![freescale semiconductor logo]

FRDM-KL46Z User's Manual

FRDM-KL46Z-UM

Rev. 1.0

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1 FRDM-KL46Z Overview

The Freescale Freedom development platform is a set of software and hardware tools for evaluation and development. It is ideal for rapid prototyping of microcontroller-based applications. The Freescale Freedom KL46Z hardware, FRDM-KL46Z, is a simple, yet sophisticated design featuring a Kinetis L series microcontroller, built on the ARM® Cortex™-M0+ core.

FRDM-KL46Z can be used to evaluate the KL46, KL36, KL26 and KL16 Kinetis L series devices. It features a MKL46Z256VLL4, this device boasting a max operating frequency of 48MHz, 256KB of flash, 32KB RAM, a full-speed USB controller, segment LCD controller, and loads of analog and digital peripherals. The FRDM-KL46Z hardware is form-factor compatible with the Arduino™ R3 pin layout, providing a broad range of expansion board options. The on-board interfaces includes a 4 digit segment LCD, a 3-axis digital accelerometer, magnetometer, capacitive touch slider, and ambient light sensor.

The FRDM-KL46Z features the Freescale open standard embedded serial and debug adapter known as OpenSDA. This circuit offers several options for serial communications, flash programming and run-control debugging.

2 References documents

The table below provides a list of reference documents for the FRDM-KL46Z hardware. All of these documents are available online at www.freescale.com/FRDM-KL46Z.

Table 1. FRDM-KL46Z Reference Documents

Filename	Description
FRDM-KL46Z Quick Start Package	Quick Start Guide and supporting files for getting started with the *FRDM-KL46Z*.
FRDM-KL46Z User's Manual	This document—overview and detailed information for the *FRDM-KL46Z* hardware.
FRDM-KL46Z Pinouts	Spreadsheet of pin connections for all MCU pins. Includes pinout for the I/O headers, Arduino R3 compatibility chart, and OpenSDA MCU pinout.
FRDM-KL46Z Schematics	PDF schematics for the *FRDM-KL46Z* hardware
FRDM-KL46Z Design Package	Zip file containing all design source files for the *FRDM-KL46Z* hardware
OpenSDA User's Guide	Overview and instructions for use of the OpenSDA embedded

3 Getting started

Refer to the *FRDM-KL46Z Quick Start Package* for step-by-step instructions for getting started with the *FRDM-KL46Z*. See the **Jump Start Your Design** section on http://www.freescale.com/FRDM-KL46Z for the Quick Start Package and software lab guides.

4   FRDM-KL46Z Hardware Overview

The features of the FRDM-KL46Z include>

- MKL46Z256VLLZ4 MCU (48 MHz, 256KB Flash, 32 KB RAM, Low power, 100LQFP package)
- Dual role USB interface with mini-B USB connector
- Open SDA
- 4 digit segment LCD module
- Capacitive touch slider
- Ambient light sensor
- MMA8451Q accelerometer
- MAG3110 Magnetometer
- 2 user LEDs
- 2 user push buttons
- Flexible power supply options – USB, coin cell battery, external source
- Battery-ready, power-measurement access points
- Easy access to MCU I/O via Arduino ™ R3 compatible I/O connectors
- Programmable OpenSDA debug interface with multiple applications available including:
  - Mass storage device flash programming interface
  - P&E Debug interface provides run-control debugging and compatibility with IDE tools
  - CMSIS-DAP interface: new ARM standard for embedded debug interface
  - Data logging application
- Arduino R3 compatibility

