Preparation for design students tackling electronics projects

Mark Easley

Texas Instruments University Program

Workshop overview

We will cover

- **IoT topics and relevance to majority of student projects**
- **Scoping manageable automation and robotics projects**
- **Picking a processor that is appropriate for the design**
- **Working smart, simplify complex circuit design with tools**
- **Leverage reference designs to speed development**
- **Accessing professional help**
- **Advice on capstone resources**
- **Q&A on technologies accessible for student projects**

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Software Engineer

Over 9 years at TI

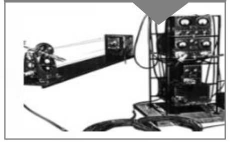
Embedded Systems

& IoT experience

Our history of reinvention

1930s
Oil exploration

1940s
Defense systems



1950s
Integrated circuit

1970s
Microprocessors

1980s
DSP, DLP®
Cinema

2000s
Analog and Embedded

2000s
Applied research – Kilby Labs

Present day
Industrial and automotive technologies

Experience matters with over 90 years of innovation

Reaching students and faculty
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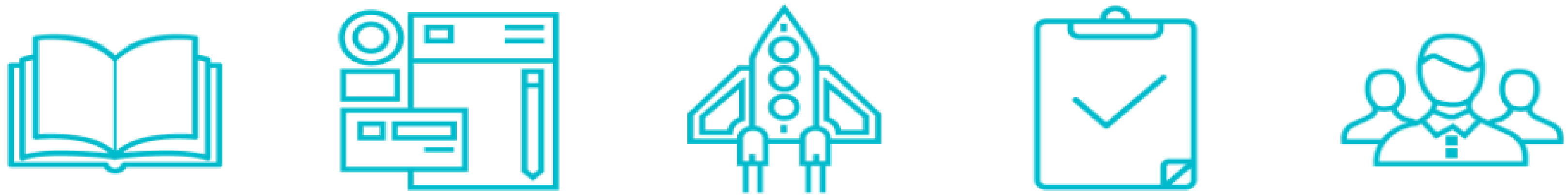
The Texas Instruments University Program is dedicated to supporting engineering educators, researchers and students worldwide.

Teaching materials	Research labs	Design projects	Course Curricula	Teaching labs



Disclaimer: Electronics are unique

The following materials will be from the perspective of an ECE project or any project involving hardware design. Electrical Engineering, Computer Engineering, and Multi-disciplinary project with electronics.

Electronics projects require:

- Software… a processor is involved more times than not
- Prototyping… hardware starting with off the shelf components, wiring and breadboarding
- PCB design… CAD software available as open source, free license, paid license
- Debugging… scopes, test & measurement, power supplies, DMM
- System integration… putting the parts together can be more challenging than designing

Electronics project

Define, Design, Prototype, Customize

- **What application are we solving for?**
- **What technologies exist today that have relevance for the application?**

Stages

- Research the problem and end user
- Identify a technical solution thesis
- Design a prototype for proof of concept
- Iterate on design to customize for the application use cases
- Optimize design for manufacturability, usability, quality, reliability, cost
- Test design under stress and adverse conditions
- Release design

Electronics project

Embedded systems

- Processor
- Power Supply
- Sensors
- Actuators
- Connectivity

Pure analog projects without device programming are rare,

Need to have team comfortable with programming

Keep it standard when possible

- Students will gravitate toward what they learned from the curriculum
- Provide microcontrollers that are commonly used at your school
- Have some easily sourced “go-to” parts or coordinate with lab staff

Electronics project

PCB design using CAD tools

- **Schematic**
- **Board layout**
- **Design Rules Check**
- **Auto routing (not recommended)**
- **Symbols and footprints**

Keep it standard when possible

- Kicad or Autodesk EAGLE are popular tools because free license
- Altium is used heavily in industry but it is a paid license
- Students will want to work on their own computers, so self setup is best
- Have students ramp up on these CAD tools over several weeks using tutorials

Questions?

Pause for Questions

Electronics project

PCB manufacturing and components

- BOM
- Board files or Gerbers
- PCB Contract Manufacturer (board house)
- Component distributor (Digi-key, Mouser, Newark, Adafruit, Sparkfun)
- Assembly (hand assemble or use a service)

Keep it standard when possible

- Find a reliable PCB manufacturer that students can use (Advanced Circuits, OSHpark, etc)
- Have ordering setup from common distributors either through online self service or Purchase Order system
- Have a BOM template that students can use
- Recommend package sizes for hand assembly

Electronics project

PCB Testing and Debugging

- **Soldering, trace cutting, blue wiring**
- **Continuity testing**
- **Power Supply**

Keep it standard when possible

- Have access to Digital Multimeter or USB oscilloscope for continuity and other basic tests
- Standalone power supply can be useful but most projects use standard voltages (5V, 9V, 12V)
- Access to benchtop equipment like an oscilloscope and logic analyzer can also
- Power supply design can be done easily with TI WEBENCH or with use of standard DC wall wart supplies available online

Electronics project

Accepting professional help

- **Company forums, email, help lines**
- **Personal contacts**

Use of reference designs

- Encourage students to search reference designs posted online for customer use
- Saves a lot of time and design effort

Questions?

Pause for Questions

Embedded Systems create a world of possibilities that will continue to change everything

Electronics rapid prototyping with TI's broad portfolio of MCUs, analog & connectivity solutions

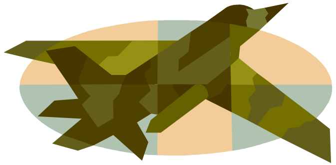
IoT + Automation

Texas Instruments

July 2021

Definitions

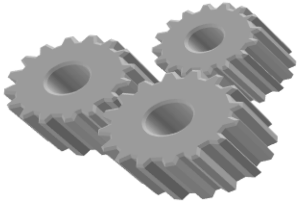
Clarity on where the fields of mechanical and electrical technical knowledge intersect



Aeronautics

Avionics

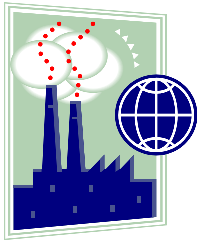
- Airplanes require many electromechanical subsystems to enable advanced flight such as lighting, communication, and safety systems



Robotics

Mechatronics

- Mobile robots that operate on land, sea, air can perform tasks too dangerous or difficult for humans or can scale beyond human capacity



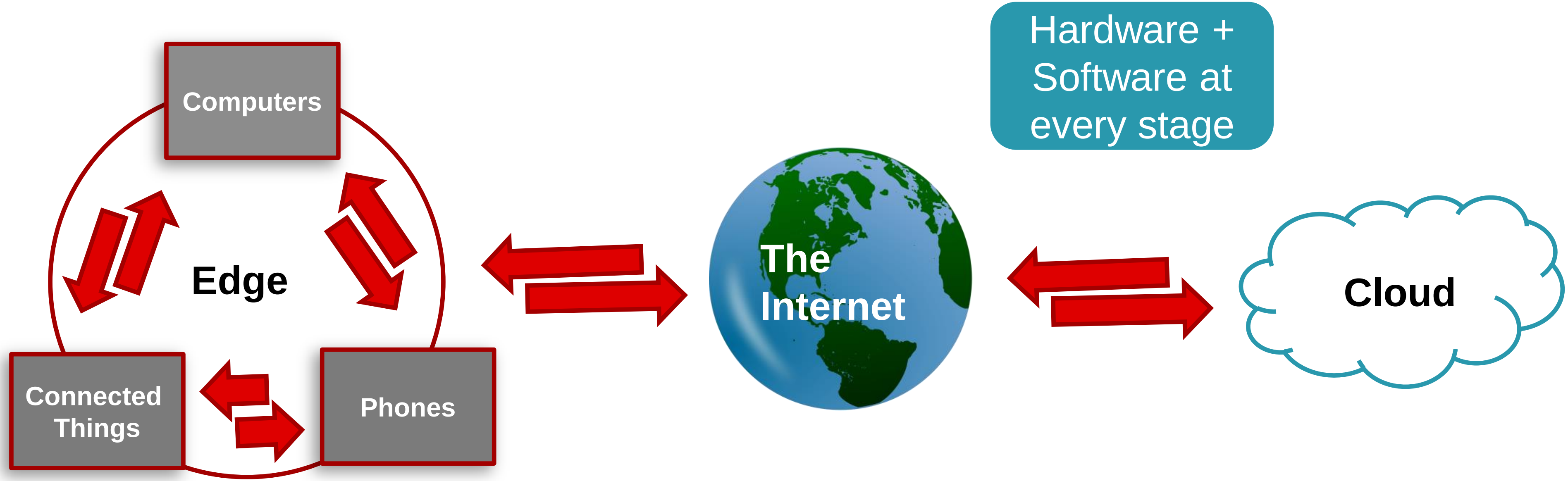
Automation

Electromechanical Machines & Systems

- Application specific machines that perform repetitive mechanical tasks and are human interface driven

Mechatronics + IoT
a birds eye view

IoT Data passes from physical hardware layers to software layers back and forth, connecting the real and digital worlds



Think products
- Anything that can talk to the internet or connect to something else that can talk to the internet

Think infrastructure
- Routers, switches, cell towers, fiber optic cable, satellite transmitters, phone lines

Think services
- Google, Amazon, Facebook, etc.

Think servers
- Server farms & data centers

Product Development
a birds eye view

Hardware is hard, so you need to have a plan and understand the product development cycle

Summary from Maker.io

1 Concept

2 Research

3 Evaluation

4 Design

5 Prototyping

6 Funding

7 Marketing

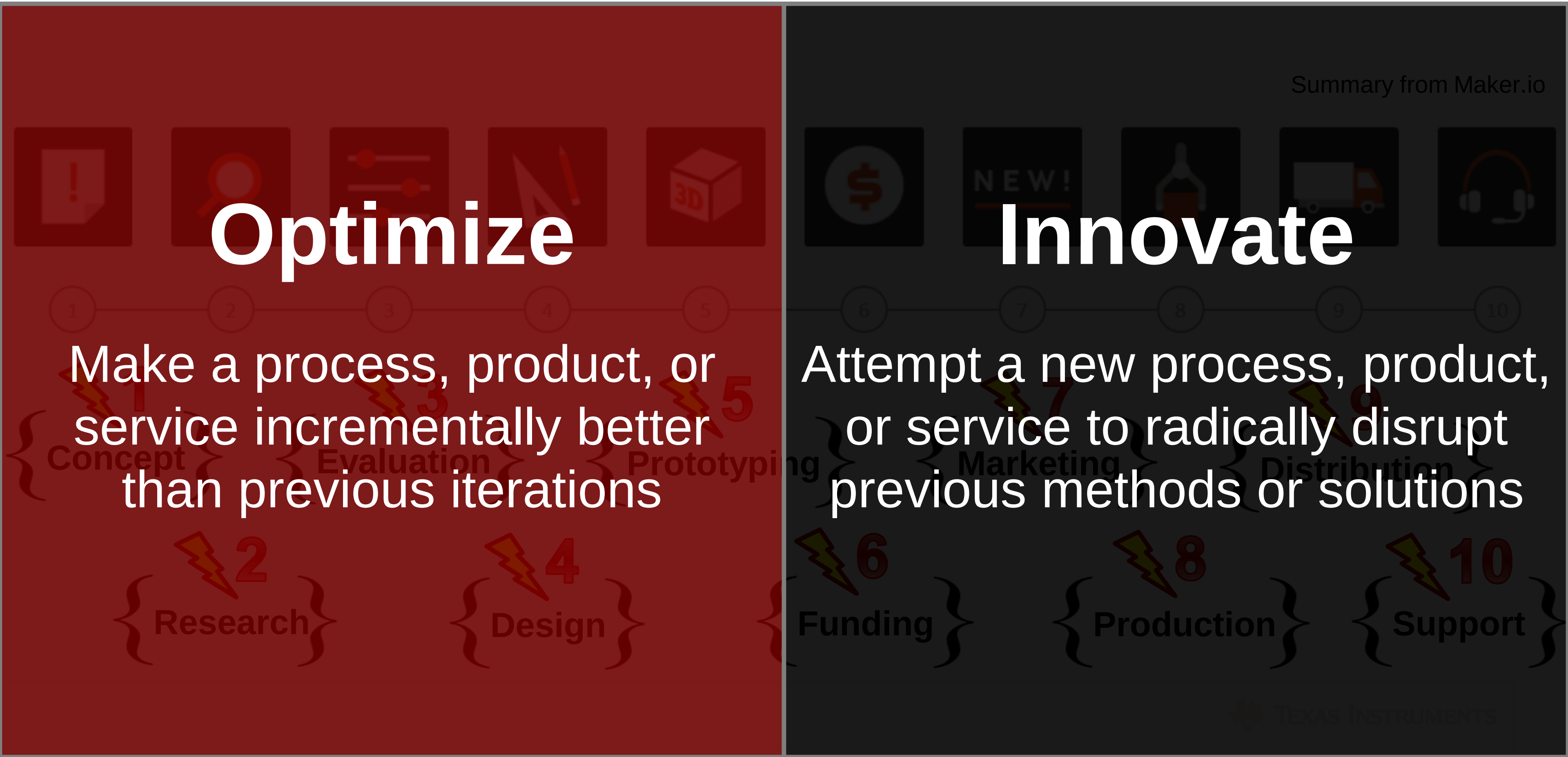
8 Production

9 Distribution

10 Support

Product Development
a birds eye view

Two major tasks in design and engineering – both have value!



