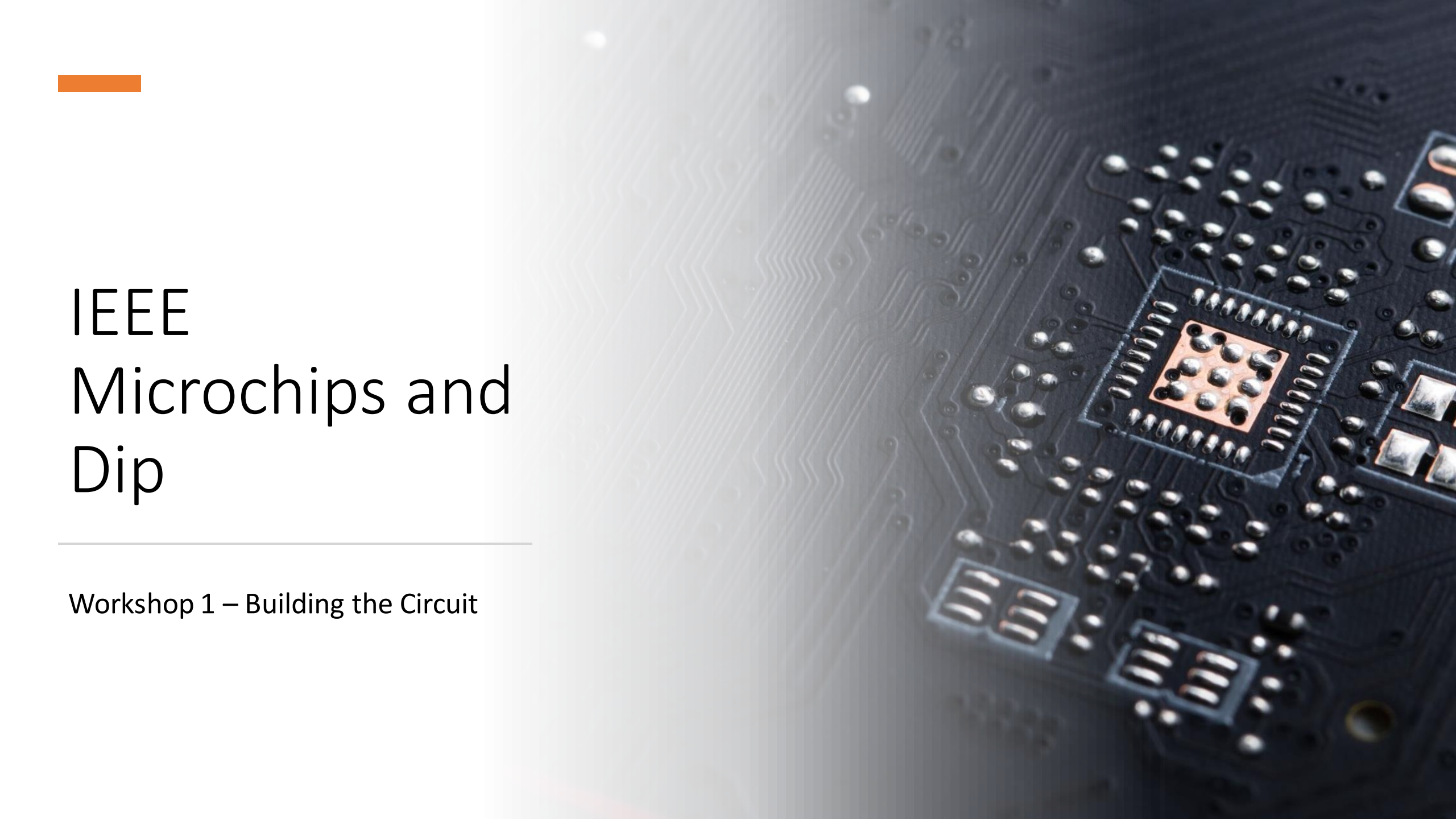
IEEE Microchips and Dip

Workshop 1 – Building the Circuit



Workshops Overview

Workshop 1 – Building the circuit:

- Design requirements
- STM32 Microcontroller
- Picking components and reading data sheets
- Drawing a schematic using KiCAD
- Assembling the circuit
- Running Hello World on STM32

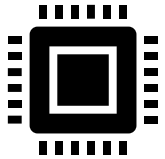
Workshop 2 – Intro to Embedded:

- Introduction to embedded software
- How to use the MCU datasheet
- Hardware Abstraction Layer
- Reading ADC (Temperature sensor)

Workshop 3 – Communication protocols and FreeRTOS:

- Intro to I2C
- Reading accelerometer data
- Intro to FreeRTOS
- Multi-tasking on a single core with FreeRTOS
- External resources

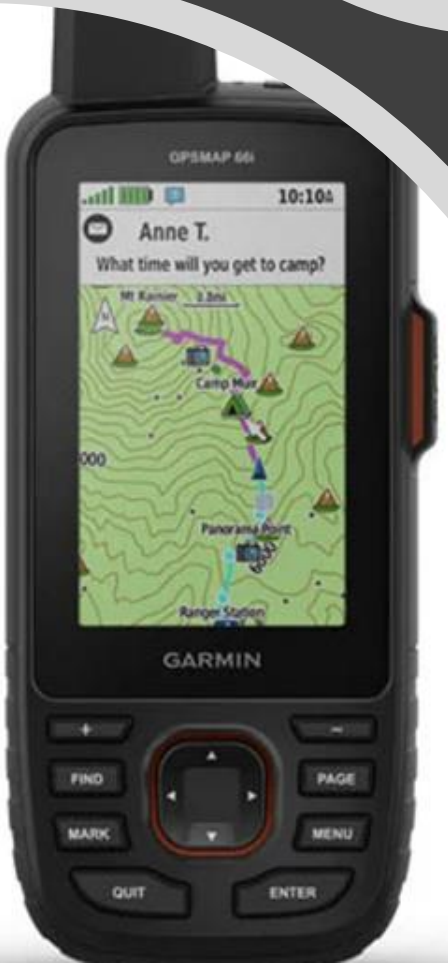
What is an embedded systems?



A computer system that involves, processor(s), memory, sensor, and other peripheral I/O devices.

This computer system performs a dedicated task, not a general purpose computer.

