

Stellaris® Intelligent Display Module with 3.5" Landscape Display Reference Design Kit

User's Manual



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Stellaris® Intelligent Display Module with 3.5" Landscape Display Reference Design Kit Overview

Stellaris® Intelligent Display Module with 3.5" Landscape Display (MDL-IDM-L35) Reference Design Kit (RDK-IDM-L35) is a highly integrated QVGA touch-panel module for automation and instrumentation applications. The compact design is based on the Stellaris® LM3S1958 microcontroller; a highly integrated microcontroller incorporating a 32-bit ARM® Cortex™-M3 core.

Development of software for the RDK-IDM-L35 is simplified by using the Stellaris comprehensive graphics library and ARM development tools from our tools partners. The IDM-L35 RDK includes the touch panel module (MDL-IDM-L35), a documentation CD, power supply, and cables.

The IDM-L35 design uses a Stellaris® LM3S1958 microcontroller to handle display functions, touchscreen control, networking, and peripheral functions. Only a few additional ICs are necessary to complete the design. The entire circuit is built on a compact four-layer printed circuit board. All design files are provided on the RDK-IDM-L35 CD.

This user's manual provides comprehensive information on the reference design hardware and software.

Figure 1-1. Intelligent Display Module with 3.5" Landscape Display



Kit Contents

The RDK-IDM-L35 reference design kit comes with the following:

- MDL-IDM-L35 Intelligent QVGA 3.5" Touch Panel
- USB to TTL Serial cable
- Debug adapter
 - Adapts 10-pin fine-pitch ARM JTAG connector to standard 20-pin connector
- Reference Design Kit CD
 - Complete documentation, including Quickstart and User's Guides
 - Graphical User Interface (GUI) installer
 - Complete source code, schematics, and PCB gerber files

The source code can be modified and compiled using any of the following tools:

- Keil™ RealView® Microcontroller Development Kit (MDK-ARM)
- IAR Embedded Workbench
- Code Sourcery GCC development tools
- Code Red Technologies development tools
- Texas Instruments' Code Composer Studio™ IDE

Using the RDK

The recommended steps for using the RDK are:

- **Follow the Quickstart guide included in the kit.** The Quickstart guide will help get the display module up and running in minutes.
- **Use your preferred ARM tool-chain and the Stellaris Graphics library to develop a touch-panel application.** Software applications are loaded into IDM flash memory using a JTAG/SWD debug interface or via the serial port using the included boot loader software. See Chapter 3, "Software Development," for the programming procedure. The *Stellaris Graphics Library Software Reference Manual* and the *Stellaris Peripheral Driver Library Software Reference Manual* each contain specific information on software structure and function.
- **Customize and integrate the hardware to suit an end application.** This user's manual is an important reference for understand circuit operation and completing hardware modification.

Features

The RDK-IDM-L35 reference design kit provides the following features:

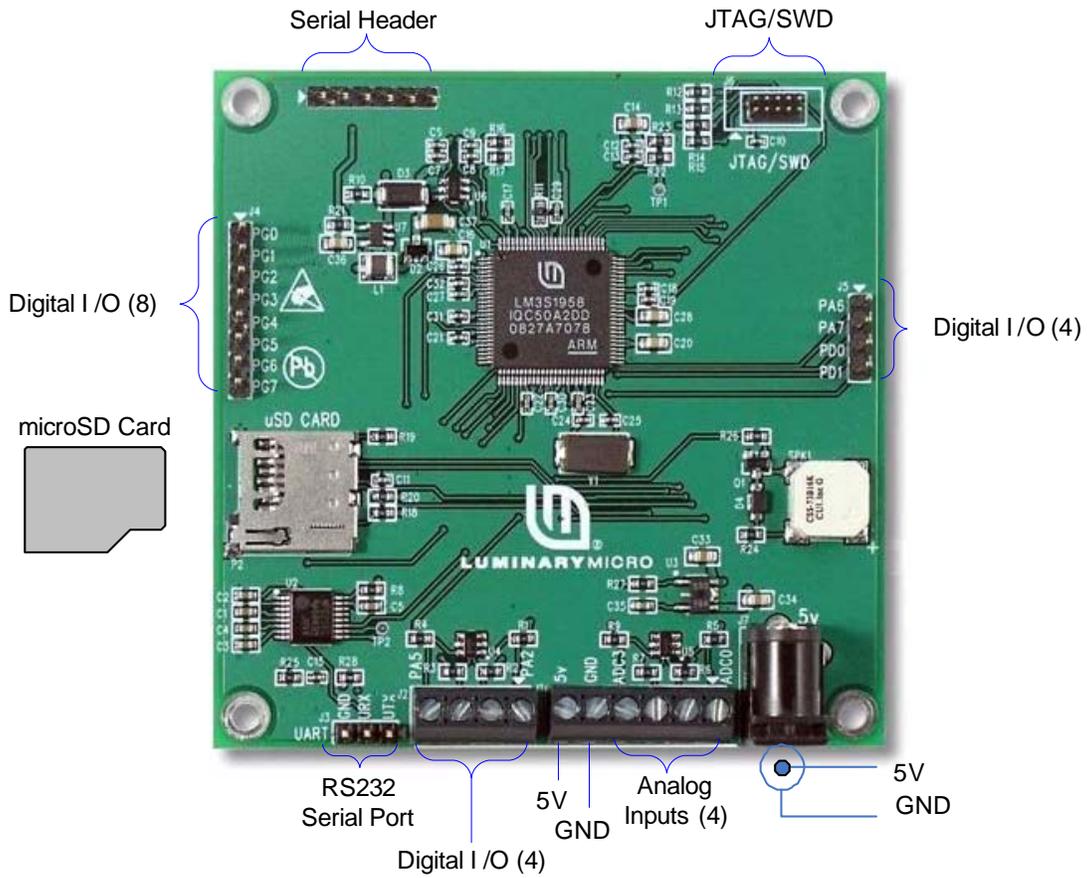
- Bright QVGA LCD touch-screen display
 - 262 K colors, 2.8" QVGA 320 x 240 pixels
 - White LED backlight with resistive touch panel
- Serial connectivity options
 - UART serial port with RS232 signal levels
 - UART serial port with TTL signal levels