Optimize

Make a process, product, or service incrementally better than previous iterations

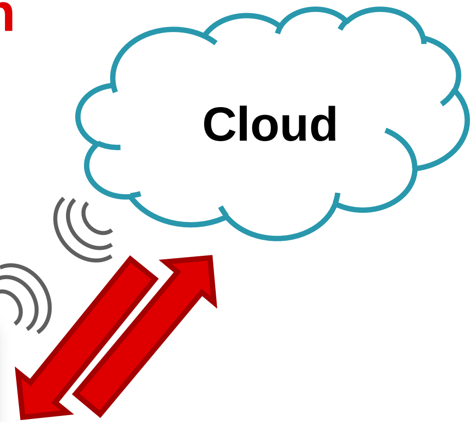
Innovate

Attempt a new process, product, or service to radically disrupt previous methods or solutions

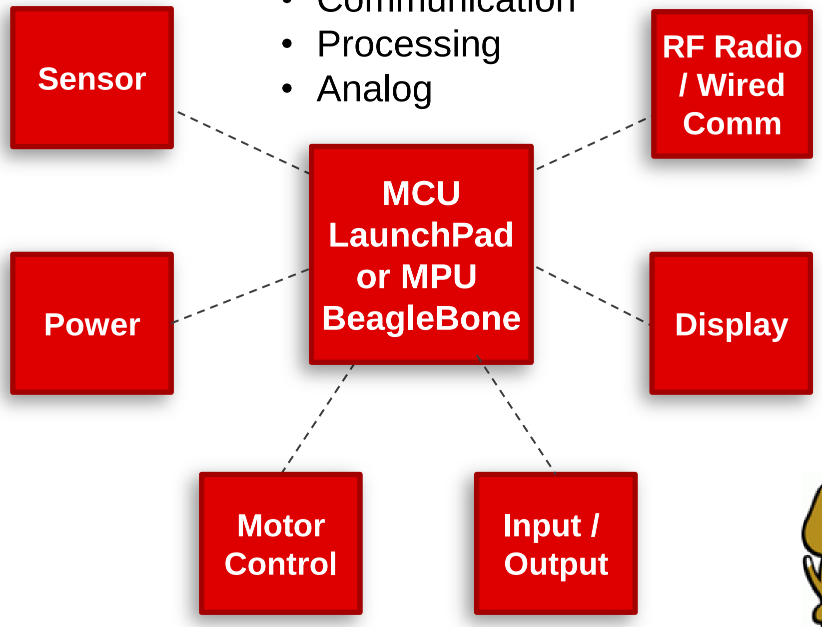
The typical block diagram

- Each project, while unique, follows a pretty standard formula

TI LaunchPad & BeagleBone Embedded System Design
a bird's eye view



Embedded System
- Power Management
- Communication
- Processing
- Analog



Design Accessories
- Plug-in modules
- Through hole (breadboard) circuits
- Oscilloscope & logic analyzer & multimeter
- EDA / CAD tool (PCB and enclosure design)
- IDEs and SW Dev tools

TI LaunchPad™

beagleboard.org

Power: Line Power vs Disposable Battery vs Rechargeable Battery
a comparison

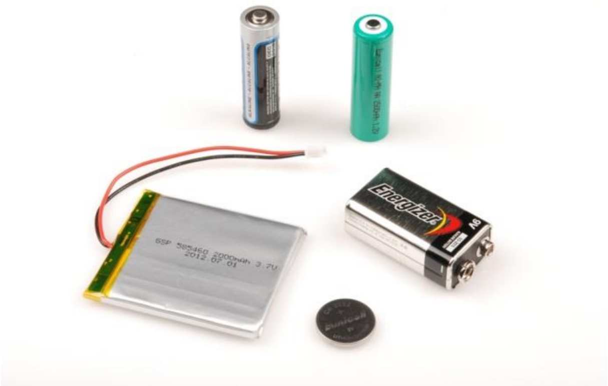
What's the difference?

- Alkaline
- Li-Ion
- Li-Po or Li-Poly
- Lead Acid
- Nickel Metal Hydride
- Nickel Cadmium

Design Considerations

- Do I need continuous power?
- How convenient is it to recharge in the application?
- How mobile is the application?
- What is the form factor?
- What are the aesthetics and usability requirements?

Make use of tools like TI WEBENCH



Microprocessors: Selecting a Processor

tips & cautions

How to pick a processor

- Don’t always trust the vendor to guide you - they have many parts they are trying to sell! Define your spec and stick to it
- Look for **community,** educational resources, and **training**
- Look for well written **documentation**, clean getting started experiences, **accessible software**
- Look for **company support** (phone or email), distributor support, **pre-certifications** to speed time to market
- Beware of NDAs, complicated licenses, poor distribution, high obsolete rates

Microprocessors: Selecting a Processor
tips & cautions

Stick with what works

- Get a standard list of development tools that are low cost and have good supply of devices for custom PCBs
- Boards the have used in curriculum and popular high utility boards like Arduino and RasPi
- Focus students on these tools to make life easier

Motors: Brushless vs Brushed vs Stepper
a comparison

Big portion of IoT is around intelligent movement

Make use of motor drivers and software libraries like TI MotorWare

What's the difference?

- Brushless
- Brushed
- Stepper
- AC / DC

Design Considerations

- Do I need accurate movement? (Stepper, encoders, hall effect sensors)
- Do I need high torque?
- Low complexity or high complexity control?
- Do I need high efficiency or long life?
- Do I need low cost?

Motors: Brushless vs Brushed vs Stepper
a comparison

Brushed DC

Brushless DC

Stepper

Advantages
- Cheapest and simplest motor
- Speed linear to applied voltage
- Simple Motor Control

Disadvantages
- High maintenance
- Low life-span (due to physical wear on brushes)

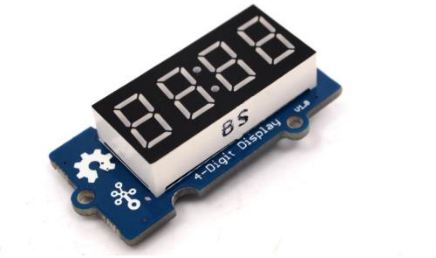
Advantages
- High efficiency, long life
- Little to no maintenance
- High output power

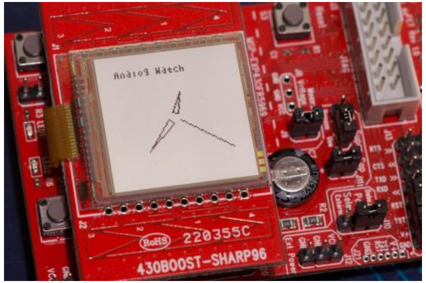
Disadvantages
- More complicated motor control
- More expensive

Advantages
- Accurate position control
- Excellent low speed torque
- Long life

Disadvantages
- Low efficiency
- Prone to noise, ripple, and resonance
- Cannot accelerate loads rapidly

Displays: LCD vs OLED vs LED vs ePaper
a comparison





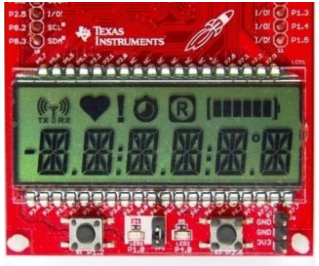
What's the difference?

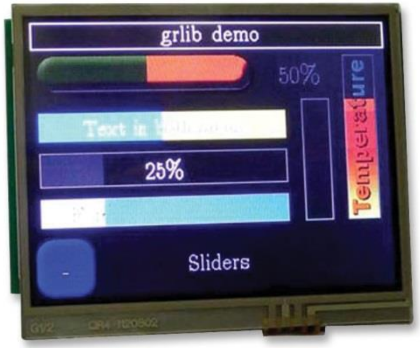
- LCD
- OLED
- LED Matrix
- LED Segment
- ePaper
- Cloud GUI, Web App, or Mobile App

Design Considerations

- Do I need color graphics?
- Does it require high refresh? Video?
- Do I need to display digits or alphanumeric?
- Does it need to be low power or battery free? Backlight?
- How will it mount in the enclosure?

Make use of display drivers and software libraries like TI Graphics Libraries





Easily add RF for wireless applications!

CONNECT MORE WITH TI

WiFi®

ZigBee®

6LoWPAN

THREAD

SIGFOX
One network A billion dreams

Bluetooth®

4G LTE

CONNECT MORE WITH TI

Which wireless?

Tradeoffs between range, bandwidth, cost, power usage, adoption

Wi Fi

- Ubiquitous
- High bandwidth
- Higher power usage

Bluetooth

- Common
- Small range
- Lower power
- Very low cost

(NFC / RFID)

- Super near range
- Low bandwidth
- Low power
- Low cost

SIGFOX
One network A billion dreams

(LPWAN)

- Limited to certain cities
- Wider range
- Low bandwidth
- Higher cost

4G LTE (Cellular)

- Wide range
- High bandwidth
- Expensive – Data & HW

THREAD / 6LoWPAN

- Mesh networking
- Low power
- Very low cost
- IPV6 Addressable

ZigBee

- Mesh networking
- Low power
- Very low cost
- Not IP addressable

Infrared

- Line of Sight
- Low power
- Very low cost

Satellite

- Global range w/ Sat available
- Expensive – Data & HW

Proprietary

- Licensed and unlicensed spectrum with trade offs

Which wireless?

Tradeoffs between implementation effort

Wi-Fi

- Direct connect
- Access a wide variety of APIs directly
- Only requires domain expertise in internet and firmware
- High data rate
- Poor for mobile and rural use cases

Wi-Fi Primary Use Cases
- Smart Home
- Industrial/Commercial
- Fixed position connectivity
- Medical

BLE Primary Use Cases
- Wearable
- Phone accessory
- Streaming music
- Smart Home
- Medical

Bluetooth

- Requires a middleman gateway (Smartphone or embedded bridge)
- Everything is custom
- Need domain expertise in frontend and backend, UX, UI, firmware
- Low data rate
- Poor for crowded environment

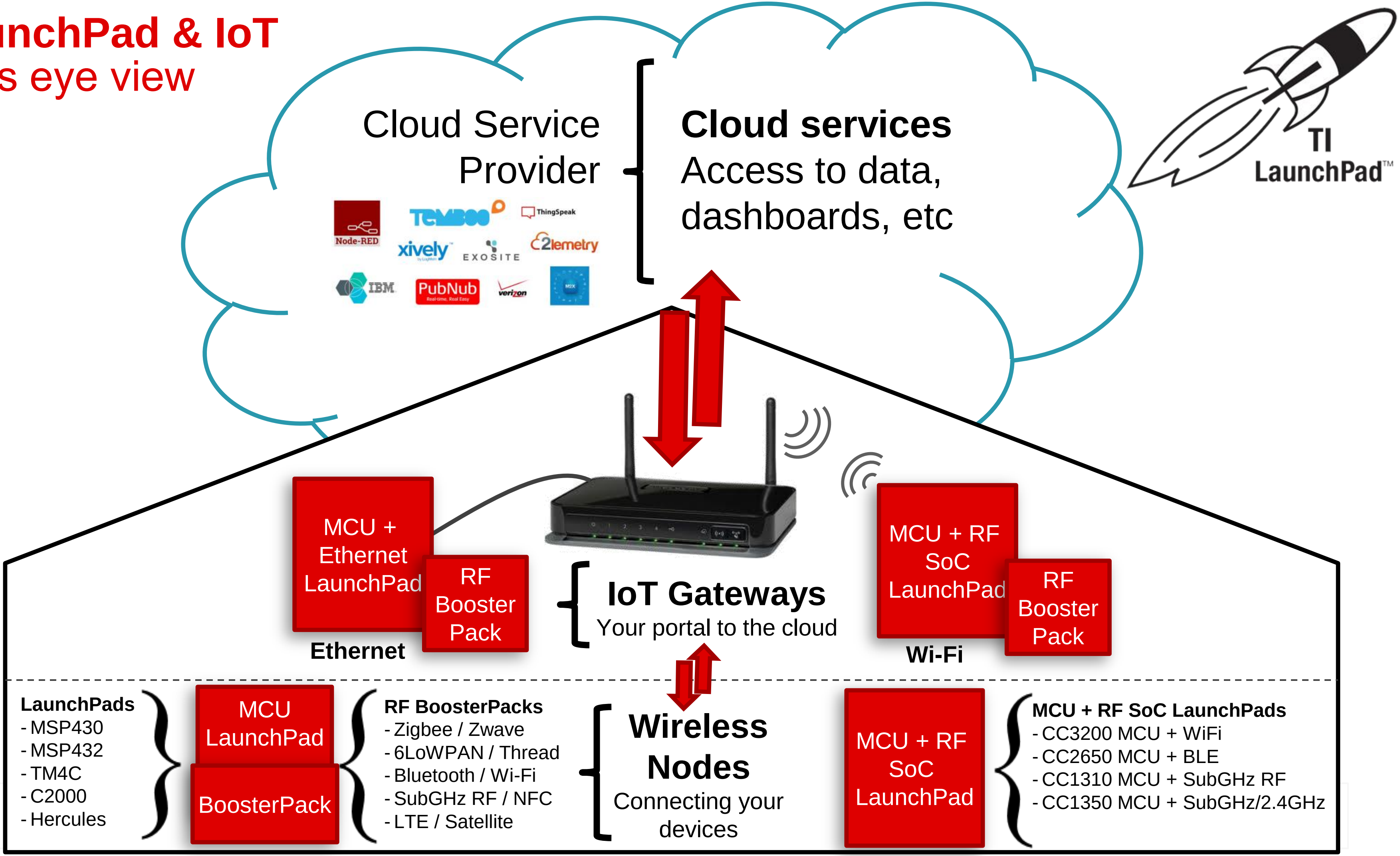
TI LaunchPad and BeagleBone in the cloud

Cloud-connected TI Hardware is supported by various cloud partners & protocols via Wi-Fi, BLE, LTE, or Ethernet.

Questions?

Pause for Questions

TI LaunchPad & IoT
a bird's eye view



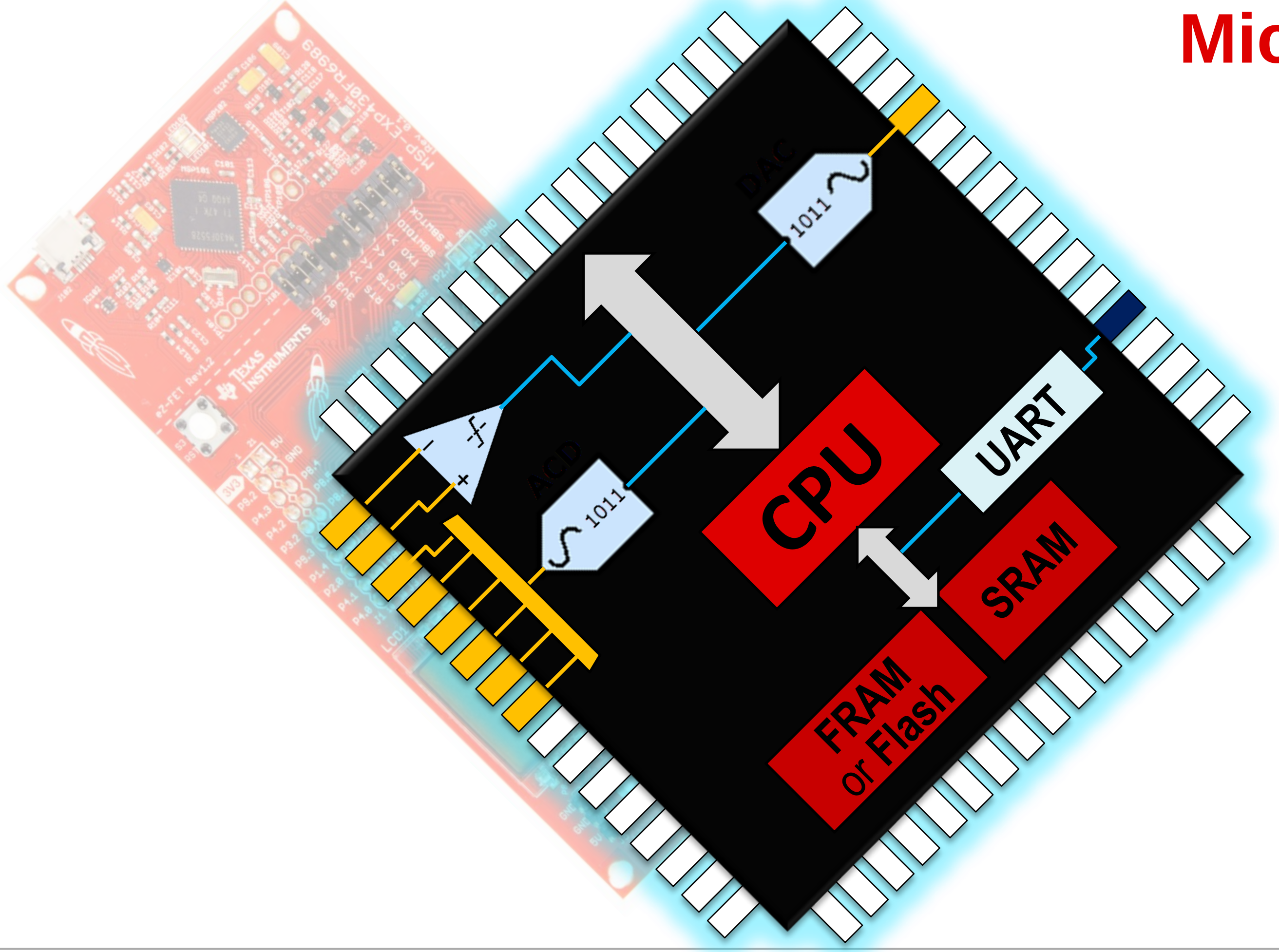
Microprocessors: Microcontrollers vs Single Board Computers
a comparison

What's the difference?
- TI LaunchPad
- BeagleBone
- Arduino
- RasPi

Design Considerations
- Do I need an operating system?
- Do I want it to be low cost?
- Can I program in C or do I need to use another language?
- Do I need real-time capability?

