Z System Designs
LCC Development Board 1

This is an attempt at creating an LCC Development Booster Pack for the TIVA Launchpad boards from Texas Instruments. The goal of this board is to build an add-on to the Launchpad which can be used to develop LCC nodes. The board has some options to allow different capabilities and it has an expansion connector to add-on IO for specific purposes. This board is entirely through-pin parts which can be soldered easily. The specific Launchpad board for which it is designed is the TM4C123G evaluation kit as noted in the BOM. A future design may be created to also support the TM4C129 versions.

Options:

Outputs can be either the output of a shift register with either 100ma. continuous current in an open Drain configuration, or an operational amplifier output which can provide 30 ma. for a stall motor turnout device (Tortoise). In addition, an optional Darlington array can be added to provide an open-collector, 500 ma. output from selected GPIO ports on the Launchpad. These GPIO ports include several that have PWM capability.

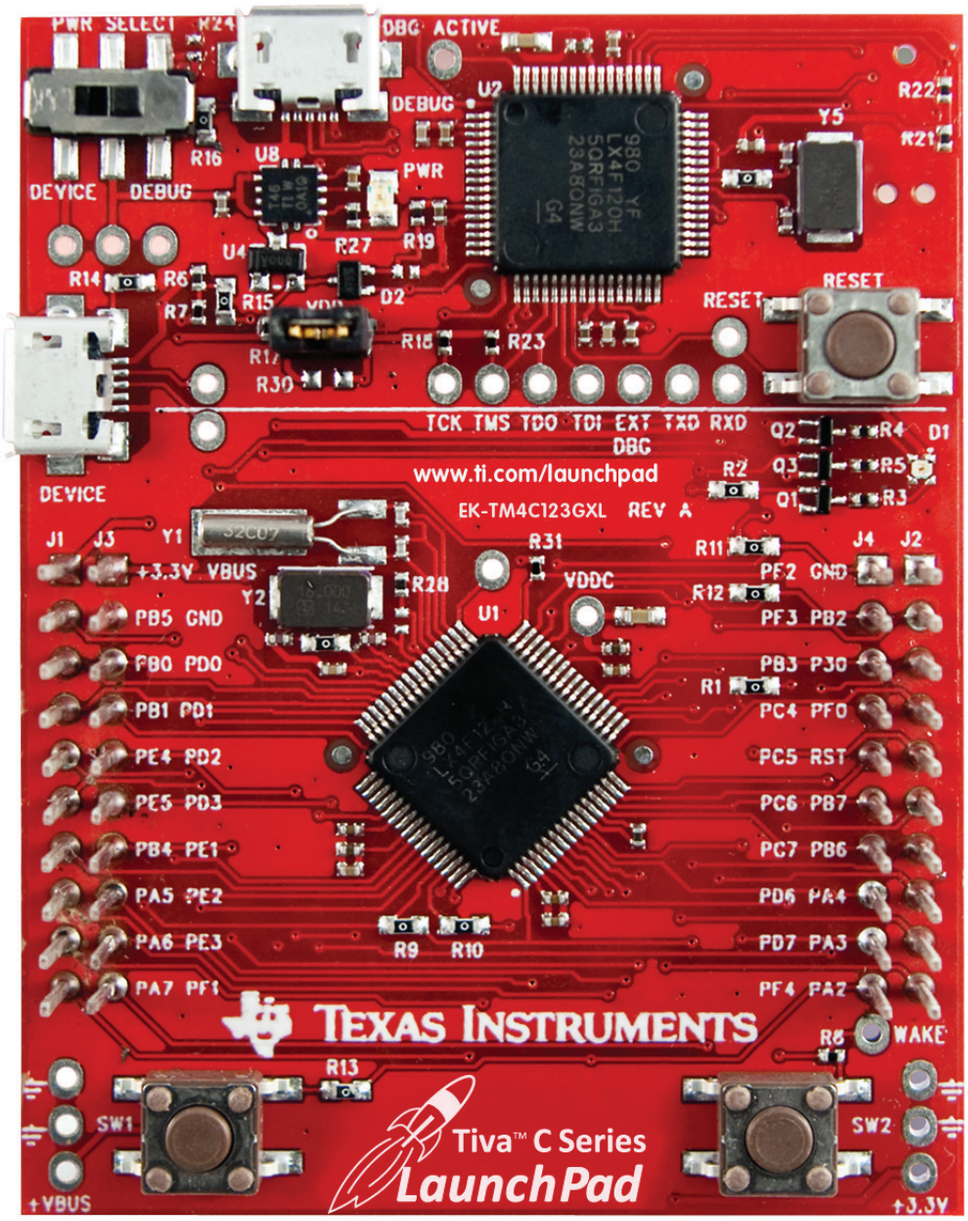
Inputs include 16 inputs through an IO Expander shift register, which can generate an interrupt in the processor. Additional inputs can be accessed directly on a header strip. These inputs are available to provide A/D conversion and interrupts — there is no buffering between the header pins and the processor for these inputs.