- Synchronous serial port
- High performance microcontroller and large memory
 - 32-bit ARM® Cortex™-M3 core
 - 256 KB Main Flash memory, 64 KB SRAM
 - microSD card slot
- Power
 - Board requires 5 V DC for operation, with an on-board regulator generating 3.3 V for the Stellaris MCU and other components. Three 5 V connector options are provided:
 - DC power jack J7
 - Terminal block J1
 - Serial header J8
- Easy to customize
 - Includes full source code, example applications, and design files
 - Develop using tools supporting Keil™ RealView® Microcontroller Development Kit (MDK-ARM), IAR Embedded Workbench, Code Sourcery GCC development tools, Code Red Technologies development tools, or Texas Instruments' Code Composer Studio™ IDE (using a Stellaris evaluation kit or preferred ARM Cortex-M3 debugger)
 - Supported by the Stellaris Graphics Library and Stellaris Peripheral Driver Library

Board Overview

Figure 1-2 shows an overview of the board.

Figure 1-2. IDM-L35 Board Overview Diagram



CHAPTER 2

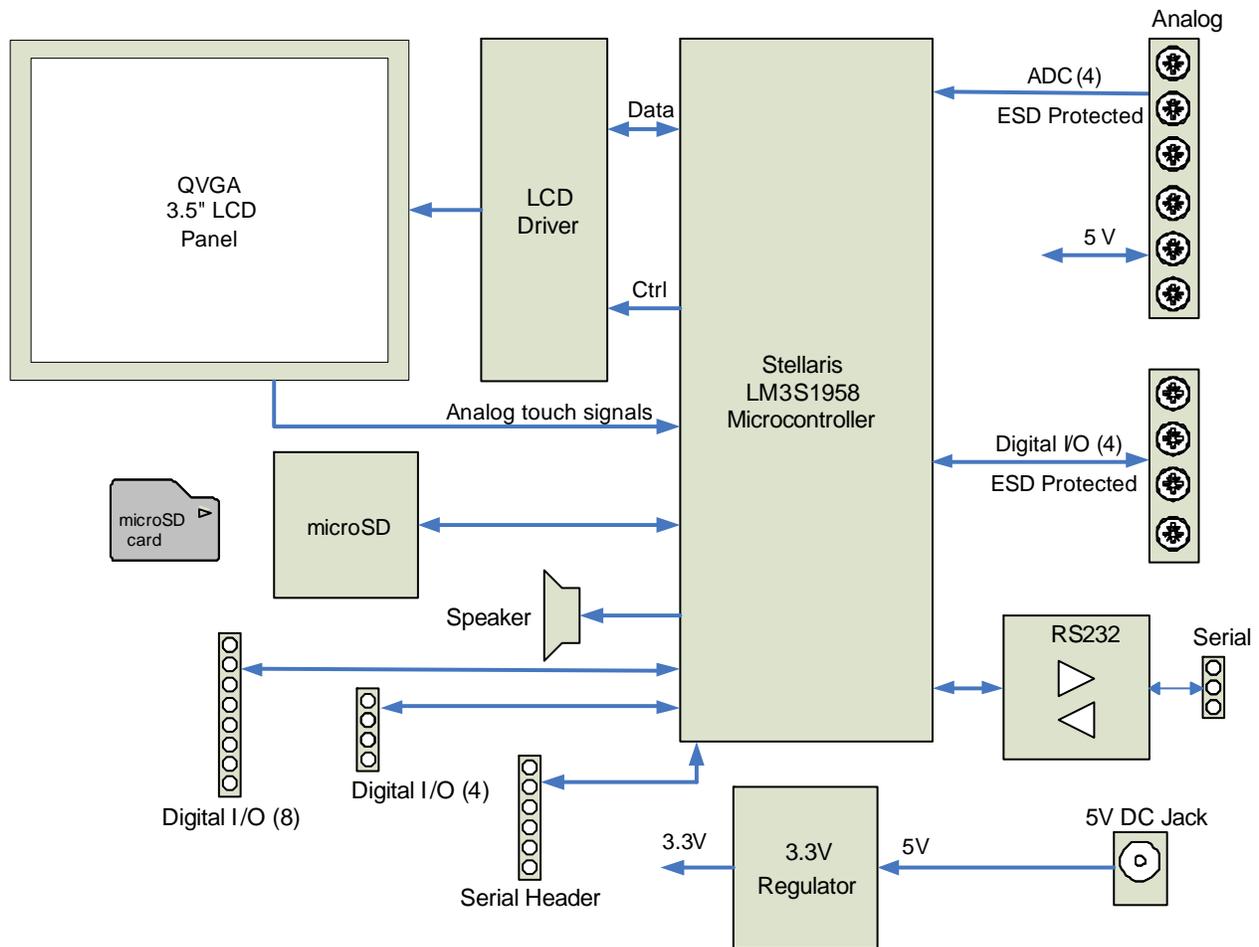
Hardware Description

The IDM-L35 design uses a Stellaris® LM3S1958 microcontroller to handle display functions, touch-screen control, UART, and peripheral functions. Only a few additional ICs are necessary to complete the design. The entire circuit is built on a compact four-layer printed circuit board. All design files are provided on the RDK-IDM-L35 CD.

Block Diagram

Figure 2-1 shows the IDM-L35 block diagram.

Figure 2-1. Intelligent Display Module with 3.5" Display Block Diagram



Functional Description

This section describes the IDM-L35's hardware design in detail.

Microcontroller, Reset, and JTAG (Schematic page 1)

Page 1 of the schematics details the microcontroller, and JTAG debug interface.

