Freedom-KL25Z Shield v12 Hardware Manual

Contents

Summary Information

General

You will need to modify your FRDM-KL25Z to use the touch screen, as described in the section FRDM-KL25Z Modifications.

Port I/O Overview

	Port				
	A	**B**	**C**	**D**	**E**
0			LCD-TS-YD ADC_SE14		
1		Debug 1	LCD-TS-XL ADC_SE15	Blue LED	SD-SPI1_MOSI
2		Debug 2			SD-SPI1_SCK
3		Debug 3	LCD-DB8		SD-SPI1_MISO
4			LCD-DB9		SD-SPI1_CS
5			LCD-DB10		Buck-SwR-Ctl
6			LCD-DB11		
7			LCD-DB12		
8		Debug 4	LCD-DB13		
9		Debug 5	LCD-DB14		
10		Debug 6	LCD-DB15		
11		Debug 7			
12	LCD-BL-PWM TPM1_CH0		LCD-D_NC		
13			LCD-NWR		
14	INT1_ACCEL				
15	INT2_ACCEL				
16		TSI	LCD-NRD		
17		TSI	LCD-NRST		
18		Red LED			
19		Green LED			
20					BUCK_ISENSEP ADC_DP0
21					BUCK_ISENSEM ADC_DM0
22					LCD-TS-YU ADC_SE3
23					LCD-TS-XR ADC_SE7
24					
25					
26					
27					
28					
29					Audio Amp Enable
30					Audio Out DAC0_OUT
31					BUCK_DRV TPM0_CH4

Signals available on FRDM-KL25Z Headers

PCB Layout

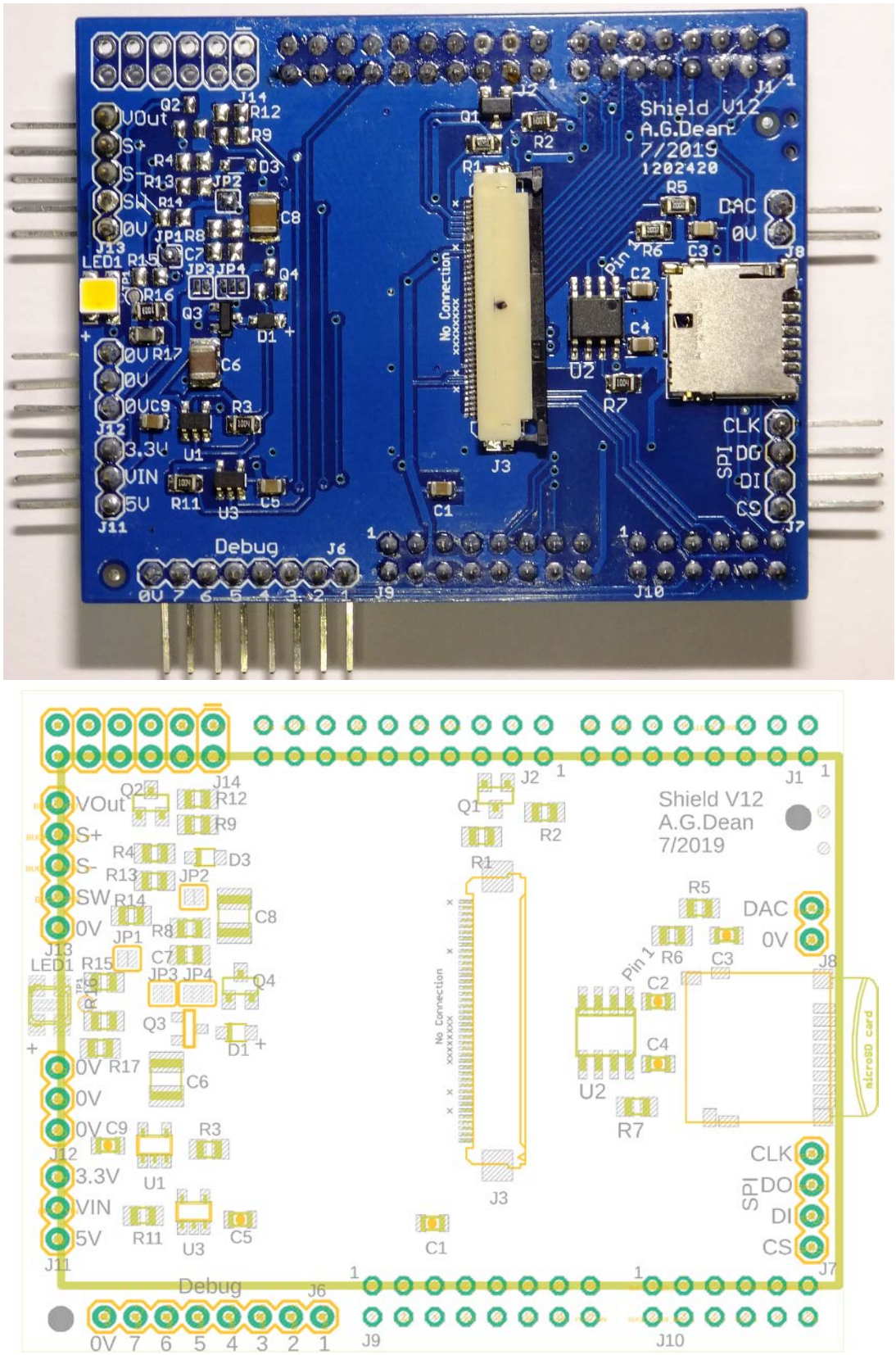


Figure 1. Top of PCB

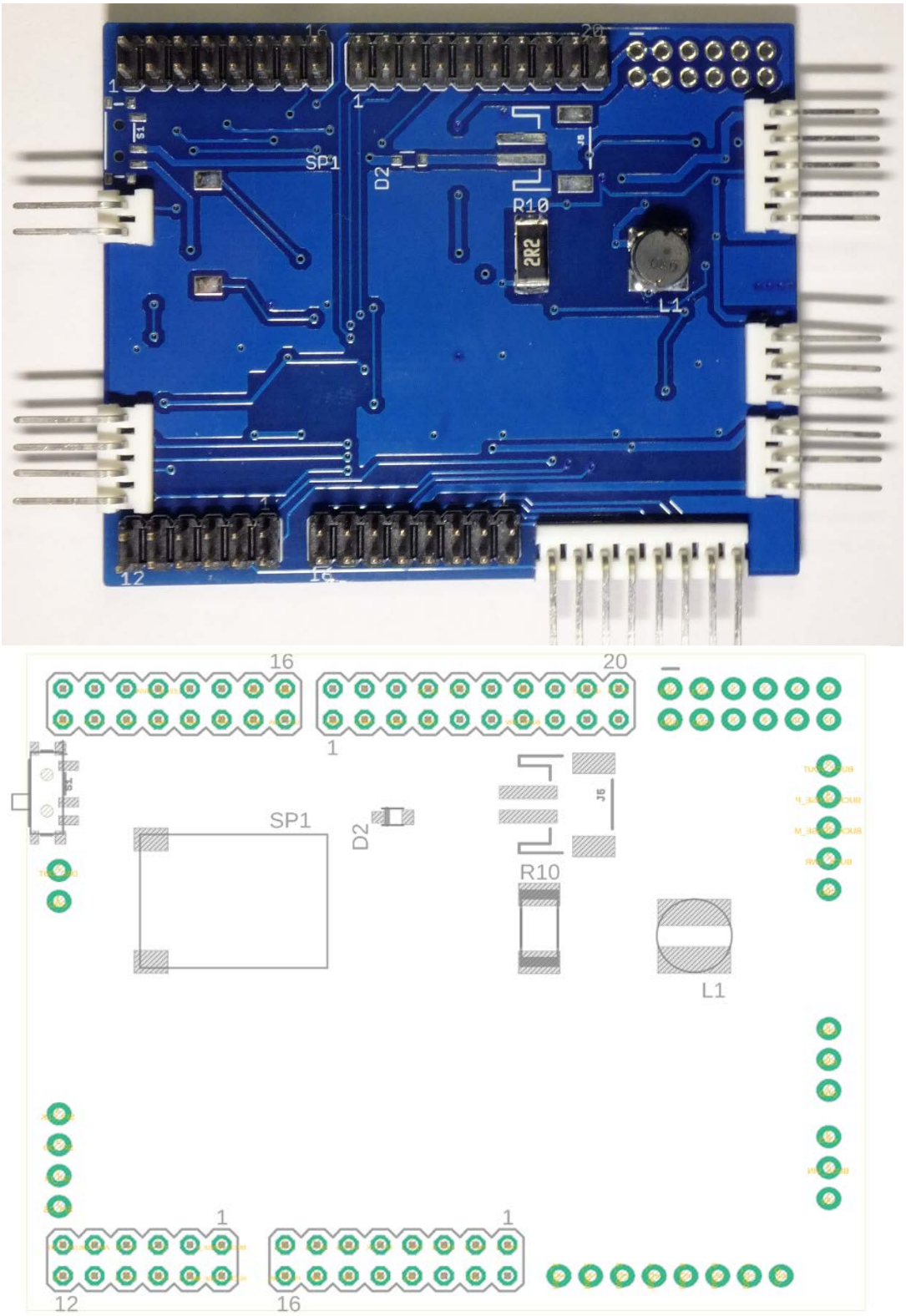
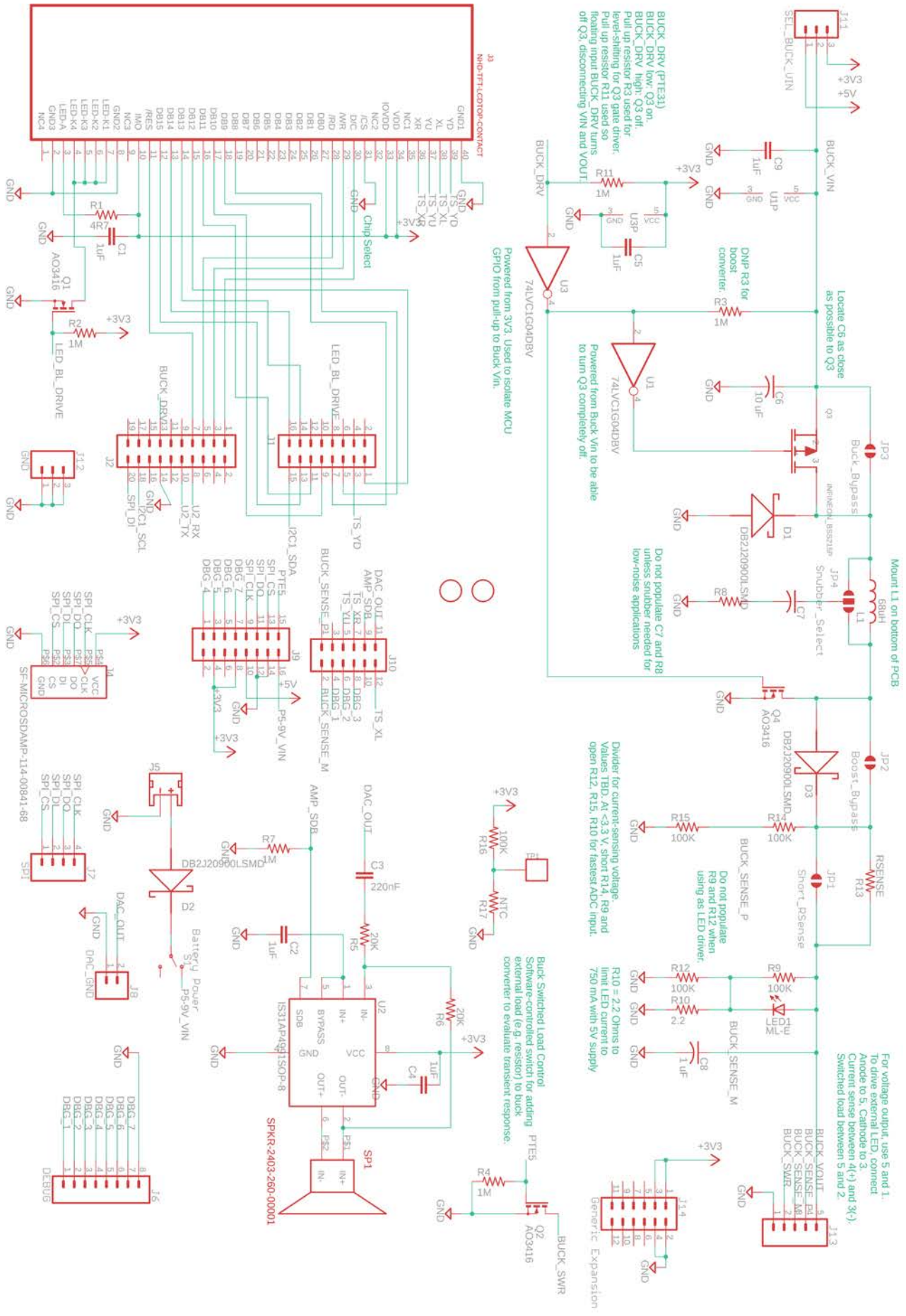