BeagleBone Black

Microcontroller



Making MADE simple

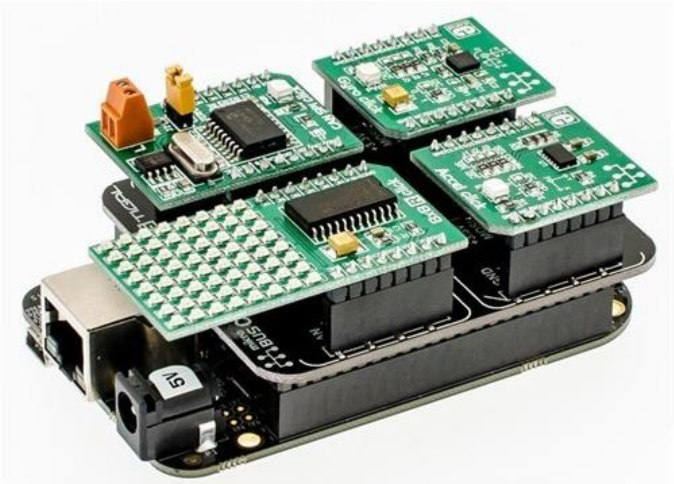
With the BeagleBone

Hardware & Software

Texas Instruments

Rapid Prototyping

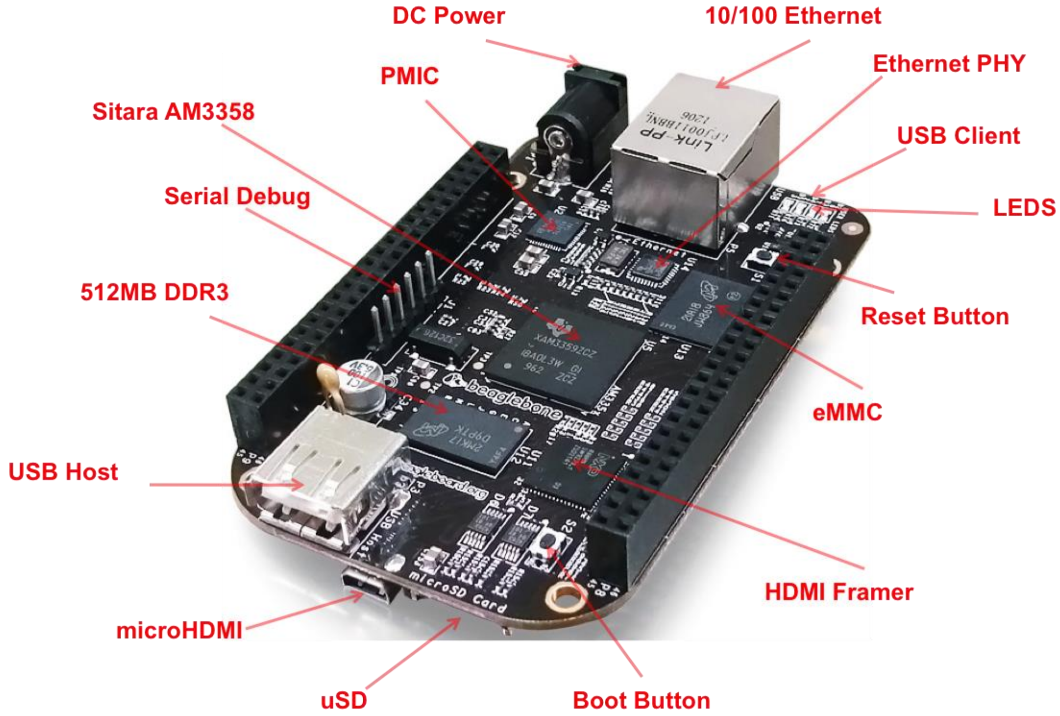
With BeagleBone Black and Capes



Why Beaglebone Black is great?

- **Price ~$45**
- **Large community**
- **Online resources from TI and Beagleboard.org**
- **Full Linux capable single board computer**
- **Multiple supported SW paths**
- **Completely open source for building your own derivative products!**

BeagleBone Black



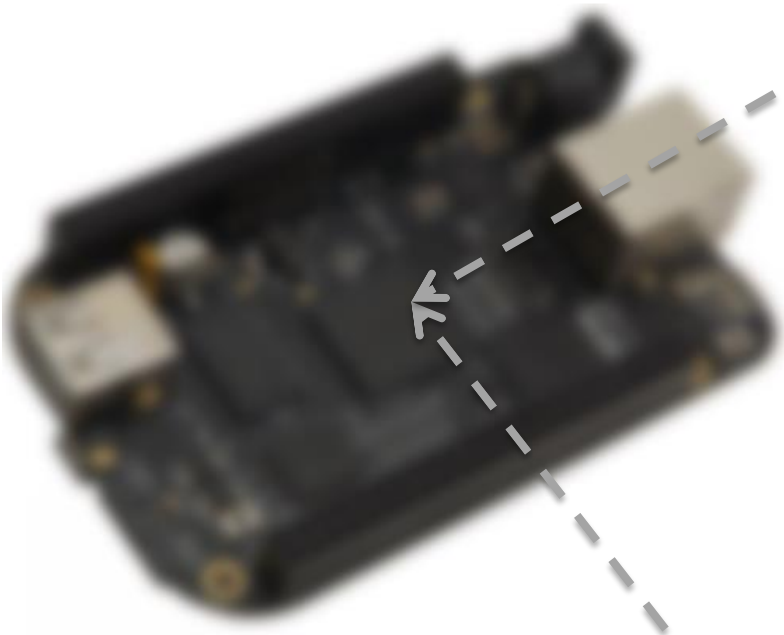
BeagleBone Black

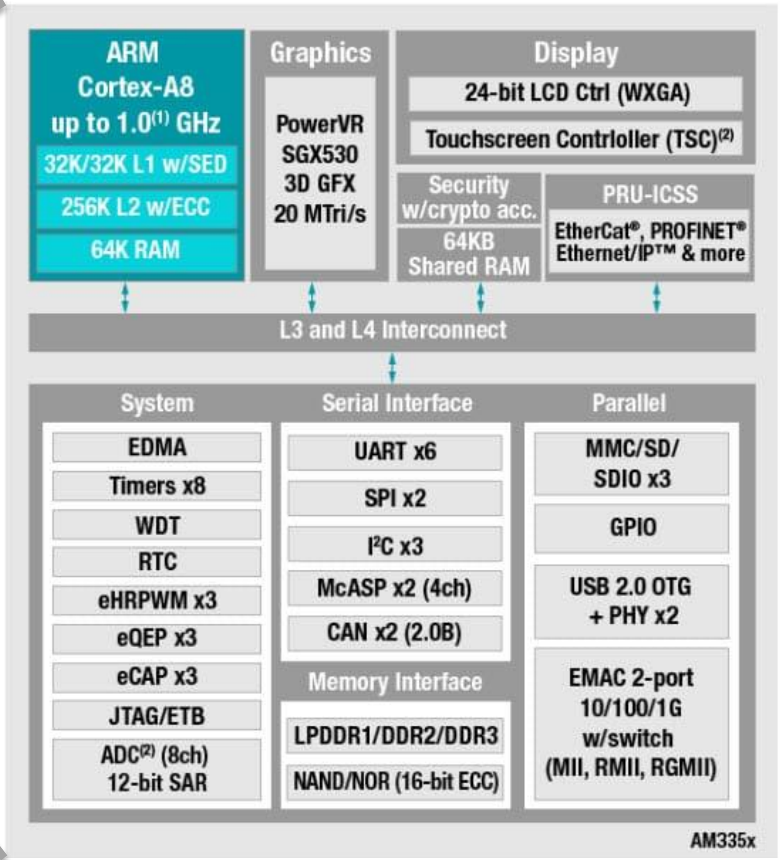
Processor: AM335x 1GHz ARM® Cortex-A8
- 512MB DDR3 RAM
- 4GB 8-bit eMMC on-board flash storage
- 3D graphics accelerator
- NEON floating-point accelerator
- 2x PRU 32-bit microcontrollers

Connectivity
- USB client for power & communications
- USB host
- Ethernet
- HDMI
- 2x 46 pin headers … Add a 'Cape'

Software Compatibility
- Debian
- Android
- Ubuntu
- Cloud9 IDE on Node.js w/ BoneScript lib
- plus much more

AM3358 Microprocessor





BeagleBone Capes

Pin access to external circuits or stackable modular hardware capes through dual 46 pin headers

Cape Expansion Headers

P9

DGND	1	2	DGND
VDD_3V3	3	4	VDD_3V3
VDD_5V	5	6	VDD_5V
SYS_5V	7	8	SYS_5V
PWR_BUT	9	10	SYS_RESETN
UART4_RXD	11	12	GPIO_60
UART4_TXD	13	14	EHRPWM1A
GPIO_48	15	16	EHRPWM1B
SPI0_CS0	17	18	SPI0_D1
I2C2_SCL	19	20	I2C2_SDA
SPI0_D0	21	22	SPI0_SCLK
GPIO_49	23	24	UART1_TXD
GPIO_117	25	26	UART1_RXD
GPIO_115	27	28	SPI1_CS0
SPI1_D0	29	30	GPIO_112
SPI1_SCLK	31	32	VDD_ADC
AIN4	33	34	GNDA_ADC
AIN6	35	36	AIN5
AIN2	37	38	AIN3
AIN0	39	40	AIN1
GPIO_20	41	42	ECAPPWM0
DGND	43	44	DGND
DGND	45	46	DGND

P8

DGND	1	2	DGND
MMC1_DAT6	3	4	MMC1_DAT7
MMC1_DAT2	5	6	MMC1_DAT3
GPIO_66	7	8	GPIO_67
GPIO_69	9	10	GPIO_68
GPIO_45	11	12	GPIO_44
EHRPWM2B	13	14	GPIO_26
GPIO_47	15	16	GPIO_46
GPIO_27	17	18	GPIO_65
EHRPWM2A	19	20	MMC1_CMD
MMC1_CLK	21	22	MMC1_DAT5
MMC1_DAT4	23	24	MMC1_DAT1
MMC1_DAT0	25	26	GPIO_61
LCD_VSYNC	27	28	LCD_PCLK
LCD_HSYNC	29	30	LCD_AC_BIAS
LCD_DATA14	31	32	LCD_DATA15
LCD_DATA13	33	34	LCD_DATA11
LCD_DATA12	35	36	LCD_DATA10
LCD_DATA8	37	38	LCD_DATA9
LCD_DATA6	39	40	LCD_DATA7
LCD_DATA4	41	42	LCD_DATA5
LCD_DATA2	43	44	LCD_DATA3
LCD_DATA0	45	46	LCD_DATA1

LEGEND
- Power/Ground/Reset
- Available Digital
- Available PWM
- Shared I2C Bus
- Reconfigurable Digital
- Analog Inputs (1.8V)

Microprocessors: Microcontrollers vs Single Board Computers
a comparison

Considerations:
- Power
- Integration
- Performance
- Cost

Advantages
- Overall less complex
- Overall less cost
- Overall lower power consumption
- Real-time capable

Disadvantages
- Less flexible software paths
- Less performance for computation intensive applications
- Only able to run RTOS but not full OS options

Advantages
- Overall higher performance
- Overall more peripheral capabilities
- More flexible software options and the ability to run Linux OS

Disadvantages
- More cost and complexity
- Managing Linux related updates
- Real-time capabilities often limited
- Higher power consumption

Microprocessors: SoC or SoM or SiP
a comparison

SoC (System on Chip)

Integrated processor chip with multiple cores and radios

Advantages

- Integrate key parts of a complex circuit to save space on a PCB circuit design

Disadvantages

- Slightly Expensive

Examples

- CC3220 Wi-Fi
- CC2640R2F BLE

SoM (System on Module)

Highly integrated compute module that is added to various embedded systems

Advantages

- Easily integrate a very complex piece of the PCB design into simpler PCB circuit designs
- Save space and design time

Disadvantages

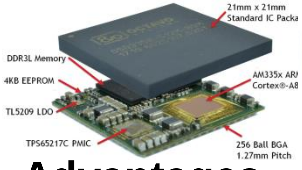
- Expensive

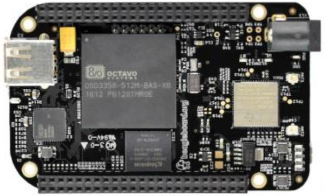
Examples

- BeagleCore
- CC2650MODA

SiP (System in Package)

Integrated processor chip and circuitry all in one





Advantages

- Very easily integrate a complex processor into a small space
- Save manufacturing cost and development time on board design

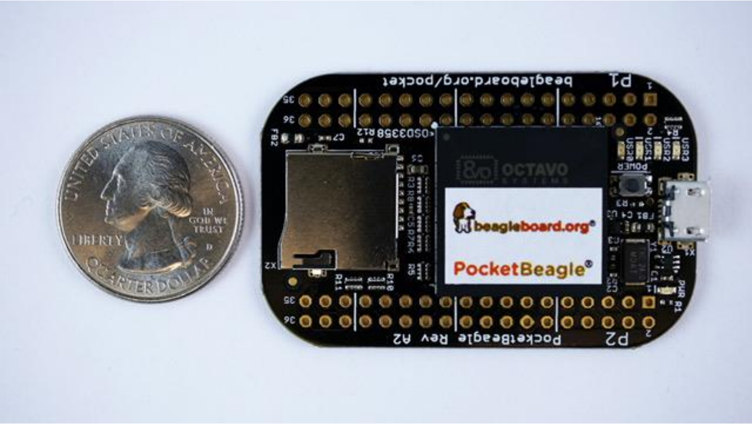
Disadvantages

- Expensive

Examples

- Octavo OSD3358

PocketBeagle
for Embedded Linux ($25)