These systems don’t consume a lot of power compared to a desktop computer (Milliwatts compared to watts)



Examples of embedded devices

Embedded system vs desktop computer

- No filesystem or operating system
- Less than 1 Mb RAM
- 16-300 Mhz CPU
- No screen/monitor to display data
- 50 cents to 5 dollar cost
- Does a few specific task very well
- Consumes milliwatts

- Filesystem or operating system
- A few Gbs of RAM
- 2-4 Ghz CPU
- Has a screen/monitor to display data
- A few hundred dollars
- Multi-purpose
- Consumes hundreds of watts

What are our requirements

The system must collect temperature every second

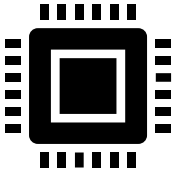
The system must collect acceleration every 100 ms

The system must display this data somewhere

Selecting Parts for Our System

Accelerometer
Needs to be able to measure acceleration in 3 axis

Temperature Sensor
Needs to be able to measure temperature within our required temperature range



Microcontroller
Needs to be able to communicate with sensor using digital protocols or analog signals

Microcontroller Selection

MICROCHIP

STM32 Nucleo

NUCLEO-L432KC

Mouser #:	511-NUCLEO-L432KC
Mfr. #:	NUCLEO-L432KC
Mfr.:	STMicroelectronics
Customer #:	Customer # Add
Description:	Development Boards & Kits - ARM STM32 Nucleo-32 dev board STM32L432KC, supports Arduino nano conn Complete Your Design
Datasheet:	NUCLEO-L432KC Datasheet (PDF)
More Information	Learn more about STMicroelectronics NUCLEO-L432KC

In Stock: 1,540

Stock:	1,540 Can Ship Immediately
On Order:	4,050 Expected 23-Jan-23
Factory Lead-Time:	35 Weeks

Long lead time reported on this product.

Enter Quantity: Minimum: 1 Multiples: 1 Maximum: 10 Buy

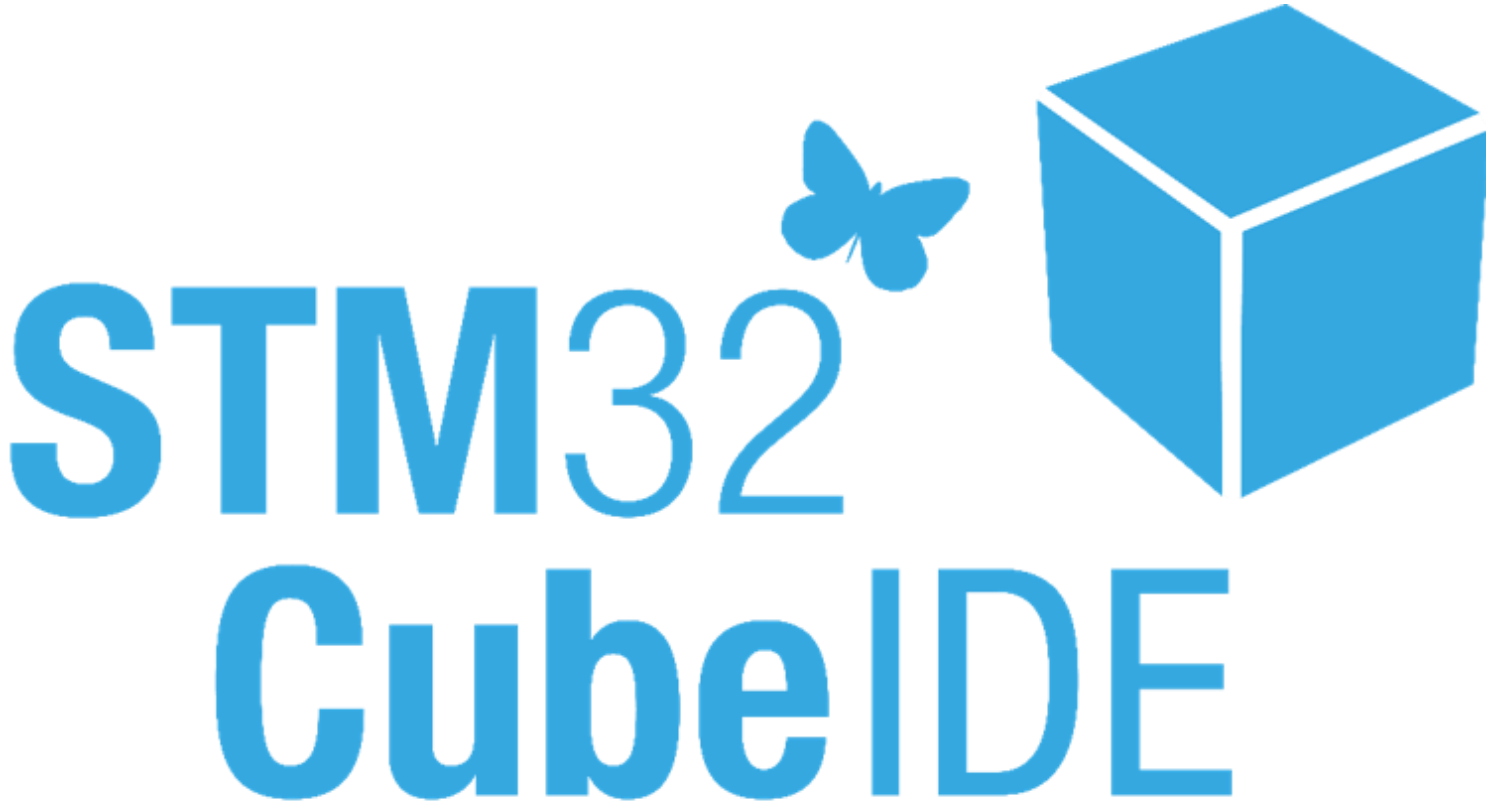
Pricing (CAD)

Qty.	Unit Price	Ext. Price
1	$14.26	$14.26

Specification

All features

- Ultra-low-power with FlexPowerControl
  - 1.71 V to 3.6 V power supply
  - -40 °C to 85/105/125 °C temperature range
  - 8 nA Shutdown mode (2 wakeup pins)
  - 28 nA Standby mode (2 wakeup pins)
  - 280 nA Standby mode with RTC
  - 1.0 µA Stop 2 mode, 1.28 µA with RTC
  - 84 µA/MHz run mode
  - Batch acquisition mode (BAM)
  - 4 µs wakeup from Stop mode
  - Brown out reset (BOR)
  - Interconnect matrix
- Core: Arm® 32-bit Cortex®-M4 CPU with FPU, Adaptive real-time accelerator (ART Accelerator™) allowing 0-wait-state execution from Flash memory, frequency up to 80 MHz, MPU, 100DMIPS and DSP instructions
- Performance benchmark
  - 1.25 DMIPS/MHz (Drystone 2.1)
  - 273.55 CoreMark® (3.42 CoreMark/MHz @ 80 MHz)
- Memories
  - Up to 256 KB single bank Flash, proprietary code readout protection
  - 64 KB of SRAM including 16 KB with hardware parity check
  - Quad SPI memory interface
- Rich analog peripherals (independent supply)
  - 1x 12-bit ADC 5 Msps, up to 16-bit with hardware oversampling, 200 µA/Msps
  - 2x 12-bit DAC output channels, low-power sample and hold
  - 1x operational amplifier with built-in PGA
  - 2x ultra-low-power comparators
- 14x communication interfaces
  - USB 2.0 full-speed crystal less solution with LPM and BCD
  - 1x SAI (serial audio interface)
  - 2x I2C FM+(1 Mbit/s), SMBus/PMBus
  - 3x USARTs (ISO 7816, LIN, IrDA, modem)
  - 1x LPUART (Stop 2 wake-up)
  - 2x SPIs (and 1x Quad SPI)
  - CAN (2.0B Active)