Power options are provided by way of jumpers on header pins. these include 1) powering the CAN bus from this card, providing higher voltage/current through a terminal block, and providing CAN termination. See the figures following for these options.

Launchpad Board Settings

To provide all the capabilities of a stand-alone board, a couple of changes need to be made to the Launchpad board. See the picture on the next page for additional detail on the location of these changes. First, the LCC board includes a 5-volt power regulator. This can be used to power the Launchpad and is normally connected to it. To avoid conflict with the USB provided power, the "Power Select" switch at the top right should be switched to the "Device" position. In this position, do not connect a USB cable to the USB connector on the side of the board. Alternately, power can be supplied through this connector, but then the CAN network cannot be powered from this card. (This constraint may be removed in a future design. The routing/protection circuitry has not been included on this board.)

Secondly, to allow all the GPIO ports to be available, two "resistors" (these resistors have zero ohms) can be removed from the Launchpad board. The resistor designations are R9 and R10. They are located just below the processor in the center opf the board. Heat them up gently with a soldering iron and slide them off there pads to remove them. These resistors are shown on the TIVA picture just below. For those who may worry about this step, these resistors short together GPIO pins to allow backward

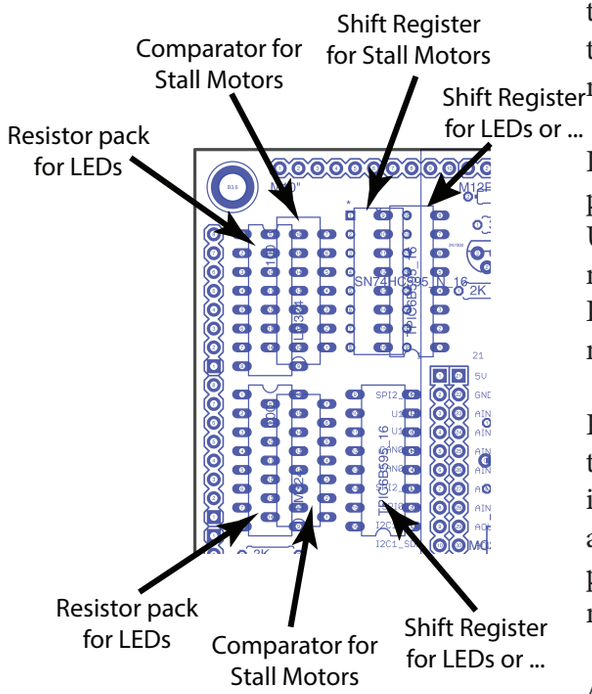


compatibility with the non-TIVA Launchpads. Since there is no intent to use other BoosterPacks at the sasme time as this one, providing the full set of GPIO pins was considered more important.

Board Assembly and Connections

The first decision is to decide which of the Output options you want. The output for stall motors is mutually exclusive with the first eight Open-Drain shift register outputs. See the BOM for the related parts. It is possible to have both four stall motor outputs and eight outputs for LEDs or other devices. Just install the Op-amp comparators and their resistors, then install the second shift register for the additional inputs. The area on the top left side of the LCC board contains these parts. The drawing

below shows the positions of the parts for shift registers and stall motor comparators. The resistor packs shown are connected to the open drain outputs to provide current for LEDs connected to +5 volts. They can be changed according to the voltage or eliminated)jumper across) for other uses. If the second shift register at the bottom is installed with the stall motor comparators, the resistors or jumpers may have to be installed on the bottom of the board.



Installation of the additional parts can be seen by the part designations on the drawing on following pages. Using the BOM as a guide, install the parts that you need. For example, if you are not intending to use the Darlington ouputs, do not install IC2, RN3 or the connectors that go with them.

Power for the board and its devices is provided through the connector at the bottom. The barrel plug is designed to accommodate a +12 volt supply rated at at least 500 ma, but if the CAN network is also supplied by this power supply, the rating should be 1000 ma. or higher.