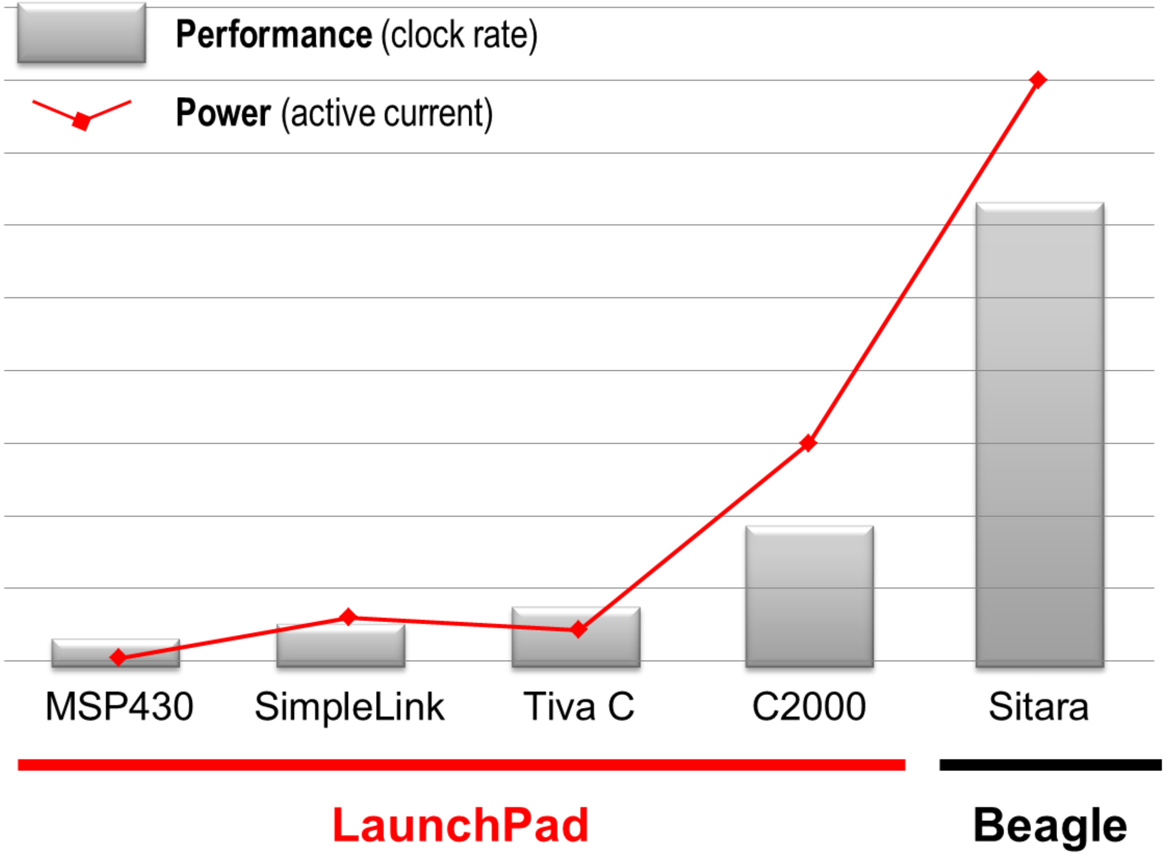
PocketBeagle

Processor: OSD335x 1GHz ARM® Cortex-A8
- 512MB DDR3 RAM
- 4GB 8-bit eMMC on-board flash storage
- 3D graphics accelerator
- NEON floating-point accelerator
- 2x PRU 32-bit microcontrollers

Connectivity
- USB

Software Compatibility
- Debian, Android, Ubuntu, plus much more
- ROS, ArduPilot, LabVIEW
- Cloud9 IDE on Node.js w/ BoneScript lib

Performance vs Power



MSP430 is leading ultra-low power processor

MSP430 microcontroller running off three grapes.

It ran for almost two weeks before the grapes dried out too much.

Is this how raisins are made?

Questions?

Pause for Questions

Automation

What is it and who cares?

- **There are many reasons why automation is taking over**
  - **Efficiency and Safety**
  - **Cost savings**
  - **Technology availability and accessibility**

- This extends to all aspects
  - IoT gives us data that we can use for automation (proof it is worth the investment)
  - IoT enables automation to be scalable (can apply in many areas)

- Examples
  - Making stuff, driving stuff, delivering stuff, trading stuff, cooking stuff

Automation

Engineering was hardware focused for centuries…

Software has seen a huge growth period over the last 20 years but now a swing back to hardware is occurring and skills in both arenas are very valuable!

Robotics project

Application and Chassis

- **Mobile robotics**
- **Robotic arm or leg**
- **Prosthetics**

Keep it standard when possible

- Use an existing chassis kit, custom design from scratch is complicated

Robotics project

Motor Drive

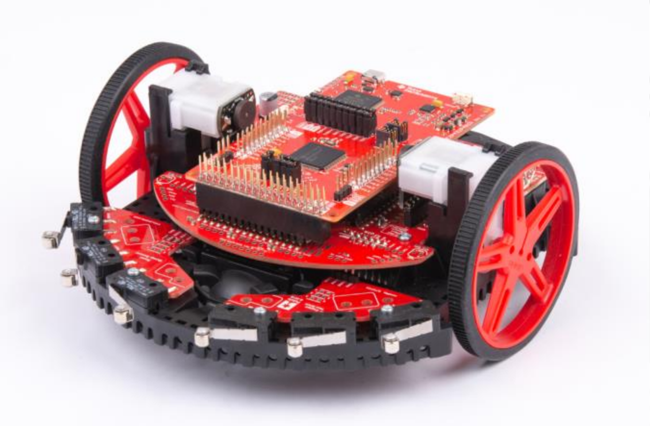
- **Motor control programming**
- **Motor selection**

Keep it standard when possible

- Use a reference design

TI-RSLK MAX

TI Robotics System Learning Kit

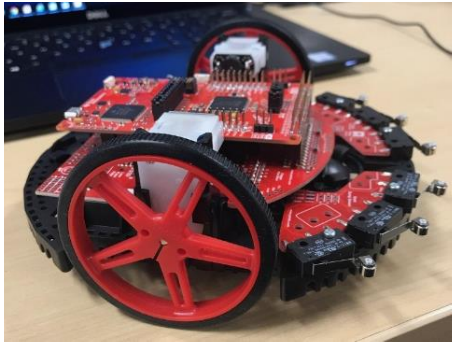


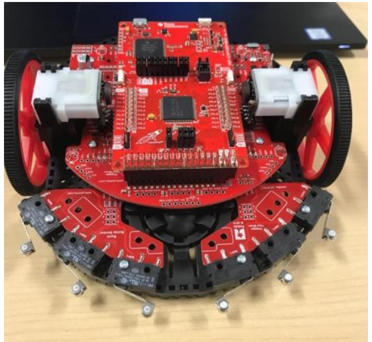
One kit, many possibilities

Tackle many fundamental and trending topics in engineering with robotics

The TI-RSLK MAX has the flexibility to teach students:

- **Intro to Engineering Design & Robotics**
- **Embedded Systems**
- **Internet of Things**
- **Sensors & Sensor Fusion**
- **AI / ML**
- **Controls**
- **Mechatronics**





But, Why?

Innovate & accelerate with robotics system learning

Robotics is everywhere!

Autonomous vehicles

Factory automation

Security & safety

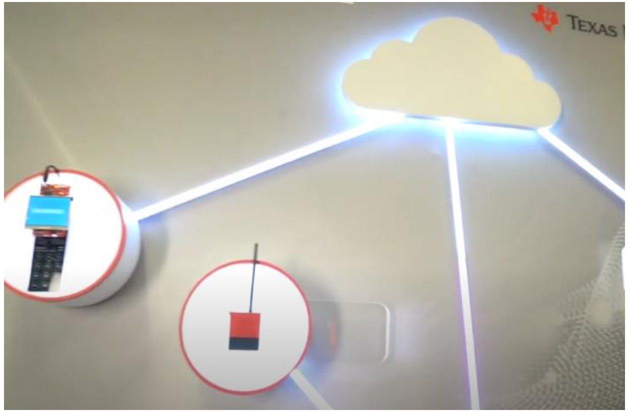
Multidisciplinary systems thinking is required to create these current and future applications

The Internet of Things is accelerating

Sensors and wireless electronics are everywhere!

Autonomous vehicles & electrification of transportation

Industrial sensing in the smart factory



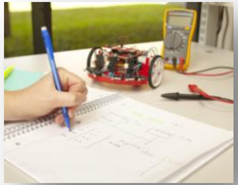
Home automation & consumer electronics

Engineers need to know how to design data streams into their work

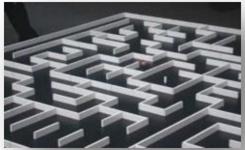
Meet the TI-RSLK product family

The TI robotics system learning kit (TI-RSLK) product family includes a series of low-cost robotics kits and classroom curriculum that provide educators and students with hands-on, customizable options for learning electronic systems design.

The TI-RSLK includes:



Code Composer™ Studio



TI Training
training.ti.com

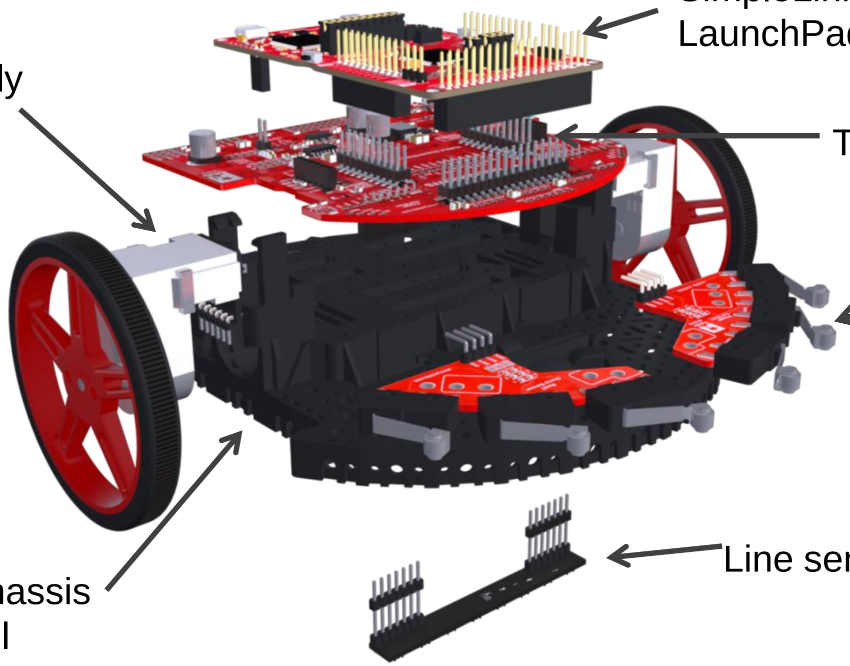
Curriculum | **Hardware** | **Software** | **Projects** | **TI Resources**

Introducing the TI-RSLK MAX

The newest addition to the TI-RSLK product family, the TI-RSLK MAX is simple to use, build and test.

With a solderless assembly process, students can have their own fully-functioning system built in under 15 minutes.

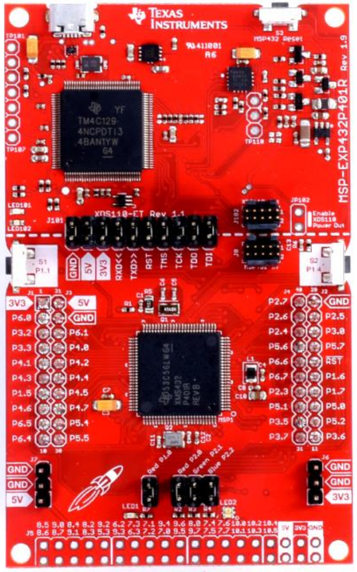
TI-RSLK MAX callouts



MSP432 LaunchPad

Introducing the SimpleLink MSP432P4 processor for Low Power + Performance

MSP-EXP432P401R



$19.99

Target MCU: MSP432P401R
BoosterPack Pinout: 40-pin
Specs:

- 48 MHz 32-bit ARM® Cortex™-M4F CPU
- 256 kB Flash / 64 kB RAM
- 14-bit 1MSPS SAR ADC, Timers, AES Accelerator, I2C, UART, SPI

Why this LaunchPad?

- EnergyTrace+ to measure system current
- Good performance balance & great for general purpose applications

DRV5013 Hall Effect Sensor

DRV5013 Digital-Latch Hall Effect Sensor

1 Features

- Digital Bipolar-Latch Hall Sensor
- Superior Temperature Stability
  - B_{OP} ±10% Over Temperature
- Multiple Sensitivity Options (B_{OP} / B_{RP})
  - 1.3 / –1.3 mT (FA, see *Device Nomenclature*)
  - 2.7 / –2.7 mT (AD, see *Device Nomenclature*)
  - 6 / –6 mT (AG, see *Device Nomenclature*)
  - 12 / –12 mT (BC, see *Device Nomenclature*)
- Supports a Wide Voltage Range
  - 2.5 to 38 V
  - No External Regulator Required
- Wide Operating Temperature Range
  - T_A = –40 to 125°C (Q, see *Device Nomenclature*)
- Open-Drain Output (30-mA Sink)
- Fast 35-µs Power-On Time
- Small Package and Footprint
  - Surface Mount 3-Pin SOT-23 (DBZ)
    - 2.92 mm × 2.37 mm
  - Through-Hole 3-Pin TO-92 (LPG)
    - 4.00 mm × 3.15 mm
- **Protection Features**
  - Reverse Supply Protection (up to –22 V)
  - Supports up to 40-V Load Dump
  - Output Short-Circuit Protection
  - Output Current Limitation

2 Applications

- Power Tools
- Flow Meters
- Valve and Solenoid Status
- Brushless DC Motors
- Proximity Sensing
- Tachometers

3 Description

The DRV5013 device is a chopper-stabilized Hall Effect Sensor that offers a magnetic sensing solution with superior sensitivity stability over temperature and integrated protection features.

The magnetic field is indicated via a digital bipolar latch output. The IC has an open-drain output stage with 30-mA current sink capability. A wide operating voltage range from 2.5 to 38 V with reverse polarity protection up to –22 V makes the device suitable for a wide range of industrial applications.

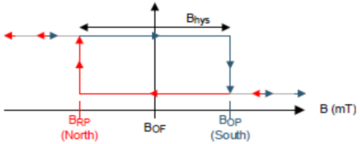
Internal protection functions are provided for reverse supply conditions, load dump, and output short circuit or over current.