Microcontroller

At the core of the IDM-L35 is the Stellaris LM3S1958 microcontroller (U1). The Stellaris microcontroller operates at up to 50 MHz using an internal PLL.

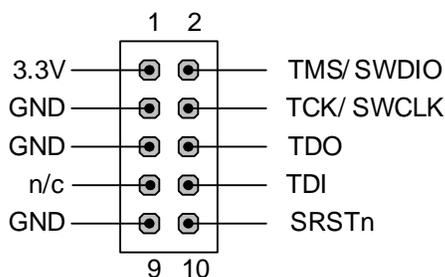
The LM3S1958 microcontroller has an internal LDO voltage regulator that supplies power for internal use. This rail requires only three capacitors for decoupling and is not connected to any other circuits.

A reset switch (SW1) and R-C network (R25, C15) connect to the microcontroller's RSTn input. An external reset circuit is not required by the LM3S1958 microcontroller, the R-C components simply serve to filter any noise on the reset line.

Debugging

The microcontroller supports JTAG and SWD debugging as well as SWO trace capabilities. To minimize board area, the IDM-L35 uses a 0.050" pitch header (J6) which matches ARM's fine-pitch definition (Figure 2-2). Some in-circuit debuggers provide a matching connector. Other debuggers can be used with the ADA1 adaptor board included in the RDK.

Figure 2-2. Debug Connection Pinout



LCD Panel and Voltage Regulators (Schematic page 2)

Page 2 of the schematics contains the LCD panel connector, 3.3 V DC regulator, and the high voltage LED driver for the LCD panel backlight.

LCD Panel

The LCD panel is attached to FPC ZIF connector P1 and is a 3.5" TFT panel with an integrated controller (SSD2119). The graphics display memory resides in the LCD panel and contains 168 kilobytes. The LCD panel requires only a 3.3 V power supply which also simplifies system design.

The LCD panel system interface has several modes of operation, for the IDM-L35 it is configured for 8080 series 16-bit parallel interface mode for improved data rate. Only two control lines (LCD_RDn, LCD_WRn) are required for reading and writing to the panel. A third signal (LCD_DC) selects between memory and display control register access. In order to meet reset signal timing requirements the microcontroller also controls the panel's reset signal (LCD_RSTn).

The LCD panel incorporates a white LED backlight with 6 LEDs in series which requires a high power serial driver (U7) for operation. The backlight power driver shutdown input is controlled by microcontroller GPIO pin PH0/CCP6. For full brightness, set PH0 high. For dim control, a 1 kHz PWM signal can be generated with CCP6.

For additional LCD panel information, refer to the data sheet on the RDK-IDM-L35 CD and LCD driver source code in the Stellaris graphics library.

Touch Panel

Four ADC channels and four GPIO lines connect directly to the resistive touch panel, allowing the microcontroller to manage all aspects of operation.

X and Y axis position measurements are made independently.

For X-axis measurement, GPIO pins PC4 and PC5 are set HIGH and LOW respectively to form a resistor divider between 3 V and 0 V. The voltage on ADC4 and ADC5 indicates the X-axis position.

To measure the Y-axis position, PD2 and PD3 are set HIGH and LOW respectively and the voltage on ADC6 or ADC7 is measured.

Software controls calibration and finger press detection functions.

High Power LED Driver

The LCD panel backlight has 6 LEDs in series and requires a high power LED driver (U7) for operation, providing 20 mA at 20 V. The LCD_BL signal driven from a microcontroller GPIO is used to turn the backlight on and off. A 1 kHz PWM signal can be used instead for dim control.

3.3 V DC Regulator

The IDM-L35 operates with 5 V DC, which can be applied via DC jack J7, terminal block J1, or header J8. The RDK includes a USB to TTL serial cable that connects to J8 and receives 5 V from the USB port. DC regulator U3 generates 3.3 V for powering the board circuits and includes power indicator LED D1.

UART, microSD Card Slot, Speaker, Analog Inputs, Digital I/O (Schematic page 3)

The third schematic page contains the UART RS-232 transceiver, microSD card slot, speaker, terminal blocks, and headers.

RS232 Serial Port

The MAX3221 (U2) line transceiver interfaces between UART2 and the RS232 port pins on J3. UART2 uses ports PG0 and PG1.

microSD Card Slot

Standard microSD media may be used for image or data storage. The SD card is wired for use in SPI mode, rather than the 1-bit or 4-bit SD modes.

Speaker

Speaker SPK1 is a small magnetic audio transducer which is driven by PC7/CCP4 through a small transistor. CCP4 can be configured to generate a free-running tone at the required frequency.

Analog Inputs

Terminal block J1 provides four electrostatic discharge (ESD) protected analog inputs (T_ADC0-T_ADC3) connected to the corresponding ADC0-ADC3 channels of the microcontroller. Refer to the MDL-IDM-L35 data sheet for electrical limits for these inputs.

Digital I/O

Terminal block J2 provides four ESD-protected digital I/O signals connected to port A (PA2-PA5) of the microcontroller. These can be used to implement an SSI port or for I/O signals as required. Refer to the MDL-IDM-L35 data sheet for electrical specifications on these signals.

Headers J4 and J5 provide 12 additional digital I/O lines directly connected to the microcontroller. Header J4 provides 8 digital I/O lines connected to port G (PG0-PG7) with PG0 and PG1 allocated for UART2, and header J5 provides 4 digital I/O lines connected to PA6, PA7, PD0, and PD1. Note that these signals do not have external ESD protection.

Serial Header

Header J8 is for use with the USB to TTL serial cable, and has connections to UART0 (PA0, PA1) and board power (5 V, GND). This provides a convenient way to power the board and provide a serial connection to update the board firmware.

Software Development

This chapter provides general information on software development as well as instructions for Flash memory programming.