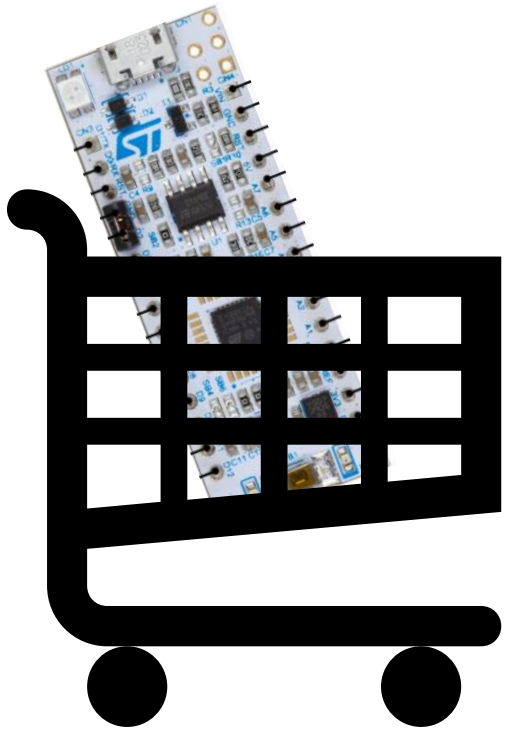


Installing the STM32CUBE IDE

- STM32CUBE IDE is STM's development environment for their microcontrollers
- Compilers
- Debugging tools (break points, memory visualization)
- Pin assignment user interface
- Board upload tools
- Hardware Abstraction Layer (SDK for STM32s)
- https://www.st.com/en/development-tools/stm32cubeide.html

Summary of STM32l432

- Available (sufficient quantity for our need)
- Comes in a development board
- Complete IDE
- Good specs
  - RAM
  - FLASH Memory
  - Sufficient inputs and outputs



Temperature sensor

Order online in **04:33:02** to ship **today**. Shipping Details

LMT86LPM

Images are for reference only
See Product Specifications

Share

Mouser #:	595-LMT86LPM
Mfr. #:	LMT86LPM
Mfr.:	Texas Instruments
Customer #:	Customer # Add
Description:	Board Mount Temperature Sensors Analog Temperature Sensor
Datasheet:	LMT86LPM Datasheet
ECAD Model:	Request Free CAD Models

Download the free Library Loader to convert this file for your ECAD Tool. Learn more about ECAD Model.

More Information Learn more about Texas Instruments LMT86LPM

Compare Product

Add To Project | Add Notes

In Stock: 3,786

Stock: 3,786 Can Ship Immediately

Factory Lead-Time: 6 Weeks

Enter Quantity: Minimum: 1 Multiples: 1 Buy

Pricing (CAD)

Qty.	Unit Price	Ext. Price
Cut Tape / MouseReel™ †		
1	$1.15	$1.15
10	$0.951	$9.51
25	$0.835	$20.88
50	$0.694	$34.70
100	$0.591	$59.10
500	$0.513	$256.50
1,000	$0.396	$396.00
Full Reel (Order in multiples of 2000)		
2,000	$0.395	$790.00

Datasheet

TEXAS INSTRUMENTS

LMT86

SNIS169E – MARCH 2013 – REVISED OCTOBER 2017

LMT86 2.2-V, SC70/TO-92/TO-92S, Analog Temperature Sensors

1 Features

- LMT86LPG (TO-92S package) has a Fast Thermal Time Constant, 10-s Typical (1.2 m/s Airflow)
- Very Accurate: ±0.4°C Typical
- Low 2.2-V Operation
- Average Sensor Gain of -10.9 mV/°C
- Low 5.4-µA Quiescent Current
- Wide Temperature Range: –50°C to 150°C
- Output is Short-Circuit Protected
- Push-Pull Output With ±50-µA Drive Capability
- Footprint Compatible With the Industry-Standard LM20/19 and LM35 Temperature Sensors
- Cost-Effective Alternative to Thermistors

2 Applications

- Infotainment and Cluster
- Powertrain Systems
- Smoke and Heat Detectors
- Drones
- Appliances

3 Description

The LMT86 are precision CMOS temperature sensors with ±0.4°C typical accuracy (±2.7°C maximum) and a linear analog output voltage that is inversely proportional to temperature. The 2.2-V supply voltage operation, 5.4-µA quiescent current, and 0.7-ms power-on time enable effective power-cycling architectures to minimize power consumption for battery-powered applications such as drones and sensor nodes. The LMT86LPG through-hole TO-92S package fast thermal time constant supports off-board time-temperature sensitive applications such as smoke and heat detectors. The accuracy over the wide operating range and other features make the LMT86 an excellent alternative to thermistors.

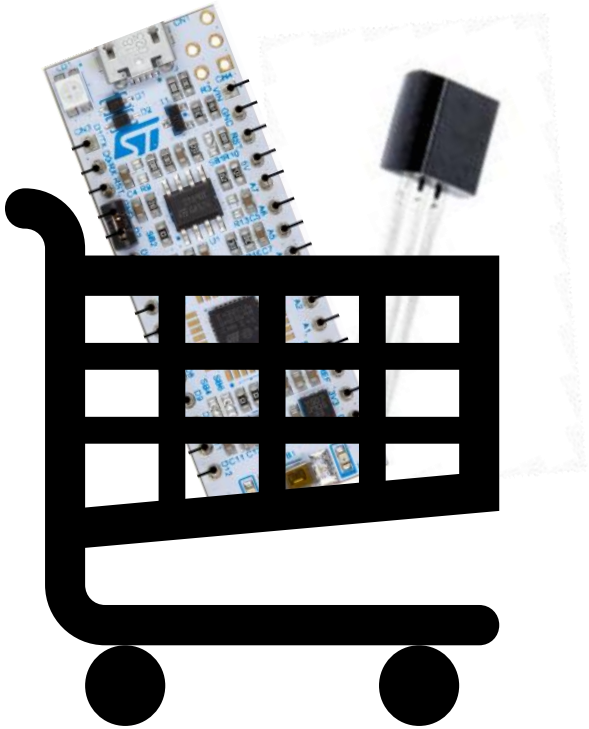
For devices with different average sensor gains and comparable accuracy, refer to *Comparable Alternative Devices* for alternative devices in the LMT8x family.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LMT86	SOT (5)	2.00 mm × 1.25 mm
	TO-92 (3)	4.30 mm × 3.50 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Electrical Characteristics



7.1 Absolute Maximum Ratings

See (1)(2)

	MIN	MAX	UNIT
Supply voltage	–0.3	6	V
Voltage at output pin	–0.3	(V_{DD} + 0.5)	V
Output current	–7	7	mA
Input current at any pin (3)	–5	5	mA
Maximum junction temperature (T_{JMAX})		150	°C
Storage temperature, T_{stg}	–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability

(2) Soldering process must comply with TI's Reflow Temperature Profile specifications. Refer to www.ti.com/packaging. Reflow temperature profiles are different for lead-free and non-lead-free packages.