Device Information[1]

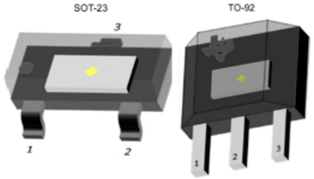
PART NUMBER	PACKAGE	BODY SIZE (NOM)
DRV5013	SOT-23 (3)	2.92 mm × 1.30 mm
	TO-92 (3)	4.00 mm × 3.15 mm

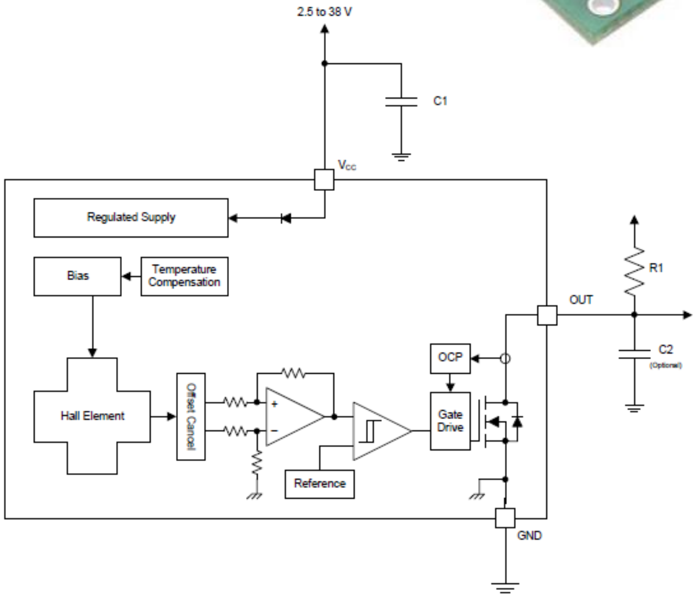
(1) For all available packages, see the package option addendum at the end of the data sheet.

Output State



Device Packages





TI Information – Selective Disclosure

DRV8838 Motor Driver

DRV883x Low-Voltage H-Bridge Driver

1 Features

- H-Bridge Motor Driver
  - Drives a DC Motor or Other Loads
  - Low MOSFET On-resistance: HS + LS 280 mΩ
- 1.8-A Maximum Drive Current
- Separate Motor and Logic Supply Pins:
  - Motor VM: 0 to 11 V
  - Logic VCC: 1.8 to 7 V
- PWM or PH/EN Interface
  - DRV8837: PWM, IN1/IN2
  - DRV8838: PH/EN
- Low-power Sleep Mode With 120-nA Maximum Sleep Current
  - nSLEEP pin
- Small Package and Footprint
  - 8 WSON (PowerPAD™)
  - 2.0 × 2.0 mm
- Protection Features
  - VCC Undervoltage Lockout (UVLO)
  - Overcurrent Protection (OCP)
  - Thermal Shutdown (TSD)

3 Description

The DRV883x provides an integrated motor driver solution for cameras, consumer products, toys, and other low-voltage or battery-powered motion control applications. The device can drive one DC motor or other devices like solenoids. The output driver block consists of N-channel power MOSFET's configured as an H-bridge to drive the motor winding. An internal charge pump generates needed gate drive voltages.

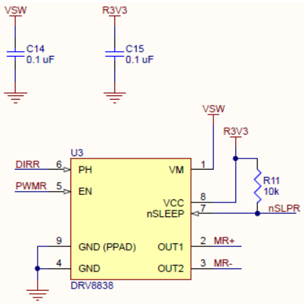
The DRV883x can supply up to 1.8 A of output current. It operates on a motor power supply voltage from 0 to 11 V, and a device power supply voltage of 1.8 V to 7.0 V.

The DRV8837 has a PWM (IN/IN) input interface; the DRV8837 has a PH/EN input interface. Both interfaces are compatible with industry-standard devices.

Internal shutdown functions are provided for overcurrent protection, short circuit protection, undervoltage lockout, and overtemperature.

Device Information

ORDER NUMBER	PACKAGE	BODY SIZE
DRV8837DSGR	WSON (8)	2.0 × 2.0 mm
DRV8838DSGR	WSON (8)	2.0 × 2.0 mm



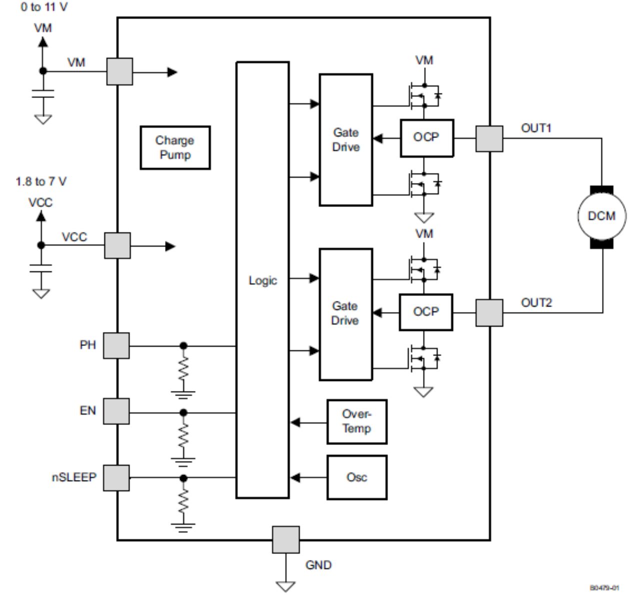
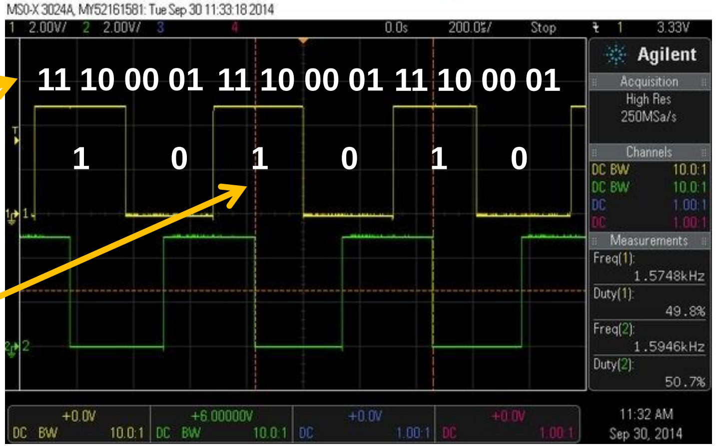


Figure 5. DRV8838 Functional Block Diagram

Gearmotor and Encoders

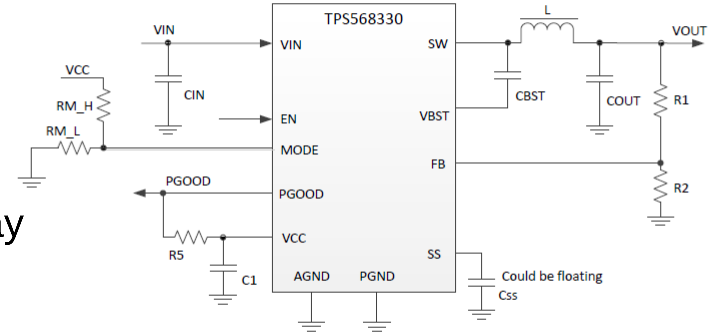
- Motors
  - 120:1 gear ratio
    - 120 rotations of small shaft/disc = 1 rotation of wheel
    - TI-RSLK powers these motors at battery voltage
      - 6 AA batteries x 1.5V max each = 9V max
- Encoders
  - Disc has 3 PN magnets = 6 poles
    - 2 magnetic field Hall Effect sensors per board
    - Provides 12 states/counts per rotation (vs 6 w/ just 1)

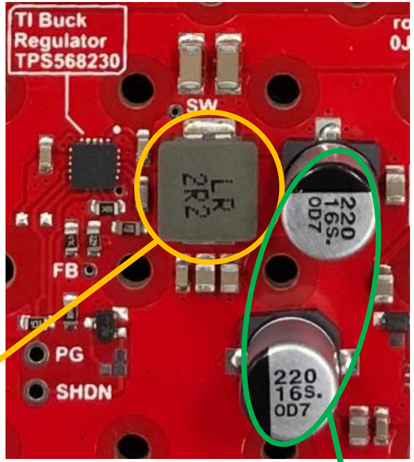


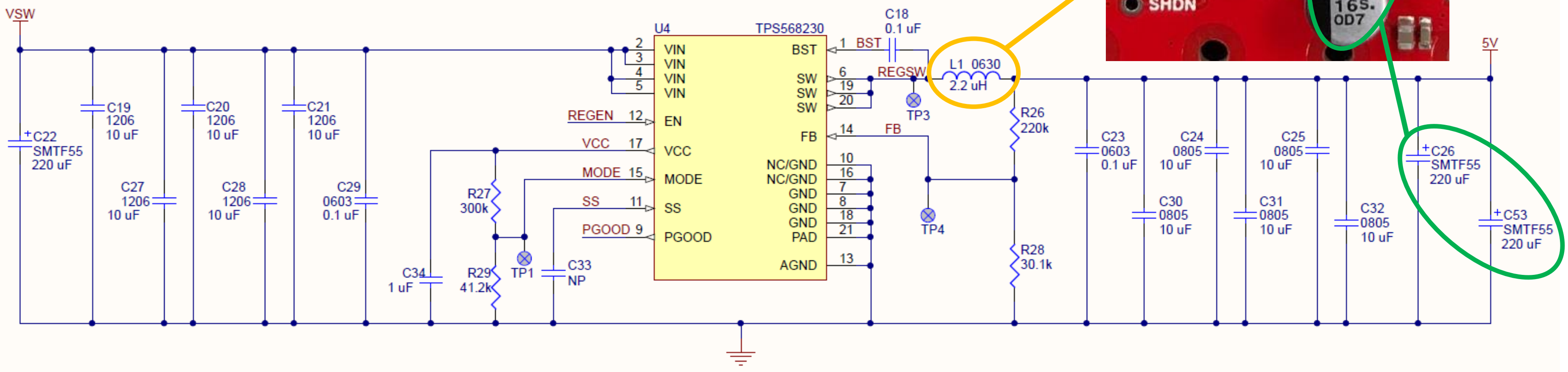
- 120 gear ratio x 12 counts per rotation = 1440 counts per rotation!

TPS568230/330 Switching Regulator = 5V, up to 8A

- Generate 5V
  - Feeds 3.3V
  - Future "Extras"
    - LCD/OLED display
    - Distance Sensors
    - Other sensors







TI Information – Selective Disclosure

TLV1117LV Linear Regulator = 3.3V, up to 1A

- 3.3V output for MSP432 LaunchPad

TLV1117LV 1-A, Positive Fixed-Voltage, Low-Dropout Regulator

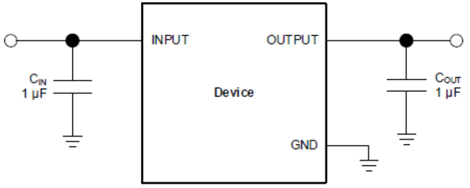
1 Features

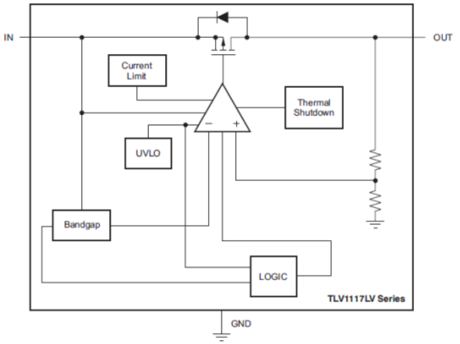
- 1.5% Typical Accuracy
- Low I_Q: 100 µA (Maximum)
  - 500 Times Lower Than Standard 1117 Devices
- V_{IN}: 2 V to 5.5 V
  - Absolute Maximum V_{IN} = 6 V
- Stable With 0-mA Output Current
- Low Dropout: 455 mV at 1 A for V_{OUT} = 3.3 V
- High PSRR: 65 dB at 1 kHz
- Minimum Ensured Current Limit: 1.1 A
- Stable With Cost-Effective Ceramic Capacitors:
  - With 0-Ω ESR
- Temperature Range: –40°C to 125°C
- Thermal Shutdown and Overcurrent Protection
- Available in SOT-223 Package

3 Description

The TLV1117LV series of low-dropout (LDO) linear regulators is a low input voltage version of the popular TLV1117 voltage regulator.

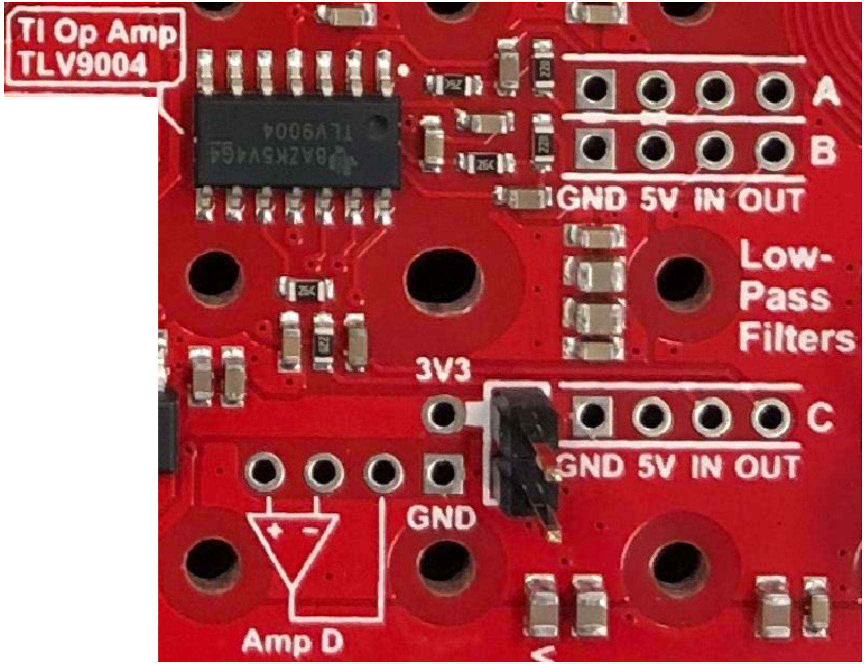
The TLV1117LV is an extremely low-power device that consumes 500 times lower quiescent current than traditional 1117 voltage regulators, making the device suitable for applications that mandate very low standby current. The TLV1117LV family of LDOs is also stable with 0 mA of load current; there is no minimum load requirement, making the device an ideal choice for applications where the regulator must power very small loads during standby in addition to large currents on the order of 1 A during normal operation. The TLV1117LV offers excellent line and load transient performance, resulting in very small magnitude undershoots and overshoots of output voltage when the load current requirement changes from less than 1 mA to more than 500 mA.