Software Description

The software provided with the IDM-L35 provides access to all of the peripheral devices supplied in the design. The Stellaris Peripheral Driver Library is used to operate the on-chip peripherals, the Stellaris Graphics Library is used to render graphical displays on the touch screen, and a set of board-specific drivers are provided to access the off-chip functionality on the IDM-L35.

The Stellaris Graphics Library provides two levels of support for rendering graphical elements. In the lowest level, basic drawing primitives are provided, such as lines, circles, rectangles, and text rendering. Each primitive supports clipping to a single clipping rectangle, allowing only a portion of the display to be affected by the drawing primitives. Building upon the drawing primitives is a widget set, which combines the drawing of graphical elements with reactions to pointer events (in this case, presses on the touch screen). The widget set includes push buttons, check boxes, radio buttons, sliders, listboxes, and drawing canvases. By using the widget set, complex interactive graphical displays can be constructed quickly.

A set of drivers for the on-board peripherals is also provided. This includes a driver for the touch screen, the audio transducer, the analog inputs, and the microSD card.

The IDM-L35 is also supplied with a set of example applications that utilize the Stellaris Peripheral Driver Library and the Stellaris Graphics Library, along with the board-specific drivers for the on-board peripherals. These applications demonstrate the capabilities of the IDM-L35, and provide a starting point for the development of the final application for use on the IDM-L35. All example applications are integrated with the Stellaris boot loader to allow automatic firmware updates to be performed over the serial port using the LM Flash Programmer application.

Source Code

The complete source code for the IDM-L35 is included on the RDK-IDM-L35 CD. Refer to the Quickstart Guide for a detailed description of initial RDK hardware set up and how to install the source code. The source code and binary files are installed in the DriverLib tree.

Tool Options

The source code installation includes directories containing projects and/or makefiles for the following tool-chains:

- Keil™ RealView® Microcontroller Development Kit (MDK-ARM)
- IAR Embedded Workbench
- Code Sourcery GCC development tools
- Code Red Technologies development tools
- Texas Instruments' Code Composer Studio™ IDE

Evaluation versions of these tools can be downloaded from www.ti.com/stellaris. Note that, due to code size restrictions, the evaluation tools may not build all example programs for the IDM. A full license is necessary to re-build or debug all examples.

Instructions on installing and using each of the evaluation tools can be found in the Quickstart guides (for example, Quickstart-Keil, Quickstart-IAR) which are available for download from the evaluation kit section of our web site at www.ti.com/stellaris.

For detailed information on using the tools, refer to the documentation included in the tool chain installation or visit the website of the tools supplier.

Programming the IDM

The IDM-L35 software package includes pre-built binaries for each of the example applications. If you installed DriverLib to the default installation path of C:/DriverLib, you can find the example applications for the IDM in "C:/DriverLib/boards/rdk-idm-l35".

The Stellaris LM Flash Programmer is a free tool for programming Stellaris microcontrollers. It can be used in two modes to update the firmware on the IDM-L35. All IDM-L35 example applications are designed for use with the Stellaris boot loader which supports updating of the main application firmware via the serial port. Alternatively, the LM Flash Programmer utility can be used in conjunction with any Stellaris evaluation board to program the IDM-L35. The Stellaris evaluation board acts as a USB-to-JTAG/SWD hardware interface and should be used in cases where the boot loader image is not present or where the main application image is not behaving correctly and cannot transfer control to the boot loader. However, in normal operation, it is more convenient to program via the serial port.

To program example applications into the IDM-L35 using the serial port for firmware update:

1. Install the LM Flash Programmer utility on a Windows PC.
2. Connect the 6-pin connector of the USB to TTL serial cable (FTDI part number TTL-232R-3V3) to header J8. Verify that J8 pin 1 (marked by the white triangle on PCB) is connected to the black wire of the 6-pin header.
3. Connect the USB connector of the serial cable to the PC. This provides power and connectivity to the serial port.
4. Run LM Flash Programmer.
5. In the Configuration tab, select "Manual Configuration - see below" in the "Quick Set" list.
6. Select "Serial (UART) Interface" in the list below "Interface" and set the COM port, set the baud rate to 115200, and click the "Disable Auto Baud Support" option.
7. Move to the Program tab and click the Browse button. Navigate to the example applications directory (the default location is "C:/DriverLib/boards/rdk-idm-l35/").
8. Each example application has its own directory. Navigate into the example directory that you want to load and then go to the /gcc directory (or the directory corresponding to the tool chain you are using) which contains the binary (*.bin) files. Select the application binary file and click Open. Files that start with a "bl_" prefix are boot loader images and cannot be updated using this method.
9. Ensure that the "Program Address Offset:" is set to 0x800. If this is incorrect, the application will not boot correctly once the flash programming is completed.
10. Click the Program button to start the download process.
11. The program starts once the download is complete.

To replace the boot loader image or to program example applications into the IDM-L35 using a Stellaris evaluation board to provide JTAG/SWD functionality:

1. Install LM Flash Programmer on a Windows PC.
2. Connect the 10-pin to 20-pin adapter (included in the RDK) to the evaluation board ribbon cable. This converts the standard 20-pin ARM header on the evaluation board to a fine pitch ARM header.
3. Carefully connect the socket of the adaptor board to J1 on the IDM.
4. Apply power to the IDM and connect the evaluation board (available separately) to a USB port.
5. Run LM Flash Programmer.
6. In the Configuration Tab use the Quick Set control to select the LM3S1968 Evaluation Board. These settings are compatible with the LM3S1958 implementation on the IDM-L35.
7. Move to the Program Tab and click the Browse button. Navigate to the example applications directory (the default location is "C:/DriverLib/boards/rdk-idm-l35/).
8. Each example application has its own directory. Navigate into the example directory that you wish to load and then into the /gcc directory (or the directory corresponding to the tool chain you are using) which contains the binary (*.bin) files. Files named with a "bl_" prefix are Stellaris boot loader images while those without the prefix are main application images. Select the binary file and click Open.
9. Set the "Erase Method" to "Erase Necessary Pages" and check the "Verify After Program" box.