Figure 1 shows a block diagram of the FRDM-KL46Z design. The primary components and their placement on the hardware assembly are pointed out in Figure 2.
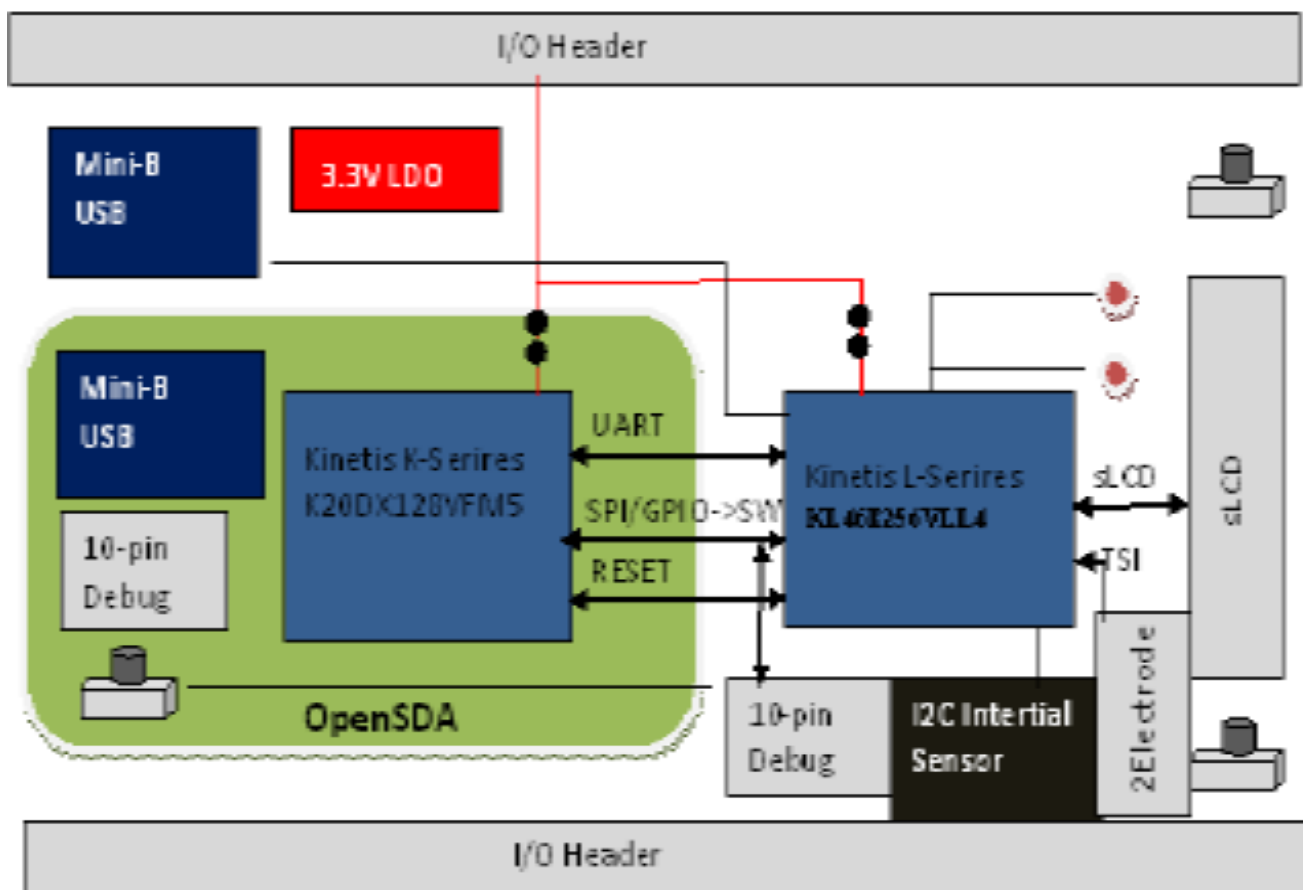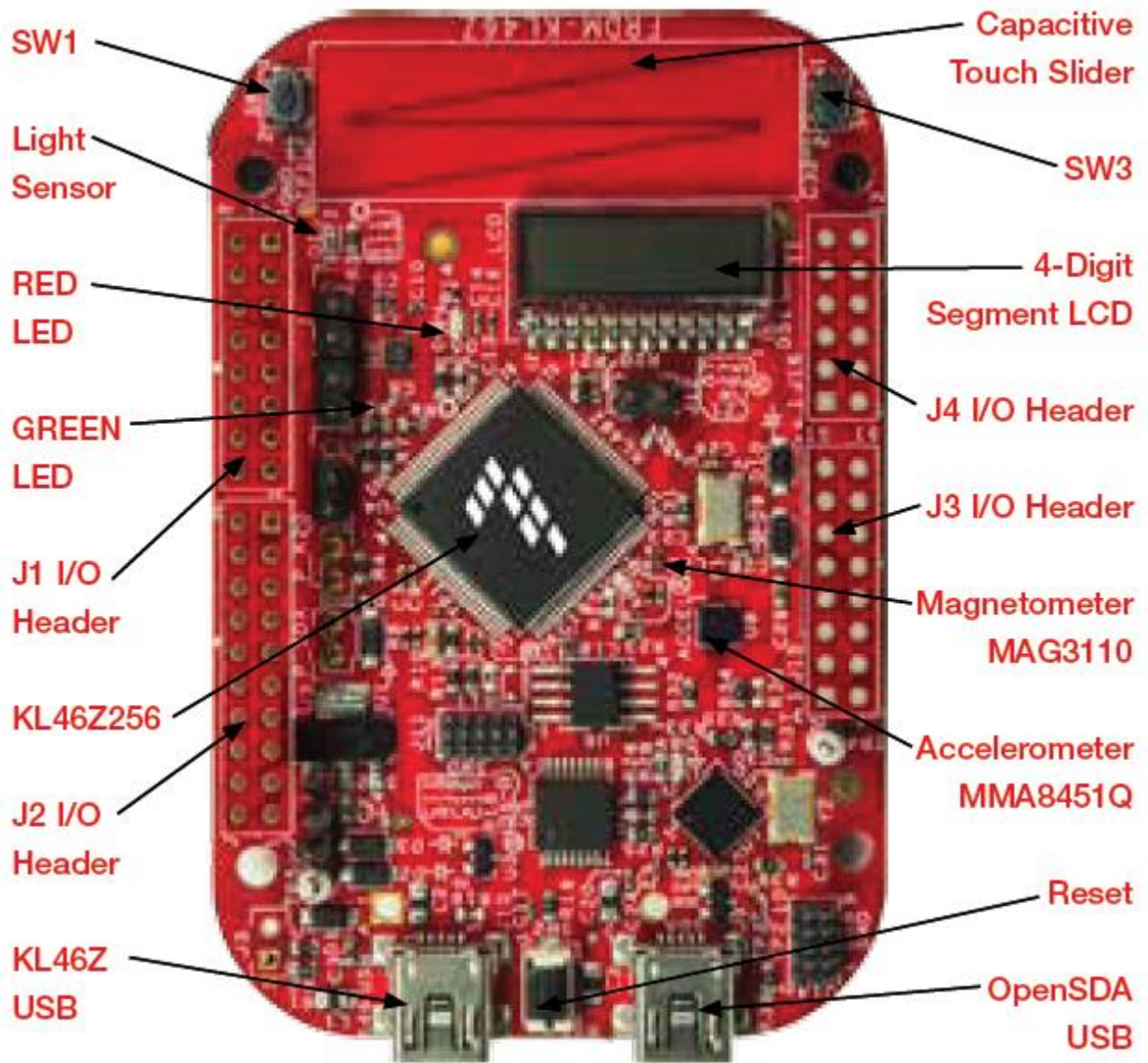
Figure 1. FRDM-KL46Z block diagram