Another possible option is to install screw terminals, headers or nothing on the edges of the card. The conveience of connectors is a cost decision.

An additional screw terminal is provided to allow other voltages for stall motors or the Darlington transistor array outputs. Providing that power depends on the jumpers at the lower right. These jumpers and others are detailed in the second drawing.

Inputs to the IO expander are assumed to be simple push-button switches or the equivalent. Since the IO expander has internal pull-up resistors (setup during intial setup of the IO Expander — see the data sheet for details), all the switch needs to do is short to ground. When one of the inputs changes, an interrupt can be sent to the processor as a signal to read the IO expander. This interrupt is currently wire ORed to pin PD7 on the board.

Expansion signals are shown in the drawings. These are tied to the shift registers and IO expander to provide additional inputs and outputs, as well as additional IO ports, including a UART, another I2C and another SPI port. The additional SPI port is set for SSI Module 2, which is the default SPI module in Energia. The expansion I2C module is module 0, so the Wire object in Energia will have to be re-directed to that module. The easiest method to use that module is to define a new object by entering “extern Twowire Wirex(0);” and use the Wirex object instead of Wire.

Software Considerations

The intent of this board is to use the OpenMRN suite to connect to the LCC network. With this set of software, many of the functions necessary to connect to the LCC network are provided. At present, that software is aimed at a Linux environment for development, however, I believe that the TI version

of Arduino called Energia can be used to create nodes with Open MRN. Therefore, the following discussion includes information on programming the board with Energia.

Node software provides the link between the events coming from LCC and the input/output pins on the board. If Energia is used to program the node, the IO Expander can be read using the Wire library. Likewise, the SPI for the shift registers can be written using the SPI library. If the noide is programmed using a command line tool chain, these libraries may still be useful, but the bare-bones approach should use the TI Peripheral library that exists in ROM. The details of using these libraries are contained in the document from TI in the se4ctions for the Inter-Integrated Control (I2C) and the Synchronous Serial Inteface. These ROM functions set and control all the interactions with the hardware modules which saves memory space and saves effort.

To configure the software, the necessary IO ports are SSI 0, I2C 1 and CAN 0. The expansion ports are SSI 2, I2C0 aND UART 1. The SSI 0 port is used for the output shift registers, the I2C 1 port is used for the IO Expander. As described above, the SSI module used for the SPI functions in Energia use module 2, so the SPI for the on-board shift registers must be re-directed to module 0. If the expansion SPI is not used, this can be accomplished by using the SPI.setModule(0); call. This must be before the SPI.begin(); statement and belongs in the setup portion of the program.

Bill Of Materials (BOM)

The BOM has part numbers and costs from Digikey, with the exception of the Booster Pack headers. The BOM is divided into section to separate the optional parts. Within the sections there are additional optional part selections to be made.