NOTE: Setting "Erase Entire Flash" when attempting to replace a main application image will erase the boot loader image and result in a hang when the IDM next boots. If this occurs, reflash a boot loader image using these instructions.

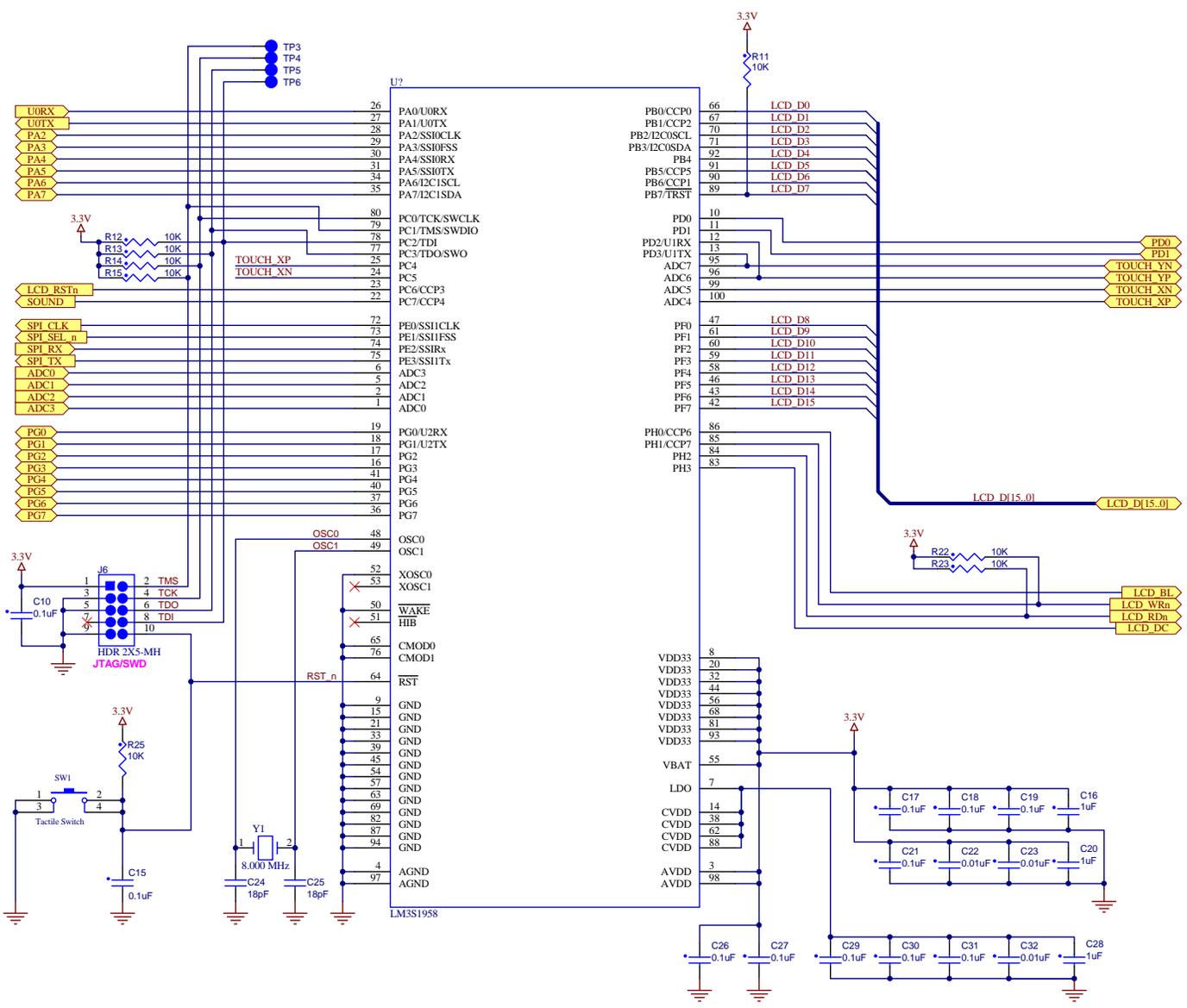
10. If flashing a boot loader image, set the "Program Address Offset:" value to 0x0000. If programming a main application image, set this value to 0x800.
11. Next, click on the Program button to start the Erase, Download, and Verify process.
12. Program execution will start once Verify is complete.

The Debuggers in each of the tool-chains also include Flash programming capabilities, including support for high-performance in-circuit debug interfaces.