Figure 2. FRDM-KL46Z main components placement.

5 FRDM-KL46Z Hardware Description

5.1.1 Power Supply

There are multiple power supply options on the FRDM-KL46Z. It can be powered from either of the USB connectors, the V$_{IN}$ pin on the I/O header, an on-board coin cell battery, or an off-board 1.71-3.6V supply from the 3.3V pin on the I/O header. The USB and V$_{IN}$ supplies are regulated on-board using a 3.3V linear regulator to produce the main power supply. The other two sources are not regulated on-board. Table 2 provides the operational details and requirements for the power supplies.

Table 2. FRDM-KL46 Power Requirements

Supply Source	Valid Range	OpenSDA Operational?	Regulated on-board?
OpenSDA USB	5V	Yes	Yes
K20 USB	5V	No	Yes
V$_{IN}$ Pin	4.3-9V	No	Yes
3.3V Pin	1.71-3.6V	No	No
Coin Cell Battery	1.71-3.6V	No	No

Note that the OpenSDA circuit is only operational when a USB cable is connected and supplying power to OpenSDA USB. However, protection circuitry is in place to allow multiple sources to be powered at once.
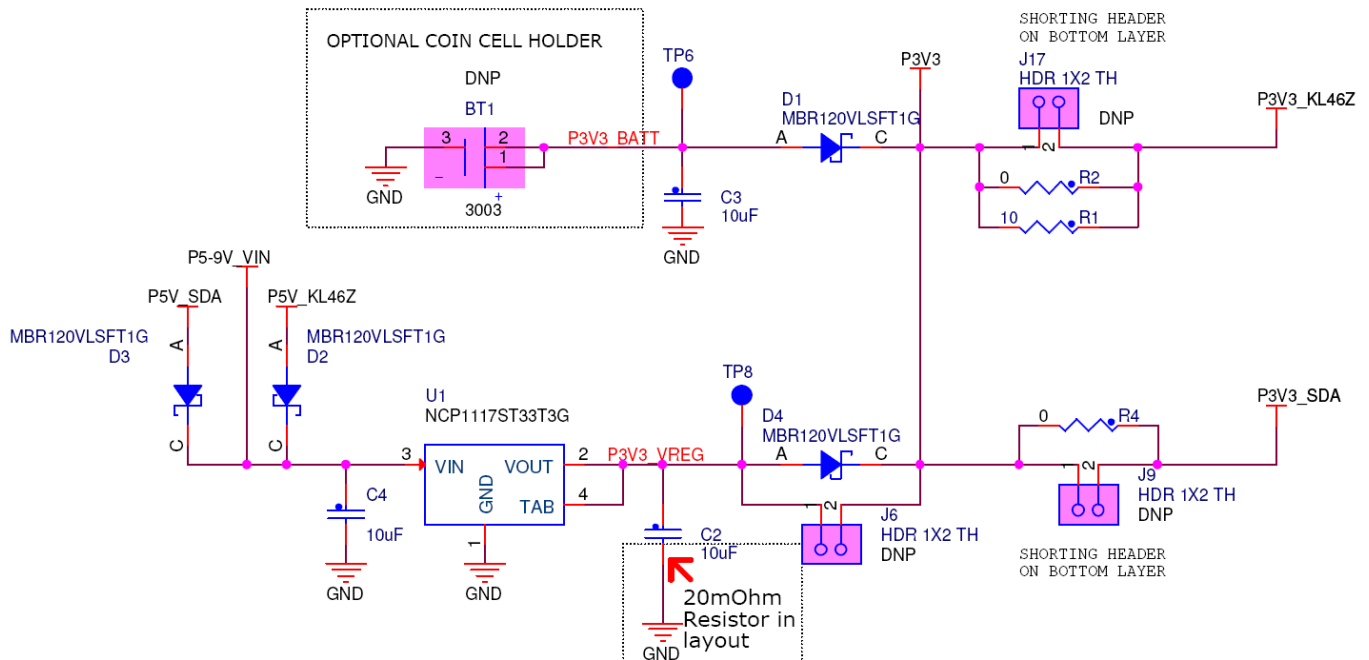

Figure 3- Power Supply Schematic

Table 3. FRDM-KL46Z Power Supplies

Power Supply Name	Description
P5-9V_VIN	Power supplied from the **V$_{IN}$ pin of the I/O headers** (J9 pin 16). A Schottky diode provides back drive protection.
P5V_SDA	Power supplied from the **OpenSDA USB** connector A Schottky diode provides back drive protection.
P5V_KL46Z	Power supplied from the **KL46Z USB** connector A Schottky diode provides back drive protection.
P3V3_VREG	**Regulated 3.3V supply**. Sources power to the P3V3 supply rail through a back drive protection Schottky diode. [1]
P3V3_BATT	**Coin cell battery** supply voltage. Sources power to the P3V3 supply rail through a back drive protection Schottky diode.
P3V3	**Main supply rail** for FRDM-KL46Z assembly. May be sourced from P3V3_VREG, P3V3_BATT, or directly from the I/O headers (J9 pin 8)
P3V3_KL46Z	**KL46Z MCU supply.** Header J17 provides a convenient means for energy consumption measurements. [2]
P3V3_SDA	**OpenSDA circuit supply.** Header J9 provides a convenient means for energy consumption measurements. [2]
P5V_USB	Nominal **5V supplied to the I/O headers** (J3 pin 10). Sourced from either the P5V_K20D50M or P5V_OSDA supply through a back drive protection Schottky diode.

NOTES:
1) By default the linear regulator, U1, is a 3.3V output regulator. However, this is a common footprint that would allow the user to modify the assembly to utilize an alternative device such as a 1.8V or 2.5V regulator. The KL46 microcontroller has an operating range of 1.71V to 3.6V
2) J17 and J9 are not populated by default. The two pins of these headers are shorted together by a trace on the bottom layer of the PCB. To measure the energy consumption of either the KL46 or the OpenSDA MCU, the trace between these pins must first be cut. A current probe or a shunt resistor and voltage meter can then be applied to measure the energy consumption on these rails.