Figure 2. Bottom of PCB

Full Schematic



Header Signal Map

	Debug 4
P3V3	Debug 5
	Debug 6
P3V3	Debug 7
P5V_USB	SD-SPI1-SCK
GND	SD-SPI1-MISO
GND	SD-SPI1_PCSO
P5-9V In	Buck-SwR-Ctl

	BUCK_ISENSEP ADC_DP0
Debug 1	BUCK_ISENSEM ADC_DM0
Debug 2	LCD_TS-YU ADC_SE3
Debug 3	LCD-TS-XR ADC_SE7
	Audio Amp Enable
LCD-TS-XL ADC_SE15	Audio Out DAC0_Out

	SD-SPI1_MOSI
	VRefH
Buck Drive TPM0_CH4	GND
	Blue LED
LCD-NRST	
LCD-NRD	
LCD-NWR	
LCD-D_NC	

	LCD-DB14
LCD-DB15	LCD-DB13
LCD-DB11	
LCD-DB10	
LCD-DB9	LCD-BL-PWM TPM1_CH0
LCD-DB8	
LCD-TS-YD ADC_SE14	U0TxD
LCD-DB12	U0RxD

Peripheral Use

Analog to Digital Converter

Channel	Input Signal(s)	Module	Use
0	ADC_SE0, ADC_DP0	Buck	Inductor current sense BUCK_SENSE_P
1			
2			
3	ADC_SE3	LCD Touchscreen	LCD-TS-YU
4	ADC_SE4a, ADC_DM0	Buck	Inductor current sense BUCK_SENSE_M
5			
6			
7	ADC_SE7	LCD Touchscreen	LCD-TS-XR
8			
9	Debug 1 (PTB1)		Unused, available on debug pin
10			
11			
12	Debug 2 (PTB2)		Unused, available on debug pin
13	Debug 3 (PTB3)		Unused, available on debug pin
14	ADC_SE14	LCD Touchscreen	LCD-TS-YD
15	ADC_SE15	LCD Touchscreen	LCD-TS-XL

Timer/PWM Module

- TPM0 Channel 4: Buck converter
- TPM1 Channel 0: LED Backlight for TFT LCD
- TPM0: DMA for Audio (conflicts with buck converter. Change it!)

SPI

SPI1 for µSD card interface

DAC

DAC0 for audio output

Circuit Reference

Subsystems

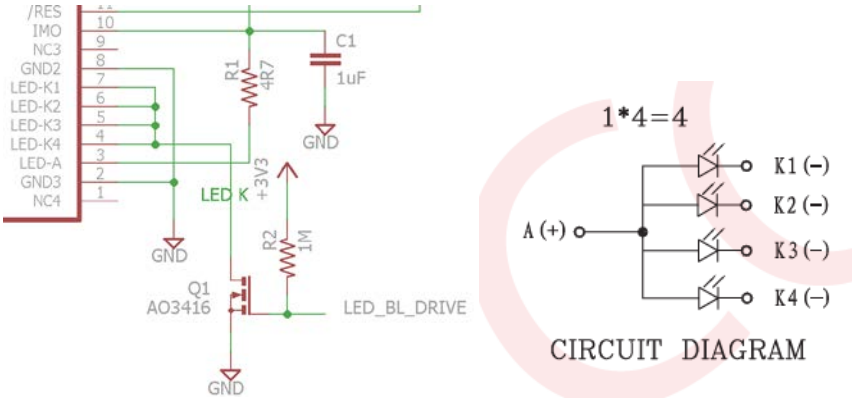
TFT Liquid Crystal Display

Newhaven Display NHD-2.4-240320CF-CTXI#-FT

Name	I/O Port	Direction	Description
LCD-DB8	Port C Bit	Input/Output	Data bus bits to LCD
LCD-DB9	Port C Bit		
LCD-DB10	Port C Bit		
LCD-DB11	Port C Bit		
LCD-DB12	Port C Bit		
LCD-DB13	Port C Bit		
LCD-DB14	Port C Bit		
LCD-DB15	Port C Bit		
LCD-D_NC	Port C Bit	Output	Data/~Control
LCD-NWR	Port C Bit	Output	~Write
LCD-NRD	Port C Bit	Output	~Read
LCD-NRST	Port C Bit	Output	~Reset

LED Backlight Driver

Name	I/O Port	Direction	Description
LEDBLDRV	Port A bit 12	Output	TFT LCD LED backlight drive (active high)



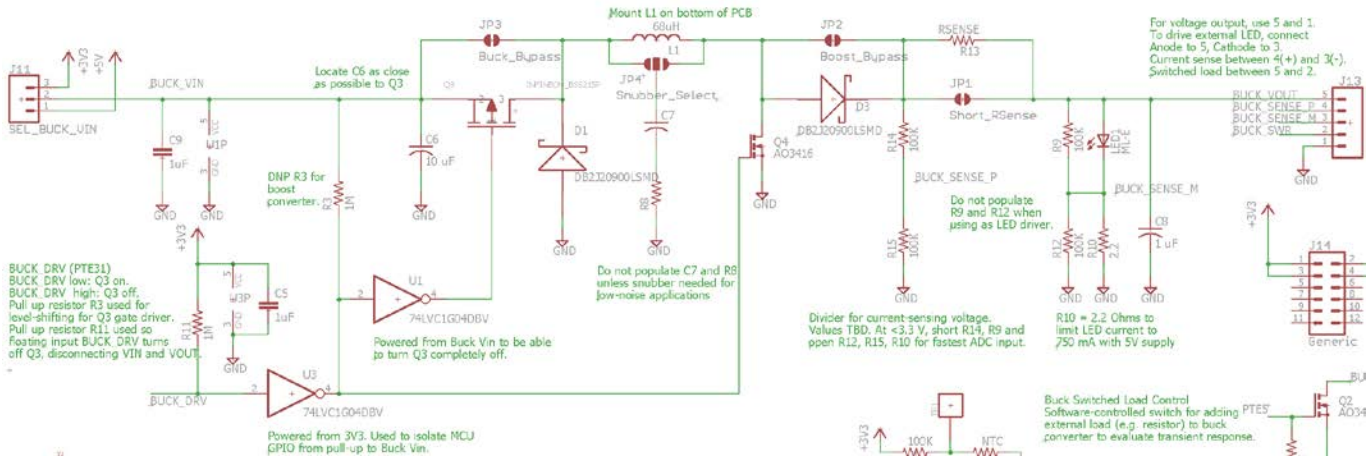
Resistive Touch Screen

Name	I/O Port	Direction	Description
LCD-TS-YD ADC_SE14	Port C bit 0	Input/Output	Bottom terminal
LCD-TS-XL ADC_SE15	Port C bit 1	Input/Output	Left terminal. Must remove R24 from FRDM-KL25Z to enable touchscreen!
LCD-TS-YU ADC_SE3	Port E bit 22	Input/Output	Top terminal
LCD-TS-XR ADC_SE7	Port E bit 23	Input/Output	Right terminal