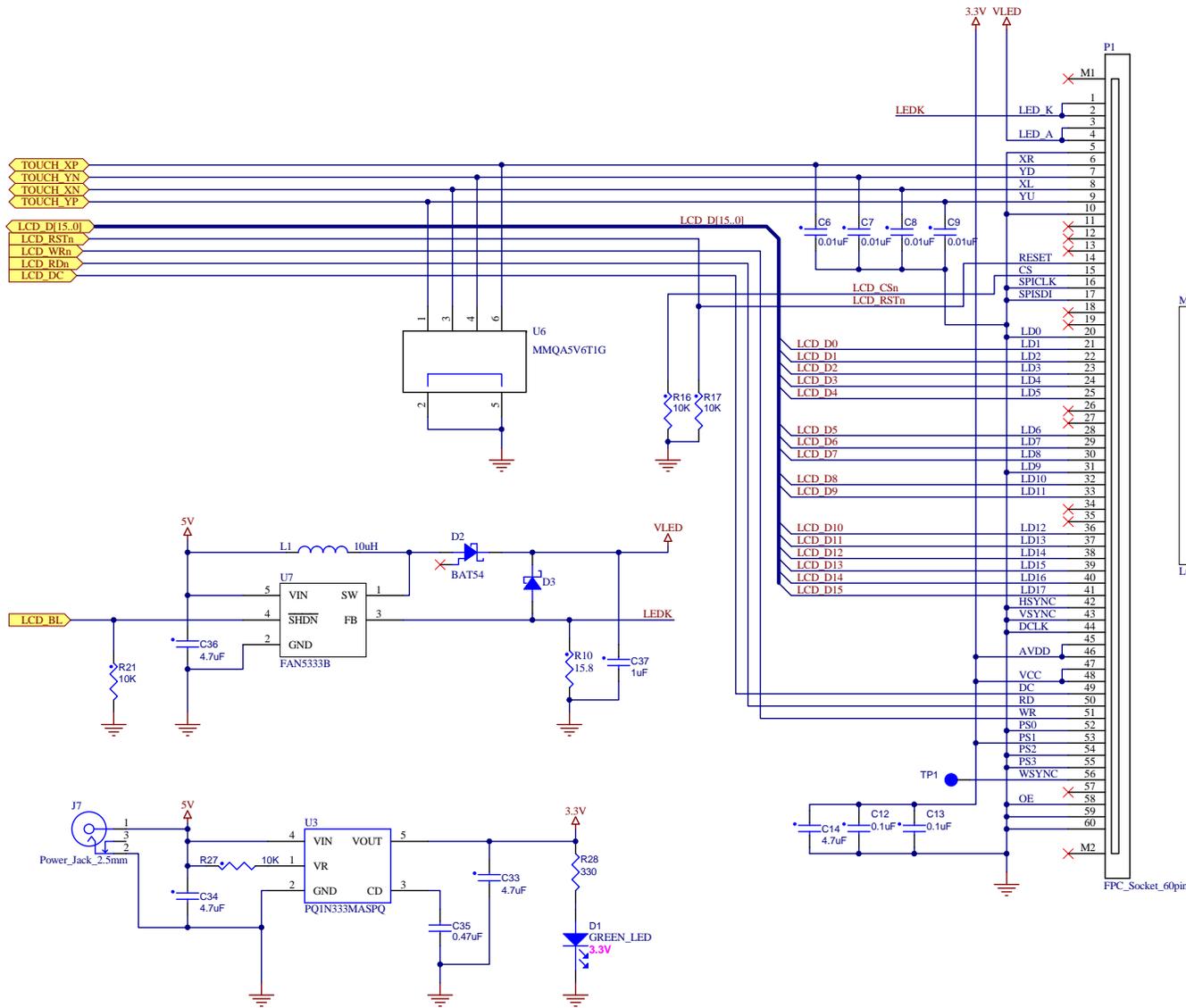
Schematics

This sections contains the schematic diagrams for the Intelligent Display Module.

- IDM-L35 Microcontroller and JTAG on page 22
- IDM-L35 LCD Display and DC Regulators on page 23
- IDM-L35 UART, microSD Card Slot, Speaker, Analog Inputs, and Digital I/O on page 24



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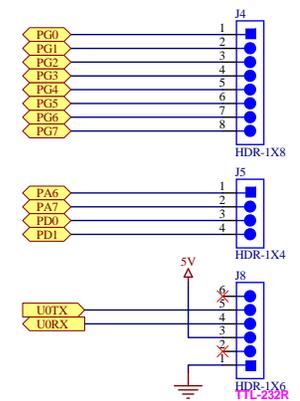
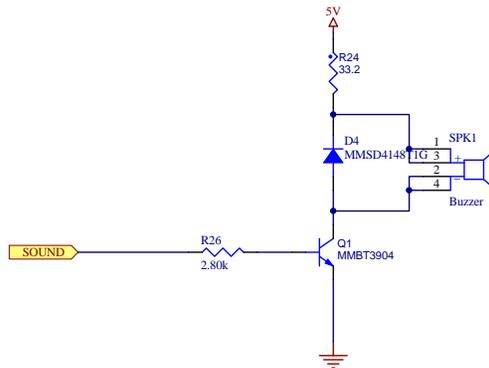
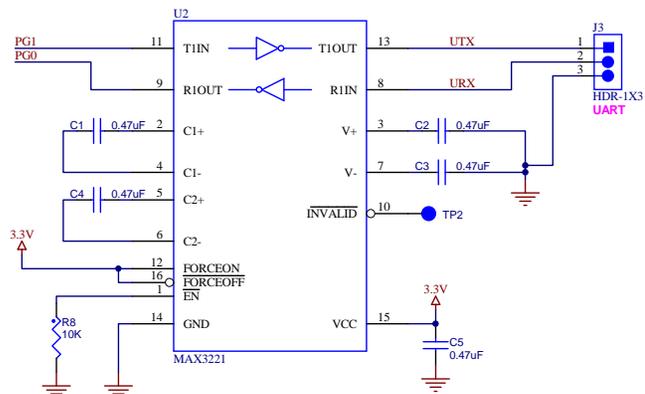
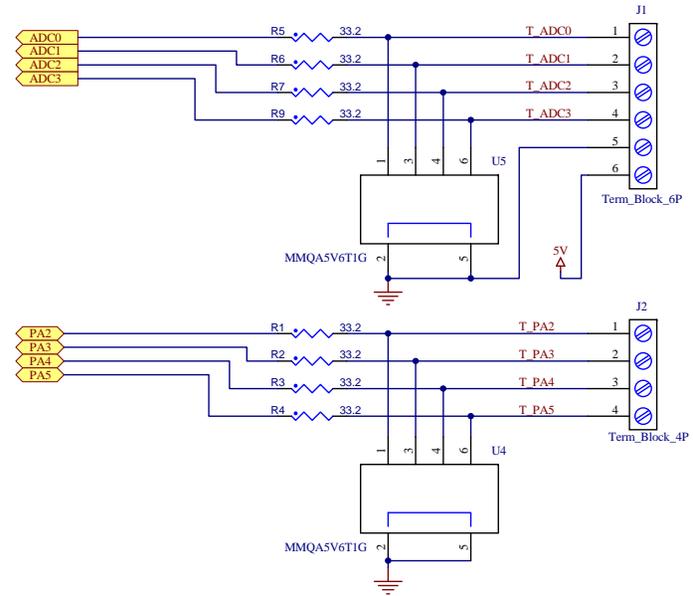
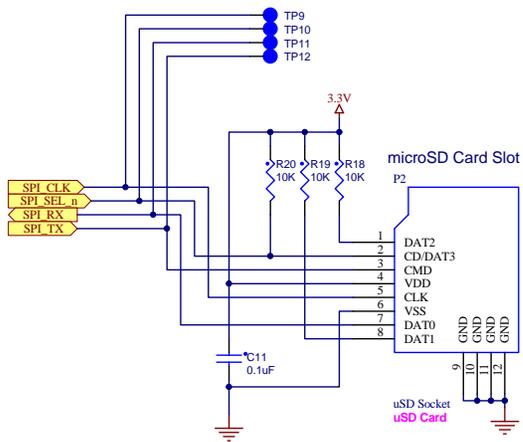