5.1.2 Serial and Debug Adapter (OpenSDA)

OpenSDA is an open-standard serial and debug adapter. It bridges serial and debug communications between a USB host and an embedded target processor as shown in Figure 4. The hardware circuit is based on a Freescale Kinetis K20 family microcontroller (MCU) with 128 KB of embedded flash and an integrated USB controller. OpenSDA features a mass storage device (MSD) bootloader, which provides a quick and easy mechanism for loading different OpenSDA Applications such as flash programmers, run-control debug interfaces, serial-to-USB converters, and more. Refer to the *OpenSDA User's Guide* for more details.
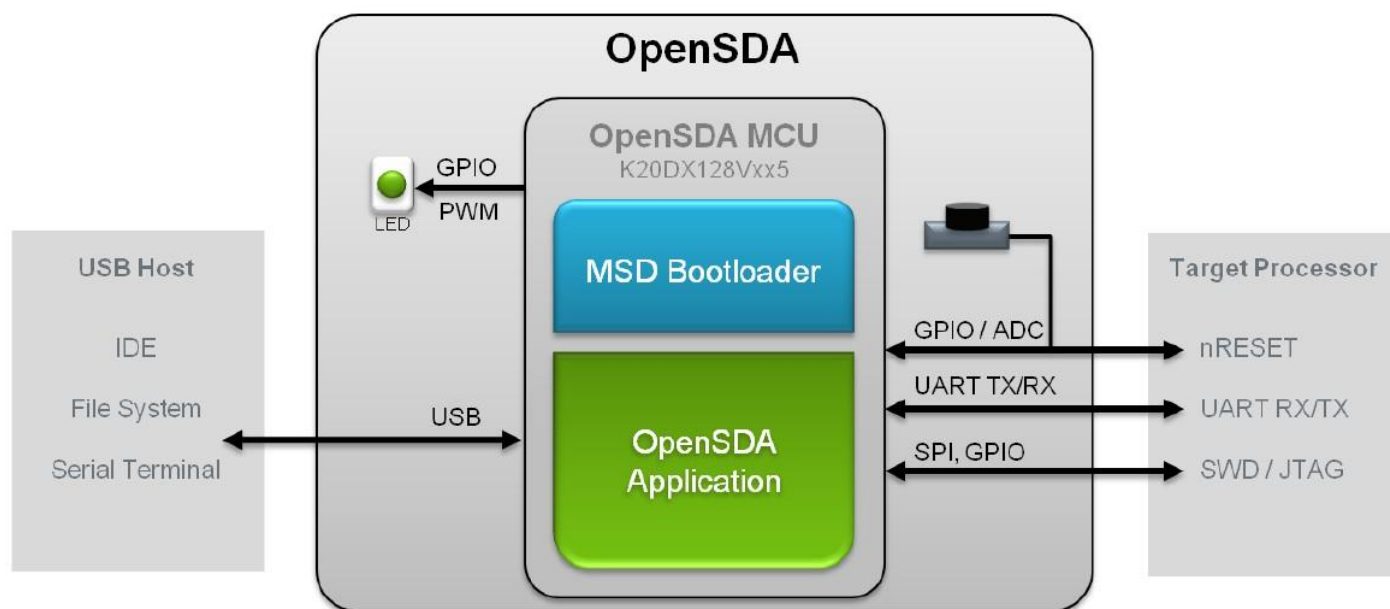

Figure 4. OpenSDA High-Level Block Diagram

OpenSDA is managed by a Kinetis K20 MCU built on the ARM® Cortex™-M4 core. The OpenSDA circuit includes a status LED (D8) and a pushbutton (SW2). The pushbutton asserts the Reset signal to the KL46 target MCU. It can also be used to place the OpenSDA circuit into Bootloader mode. SPI and GPIO signals provide an interface to either the SWD debug port of the K20. Additionally, signal connections are available to implement a UART serial channel. The OpenSDA circuit receives power when the USB connector J13 is plugged into a USB host.

Debug Interface
Signals with SPI and GPIO capability are used to connect directly to the SWD of the KL46. These signals are also brought out to a standard 10-pin (0.05") Cortex Debug connector (J11). It is possible to isolate the KL46 MCU from the OpenSDA circuit and use J11 to connect to an off-board MCU. To accomplish this, cut the trace on the bottom side of the PCB that connects J18 pin 2 to J11 pin 2. This will disconnect the SWD_CLK pin to the KL46 so that it will not interfere with the communications to an off-board MCU connected to J11.
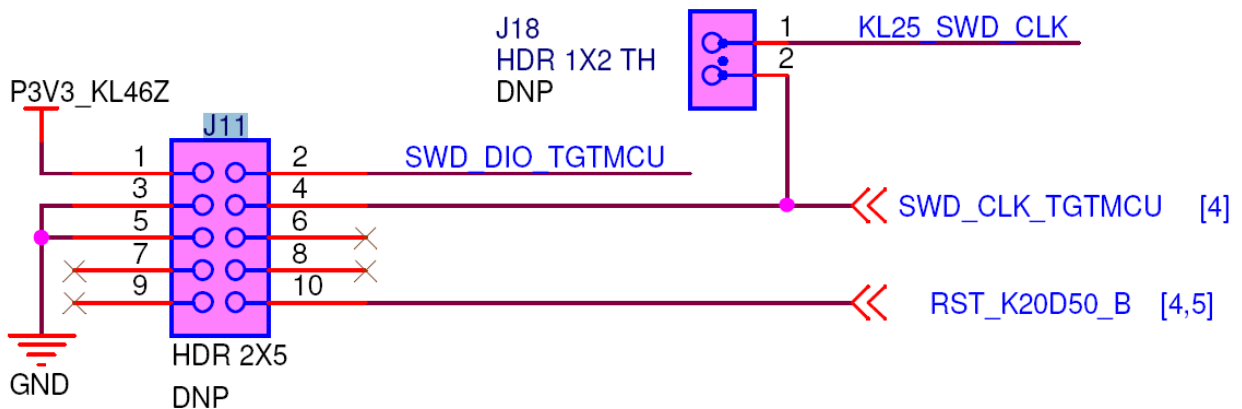
Figure 5 SWD Debug Connector