Analog Audio Output

Name	I/O Port	Direction	Description
Audio Amp Enable	Port E bit 29	Out	Enables audio amp when 1
Audio Out	Port E bit 30	Out	DAC 0 Output

Switch-Mode Power Converter



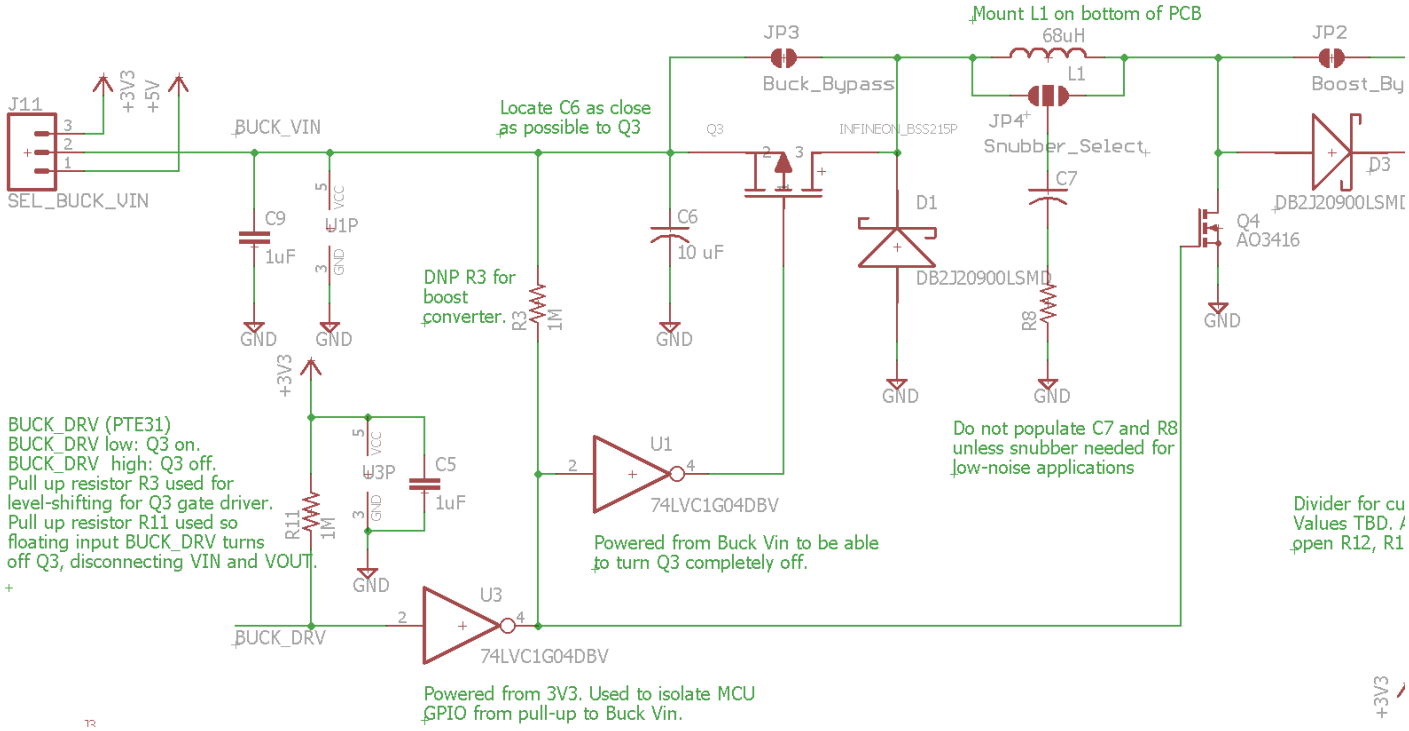
The PCB supports either a buck or boost converter, based on which parts are populated. The converter is asynchronous, using a P-MOSFET or N-MOSFET and a Schottky diode as the switches. Signal names and text may refer to the buck converter, which was the only converter option until PCB version 11.

Table 1. SMPS Signals

Name	I/O Port	Peripheral	Direction	Description
BUCKVIN			MCU -> Buck	Supply voltage input to buck converter
BUCKDRV	PTE31	TPM0 Ch. 4	MCU -> Buck	Drive signal for buck converter (active low)
QDRV			Buck -> Debug	Buffered drive signal for buck converter (active low)
BUCK_SENSE_P	PTE20	ADC_SE0, ADC_DP0	Buck -> MCU	Voltage sense from buck converter output (V_{out}/2), or positive side of R13 current sense resistor
BUCK_SENSE_M	PTE21	ADC_SE4A, ADC_DM0	Buck -> MCU	Voltage sense of LED current (I_{LED}*2.2 Ω), or negative side of R13 current sense resistor
SWRDRV	PTE5	GPIO	MCU -> Buck	Drive signal for switched load resistor on buck converter (active high)
SWR			MCU -> Buck	Switched load resistor connection

Identifier	Name	Description
JP1	Short_RSense	Short out (if not using R_{Sense} (R13) to measure SMPS output current)
JP2	Boost_Bypass	Short out if using buck (not boost) configuration
JP3	Buck_Bypass	Short out if using boost (not buck) configuration
JP4	Snubber_Select	Short out if using snubber circuit (C7 and R8)
J11	Sel_Buck_VIn	SMPS input voltage selection – 3.3 V or 5 V

Common Input Section

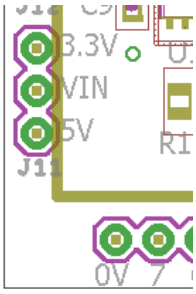


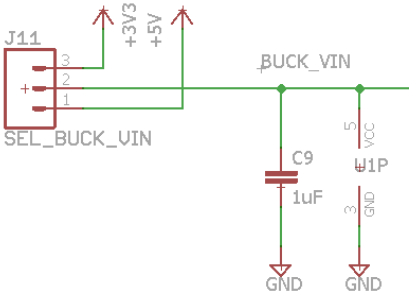
U3 inverts the BUCK_DRV signal from the MCU, speeds up its transitions, and buffers the MCU from the pulled-up voltage. If the input to U3 is disconnected, R11 pulls it high, causing U1 to disable the Q3. R3 provides level-shifting up to BUCK_VIN.

- Buck: U1 inverts the drive signal again to drive Q3, a P-channel MOSFET.
- Boost: U3 drives Q4, an N-channel MOSFET.

Input Voltage Selection

Select the input supply voltage for the buck converter with J11 by shorting VIN to 3.3 V or 5V. You can quickly and safely cut off power to the converter by removing J11.





Snubber for EMI Reduction

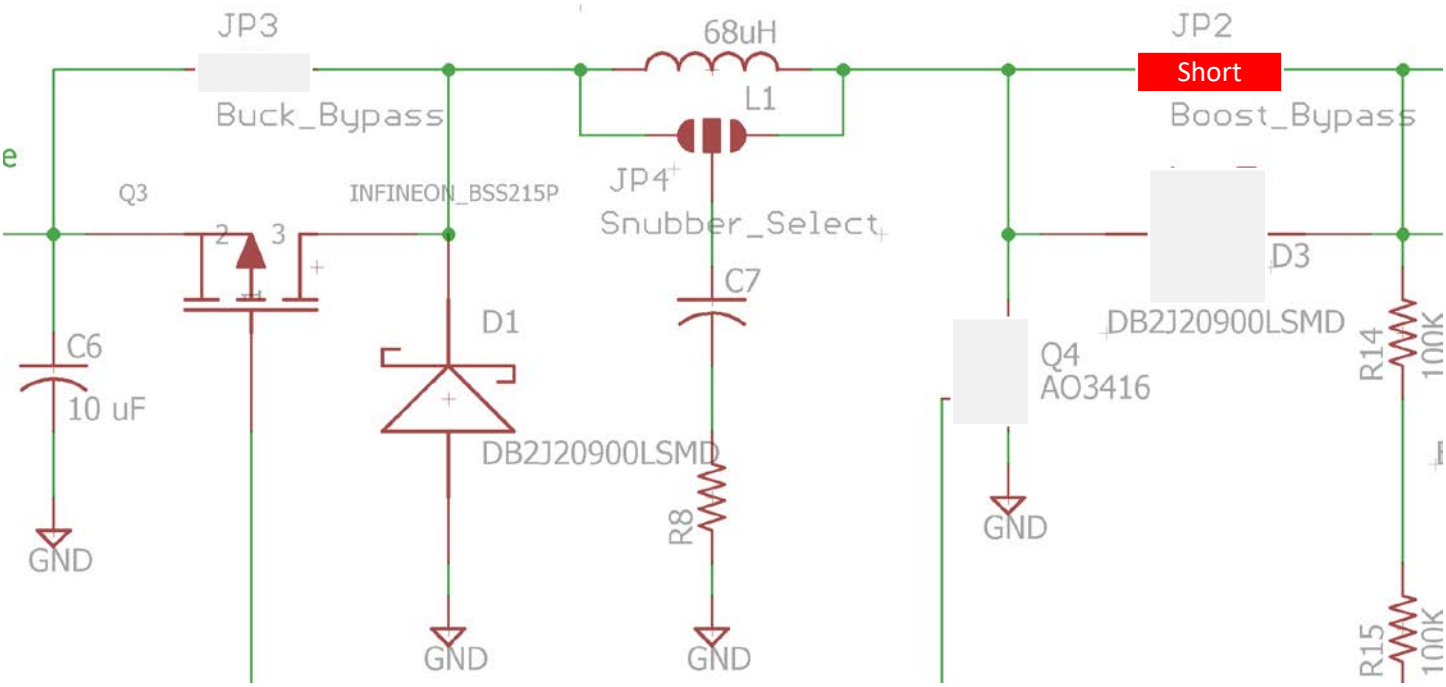
R7 and C8 are for an optional snubber (Buck – Snubber) to reduce noise. They are generally not needed.