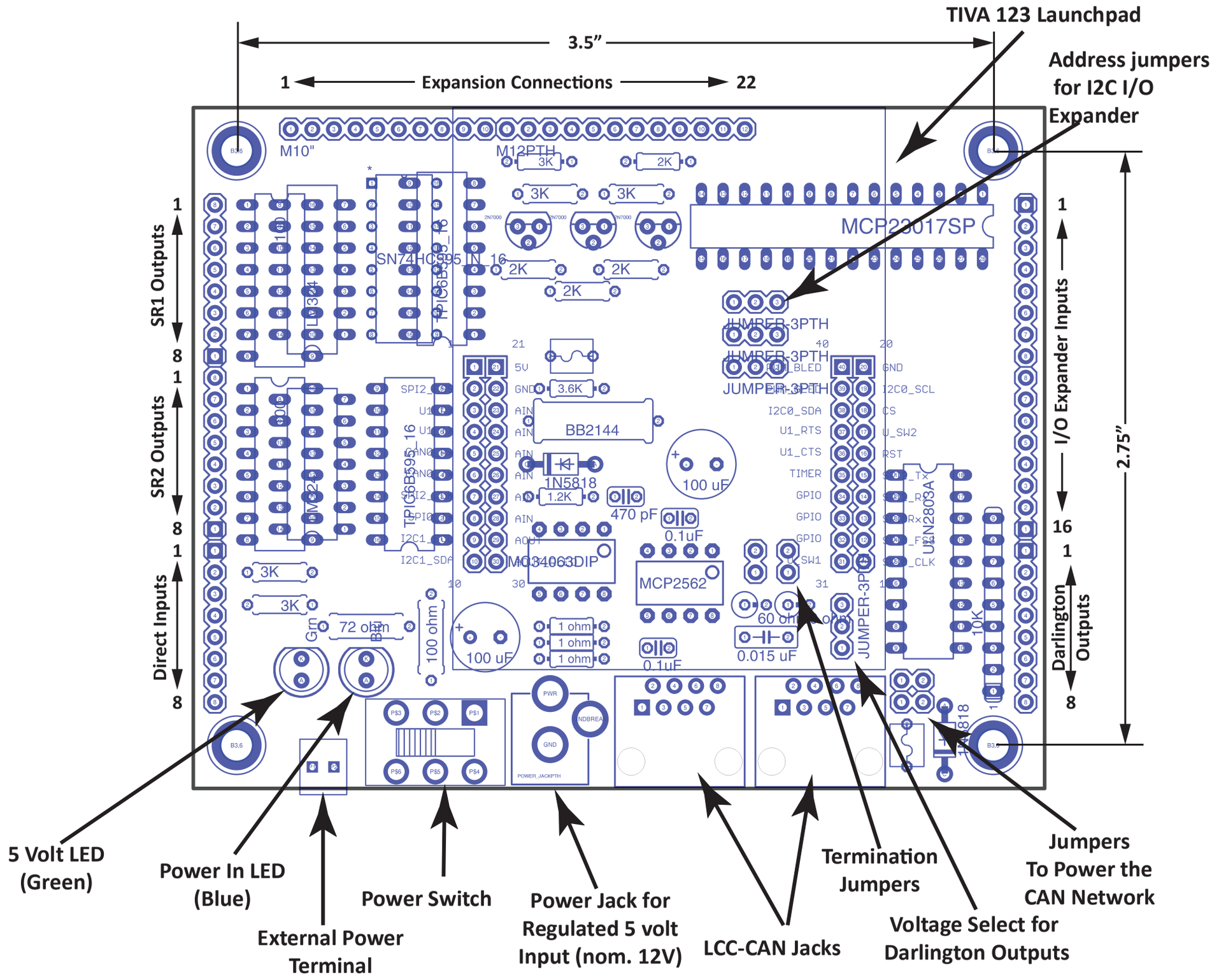
References and Hyperlinks

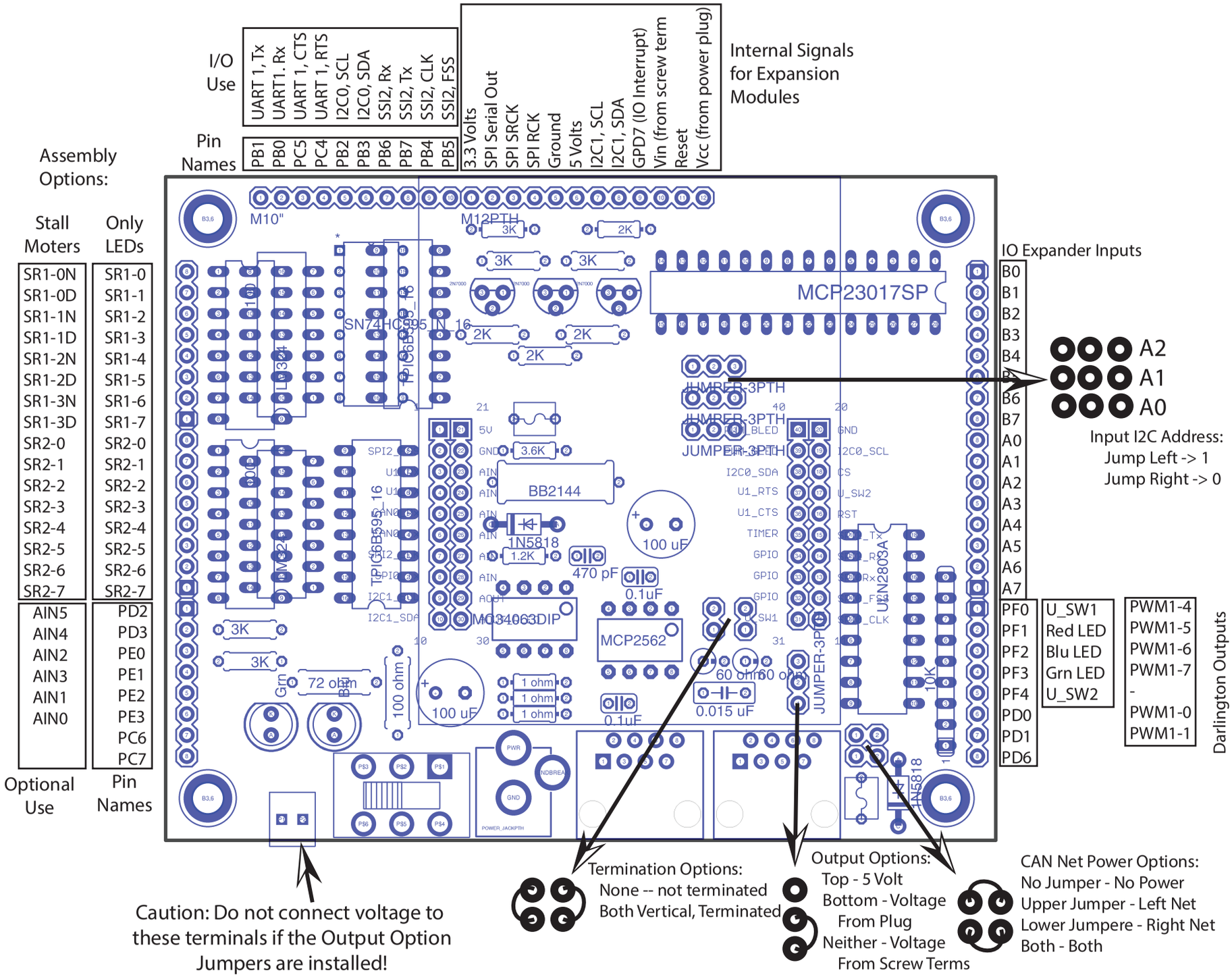
These references may be useful to the programmer:

Energia — The Energia IDE is available from ***this*** website. Follow instructions to download it. Then, install the TIVA board using the board manager. While Energia has a set of Reference pages accessible from the Help menu, they are incomplete, especially in the Libraries pages. Using the Arduino References as a supplement usually works, but sometimes the actual libraries may be necessary to figure out how to implement functions.

Tiva Launchpad Documents — Use of the TM4C123G evealuation board is containe4d in the ***TM4C123G Users Manual.*** This manual describes the Launchpad Board and all of the IO pins attached to it. Details of the TM4C123G processor are in the ***data sheet***. All the details of the hardware are in this document.

ALL other parts — The parts used may be purchased from Digikey, and the daa sheets for thesed parts are available from Digikey.

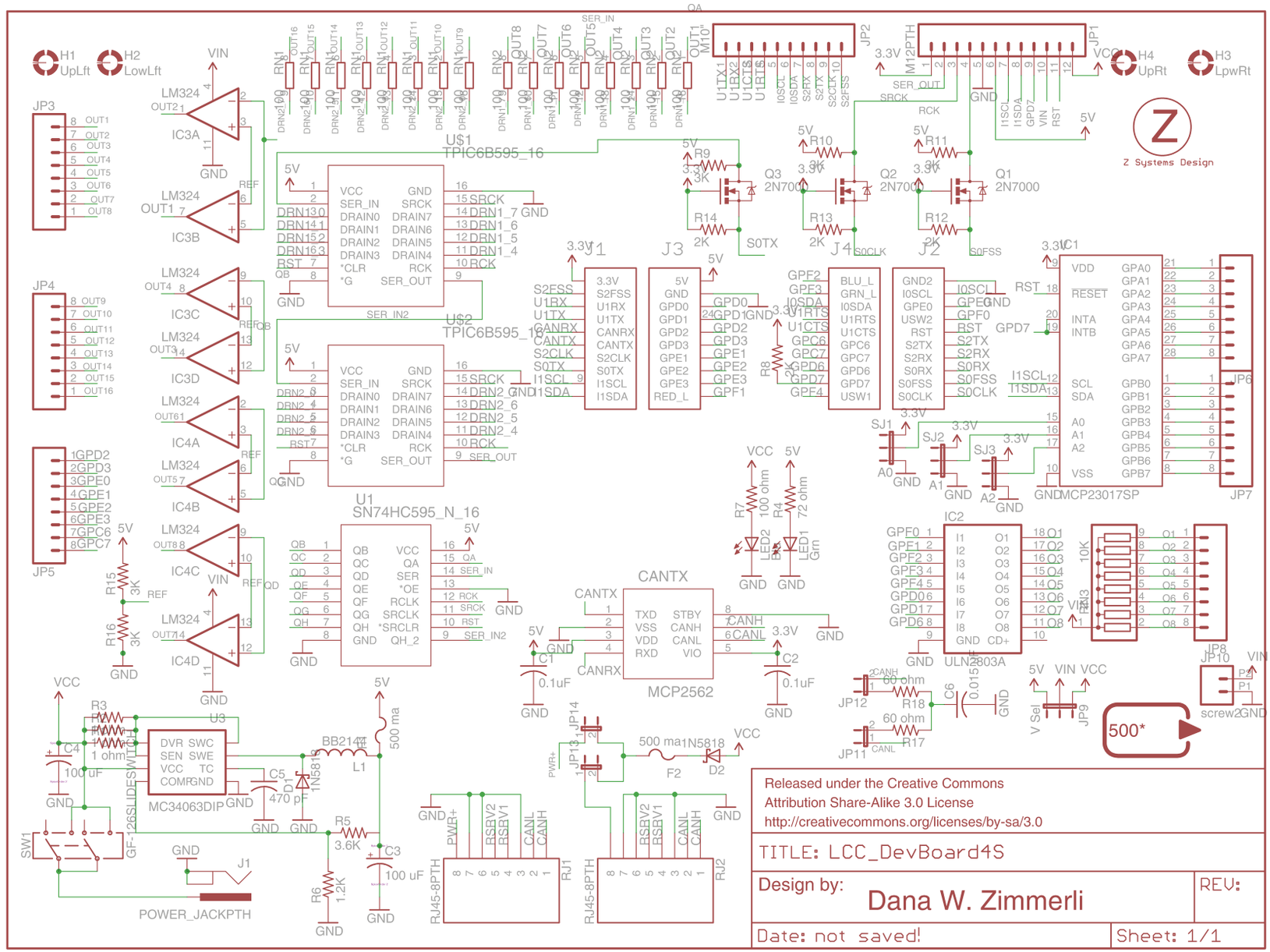

TIVA 123 Launchpad
3.5”
1
Expansion Connections
22
Address jumpers
for I2C I/O
Expander
SR1 Outputs
SR2 Outputs
Direct Inputs
I/O Expander Inputs
Darlington
Outputs
2.75”
MCP23017SP
SN74HC595_IN_16
BB2144
1N5818
MC34063DIP
MCP2562
JUMPER-3PTH
5 Volt LED
(Green)
Power In LED
(Blue)
External Power
Terminal
Power Switch
Power Jack for
Regulated 5 volt
Input (nom. 12V)
LCC-CAN Jacks
Termination
Jumpers
Voltage Select for
Darlington Outputs
Jumpers
To Power the
CAN Network


I/O Use
UART 1, Tx
UART1. Rx
UART 1, CTS
UART 1, RTS
I2C0, SCL
I2C0, SDA