Note that J11 is not-populated by default. A Samtec FTSH-105-02-F-D or compatible connector can be added to the J11 through-hole connector. A mating cable, such as a Samtec FFSD IDC cable, can then be used to connect from the OpenSDA of the FRDM-KL46Z to an off-board SWD connector.

Virtual Serial Port

A serial port connection is available between the OpenSDA MCU and pins PTA1 and PTA2 of the KL46. Several of the default OpenSDA Applications provided by Freescale, including the MSD Flash Programmer and the P&E Debug Application, provide a USB Communications Device Class (CDC) interface that bridges serial communications between the USB host and this serial interface on the K20.

5.3 MKL46Z4 Microcontroller

The target microcontroller of the FRDM-KL46Z is the KL462Z256VLL4, a Kinetis L series device in an 100 LQFP package. The KL46Z MCU features include:.

- 32-bit ARM Cortex-M0+ core

  o up to 48 MHz operation

  o Single-cycle fast I/O access port

- Memories

- 256 KB flash

- 32 KB SRAM

- System integration

  - Power management and mode controllers
  - Low-leakage wakeup unit
  - Bit manipulation engine for read-modify-write peripheral operations
  - Direct memory access (DMA) controller
  - Computer operating properly (COP) Watchdog timer

- Clocks
  - Clock generation module with FLL and PLL for system and CPU clock generation
  - 4 MHz and 32 kHz internal reference clock
  - System oscillator supporting external crystal or resonator
  - Low-power 1kHz RC oscillator for RTC and COP watchdog

- Analog peripherals
  - 16-bit SAR ADC w/ DMA support
  - 12-bit DAC w/ DMA support
  - High speed comparator
  -
- Communication peripherals
  - One Integrated Interchip Sound(I2S) Audio Interface(SAI)
  - Two 8-bit Serial Peripheral Interfaces (SPI)
  - USB dual-role controller with built-in FS/LS transceiver
  - USB voltage regulator
  - Two I2C modules
  - One low-power UART and two standard UART modules

- Timers
  - One 6-channel Timer/PWM module
  - Two 2-channel Timer/PWM modules
  - 2-channel Periodic Interrupt Timer (PIT)
  - Real time clock (RTC)
  - Low-power Timer (LPT)
  - System tick timer

- Human-Machine Interfaces (HMI)
  - Segment LCD controller. Maximum segment is 8X47 or 4x51.
  - General purpose input/output controller
  - Capacitive touch sense input interface hardware module

5.1.3 Clock source

The Kinetis KL46 microcontrollers feature an on-chip oscillator compatible with three ranges of input crystal or resonator frequencies: 32-40 kHz (low freq. mode), 3-8 MHz (high freq. mode, low range) and 8-32 MHz (high freq. mode, high range). The KL46Z256on the FRDM-KL46Z is clocked from an 8 MHz crystal..

5.1.4 USB Interface

The Kinetis KL46 microcontrollers feature a dual-role USB controller with on-chip full-speed and low-speed transceivers. The USB interface on the FRDM-KL46Z is configured as a full-speed USB device.
VREGIN must be powered to enable the internal circuitry of USB (by jumper J7)

5.1.5 Serial Port

The primary serial port interface signals are PTA1 UART0 RX and PTA2 UART0_TX. These signals are connected the OpenSDA

5.1.6 Reset

The RESET signal on the K20 is connected externally to a pushbutton, SW2, and also to the OpenSDA circuit. The reset button can be used to force an external reset event in the target MCU. The reset button can also be used to force the OpenSDA circuit into bootloader mode. Please refer to section 5.2, Serial and Debug Adapter (OpenSDA), for more details.