(3) When the input voltage (V_I) at any pin exceeds power supplies (V_I < GND or V_I > V), the current at that pin should be limited to 5 mA.

7.2 ESD Ratings

			VALUE	UNIT
LMT86LP in TO-92 package				
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)(2)	±2500	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 (3)	±1000	
LMT86DCK in SC70 package				
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per JESD22-A114 (2)	±2500	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 (3)	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

(2) The human body model is a 100-pF capacitor discharged through a 1.5-kΩ resistor into each pin.

(3) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.3 Recommended Operating Conditions

	MIN	MAX	UNIT
Specified temperature	$T_{MIN} \le T_A \le T_{MAX}$		°C
	$-50 \le T_A \le 150$		°C
Supply voltage (V_{DD})	2.2	5.5	V

Accelerometer

SEN0409

Images are for reference only
See Product Specifications

Share

Mouser #:	426-SEN0409
Mfr. #:	SEN0409
Mfr.:	DFRobot
Customer #:	Customer #
Description:	Acceleration Sensor Development Tools Gravity: I2C LIS2DW12 Triple Axis Accelerometer Sensor (+/-2g/+/-4g/+/-8g/+/-16g)
Lifecycle:	NEW **New Product:** New from this manufacturer.
More Information	Learn more about DFRobot SEN0409

Compare Product

Add To Project | Add Notes

Specifications

In Stock: 65

Stock:	65 Can Ship Immediately
Factory Lead-Time:	6 Weeks
Enter Quantity:	Minimum: 1 Multiples: 1

Buy

Pricing (CAD)

Qty.	Unit Price	Ext. Price
1	$5.38	$5.38

FEATURED PRODUCTS
DFROBOT

Fermion I2C H3LIS200DL Triple Axis Accelerometer

Features low noise and large scale ranges, and ultra-low-power operational modes.
Learn More

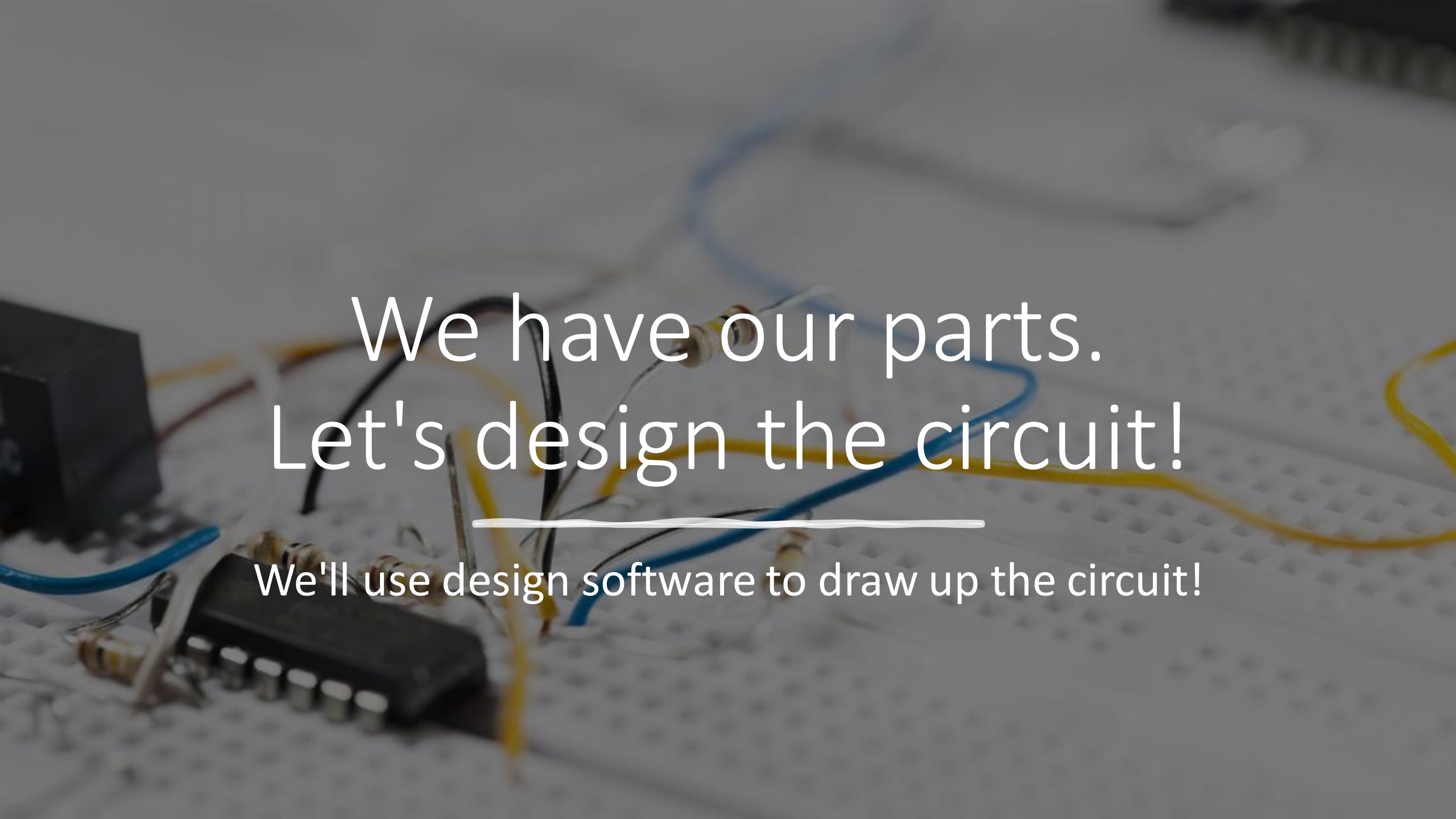
Datasheet

Datasheet

MEMS digital output motion sensor: high-performance ultra-low-power 3-axis "femto" accelerometer

Features

- Ultra-low power consumption: 50 nA in power-down mode, below 1 µA in active low-power mode
- Very low noise: down to 1.3 mg RMS in low-power mode
- Multiple operating modes with multiple bandwidths
- Android stationary detection, motion detection
- Supply voltage, 1.62 V to 3.6 V
- Independent IO supply
- ±2g/±4g/±8g/±16g full scale
- High-speed I²C/SPI digital output interface
- Single data conversion on demand
- 16-bit data output
- Embedded temperature sensor
- Self-test
- 32-level FIFO
- 10000 g high shock survivability
- ECOPACK, RoHS and "Green" compliant



We have our parts. Let's design the circuit!