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Intelligent Display Module IDM-L35

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LCD Display, DC Regulators

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A P P E N D I X B

Bill of Materials (BOM)

Table B-1 provides the BOM for the RDK-IDM-L35.

Table B-1. RDK-IDM-L35 Bill of Materials (BOM)

Texas Instruments - Stellaris Microcontrollers
IDM-L35 BOM Rev B 7/29/2010

Parts soldered to IDM-L35 PCB

Designator	Comment	Description	Footprint	MFG	Ordering	Quantity
C1, C2, C3, C4, C5, C35	0.47uF	CAP, 0603, 0.47uF, 10%, 16V, X7R	1608[0603]	Murata	GRM188R71C474KA88D	6
C6, C7, C8, C9, C22, C23, C32	0.01uF	CAP, 0402, 0.01uF, 10%, 25V, X7R	1005[0402]	Murata	GRM155R71E103KA01D	7
C10, C11, C12, C13, C15, C17, C18, C19, C21, C26, C27, C29, C30, C31	0.1uF	CAP, 0402, 0.1uF, 10%, 16V, X7R	1005[0402]	Murata	GCM155R71C104KA55D	14
C14, C33, C34, C36	4.7uF	CAP, 0805, X7R, 4.7uF, 20%, 10V	C0805	Murata	GRM21BR61A475MA73L	4
C16, C20, C28	1uF	CAP, 0805, X7R, 1uF, 10%, 10V	C0805	Murata	GRM21BR71A105KA01L	3
C24, C25	18pF	CAP, 0402, C0G, 18pF, 50V	1005[0402]	Murata	GRM1555C1H180JZ01D	2
C37	1uF	CAP, 1206, X7R, 1uF, 10%, 50V	C1206	Murata	GRM31CR71H105KA61L	1
D1	GREEN_LED	LED GREEN SGL 20mA 0805	D2012[0805]	CML Innovative Technologies	7012X5	1
D2	BAT54	DIODE SCHOTTKY 200mA 30V	SOT23A	Fairchild Semiconductor	BAT54	1
D3	Zener_24V	ZENER DIODE, 24V, 1W, SMA	smb-85x108	Diodes Inc	SMAZ24-13-F	1
D4	MMSD4148T1G	DIODE Switching	SOD-123	ON Semiconductor	MMSD4148T1G	1
J1	Term_Block_6P	Terminal Block, 6 pin, 3.5mm, T/H	CON6/3.5mm_ED555	On Shore Technology	ED555/6DS	1
J2	Term_Block_4P	Terminal Block, 4 pin, 3.5mm, T/H	CON4/3.5mm_ED555	On Shore Technology	ED555/4DS	1
J3	HDR-1X3	HDR, 1x3, 0.025" PIN, 0.1" CTR	HDR1X3	FCI	68000-103HLF	1
J4	HDR-1X8	HDR, 1x8 0.025" PIN, 0.1" CTR	HDR1X8	FCI	68000-108HLF	1
J5	HDR-1X4	HDR, 1x4 0.025" PIN, 0.1" CTR	HDR1X4	FCI	68000-104HLF	1
J6	HDR 2X5-MH	MICRO HDR, 2X5, 0.050" CTR	HDR2X5_SHRD_050	HARWIN	M50-3500542	1
J7	Power_Jack_2.5	Power Jack 2.5MM X 6.5MM	conn3-200120-pwrik	CUI Inc	PJ-102B	1
J8	HDR-1X6	HDR, 1x6 0.025" PIN, 0.1" CTR	HDR1X6	FCI	68000-106HLF	1
L1	10uH	IND -- 10uH 0.9A, 0.133Ohms SMD	3225[1210]	Taiyo Yuden	CBC3225T100MR	1
P1	FPC_Socket_60	FPC Socket 60 pin SMT 0.5mm pitch, Top, RA ZIF	CONN_FPC_60P_4UCONN_11792	4UCON Technology Inc	11792	1
P2	uSD Socket	CONN micro SD card socket SMT	CON8/MICROSD	3M	2908-05WB-MG	1
Q1	MMBT3904	General purpose NPN transistor	SOT-23	ONSEMI	MMBT3904LT1G	1
R1, R2, R3, R4, R5, R6, R7, R9, R24	33	RES, SO, 0603, 33ohm, 1%, 1/10W	J1-0603	Vishay/Dale	CRCW060333R0FKEA	9
R8, R11, R12, R13, R14, R15, R16, R17, R18, R19, R20, R21, R22, R23, R25, R27	10K	RES, SO, 0603, 10K, 1%, 1/10W	J1-0603	Vishay/Dale	CRCW060310K0FKEA	16
R10	15.8	RES, SO, 0603, 15.8, 1%, 1/10W	J1-0603	Vishay/Dale	CRCW060315R8FKTA	1
R26	2.80k	RES, SO, 0603, 2.80K, 1%, 1/10W	J1-0603	Vishay/Dale	CRCW06032800FKEA	1
R28	330	RES, SO, 0603, 330 Ohm, 1%, 1/10W	J1-0603	Vishay/Dale	CRCW0603330RFKEA	1
SPK1	Buzzer	Magnetic Buzzer	PIN2	CUI Inc	CSS-73B16K	1
SW1	Tactile Switch	SWITCH TACT SPST-NO 200GF GW SMD	SW/KMR211G	C&K Components	KMR221GLFS	1
U1	LM3S1958	ARM Cortex-M3 Microcontroller without board-lock security feature	Stellaris_PQFP100	Luminary Micro	LM3S1958-IQC50*	1
U2	MAX3221	RS-232 Transceiver	SSOP16	Texas Instruments	MAX3221ECDB	1
U3	PQ1N333MASPQ	IC, 350mA LDO regulator	SOT89-5	Sharp Microelectronics ON SEMICONDUCTOR	PQ1N333MASPQ	1
U4, U5, U6	MMQA5V6T1G	Quad monolithic common anode TVS	SC-74/.95mm	ON SEMICONDUCTOR	MMQA5V6T1G	3
U7	FAN5333B	Serial LED Driver Switcher, 1.5MHz, 30V, SMT	SOT23-5	Fairchild	FAN5333BSX	1
Y1	8.000 MHz	XTAL 8.000MHz	Crystal_NX8045	NDK	NX8045GB-8.000000MHZ	1