SSI2, Rx
SSI2, Tx
SSI2, CLK
SSI2, FSS
Pin Names
PB1
PB0
PC5
PC4
PB2
PB3
PB6
PB7
PB4
PB5
3.3 Volts
SPI Serial Out
SPI SRCK
SPI RCK
Ground
5 Volts
I2C1, SCL
I2C1, SDA
GPD7 (IO Interrupt)
Vin (from screw term
Reset
Vcc (from power plug)
Internal Signals for Expansion Modules
Assembly Options:
Stall Moters
SR1-0N
SR1-0D
SR1-1N
SR1-1D
SR1-2N
SR1-2D
SR1-3N
SR1-3D
SR2-0
SR2-1
SR2-2
SR2-3
SR2-4
SR2-5
SR2-6
SR2-7
Only LEDs
SR1-0
SR1-1
SR1-2
SR1-3
SR1-4
SR1-5
SR1-6
SR1-7
SR2-0
SR2-1
SR2-2
SR2-3
SR2-4
SR2-5
SR2-6
SR2-7
Optional Use
AIN5
AIN4
AIN2
AIN3
AIN1
AIN0
Pin Names
PD2
PD3
PE0
PE1
PE2
PE3
PC6
PC7
IO Expander Inputs
B0
B1
B2
B3
B4
B5
B6
B7
A0
A1
A2
A3
A4
A5
A6
A7
A2
A1
A0
Input I2C Address:
Jump Left -> 1
Jump Right -> 0
PF0
PF1
PF2
PF3
PF4
PD0
PD1
PD6
U_SW1
Red LED
Blu LED
Grn LED
U_SW2
PWM1-4
PWM1-5
PWM1-6
PWM1-7
-
PWM1-0
PWM1-1
Darlington Outputs
Caution: Do not connect voltage to these terminals if the Output Option Jumpers are installed!
Termination Options:
None -- not terminated
Both Vertical, Terminated
Output Options:
Top - 5 Volt
Bottom - Voltage From Plug
Neither - Voltage From Screw Terms
CAN Net Power Options:
No Jumper - No Power
Upper Jumper - Left Net
Lower Jumpere - Right Net
Both - Both
MCP23017SP
MCP2562
MC34063DIP
BB2144
1N5818
ULN2803A
JUMPER-3PTH
JUMPER-3PTH
JUMPER-3PTH
JUMPER-3PTH
JUMPER-3PTH
M10"
M12PTH
3K
2K
3.6K
1.2K
10K
470 pF
0.1uF
0.015 uF
100 uF
72 ohm
100 ohm
60 ohm
1 ohm
SN74HC595_IN_16
TPIC6B595_16
PWR
GND
NDBREA
POWER_JACKPTH