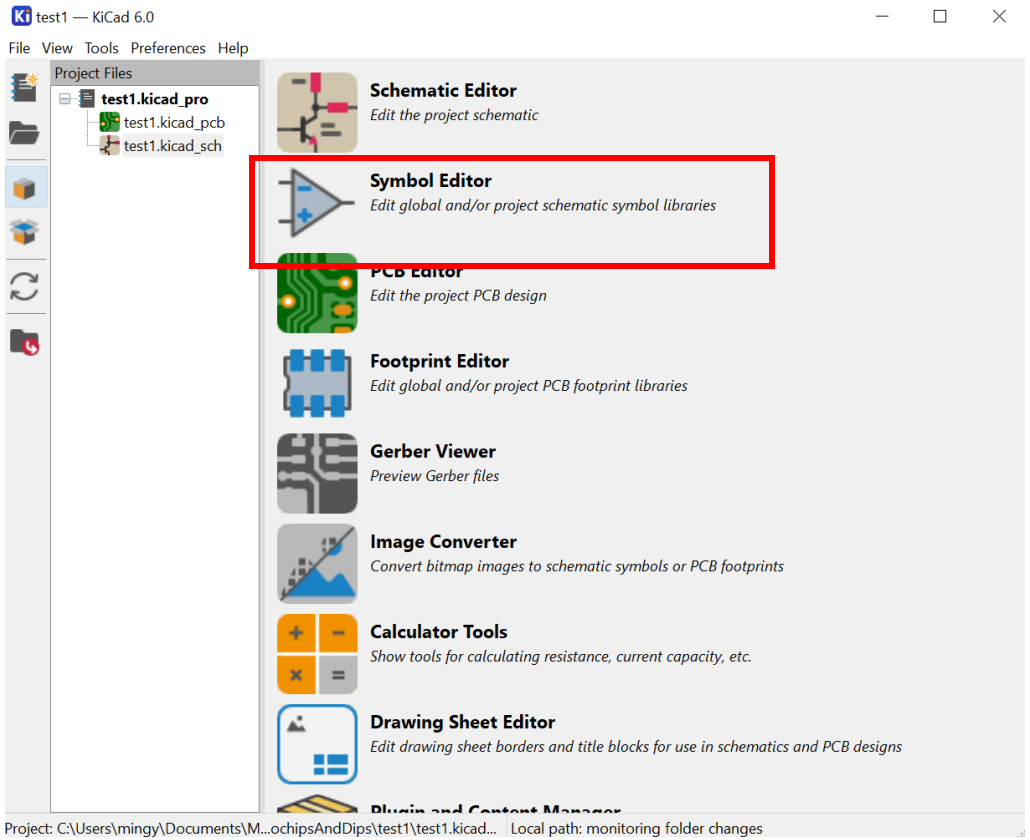
We'll use design software to draw up the circuit!

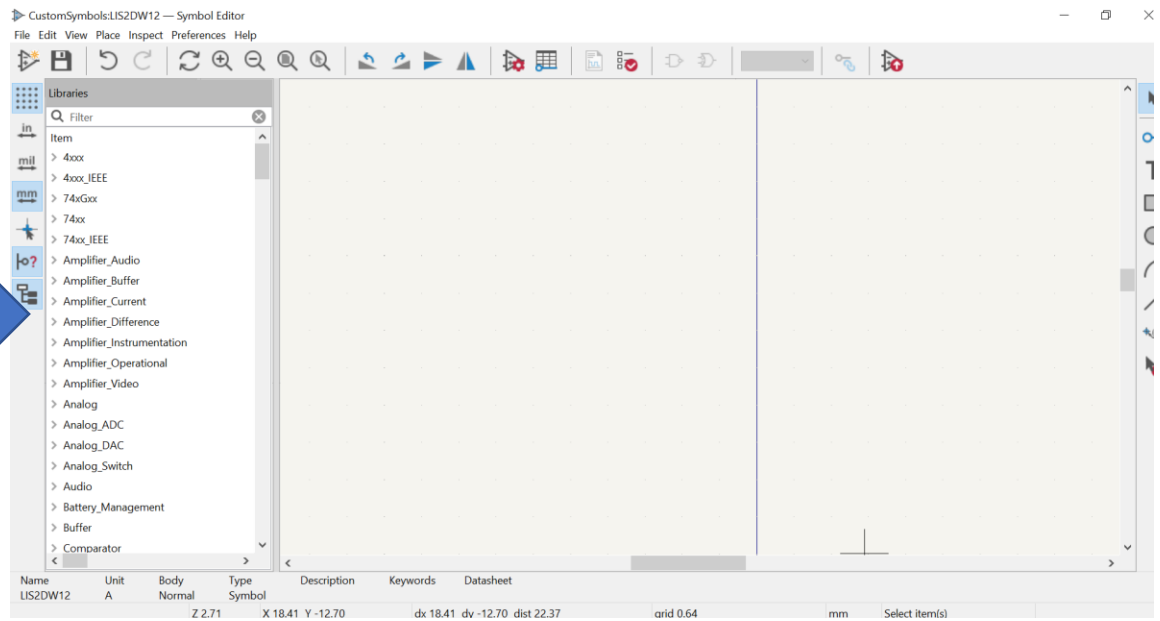
Designing the circuit with KiCAD

- KiCAD is an open source circuit design tool used for making electrical schematics and printed circuit boards (PCBs)
- We will be using it for designing a schematic
- https://www.kicad.org/download/

Creating Symbols

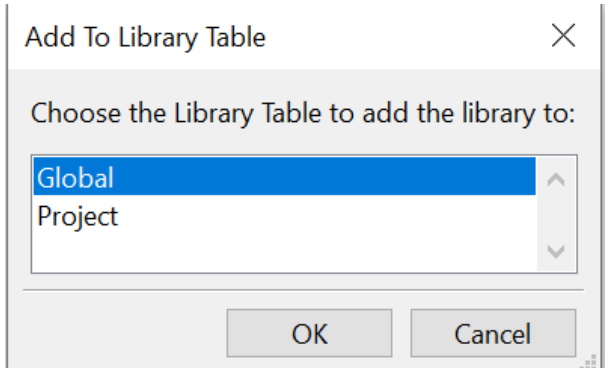
Not all parts have a pre-made symbol, we need to make symbols for our sensors





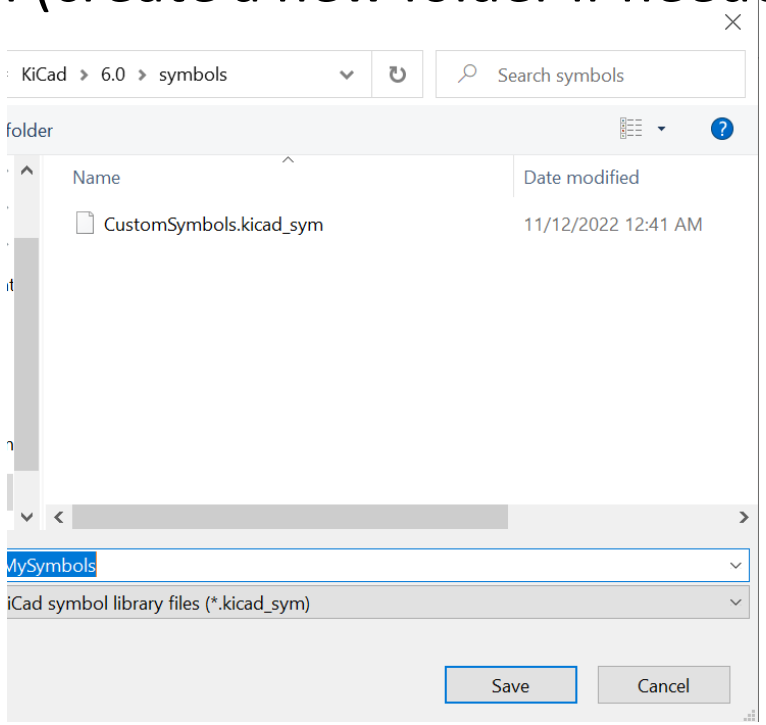
Creating the Symbol (Continued)