Converter Configurations

Buck Converter

Populate the PCB as shown below to create a buck converter. Short JP2 with solder. The maximum output current is limited by Q3 (BSS215P), D1 (DB2J20900LSMD) and L1 (SDR0604-680KLCT-ND), as well as the input power supply. The maximum output voltage is limited by C8 and the ADC inputs.

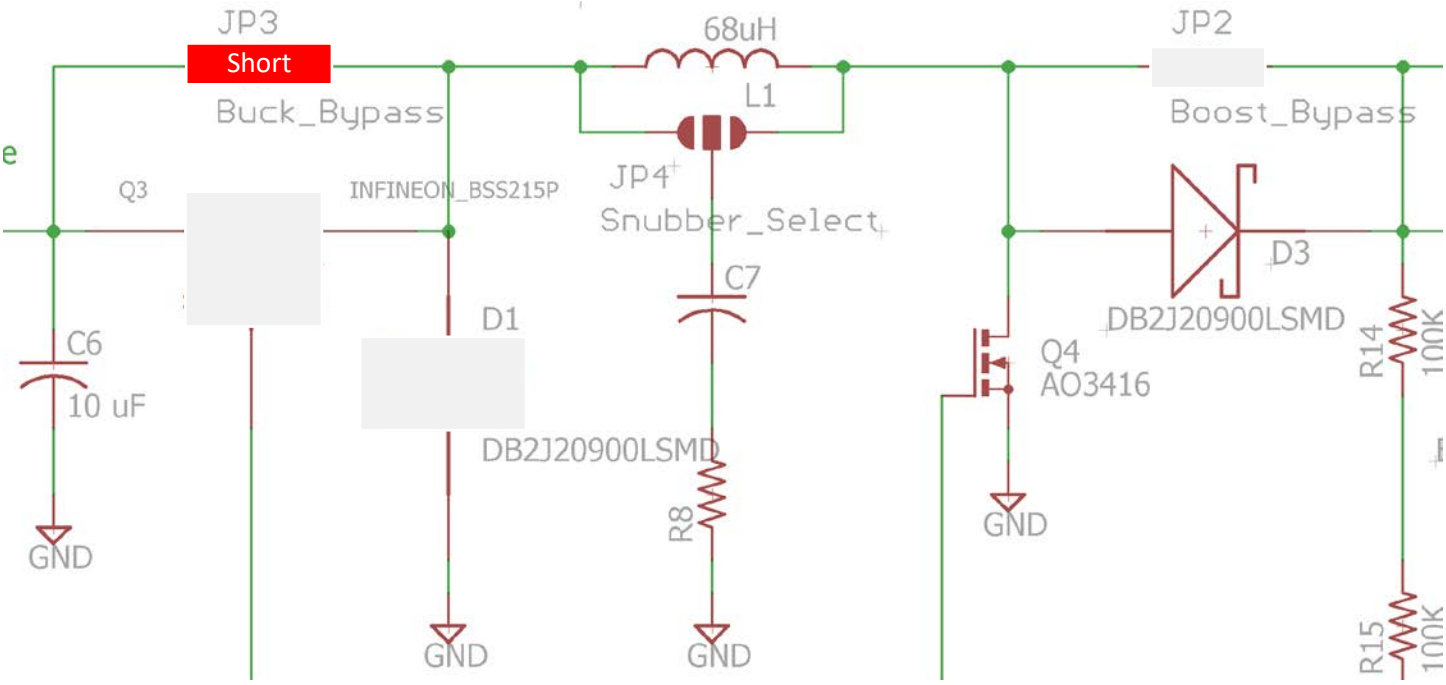
- Q3: BSS215P. Max I_D @ 25C = -1.5 A. $R_{DS(on)}$ = 105-280 mΩ
- D1: DB2J20900LSMD. V_{RMax} = 20 V, I_{FAve} = 0.5 A, I_{FSurge} = 3 A
- L1: SDR0604-680KLCT-ND. $I_{RMS\ Max}$ = 0.62 A, I_{sat} = 0.84 A, R_{DCMax} = 0.52Ω



Boost Converter

Populate the PCB as shown below to create a boost converter. Short JP3 with solder. The maximum output current is limited by Q4 (AO3416), D3 (DB2J20900LSMD) and L1 (SDR0604-680KLCT-ND). The maximum output voltage is limited by C8 and the ADC inputs.

- Q1: AO3416. Max I_D @ 25C = 6.5 A. $R_{DS(on)}$ = 34 mΩ
- D3: DB2J20900LSMD. V_{RMax} = 20 V, I_{FAve} = 0.5 A, I_{FSurge} = 3 A
- L1: SDR0604-680KLCT-ND. $I_{RMS\ Max}$ = 0.62 A, I_{sat} = 0.84 A, R_{DCMax} = 0.52Ω

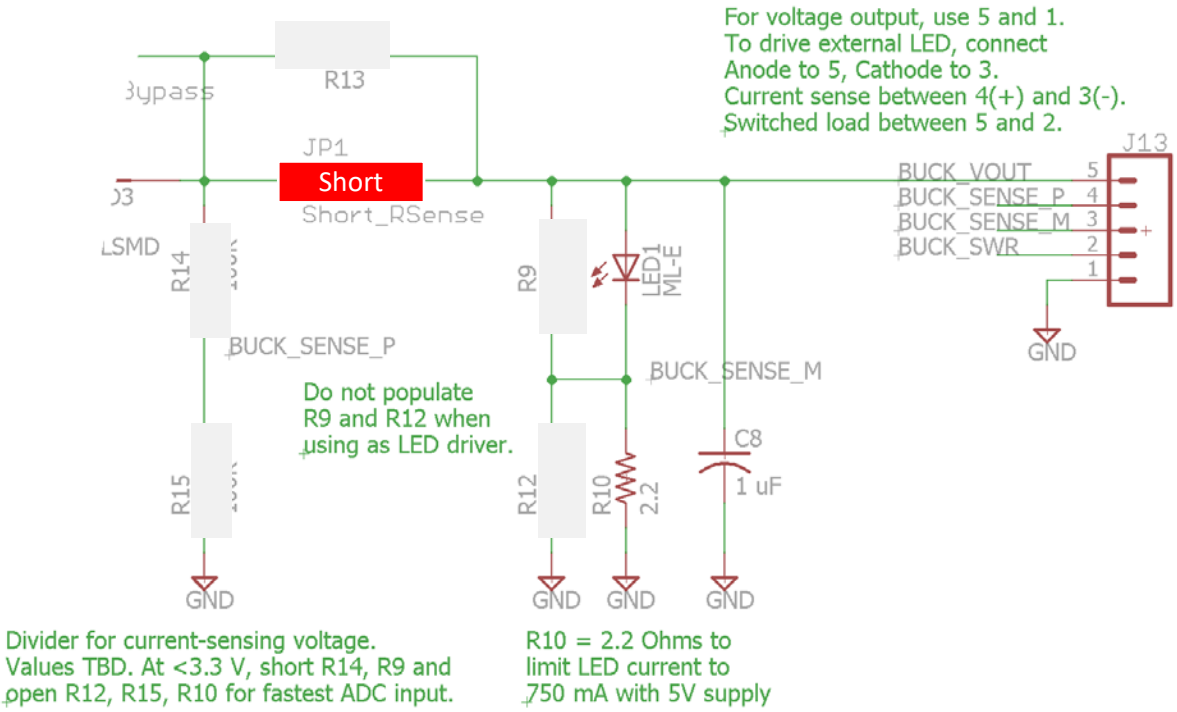


Voltage- and Current-Sensing Configurations

The converter supports various configurations to sense output voltage or current.

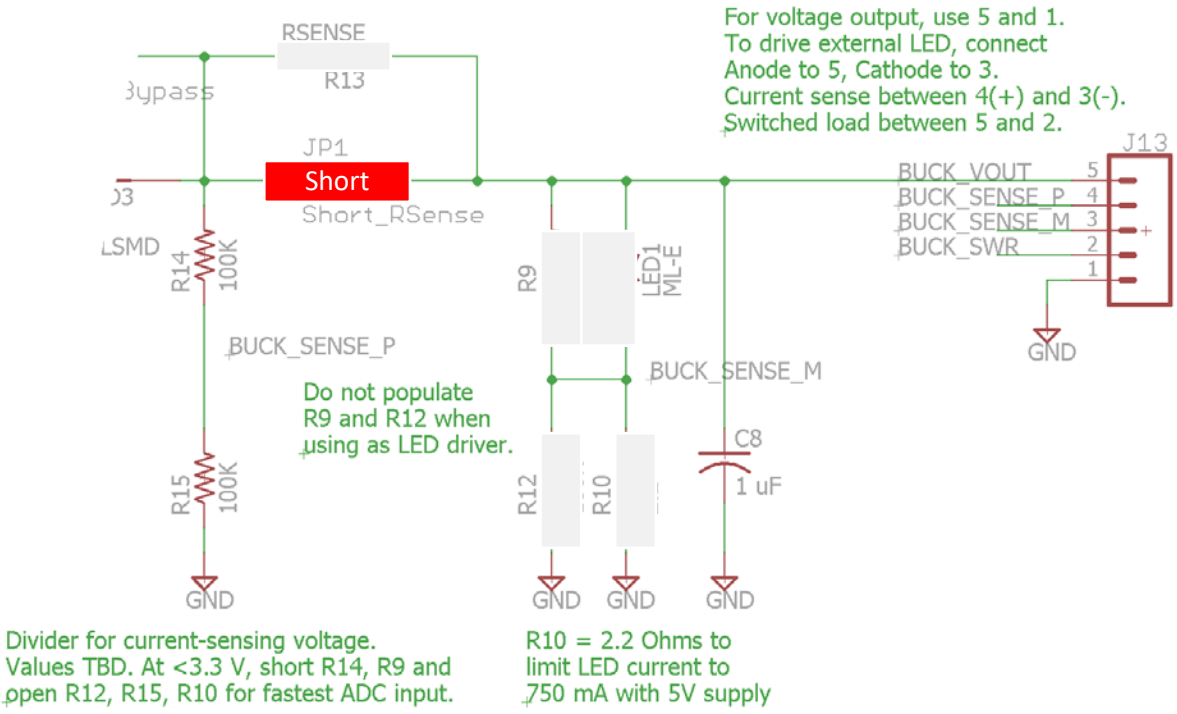
HBLED Driver Configuration with Voltage-Mode Control (Buck – HBLED)