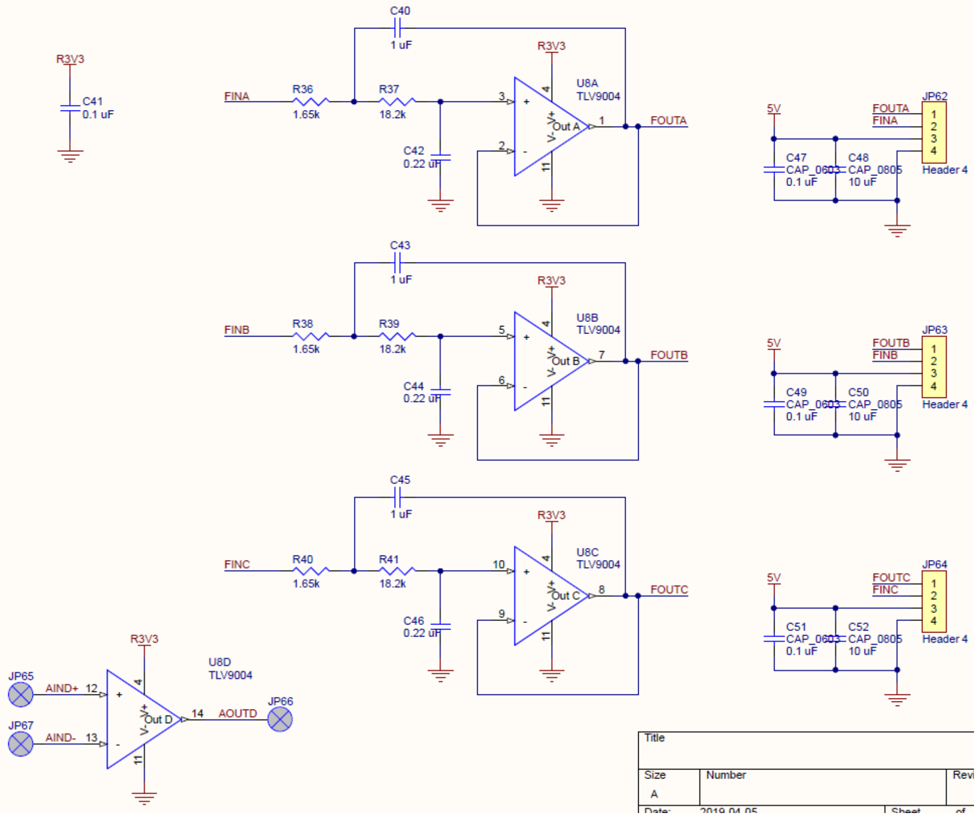




TLV9004 4-channel Operational Amplifier

- For Distance Sensors (or other)





Hardware for TI-RSLK MAX (TIRSLK-EVM)

KIT CONTENTS

Teaches the foundations of an electronic system; robot can solve its way through a maze with line and collision detection

SimpleLink™ MSP432P401R MCU LaunchPad™ Development Kit

Line IR sensors

Bump switches

TI-RSLK Chassis Board

Chassis & Motor assembly with encoder

Wires

Breadboard

+ other mechanical & electronic components

OPTIONAL PURCHASES

Expand the capabilities and complexity of the system with additional accessories like sensors, connectivity, and actuators

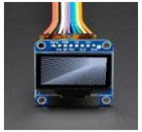
SimpleLink Bluetooth® low energy CC2650 module BoosterPack™ plug-in module

SimpleLink Wi-Fi® CC3100 wireless network processor BoosterPack™ plug-in module

Robot arm

Sensors BoosterPack™ plug-in module

OPT3101 Distance Sensor

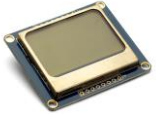


OLED screen

Distance IR sensors

Audio BoosterPack™ plug-in module

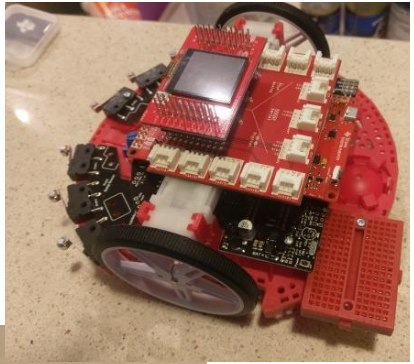
Sidekick Kit for TI LaunchPad

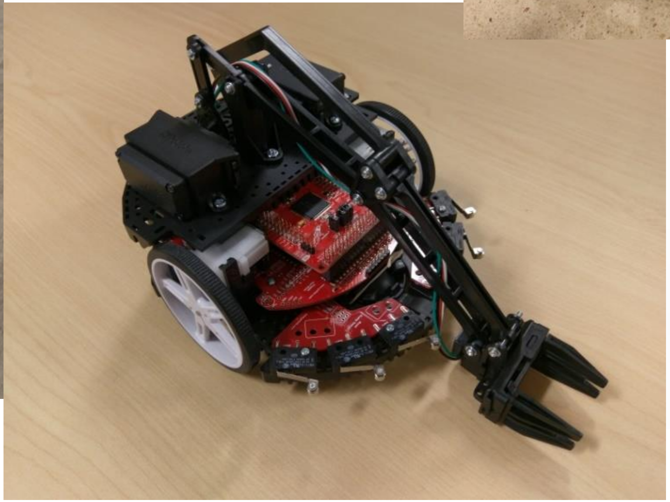


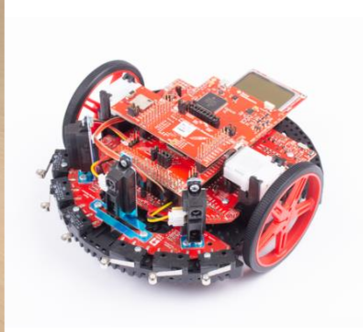
LCD screen

+ additional BoosterPack plug-in modules & electronic components

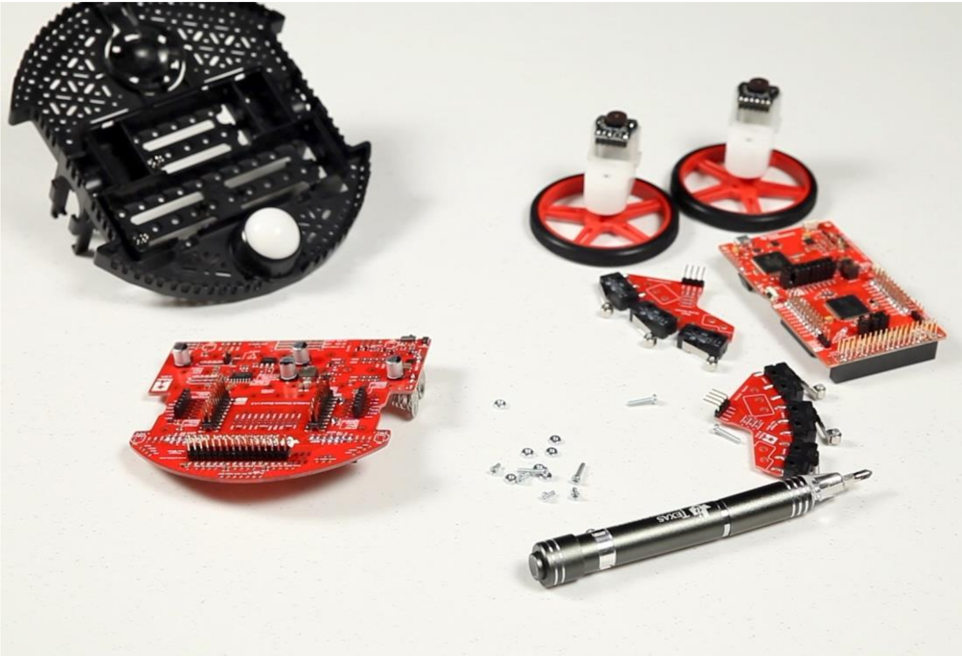
Customize: Alternate applications

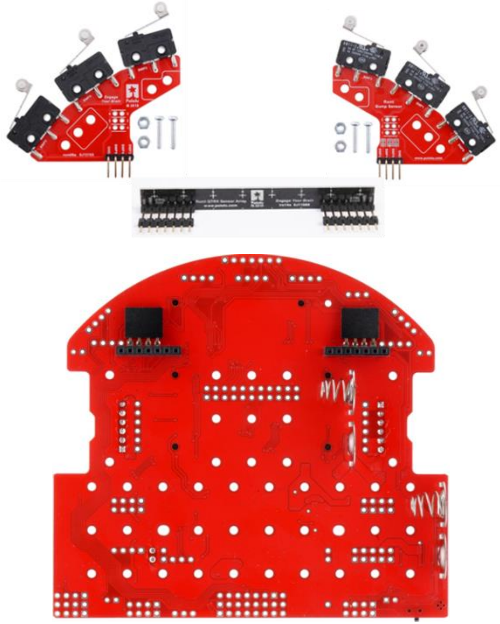






TI-RSLK MAX reusability





Designed with today's classroom in mind

- Low-cost makes it accessible for students to own or for classroom sets to be reused year-over-year

- Easily implemented into large classes and multiple course-types

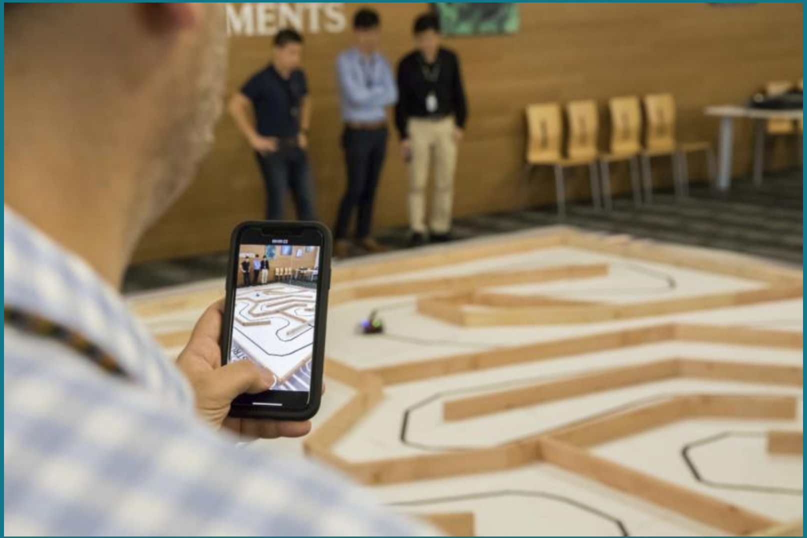
- Works well for virtual distance learning, flipped classrooms and classrooms without access to soldering equipment or lab benches

Expanded curriculum experiences

- Accessory hardware for multiple year + multiple course investment
  - Attach new sensors, servo driven gripper arm, wireless modules, and analog circuits to keep the course fresh for students and instructors, preserve academic integrity
  - Evolve the hardware to serve breadth and depth to match introductory and advanced levels of course requirements

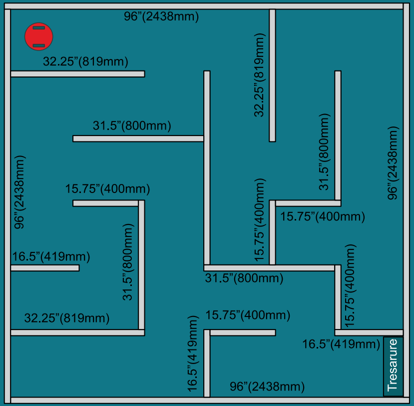
- Flexibility for course customizations
  - Integrate course objectives around specific instrumentation or specialized topics

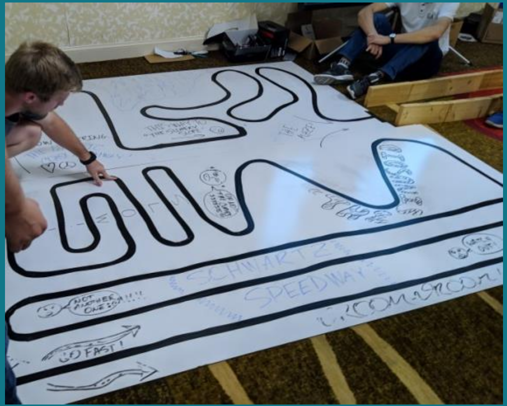
Engage students with robotic challenges

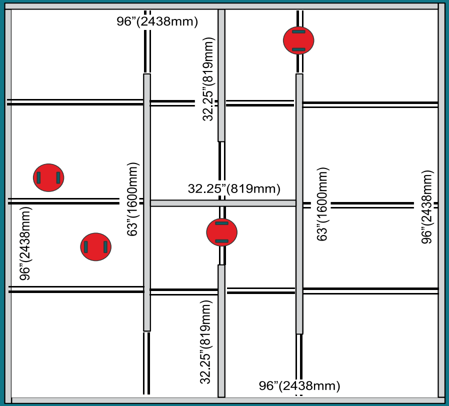


The TI-RSLK series helps students physically grasp abstract concepts while having fun. The TI-RSLK MAX can solve a maze, line follow and avoid obstacles. Your robot can also be customized to complete any challenge or task students dream up.

Engage students with robotic challenges







The TI-RSLK website provides community resources for making DIY challenges easy to set up for department or campus competitions. Generate excitement within department or college and buzzworthy content for campus publications and alumni newsletters. Robot racing and time trials are easily put together at low cost and a standard platform with the TI-RSLK keeps the competition fair and accessible.

Compete: Beyond the maze!

- Obstacle course (navigate different terrains and obstacles in confined area)
- Head-to-head competitions (racing, battle bots, balloon popping and team games)
- Mobile sensor (IoT robot measuring air quality)
- Mobile security platform (IoT robot measuring human detection)

- AI / Machine Learning
  - Transportation algorithms (simulate automotive traffic patterns or people movers)
  - Robotic warehouse (swarm robotics to navigate crowded area efficiently)
  - Room traversal for cleaning tasks (robotic vacuum patterns)

- Cybersecurity and network integrity (real world cybersecurity practice)

Using TI-RSLK MAX

Programming

Code Editors

Arduino | C | DriverLib
TI-RTOS | Simplelink SDK

Code Composer Studio
CCS Cloud | Arduino | IAR | Keil

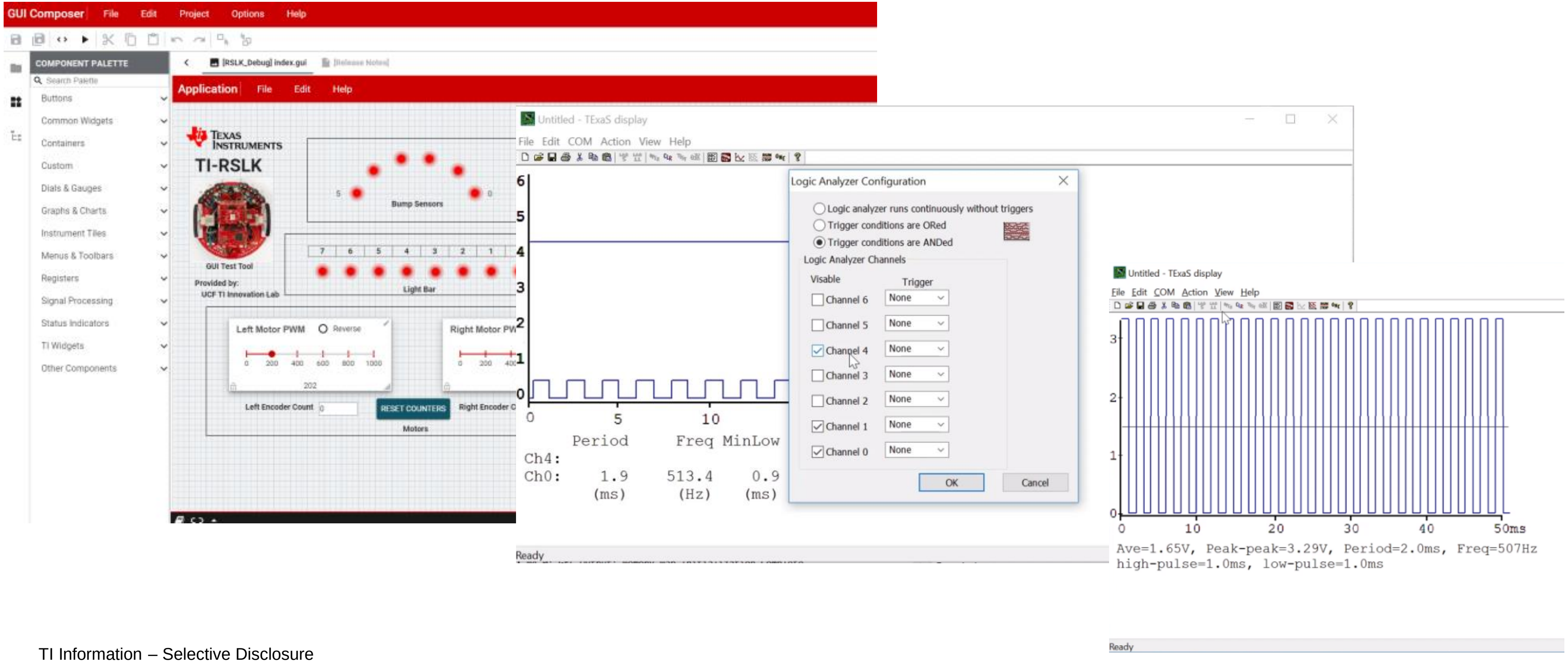
Preparing future engineers with TI-RSLK MAX