File >> New Library



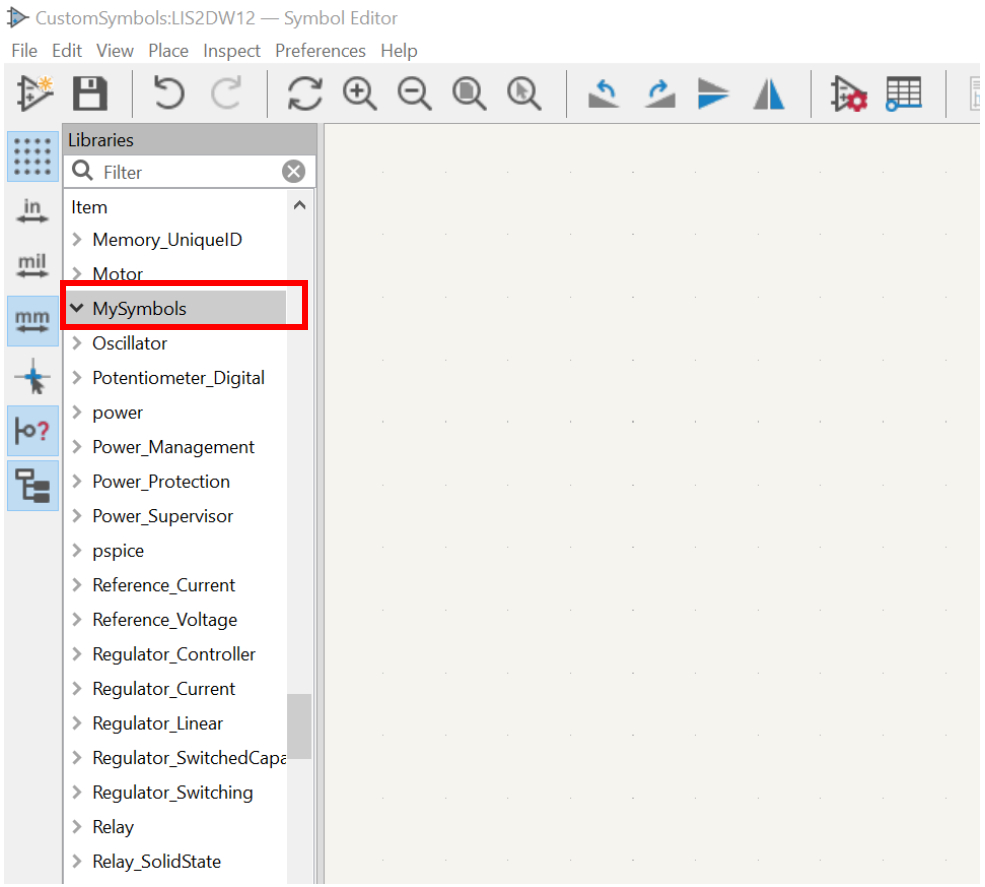
Press OK

Find a folder to save the symbols in (create a new folder if needed)



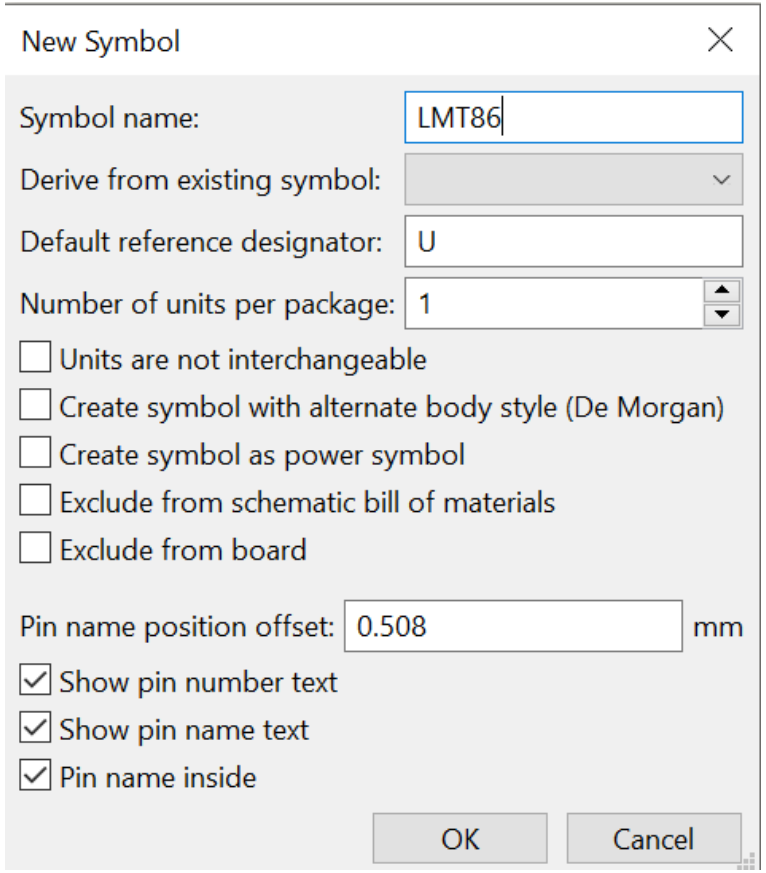
Creating the Symbol (Continued)