Short JP1 with solder. Use BUCK_SENSE_M as a single-ended input to measure the LED current via R10. R10 is sized to limit maximum current through LED1 to a safe level regardless of buck converter output (given a maximum input of 5 V). Reduce the resistance of R10 to improve energy efficiency.



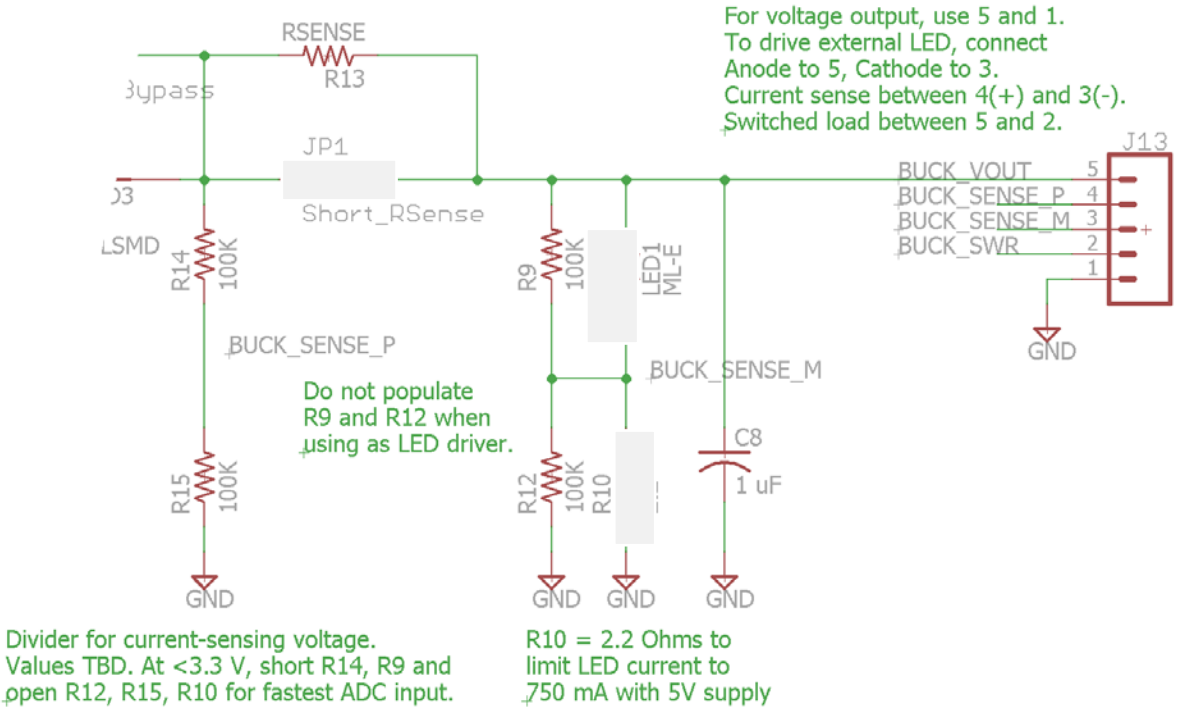
Voltage Source with Voltage-Mode Control (Buck – VSVM)

Short JP1 with solder. Use BUCK_SENSE_P to measure the output voltage, as divided by R14 and R15.



Voltage Source with Current-Mode Control (Buck – VSCM)

Use BUCK_SENSE_P and BUCK_SENSE_M as differential inputs to measure the load current via R13.

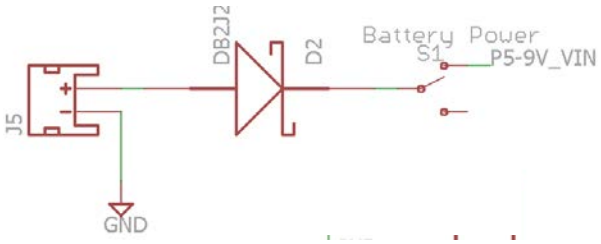


MicroSD Card

Name	I/O Port	Direction	Description
SPICLK	PTE2	Output	SCK, SPI Clock
SPICS	PTE4	Output	PCS0, SPI Chip Select
SPIDI	PTE3	Input	MISO, SPI Data in (to MCU)
SPIDO	PTE1	Output	MOSI, SPI Data out (from MCU)

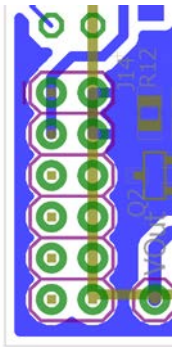
External Battery Support

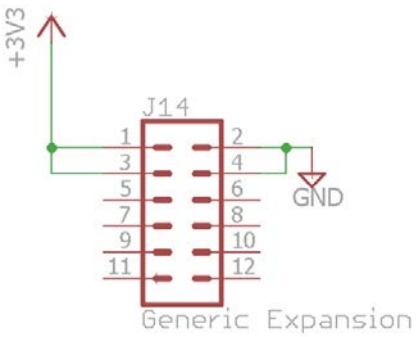
An external Li-Ion cell can be used to power the shield and Freedom board through the P5-9V_VIN connection, which can drive the Freedom's linear regulator. S1 allows the power to be switched by the user. D2 provides protection against a reversed battery connection and accidentally charging the battery.



Generic Expansion Header

J14 provides a footprint for a 2x6 0.1" header for expansion opportunities. It provides connection for 3.3V power (1,3) and ground (2,4), and then eight free pads for custom use (5-12).





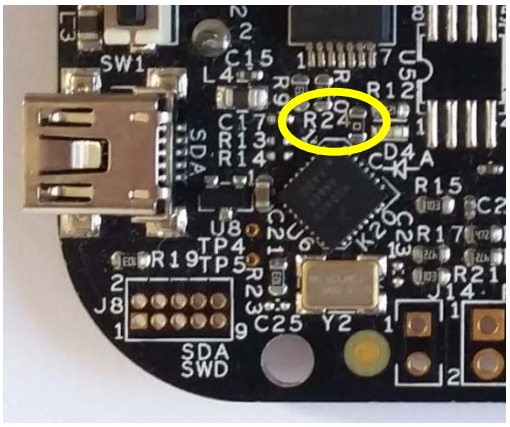
Component List

Part	Value	Device	Package	Description	Digikey Part No.
C1	1uF	CAP0805	0805-CAP		399-1284-1-ND
C2	1uF	CAP0805	0805-CAP		399-1284-1-ND
C3	220nF	CAP0805	0805-CAP		399-8051-1-ND
C4	1uF	CAP0805	0805-CAP		399-1284-1-ND
C5	1uF	CAP0805	0805-CAP		399-1284-1-ND
C6	10 uF	C-USC1210	C1210		399-1272-1-ND
C7		C-USC0805	C0805		N/A
C8	1 uF	C-USC1210	C1210		587-1367-1-ND
C9	1uF	CAP0805	0805-CAP		399-1284-1-ND
D1	DB2J20900LSMD	DB2J20900LSMD	SMINI2-F5-B	Schottky Diode	DB2J20900LCT-ND
D2	DB2J20900LSMD	DB2J20900LSMD	SMINI2-F5-B	Schottky Diode	DB2J20900LCT-ND
D3	DB2J20900LSMD	DB2J20900LSMD	SMINI2-F5-B	Schottky Diode	DB2J20900LCT-ND
J1		MA08-2	MA08-2	PIN HEADER	609-3220-ND
J10		MA06-2	MA06-2	PIN HEADER	609-3219-ND
J11	SEL_BUCK_VIN	CONN_03	1X03	Multi connection point.	A19340-ND
J12	GND	CONN_03	1X03	Multi connection point.	A19340-ND
J13	BUCK_OUT	CONN_05	1X05	Multi connection point.	A19341-ND
J14	Generic Expansion	CONN_06X2PTH_FEMALE			
J2		MA10-2	MA10-2	PIN HEADER	609-3221-ND
J3	NHD-TFT-LCDTOP-CONTACT	NHD-TFT-LCDTOP-CONTACT			609-1200-1-ND
J4	SF-MICROSDAMP-114-00841-68	SF-MICROSDAMP-114-00841-68			114-00841-68-1-ND
J5		JST_2MM_MALE	JST-2-SMD	JST 2MM MALE RA CONNECTOR	
J6	DEBUG	CONN_08"	1X08	Multi connection point.	A1919-ND
J7	SPI	CONN_04	1X04	Multi connection point.	A1917-ND
J8	DAC_GND	CONN_02	1X02	Multi connection point.	A1916-ND
J9		MA08-2	MA08-2	PIN HEADER	455-1749-1-ND
JP1	Short_RSense	JUMPER-SMT_2_NO_SILK			
JP2	Boost_Bypass	JUMPER-SMT_2_NO_SILK			
JP3	Buck_Bypass	JUMPER-SMT_2_NO_SILK			
JP4	Snubber_Select	JUMPER-SMT_3_NO_SILK			
L1	68uH	L-USSDR0604-BOTTOM	SDR0604	INDUCTOR, American symbol	SDR0604-680KLCT-ND
LED1	ML-E	ML-E	ML-E	Cree® XLamp® ML-E LEDs 1/2 watt, 3.5 x 3.5 mm	MLEAWT-A1-0000-0003F7CT-ND
Q1	AO3416	NMOSFETSOT23-3	SOT23	N-CHANNEL MOS FET	785-1011-1-ND
Q2	AO3416	NMOSFETSOT23-3	SOT23	N-CHANNEL MOS FET	785-1011-1-ND
Q3	INFINEON_BSS215P	INFINEON_BSS215P	INFINEON_PG-SOT-23		BSS215P H6327CT-ND
Q4	AO3416	NMOSFETSOT23-3	SOT23	N-CHANNEL MOS FET	785-1011-1-ND
R1	4R7	R-US_R0805	R0805		RNCP0805FTD4R70CT-ND
R10	2.2	R-US_R2512	R2512		RHM2.2BCCT-ND
R11	1M	R-US_R0805	R0805		RMCF0805FT1M00CT-ND
R12	100K	R-US_R0805	R0805		RMCF0805FT100KCT-ND
R13	RSENSE	R-US_R0805	R0805		TBD
R14	100K	R-US_R0805	R0805		RMCF0805FT100KCT-ND
R15	100K	R-US_R0805	R0805		RMCF0805FT100KCT-ND
R16	100K	R-US_R0805	R0805		RMCF0805FT100KCT-ND
R17	NTC	R-US_R0805	R0805		490-2451-1-ND
R2	1M	R-US_R0805	R0805		RMCF0805FT1M00CT-ND
R3	1M	R-US_R0805	R0805		RMCF0805FT1M00CT-ND
R4	1M	R-US_R0805	R0805		RMCF0805FT1M00CT-ND