Option 1	16 Inputs, 16 outputs, no other	35.29
Option 2	16 inputs, 8 outputs, 4 stall 3	5.31
Option 3	Option 2 + Darlington3	6.72
Option 4	Everything with Stall Moters	41.61
Option 5	Option1 w/o 5-volt regulator	30.57
Option 6	15 outputs, 8 output, only	33.60

Basic required parts						
DesignationD	escription	Qty	Manuf Part Num	Digikey PN	Cost @	Extended
				Required Parts		28.88
	Tiva board	1	TM4C123G	296-35760-ND	13.491	3.49
	PCB (10cm x 10cm)	1			.503	.50
	CAN Transceiver (Required)					
CANTXT	ransceiver	1	MCP2562E/P	MCP2562-E/P-ND	0.93	0.93
C1, C2B	ypass caps -- 0.1uf	2	K104Z15Y5VE5TL2	BC1148CT-ND	0.15	0.29
RJ1, RJ2	RJ45 sockets	2	A-2004-2-4-LP-N-R	AE10384-ND	0.69	1.38
	5-volt Switching regulator (Required)					
U3	Vreg for 5 volt1		MC34063AP	296-17766-5-ND	0.58	0.58
L1	inductor 100 uH1		B82144A2104J	495-5613-1-ND	0.71	0.71
C5	Vreg Cap 1 -- 470 pF1		K471J15C0GF5TL2	BC1021CT-ND	0.24	0.24
C3,C4V	reg Cap 2 - 100 uF2		UMA1E101MDD1TP	493-10432-1-ND	0.32	0.64
D1	Schottkey Rectifier	1	1N5819	1N5819FSCT-ND	0.43	0.43
F1	PTC fuse for 5 volt - 1 amp	1	PTCCL05H940EBE	BC2319-ND	0.67	0.67
R1,R2,R3	Sense resistor 0.33 ohm, 1/4 W	3	RNF14FTD1R00	RNF14FTD1R00CT-ND	0.14	0.42
R6	Resistor R1 for 5 volts = 1.2K	1	RNMF14FTC1K20	S1.2KCACT-ND	0.10	0.10
R5	Resisto R2 for 5 volts = 3.6K1		RNMF14FTC3K60	S3.6KCACT-ND	0.10	0.10
J1	Power input connector	1	EJ508A	EJ508A-ND	0.83	0.83
	Board Support Parts (Some Options)					3.45
JP10	2 terminal screw for Vin	1	OSTVN02A150	ED10561-ND	0.58	0.58
A1	Booster Pack Stacking Header4		SSW-110-23-S-D	Special Part	0.74	2.96
	Booster Pack male Headers	0	TSW-110-07-F-D	SAM9002-ND	1.45	0.00
JP+JP2	22 pin rt. Angle stackingheader1		SLW-122-01-T-S	SAM1093-22-ND	2.22	2.22
F2	PTC fuse for CAN	1	B59758B110A70	495-3885-ND	0.22	0.22
SW1E	xternal power switch	1	GF-126-0312	CWI349-ND	0.78	0.78
D2	Power protect diode	1	1N5819	1N5819FSCT-ND	0.43	0.43
LED1	Power LED - 5 volt - green	1	C503B-BAN-CZ0A0452	C503B-BAN-CZ0A0452CT-ND	0.30	.30
LED2	Power LED - 12 volt - Blue1		C503B-GCS-CA0B0782	C503B-GCS-CA0B0782CT-ND	0.33	0.33
R4	LED 5v resistor - 22 ma, 3.4v = 7	1	RNF14FTD75R0	RNF14FTD75R0CT-ND	0.10	.10
R7	LED 12V resistor - 18ma, 3.2v =	1	RNF14FTD100R	RNF14FTD100RCT-ND	0.10	.10
	CAN Trermination Parts (Optional;)					1.44
C6	termination capacitor -- 0.015uF1		B32529C153K189	495-5001-1-ND	0.32	0.32

