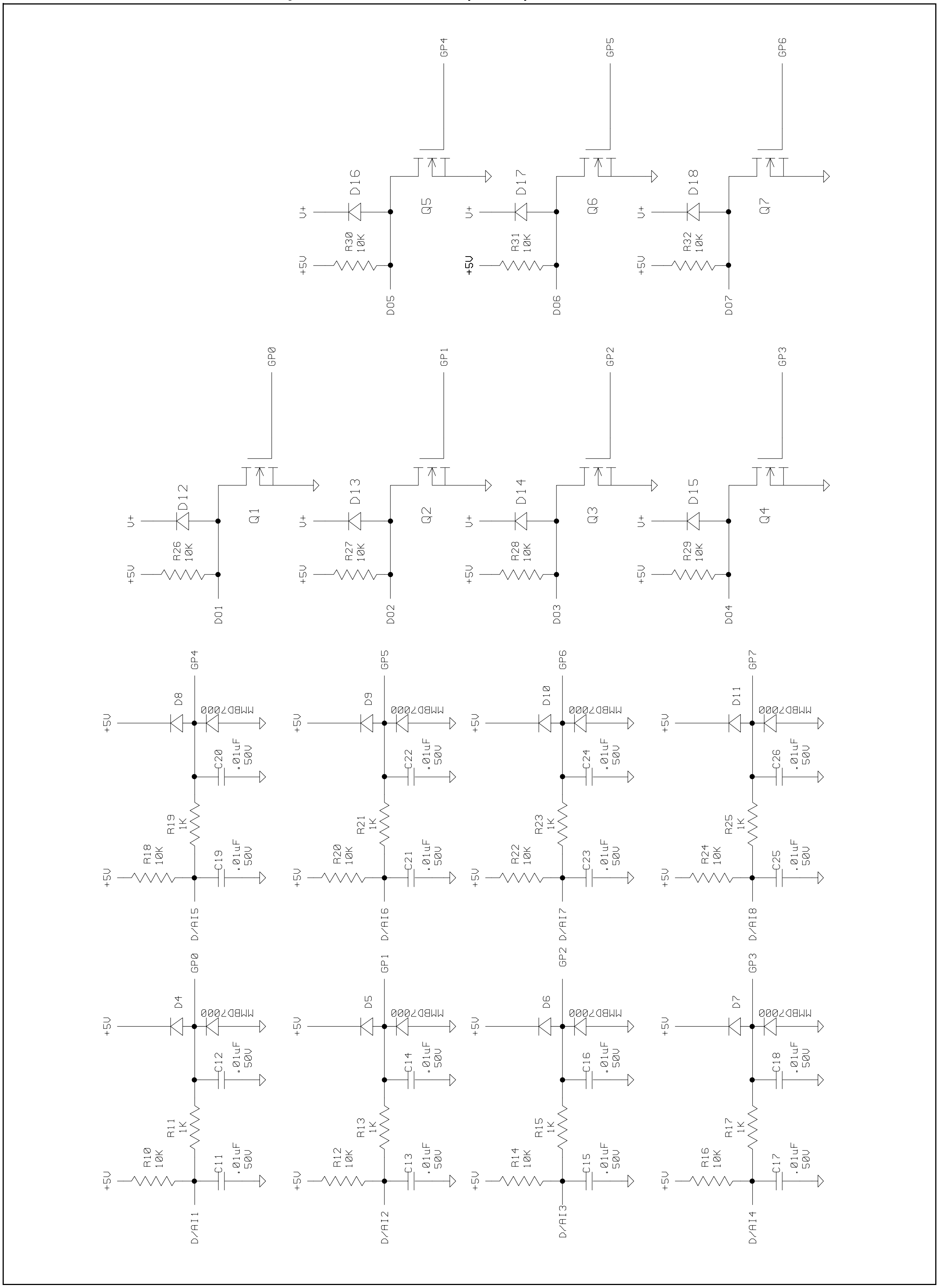


FIGURE A-3: CAN I/O Expander Schematic (2 of 2)



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