R5	20K	R-US_R0805	R0805		RMCF0805FT20K0CT-ND
R6	20K	R-US_R0805	R0805		RMCF0805FT20K0CT-ND
R7	1M	R-US_R0805	R0805		RMCF0805FT1M00CT-ND
R8		R-US_R0805	R0805		N/A
R9	100K	R-US_R0805	R0805		RMCF0805FT100KCT-ND
S1	Battery Power	SWITCH-SPDT-SMD-RIGHT-ANGLE			
SP1	SPKR-2403-260-00001	SPKR-2403-260-00001	SPEAKER-FOOTPRINT		433-1129-ND
TP1	PIXHAWK2_PAD.04	PIXHAWK2_PAD.04	PIXHAWK2_PAD.04X.04	Test pad	
U1	74LVC1G04DBV	74LVC1G04DBV	SOT23-5	INVERTER Gate	296-39208-1-ND
U2	IS31AP4991SOP-8	IS31AP4991SOP-8	SO8	IS31AP4991 Mono Audio amplifier	706-1164-1-ND
U3	74LVC1G04DBV	74LVC1G04DBV	SOT23-5	INVERTER Gate	296-39208-1-ND

Assembly Notes

FRDM-KL25Z Modifications



Remove resistor R24 (zero ohms, marked “0”) from the FRDM-KL25Z to enable the touchscreen to operate correctly. Using solder tweezers will simplify resistor removal.

General Information

If hand-soldering, tin one pad (either upper or right) for each component. Then mount the component and reflow the solder while aligning the component. After each component is aligned, allow the solder to cool. Then solder the other pads. Flux may be needed to make the solder flow properly.

Note that certain components (L1, SP1, R10) are to be mounted on the back of the PCB.

TFT Liquid Crystal Display

The connector should already be mounted. Display connection and disconnection instructions are located in the Mechanical section below.

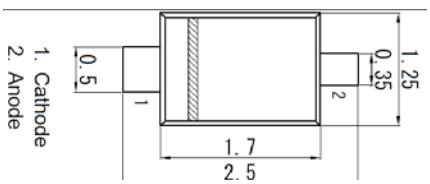
If the connector is not already mounted, the following procedure is recommended:

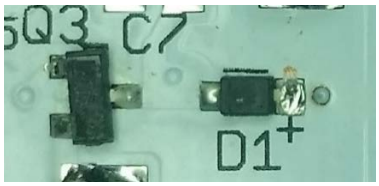
- Apply flux (no-clean or water-soluble preferred) to the connector lead pads.
- Lightly tin the pad for one mounting tab of the connector. If the solder is too thick, then the connector leads won’t touch the pads, complicating soldering.
- Align the connector on the PCB so leads are centered over pads.
- Reflow the solder on the pad, connecting the mounting tab
- Verify proper lead alignment (x, y) and that leads touch their pads (z).
- Solder the other mounting tab with a small amount of solder.
- Confirm proper alignments and lead contact with pads.
- Apply flux (no-clean or water-soluble preferred) to leads.
- Solder leads to pads using one of these methods:
    - Solder paste: apply a small amount of solder paste to the leads with a toothpick. Mixing flux with the solder paste will reduce its viscosity and make it easier to apply. This especially helps with older solder paste.
    - Solder wire: Solder each lead by touching it and its pad with a fine-tip soldering iron coated with a small amount of solder. Too much solder will result in solder bridges. Keep the tip clean of debris and old flux.
- Remove flux as needed.

Buck Converter

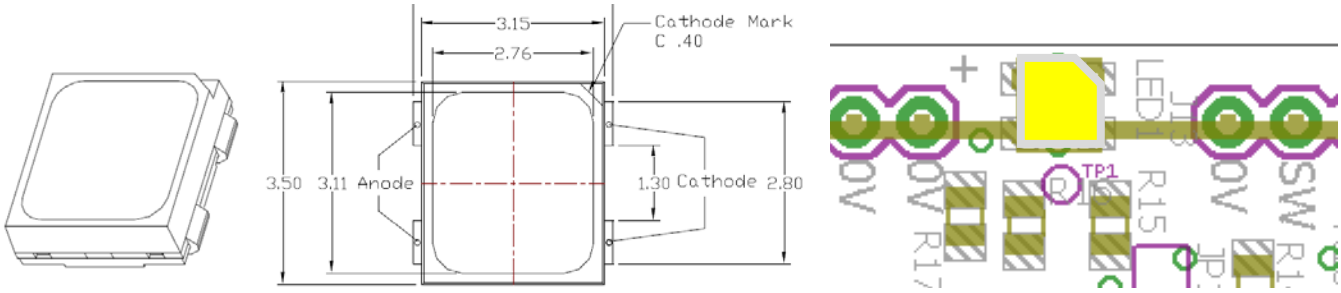
The buck converter can be configured to drive a high-brightness LED based on current feedback, or generate a constant voltage based on voltage feedback.

Mount diode D1 so the cathode (bar, wide lead) is to the left.





High-Brightness LED (Cree XLAMP-MLE)

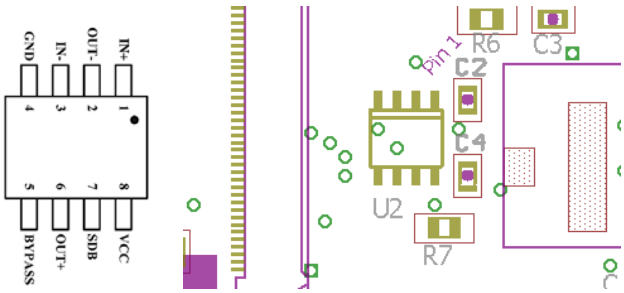


The cathode connections are marked by the missing corner on the LED package (upper right in all figures above). That corner should be placed near the LED1 label. The anode connections should be next to the + symbol.

Analog Audio Output

Audio Amplifier

IC U2 is rotated 180^{o} so that pin 1 of U2 (marked by a small circle on the IC package) is next to C2 – at the 1:30 position. Mount U2 as shown below.



Speaker

Mount the speaker after mounting all surface mount components on top of PCB.

First tin the speaker pads on the PCB. Then place the speaker contacts against the pads and heat the pads to reflow the solder. Attach the speaker to the PCB with hot-melt glue or double-sided tape.

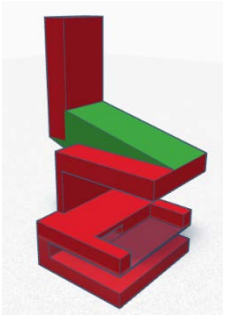
Battery

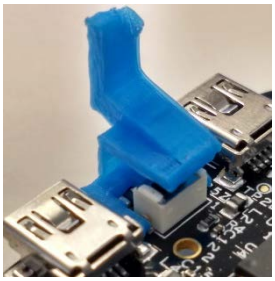
The cathode for Diode D2 should be placed closest to the D2 label on the PCB.

Mechanical

Reset Switch Extender

The shield blocks easy access to the FRDM-KL25Z's reset switch. The design for a switch extender is available at TinkerCAD.com (https://www.tinkercad.com/things/6tj7AOvGaO3) or by searching for "switch extender" or the #NCSU ECE tag. Slide it over the edge of the FRDM-KL25Z board and onto the reset switch.