	SPI Output parts -- 16 Open Collector (Output Option1)					4.83
Q1, Q2, Q3	Level Shift MOSFETs for SPI	3	2N7000TA	2N7000TACT-ND	0.34	1.02
R9, R10, R11	Pull-up Resistors 5 volt side	3	RNMF14FTC3K00	S3KCACT-ND	0.07	0.22
R12,R13,R14	Pull-up Resistors 3.3 volt	3	RNMF14FTC2K00	S2KCACT-ND	0.07	0.22
U1	Output shift register - open drain	2	TPIC6B595	296-2020-5-ND	1.15	2.30
RN1, RN2	output-resistor array - 100 for LEI	2	4116R-1-101LF	4116R-1-101LF-ND	0.39	0.78
	screw terminal 8x	0	OSTVN08A150	ED10566-ND	1.96	0.00
	Header 1 x 16	1	PREC016SAAN-RC	S1012EC-16-ND	0.3	0.30
	SPI Open Collector (8) and Stall motor(4) outputs (Output Option2)					4.85
Q1, Q2, Q3	Level Shift MOSFETs for SPI	3	2N7000TA	2N7000TACT-ND	0.34	1.02
R9, R10, R11	Pull-up Resistors 5 volt side	3	RNMF14FTC3K00	S3KCACT-ND	0.07	0.22
R12,R13,R14	Pull-up Resistors 3.3 volt	3	RNMF14FTC2K00	S2KCACT-ND	0.07	0.22
U1	output-shift registers	1	74HC595	296-1600-5-ND	0.58	0.58
U2	Output shift register - open drain	1	TPIC6B595	296-2020-5-ND	1.15	1.15
RN1, RN2	output-resistor array - 100 for LEI	1	4116R-1-101LF	4116R-1-101LF-ND	0.39	0.39
R15, R16	Comparator Resistor Dividers	2	RNMF14FTC3K60	S3.6KCACT-ND	0.10	0.20
IC3, IC4	tortoise-comparator x4	2	LM324	296-9542-5-ND	0.39	0.78
	screw terminal 8x	0	OSTVN08A150	ED10566-ND	1.96	0.00
	Header 1 x 16	1	PREC016SAAN-RC	S1012EC-16-ND	0.3	0.30
	Darlington Outputs for PWM from Tiva (Optional)					1.41
IC2	Darlington Output array	1	ULN2803A	497-2356-5-ND	0.87	0.87
RN3	output-resistor array - 10K	1	4609X-101-103LF	4609X-101-103LF-ND	0.39	0.39
	screw terminal 8x	0	OSTVN08A150	ED10566-ND	1.96	0.00
	Header 1 x 16	1	PREC016SAAN-RC	S1012EC-16-ND	0.3	0.15
	Input Register (16 inputs, I2C)					1.57
IC1	Input Expander, I2C	1	MCP23017	MCP23017-E/SP-ND	1.20	1.20
R8	Pull-up Resistors	1	RNMF14FTC2K00	S2KCACT-ND	0.07	0.07
	screw terminal 8x	0	OSTVN08A150	ED10566-ND	1.96	0.00
	Header 1 x 16	1	PREC016SAAN-RC	S1012EC-16-ND	0.3	0.30


H1 UpLft
H2 LowLft
H3 LpwRt
H4 UpRt
Z Systems Design
U$1 TPIC6B595_16
U$2 TPIC6B595_16
U1 SN74HC595_N_16
IC1 MCP23017SP
IC2 ULN2803A
IC3A
IC3B
IC3C
IC3D
IC4A
IC4B
IC4C
IC4D
U3 MC34063DIP
CANTX
MCP2562
Q1 2N7000
Q2 2N7000
Q3 2N7000
J1
J2
J3
J4
JP1
JP2
JP3
JP4
JP5
JP6
JP7
JP8
JP9
JP10
JP11
JP12
JP13
JP14
SW1
POWER_JACKPTH
RJ1
RJ2
RJ45-8PTH
screw2
500*
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TITLE: LCC_DevBoard4S
Design by: Dana W. Zimmerli
REV:
Date: not saved!
Sheet: 1/1