- The TI-RSLK MAX teaches systems-thinking through robotics, providing a foundation for future product design
- Provides a hands-on experience, which is proven to be more engaging and fun
- As early as freshmen year, students are seeing abstract concepts come to life in real ways
- Students prepare for their future by working as a team and using real-world engineering tools to solve problems

TI-RSLK MAX is available for purchase for $109 at TI.com
and available for purchase through authorized distributors

Free tools to maximize hardware

- TExaS display & GUI debug tool, Code Composer Studio & TI-RSLK starter code



Module topics TI-RSLK MAX

Base | Supplemental

1 Code Composer Studio IDE

2 Voltage, Current, and Power

3 ARM Architecture (Assembly Program)

4: Software Design using MSP432

5: Build the robot

6 General Purpose Input Output Ports

7 Finite State Machines

8 LEDs and Switches

9 SysTick Timer

10 Debugging Real-time Systems

11 Interfacing graphical displays

12 DC Motors

13 PWM and Periodic interrupts

14 I/O Triggered Interrupts

15 Data Acquisition

16 Tachometer

17 Control Systems

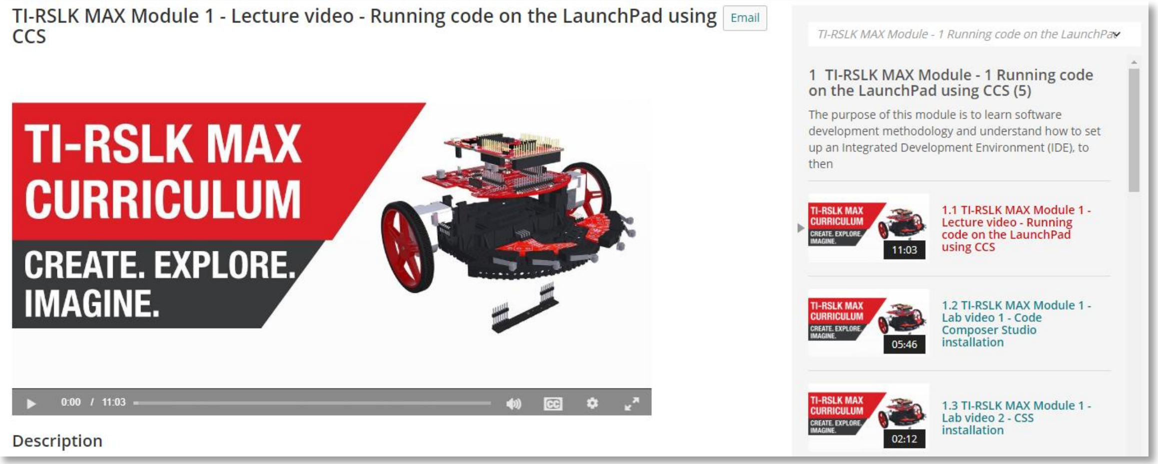
18 Serial Communications

19 Bluetooth Low Energy - IOT

20 Wi-Fi

Learn: Video lectures

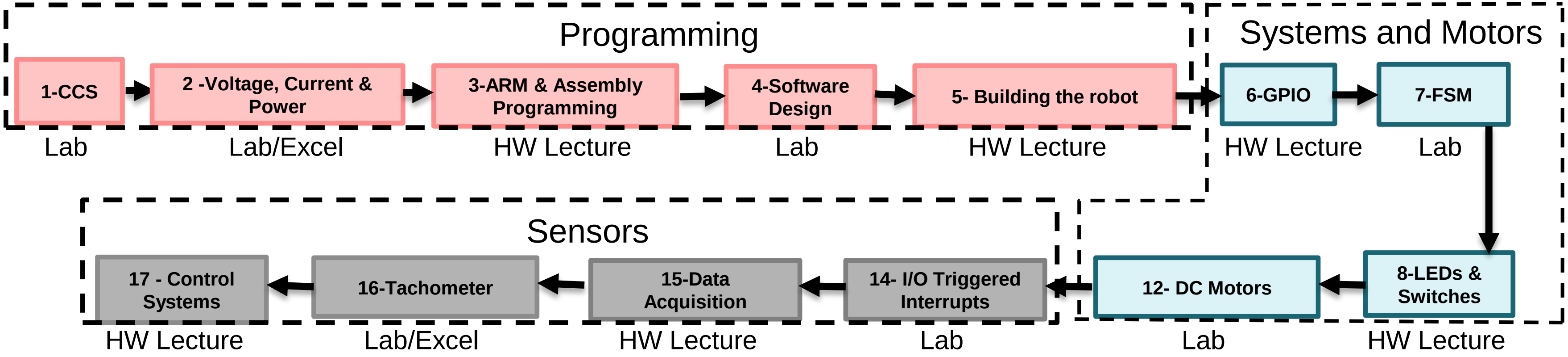
- Get personal instruction from Dr. Jonathan Valvano
- Walk through and preview lab exercises



Learn: Inside each module

- Introduction document with educational objectives, pre-requisites and references
- Class Lecture slides and video
- Lab document along with demo videos of completed lab
- Quiz document for testing students
- Class Activity document with homework exercises or practice problems

Learn: Curated curriculum pathways



You will learn in this curriculum

- Engineering Design Skills – Measurement, Data Acquisition, Excel data plotting, CAD Modeling, 3D Printing, soldering, wiring and documentation
- Electrical Engineering concepts – Voltage, current, power and energy
- Microcontroller C programming – PWM, ADC, GPIO and serial
- Software design and testing – Algorithms and Debugging
- Fundamental Theories- Nyquist, Central Limit, Little's
- Systems – State Machines, Controls and System Integration

Notes

- Selected solutions could be provided to students
- Consider having some pre assembly and prep in summer to cut down on lab crowding and errors
- 3D modeling with Solidworks and printing exercises can be inserted
- MS Excel plotting can be done in lab 2 and 16

Learn: Ample academic resources

- Textbook resources and technical references on MSP432
  - Deep dive into the microcontroller with textbook references from university educators and technical manuals published by TI
  - Many print resources available for the MSP43x chipset
    - https://university.ti.com/en/faculty/teaching-materials-and-classroom-resources/embedded-learning-materials

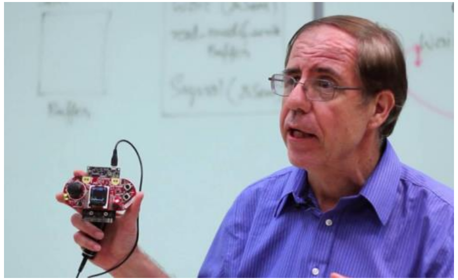
- Additional online courses and tutorials
  - Make use of tutorial content from popular online classes and websites
  - Online workshops compatible with MSP432P401R and MSP432 architecture and peripherals
    - https://training.ti.com/msp432-low-power-high-performance-mcus-training-series
    - https://training.ti.com/msp430-workshop-series

edX course: Fundamentals of Mechatronics MOOC

- High impact, first of it’s kind online course offering for Mechatronics
  - Deep dive for students, hobbyists, and professionals
  - Trends toward automation is boosting demand for mechatronics educational content
  - On-demand content on the popular EdX platform, free to audit & paid certificates are offered
  - Featuring TI-RSLK MAX and MSP432 LaunchPad, highly tied to TI-RSLK concepts and covering supplemental topics

Dr. Jonathan Rogers brings years of experience teaching mechatronics at Georgia Tech and as the Director of Aerial Robotics and Experimental Autonomy Lab

edX course: Real-Time Bluetooth networks



- https://www.edx.org/course/real-time-bluetooth-networks-shape-the-world
- Taught by professors at University of Texas Austin
- Comprehensive, self paced, hands-on course on RTOS & IoT

edX course: Embedded Systems - Shape The World

- https://www.edx.org/course/embedded-systems-shape-the-world-microcontroller-i
- Taught by professors at University of Texas Austin
- Comprehensive, self paced, hands-on course on embedded systems

TI-RSLK MAX

TI Robotics System Learning Kit MAX

Questions?

Pause for Questions

Developing IoT Products

- Create Block diagram
- Prototype using evaluation modules provided by vendors
- Design PCB
- Write Firmware
- Develop cloud software using APIs

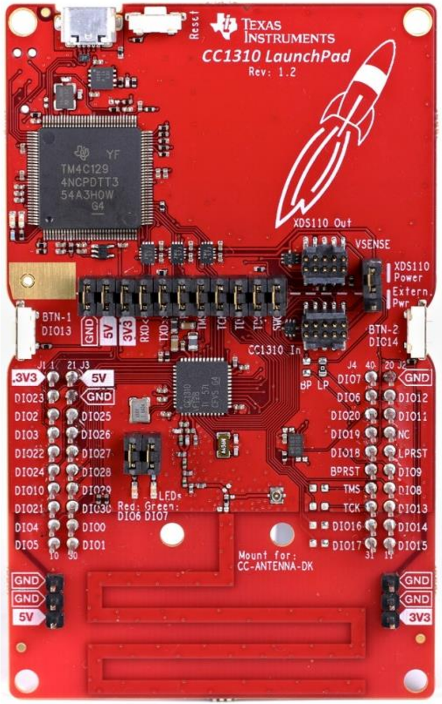
Sensor IoT

- Typical Characteristics
  - Long Range (deployed far from gateway)
  - High Density (in some cases)
  - Low Power (battery powered)
  - Low Bandwidth (small data packets)
- I^2C protocol is commonly used peripheral for sensors
- RF protocols range from mesh to star topology networks
  - Proprietary stack (provides lowest latency)
  - Zigbee, Xbee, TI 15.4
  - OpenThread, 6LoWPAN

Create multi-band sensor networks with the LaunchPad™ SensorTag Kit (LPSTK)

SimpleLink™ CC1310 Wireless MCU LaunchPads

ARM® Cortex™ M3 based SoC with integrated Sub-1GHz, 6LoWPAN connectivity



$29.00

Target MCU: CC1310
BoosterPack Pinout: 40-pin
Specs:

- 48MHz ARM® Cortex™-M3 CPU
- 128kB Flash / 20 kB RAM
- 12-bit ADC, I^{2}C, I^{2}S, UART, SPI, Ultra-low Power Sensor Controller
- Supports OTA upgrades & up to 8 capacitive sense buttons

Why this LaunchPad?

- Great starting point for IoT Applications
- All in one solution for 6LoWPAN or proprietary Sub-1GHz radio

LAUNCHXL-CC1310

SimpleLink™ CC1352R1 LaunchPad SensorTag

ARM® Cortex™ M4 based SoC with integrated Sub-1GHz, 6LoWPAN connectivity

$30.00

Target MCU: CC1352R1

BoosterPack Pinout: 40-pin

Specs:

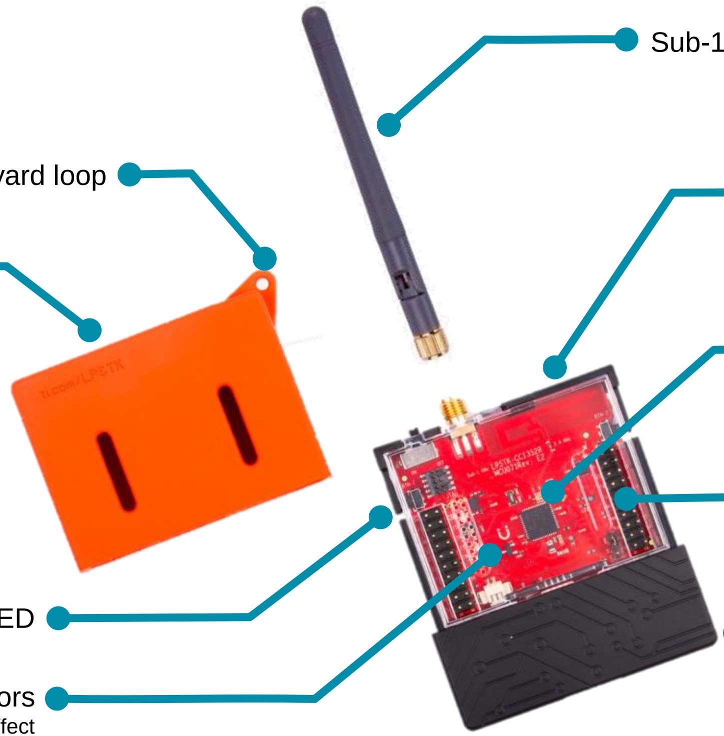
- 48MHz ARM® Cortex™-M4 CPU
- 352kB Flash / 80 kB RAM
- 12-bit ADC, I^2C, I^2S, UART, SPI, Ultra-low Power Sensor Controller
- Supports OTA upgrades & up to 8 capacitive sense buttons

Why this LaunchPad?