Select the Symbol Library



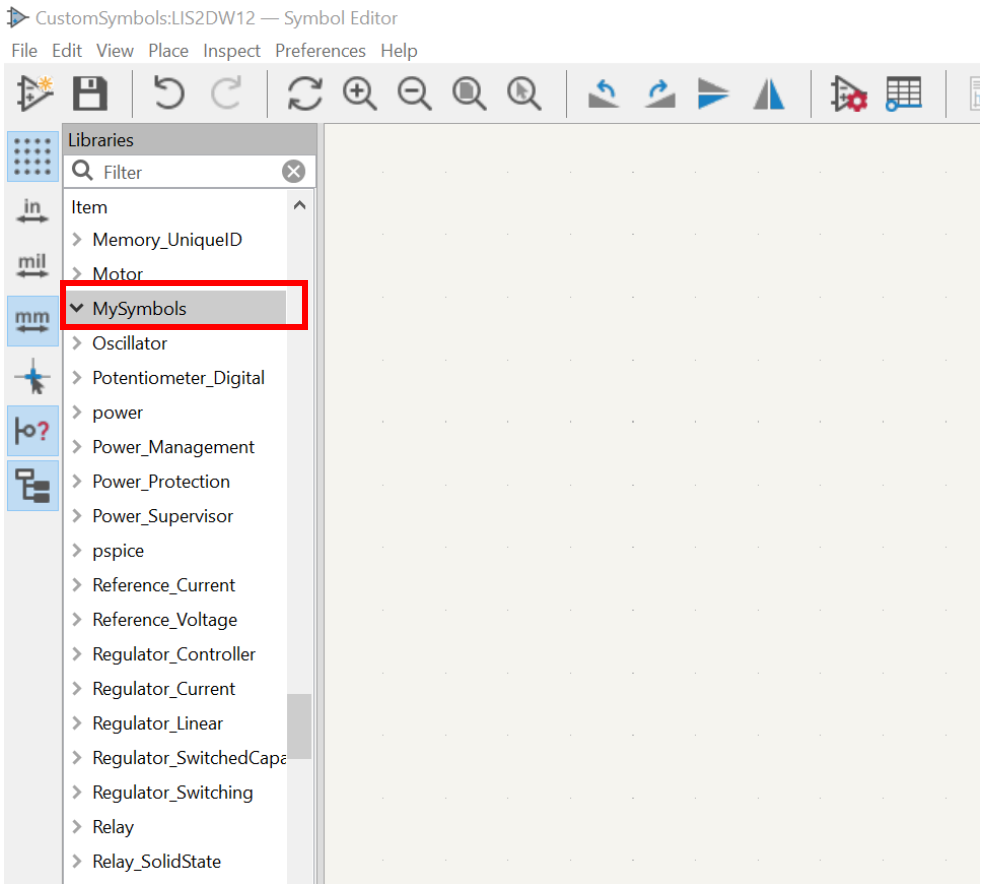
File >> New Symbol

Give the symbol a name



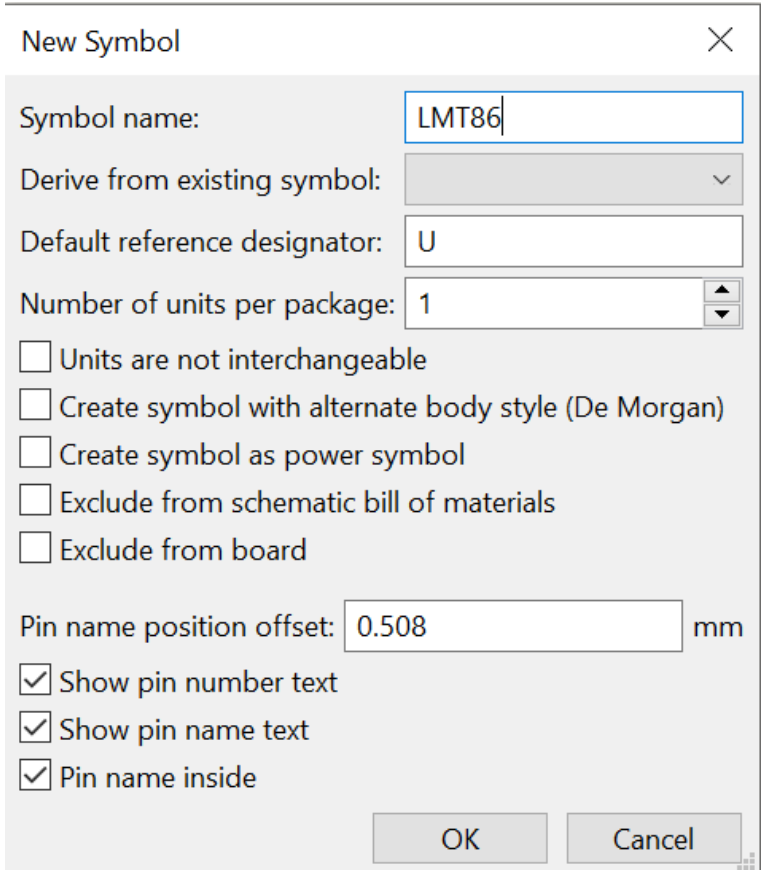
Creating the Symbol (Continued)