Using Display Connector J3

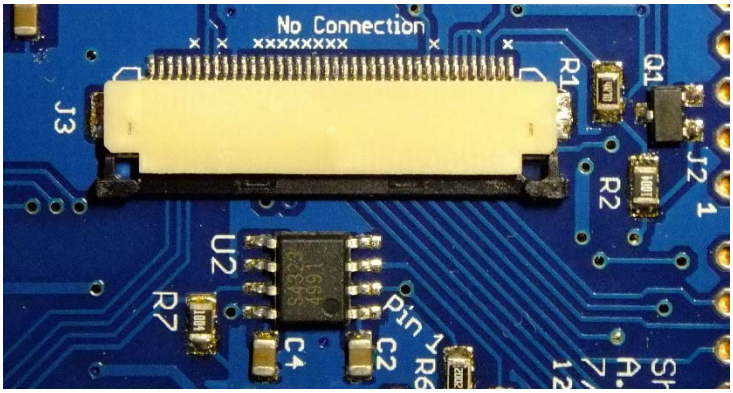


Figure 3. Connector J3 holds the LCD cable. The dark portion is a sliding locking bar.

Optional: Trim the top of the pins from J7 (SPI) and J8 (DAC) to prevent possible damage to the LCD cable.

Connecting LCD

1. Open connector J3 by pulling the two locking tabs (on either end of the dark brown plastic locking bar) toward U2.
2. Slide the bezel over the shield from the uSD card end until it stops.
3. Insert the LCD cable (with the shiny gold contacts facing up) into connector J3.
4. Push J3's locking bar tabs away from U2 to slide in the locking bar.
5. Gently press the LCD into place in the bezel.

Removing LCD

1. Gently pry up the LCD. If using the bezel, insert a thin, wide tool in the bezel gap near the USB connectors.
2. Slide out J3's locking mechanism.
3. Disconnect the LCD cable.
4. Slide the bezel off the shield.

Display Mounting with Magnets

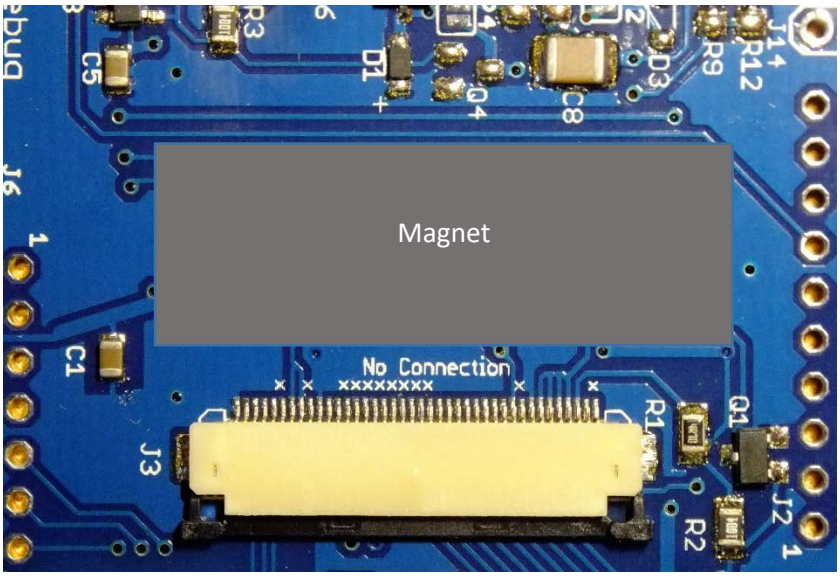


Figure 4. Magnet strip location.

Use two adhesive magnet strips, about ½" x 1¼".

1. Remove the white backing from one of the magnets to reveal the adhesive. Mount the magnet (adhesive down) between R3/D1 and C1, roughly parallel to J3. Press firmly for good adhesion.
2. Place the remaining magnet (with white backing up) on the mounted magnet, aligning it for maximum magnetic holding force. Note that the exact positions will vary.
3. Slide out J3's locking bar by gently pulling on the ears with your fingernails. Insert the LCD module's ribbon cable with contacts facing up. Then push ears back in to lock the connector.
4. Remove the adhesive backing from the remaining magnets. Align the LCD module above the magnets and press it down firmly.

Display Mounting with Bezel

A bezel can be used to hold the LCD to the shield. The design (with OBJ or STL files) is available for 3-D printing at TinkerCAD.com by searching for "Frame Bezel (v11.a)" or the #NCSU ECE tag.

Troubleshooting

LCD

Blank white display: Backlight is powered, but LCD controller is not initialized. Confirm cable is properly seated and cable latch is fully closed.

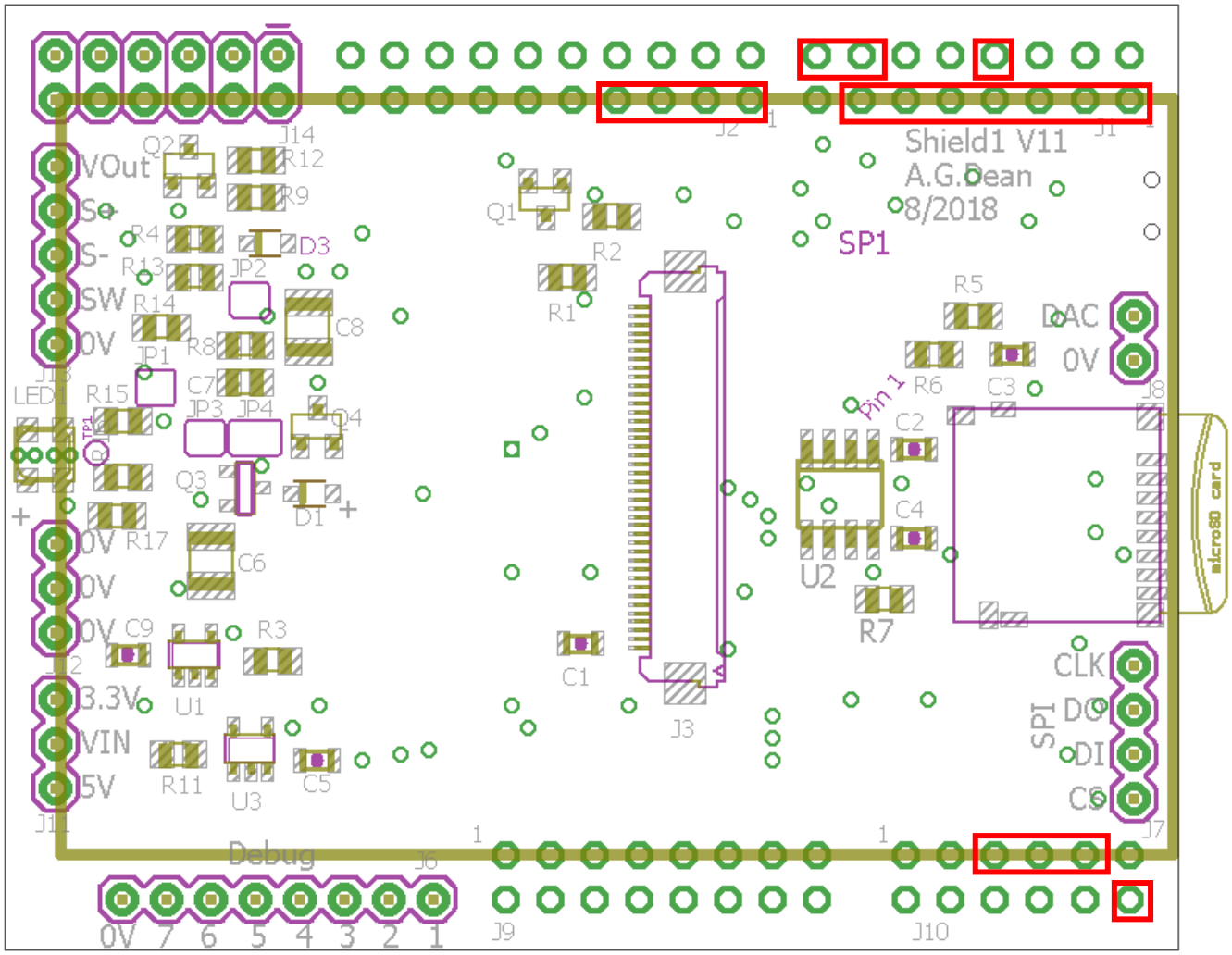


Figure 5. FRDM connections used by LCD and touchscreen (in addition to P3V3 and ground). Make sure there is continuity between each of these pins and the corresponding pin on the bottom of the FRDM board.

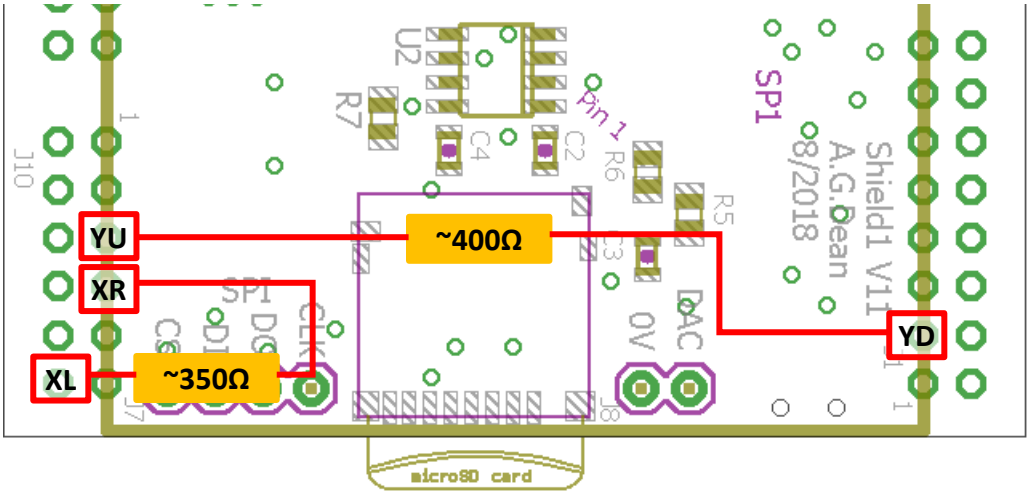


Figure 6. FRDM connections used by touchscreen. Make sure there is continuity between each of these pins and the corresponding pin on the bottom of the FRDM board. Also, verify resistances between marked pins are as shown to confirm these four signals are connected to the LCD through J3 correctly.