5.1.7 Debug

The sole debug interface on all Kinetis L Series devices is a Serial Wire Debug (SWD) port. The primary controller of this interface on the FRDM-KL46Z is the onboard OpenSDA circuit (see section 5.2). However, an unpopulated 10-pin (0.05") Cortex Debug connector, J11, provides access to the SWD signals. The Samtec FTSH-105-02-F-D or compatible connectors can be added to the J11 through-hole debug connector to allow for an external debug cable to be connected.

5.1.8 Segment LCD

FRDM-KL46Z is using a 4 digit display (LUMEX LCD-S401M16KR) 4x8 segments. following table shows connection from KL46 to s401 display.

Table 4. sLCD connections

s401 pin	KL46 LCD Pin
1	LCD_P40 (COM0)
2	LCD_P52 (COM1)
3	LCD_P19 (COM2)
4	LCD_P18 (COM3)
5	LCD_P37
6	LCD_P17
7	LCD_P7
8	LCD_P8
9	LCD_P53
10	LCD_P38
11	LCD_P10
12	LCD_P11

Figure 6 s401 segments layout

5.1.9 Capacitive Touch Slider

Two Touch Sense Input (TSI) signals, TSI0_CH9/PTB16, and TSI0_CH10/PTB17 are connected to capacitive electrodes configured as a touch slider. Freescale's Touch Sense Software (TSS) provides a software library for implementing the capacitive touch slider.

5.1.10 Three-axis Accelerometer

A Freescale MMA8451Q low-power, three-axis accelerometer is interfaced through an I2C bus and two GPIO signals as shown in Table 5 below. By default, the I2C address is 0x1D (SA0 pulled high).

Table 5. Accelerometer Signal Connections

MMA8451Q	KL46
SCL	PTE25/TPM0_CH1/**I2C0_SDA**
SDA	PTE24/TPM0_CH0/**I2C0_SCL**
INT1_ACCEL	*PTC5/LLWU_P9*
INT2 _ACCEL	PTD1 (shared with INT2_MAG)

5.1.11 Three-axis Digital Magnetometer

A Freescale MAG3110 Three-Axis, Digital Magnetometer is interfaced through an I2C bus, and one GPIO signals as shown in Table 6 below

Table 6. Magnetometer Signal Connections

MAG3110	KL46
SCL	PTE25/TPM0_CH1/**I2C0_SDA**
SDA	PTE24/TPM0_CH0/**I2C0_SCL**
INT1_MAG	PTD1 (shared with INT2_ACCEL) can be isolated removing R50

5.1.12 LEDs

Two LED,   Green LED is PWM capable, Signal connections are shown in Table 7.

Table 7. LED Signal Connections

LED	KL46
Red	PTD5
Green	PTE29/TPM0_CH2

5.1.13 Visible light sensor

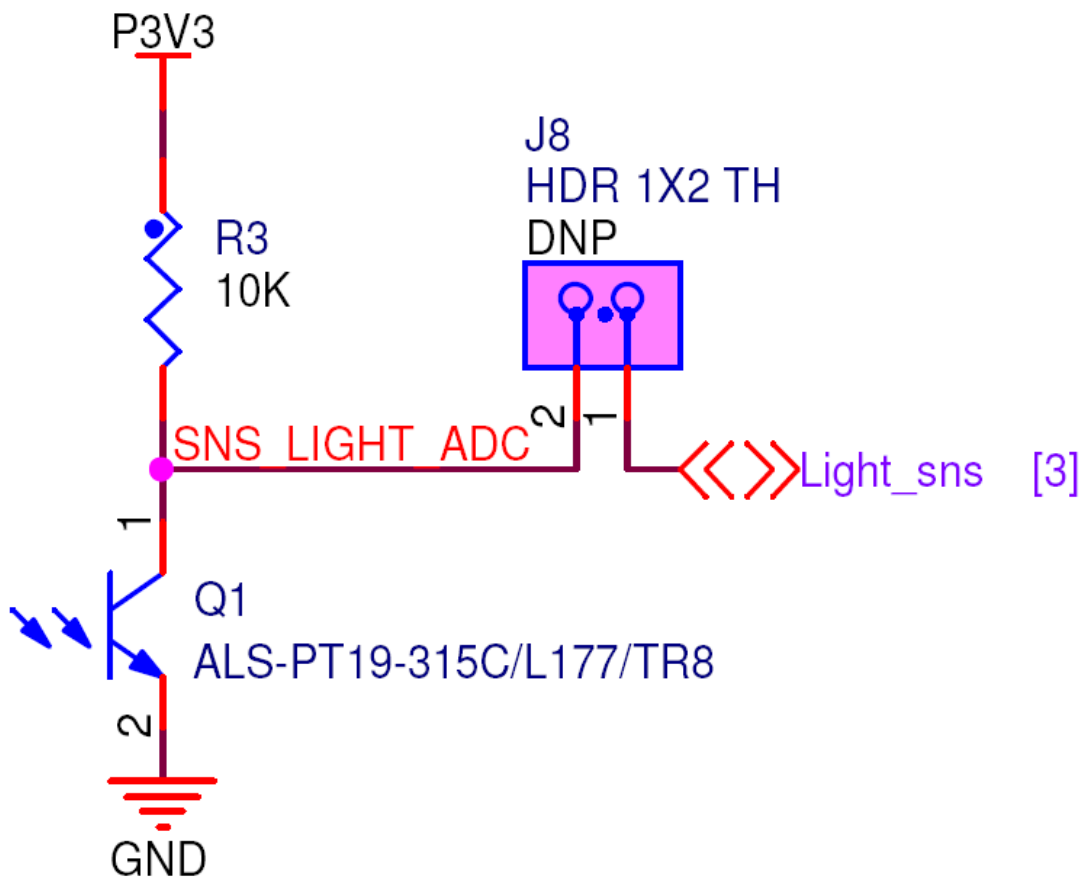The FRDM-KL46Z has a visible light sensor that is connected to ADC0_SE3