Select the Symbol Library



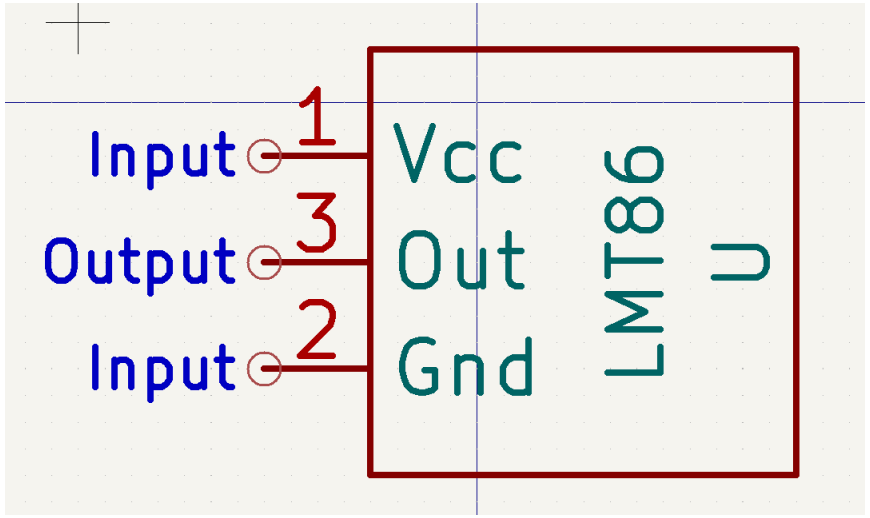
File >> New Symbol

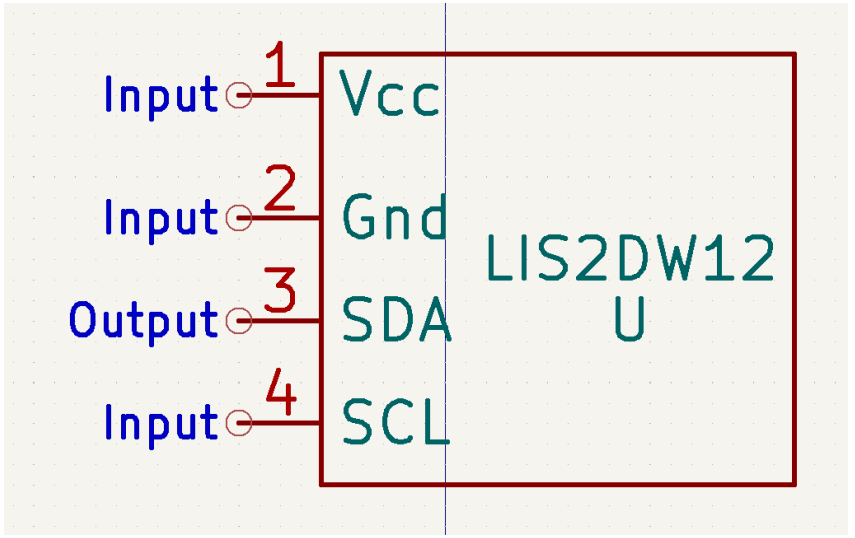
Give the symbol a name



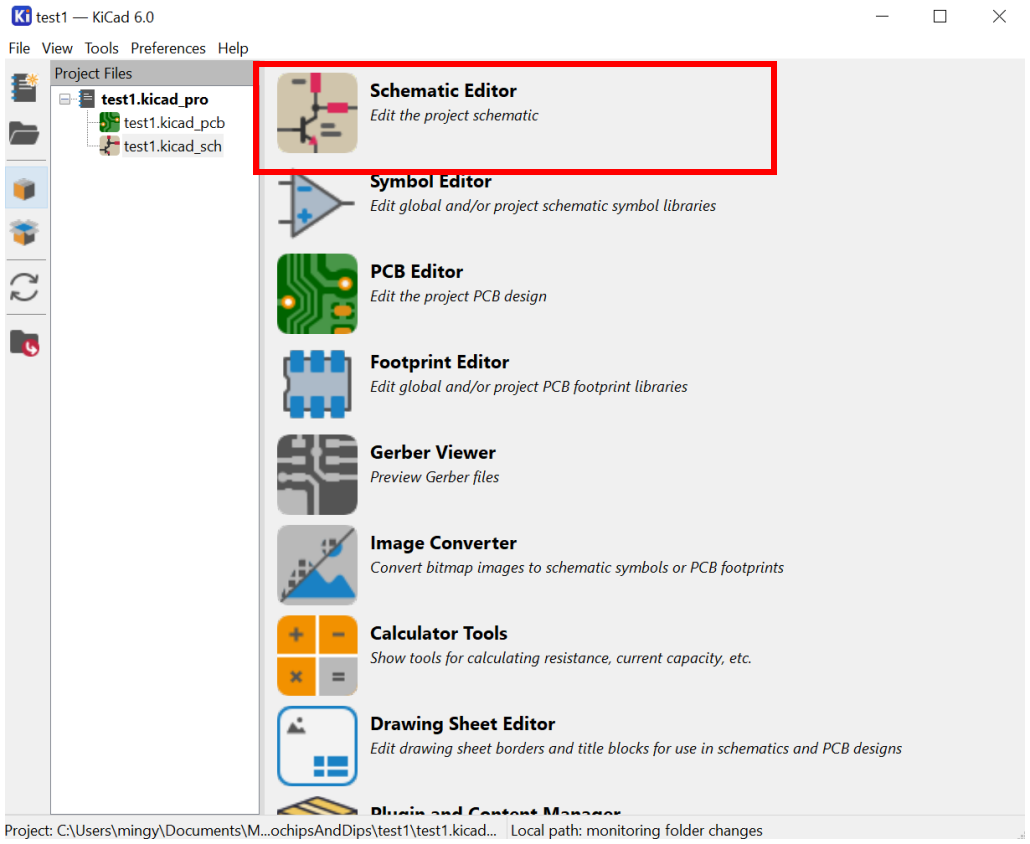
Creating the Symbol (Continued)

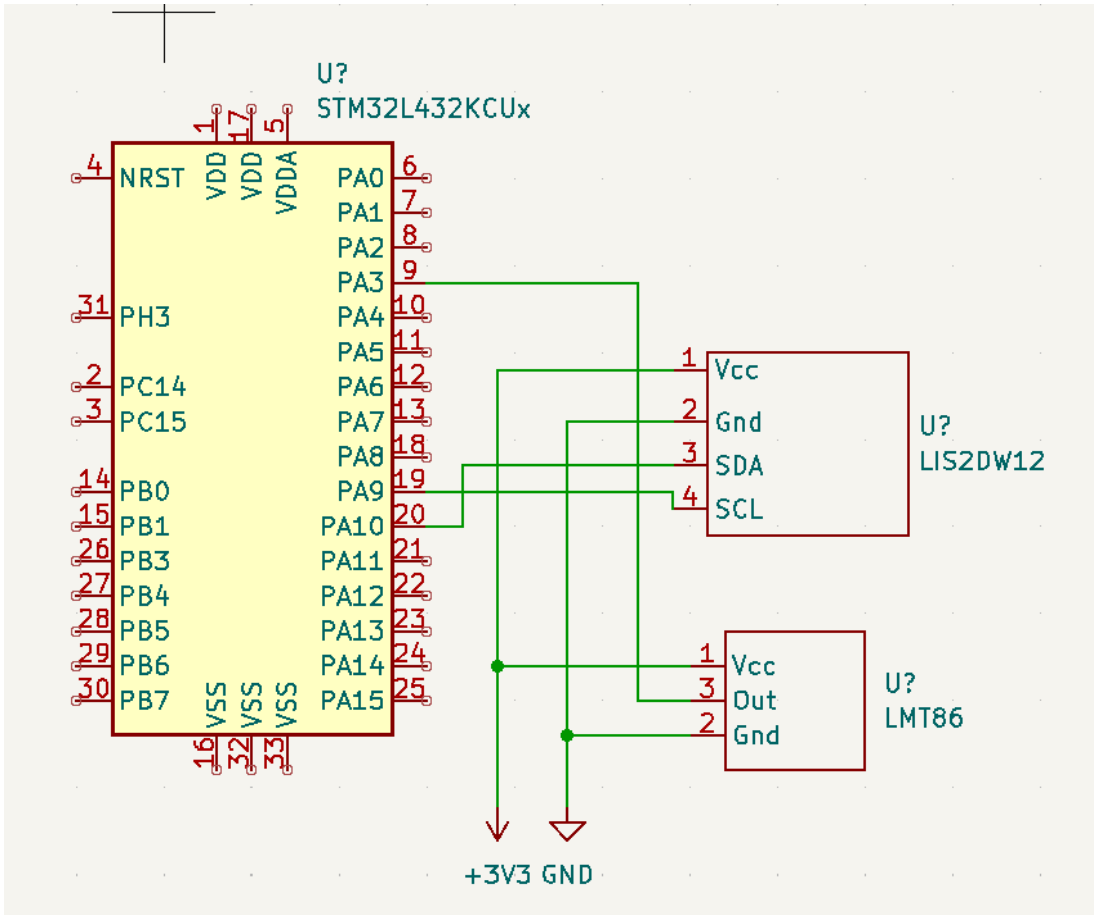
Add the pins and create the symbol.
Refer to the data sheet for specifics





Creating the schematic





Time to build the circuit

Please try not to reverse polarity anything :)

Hello World! Blinking an LED

Let's get the LED on the Nucleo board to blink!