LCD Connections

Each “x” on the PCB should mark a J3 contact with no connection, but they are not positioned correctly. Please refer to the figures below for correct information.

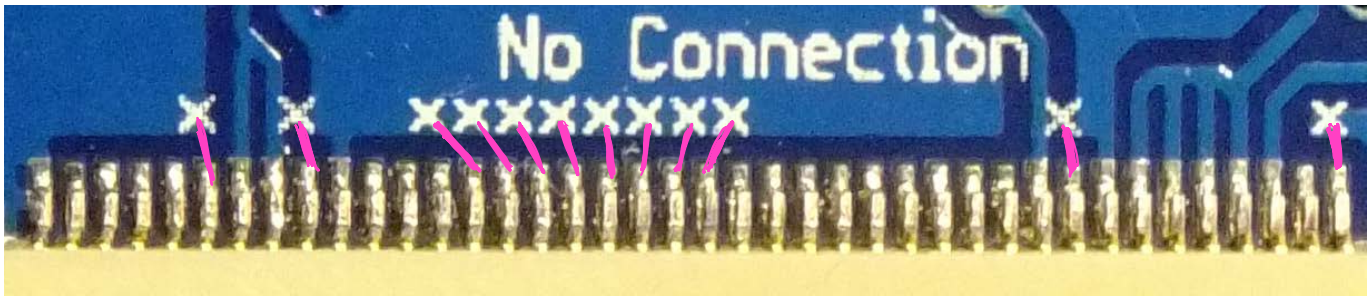


Figure 7. V12 board's "No Connection" marks are mislocated.

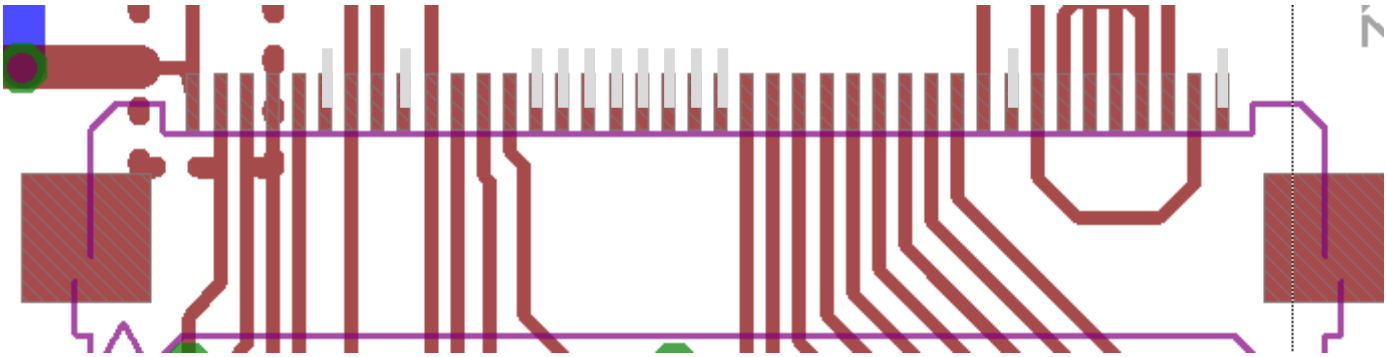


Figure 8. LCD connections used on J3. Unused connections are marked with gray lines.

Buck Converter/HBLED

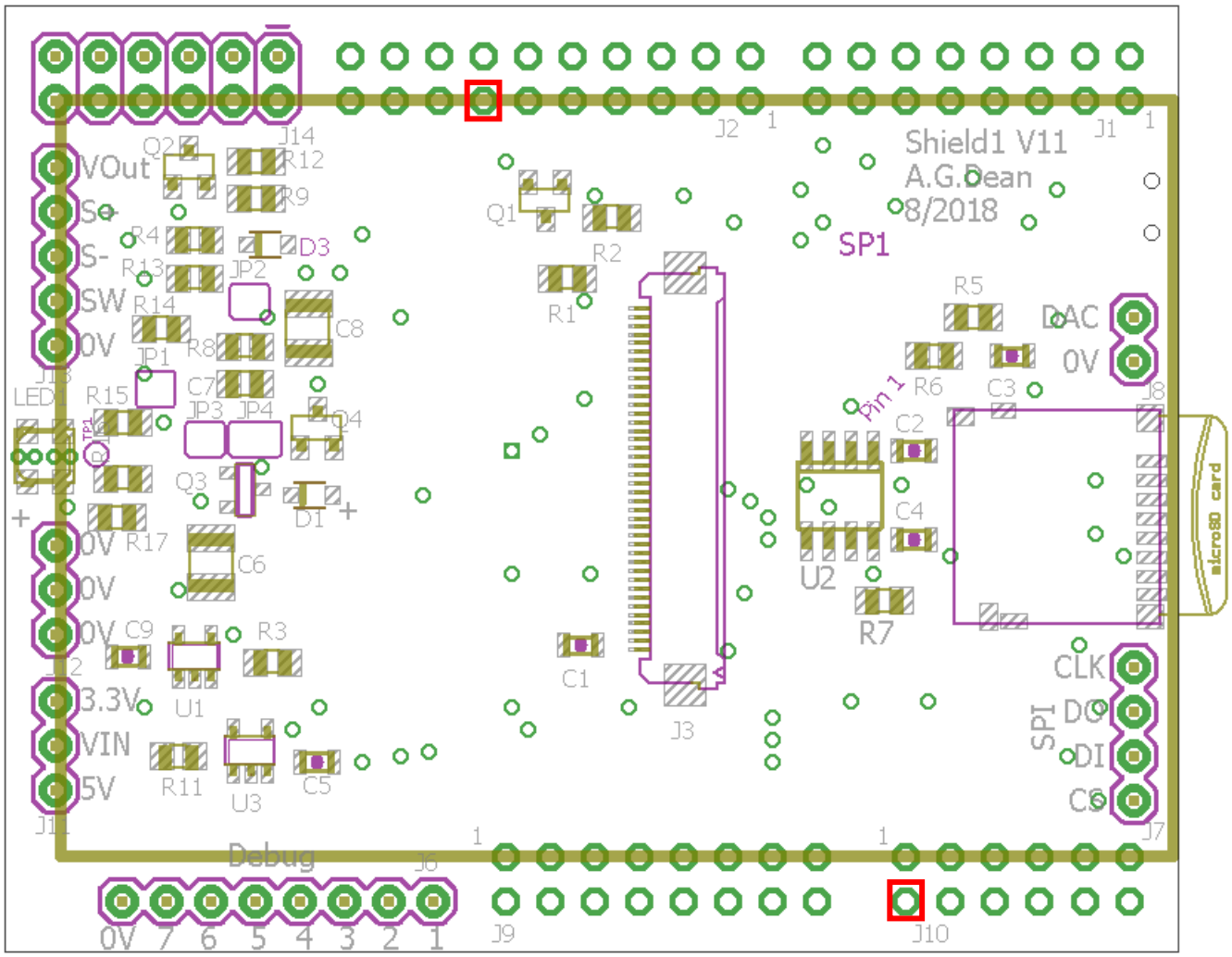


Figure 9. FRDM connections used by Buck converter (in addition to power and ground).

Alternatives

Skinny Stack

	Height (mm)	
Item	**Original**	**Skinny**
Foot	5.32	1
FRDM PCB	1.21	1.21
Socket Insulation	8.2	4.57
Pin Insulation	2.7	1.52
Shield PCB	1.6	1.6
Components	4.15	2
LCD	3.75	3.75
Total	**26.93**	**15.65**

Reduce the thickness of the Freedom/Shield/LCD stack:

- Using shorter headers.
  - Female (Freedom): Samtec SLW low-profile series , insulation is 0.180” (4.57 mm) high. Insertion depth 2.16 mm to 2.92 mm. Mated stacking height 6.09 mm.
    - 12 pin: SAM1088-06-ND, $1.95. Value added

        - 16 pin: SAM9949-ND, $2.23. SAM1092-08-ND, $1.41, VA
        - 20 pin: SAM1090-10-ND, $3.12. VA. SAM11803-ND, $2.60 Imm.
        - (40 pin: SAM11804-ND, $5.18)
    - Male (Shield): Samtec Flex Stack TLW. Insulation 1.52 mm, 2.67 mm mating pin length.
        - 12 pin
        - (40 pin: SAM1100-40-ND, $7.72)
        - (72 pin: SAM1096-36-ND, $11.86)
- Replace adhesive feet with shorter ones (e.g. 2 mm) as needed to clear header pins
- Remove Freedom board reset switch, relocate (location TBD. Perhaps on header?)

Changes

Changes to v12 (blue)

- Moved C1 from J3 to simplify soldering.
- Mark unused pins on J3 as X on silkscreen with limited success.
- Moved Q1, R1, R2, C1 to allow use of ½" wide magnetic tape.
- Added fiducials and mounting holes (~1mm) to aid automated assembly
- Note: Should white shorting jumper for J11 (better visibility).

Changes from v10 (tan) to v11 (green)

- Rotated parts to consistent horizontal orientation.
- Added support for boost or buck converter.
- Added generic expansion header (J14).

Changes from v9 (white) to v10 (tan)

- Moved some connectors slightly inwards.

Major changes from v8 (red) to v9 (white)

- Moved two touchscreen ADC input channels to make space for differential ADC input of current-sense resistor.
- Added jumper to select 3.3V or ~5V input voltage for buck converter
- Added and moved existing BUCK sense channel to support differential inductor current sense
- Added headers for debug signals
- Changed 0603 components to 0805 (R1-7, R11)