Figure 7 Visible light sensor schematic

5.1.14 Input/Output Connectors

The MKL46Z256VLL4 microcontroller is packaged in a 100-pin LQFP. Some pins are utilized in on-board circuitry, but many are directly connected to one of four I/O headers.

The pins on the KL46 microcontroller are named for their general purpose input/output port pin function. For example, the 1_{st} pin on Port A is referred to as PTA1. The I/O connector pin names are given the same name as the KL46 pin connected to it, where applicable.
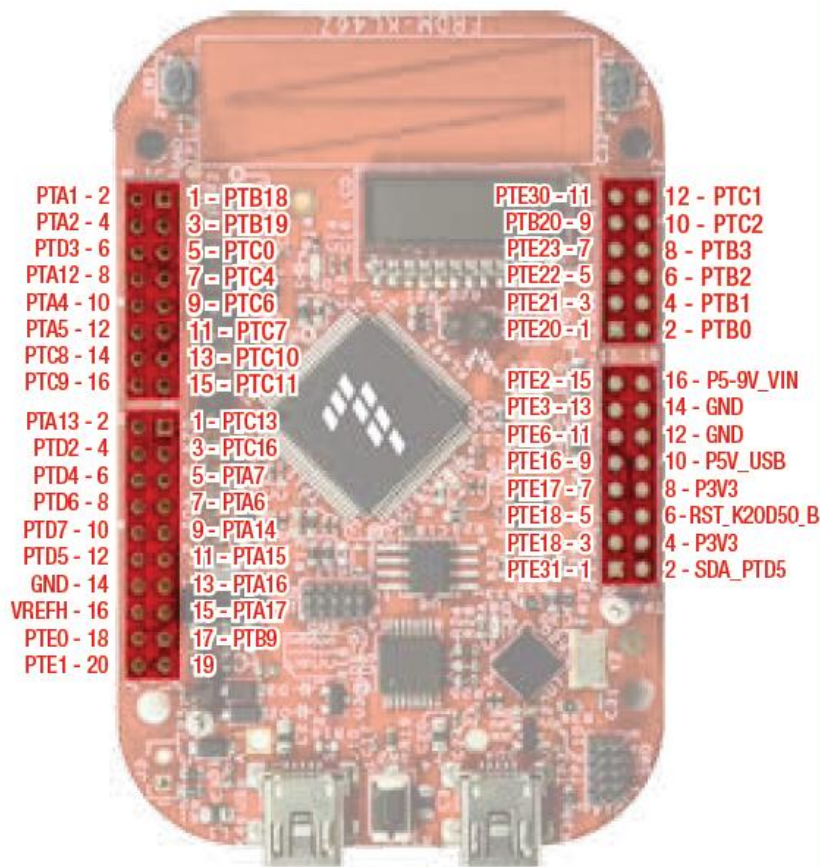

Figure 8 FRDM-KL46 Pin-Out

Note that all pinout data is available in spreadsheet format in *FRDM-KL46Z Pinouts*. See the Reference Documents section for details.

5.1.15 Arduino Compatibility

The I/O headers on the FRDM-KL46Z are arranged to allow compatibility with peripheral boards (known as shields) that connect to Arduino™ and Arduino-compatible microcontroller boards. The outer rows of pins (the even numbered pins) on the headers share the same mechanical spacing and placement as the I/O headers on the Arduino Revision 3 (R3) standard.