Additional Parts for Module

Designator	Comment	Description	Footprint	MFG	Ordering	Quantity
	LCD panel	LCD module 320 x 240 RGB, 3.5", 262K colors, touch panel	3" x 2.5"	Kentec	ATP350G01	1
	Tape	Double sided foam tape, 0.125" thick, 2" x 1/2" cut piece		3M	4008-1/2"X36YD	2
		Double sided foam tape, 0.125" thick, 1" x 3/4" cut piece				1

Additional Parts for RDK Assembly

Designator	Comment	Description	Footprint	MFG	Ordering	Quantity
	Standoff	Standoff, aluminum, 4-40 thread, 0.187" OD, 1.0" long		Keystone	534-2031	4
	Screws	Machine screw 4-40 x 0.25" lead free machine screw		Richco Plastic	NSP-4-4-01	4
		Alternate supplier for screws above		Building Fasteners	NY PMS 440 0025 PH	

Component Details

This appendix contains details on component locations, including:

- Component placement plot for top (Figure C-1)
- Component placement plot for bottom (Figure C-2)

Figure C-1. Component placement plot for top

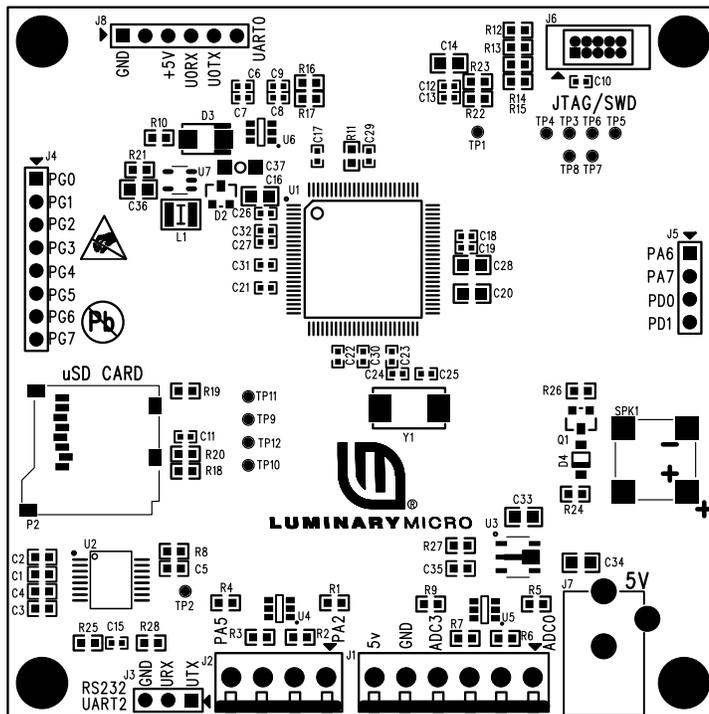
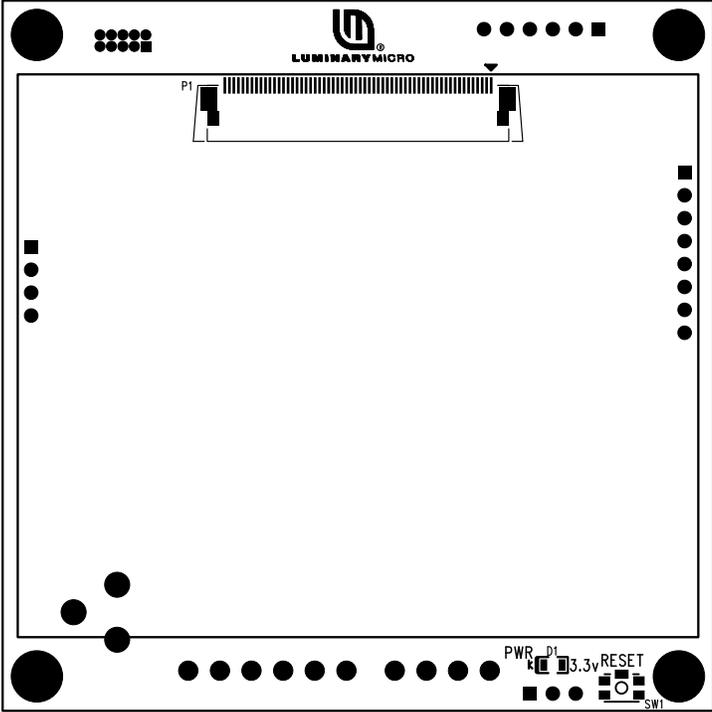


Figure C-2. Component placement plot for bottom



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