- Great starting point for IoT Applications
- All in one solution for BLE & Sub-1GHz radio

LPSTK-CC1352R

Meet the LPSTK *(LaunchPad SensorTag Kit)*



Sub-1GHz SMA swivel antenna

Sub-1GHz (TI-15.4 or proprietary stacks)

Lanyard loop

2.4GHz PCB antenna

Bluetooth zigbee THREAD

Remove-able enclosure
for easy access to PCB

Featuring SimpleLink™ multi-band CC1352R wireless MCU

Paired with Johanson Technology IPC

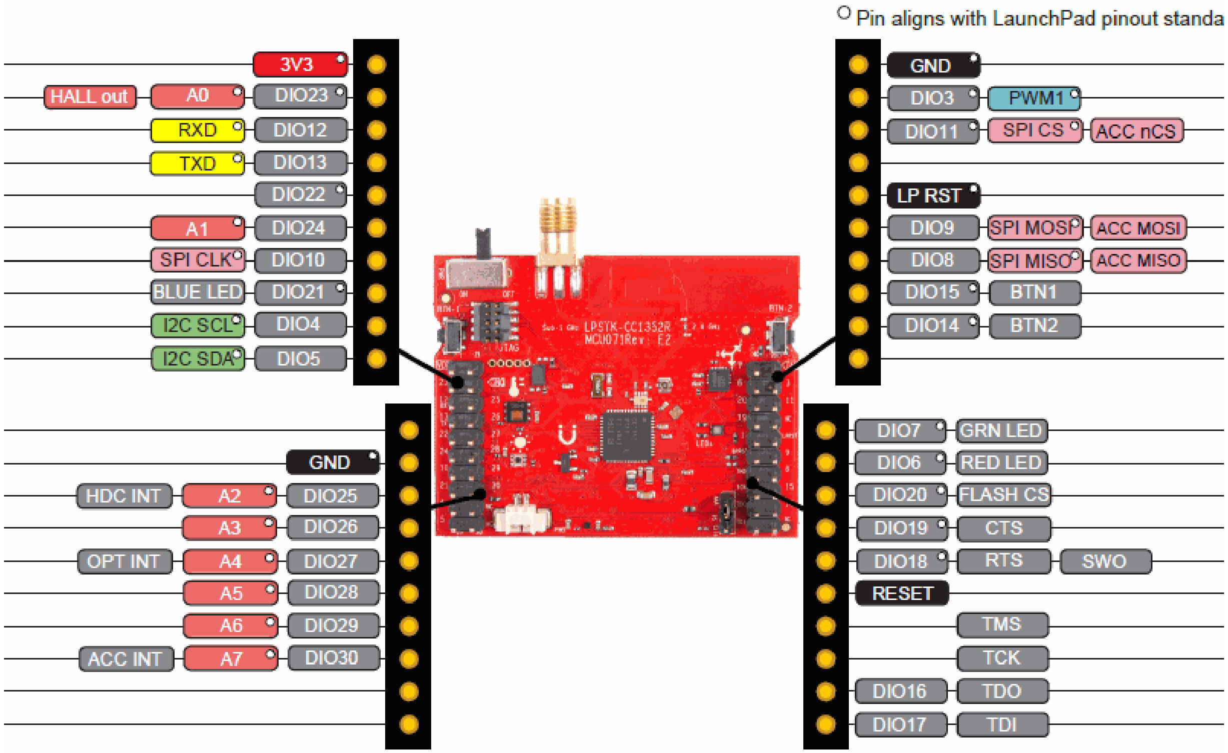
Easy access to I/Os & BoosterPack-compatible

Power switch, 2 user buttons & RGB LED

2x AAA battery-operation

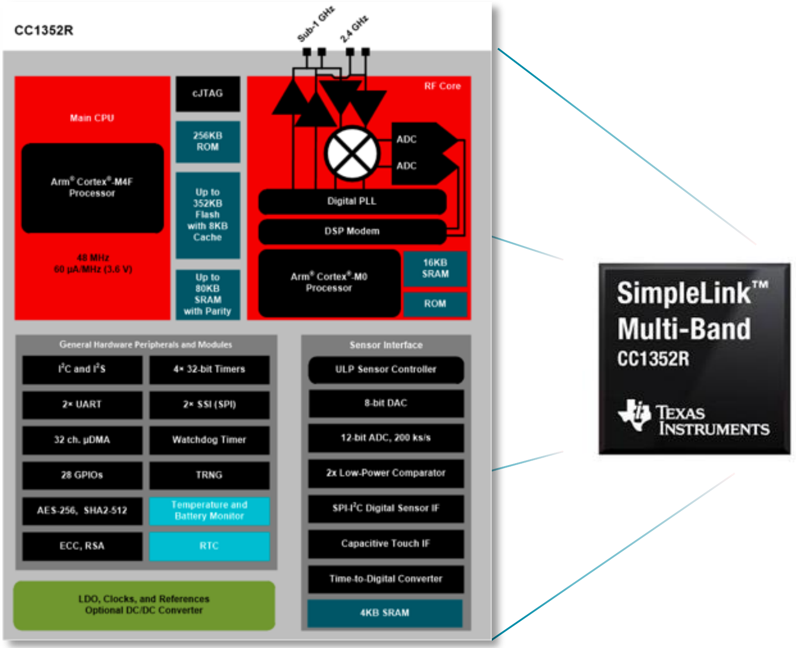
Various on-board sensors

Temp, Humidity, Light, Motion, Hall Effect



Pin aligns with LaunchPad pinout standa
3V3
HALL out
A0
DIO23
RXD
DIO12
TXD
DIO13
DIO22
A1
DIO24
SPI CLK
DIO10
BLUE LED
DIO21
I2C SCL
DIO4
I2C SDA
DIO5
GND
HDC INT
A2
DIO25
A3
DIO26
OPT INT
A4
DIO27
A5
DIO28
A6
DIO29
ACC INT
A7
DIO30
GND
DIO3
PWM1
DIO11
SPI CS
ACC nCS
LP RST
DIO9
SPI MOSI
ACC MOSI
DIO8
SPI MISO
ACC MISO
DIO15
BTN1
DIO14
BTN2
DIO7
GRN LED
DIO6
RED LED
DIO20
FLASH CS
DIO19
CTS
DIO18
RTS
SWO
RESET
TMS
TCK
DIO16
TDO
DIO17
TDI

Meet the SimpleLink™ multi-band CC1352R wireless MCU.



Part of the SimpleLink Platform – the industry's broadest portfolio of connected, low-power & secure MCUs

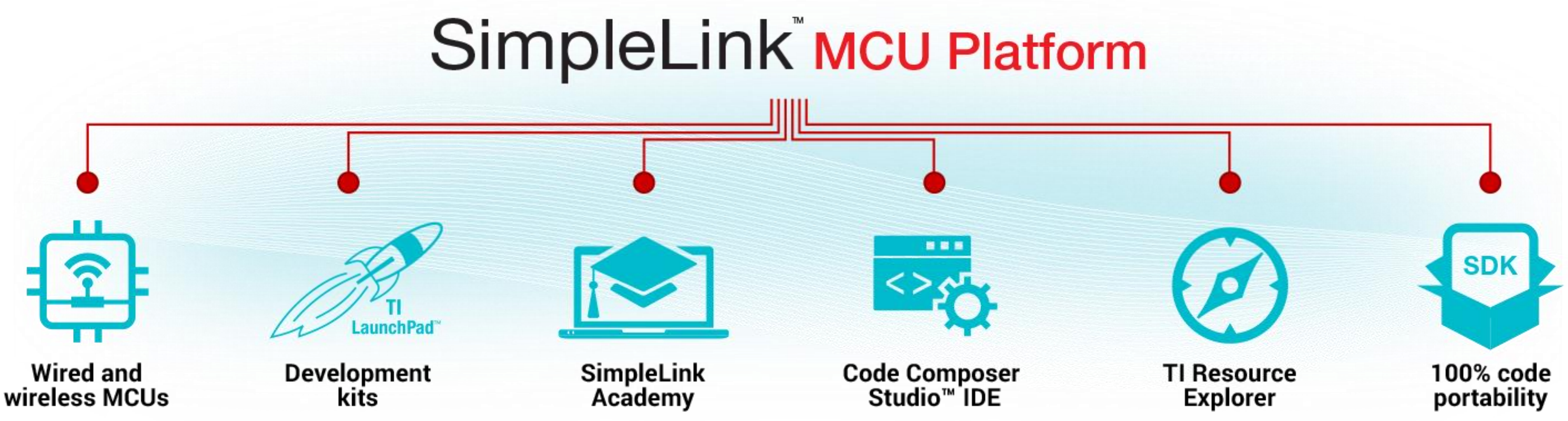
- 48-MHz arm Cortex –M4F MCU
- 352kB flash (user programmable)
- 256kB ROM (protocols & library functions)
- 8kB cache SRAM (also available as general purpose RAM)
- Integrated Sensor Controller
- Multi-band sub-1 GHz and 2.4 GHz RF transceiver
- Integrated digital & analog peripherals
- Full support of the SimpleLink SDK

SimpleLink™

MCU Platform

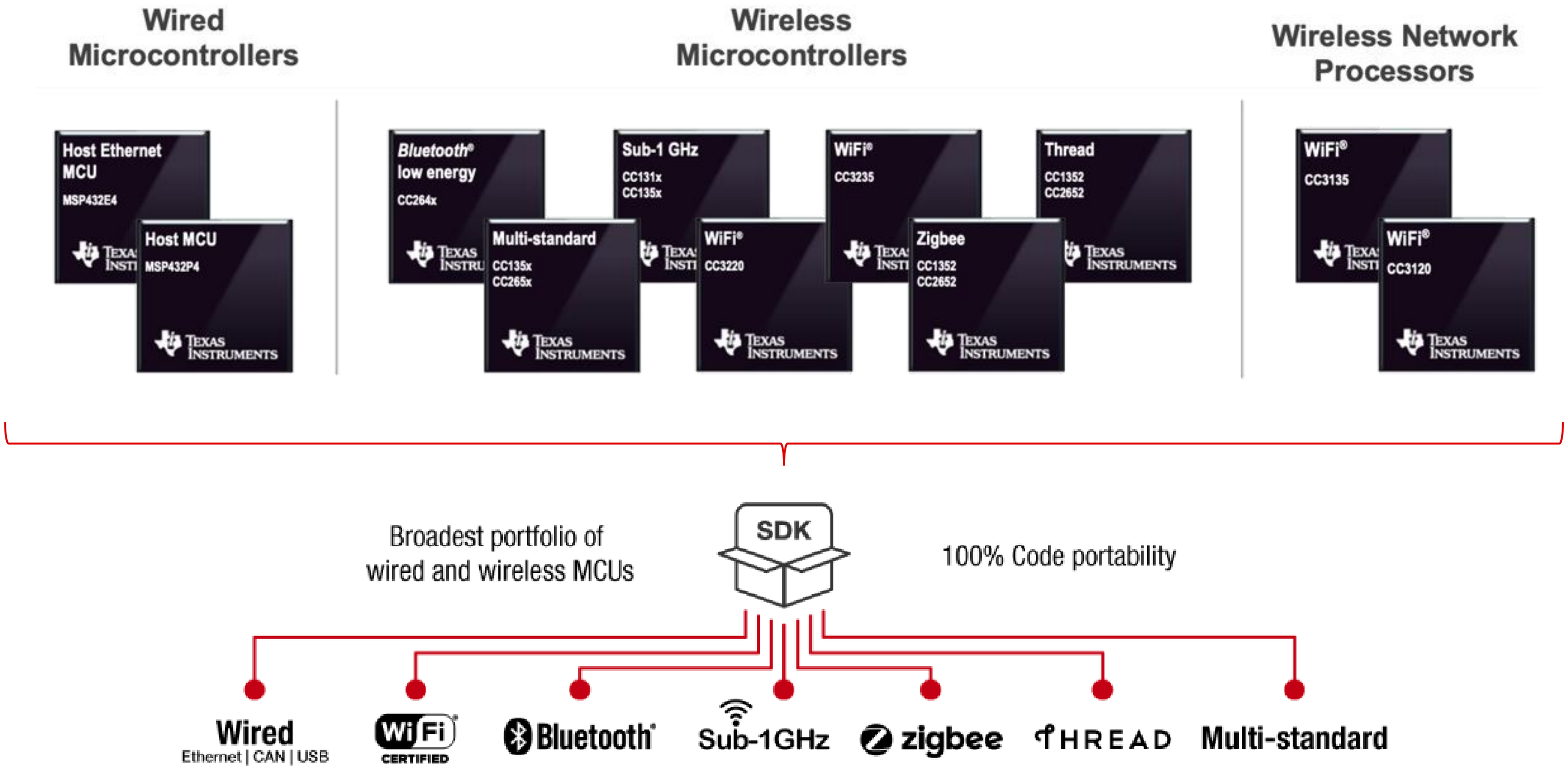
One environment.
Unlimited potential.

Texas Instruments

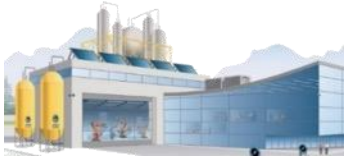


Unified experience to speed up customer time to market and manage IoT product life cycle

SimpleLink MCU Platform



SimpleLink MCUs | Connecting every market



BUILDING AUTOMATION

CAR ACCESS

SimpleLink™
MCU Platform
One environment.
Unlimited potential.

GRID
INFRASTRUCTURE

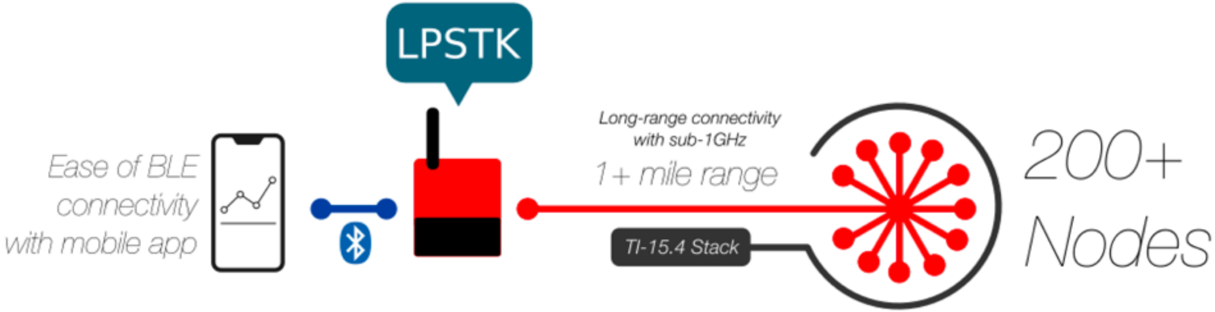
PE & COMMS
EQUIP.

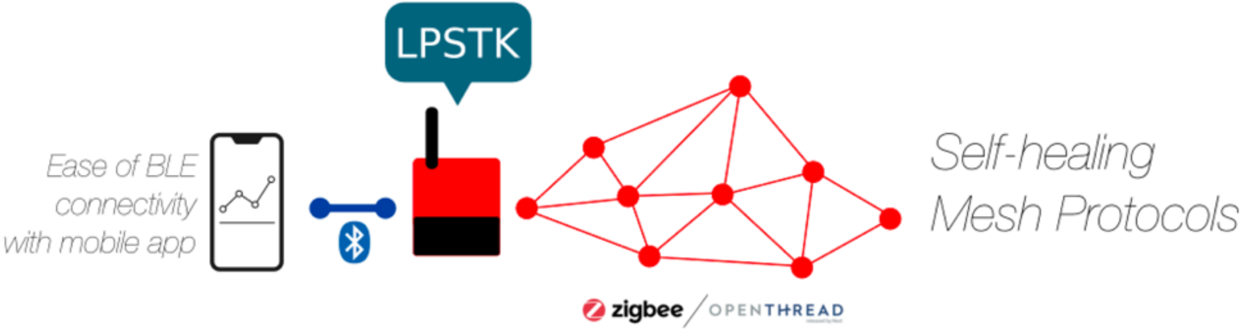
MEDICAL

ASSET TRACKING

FACTORY
AUTOMATION

Seamless multi-protocol & multi-band operation.

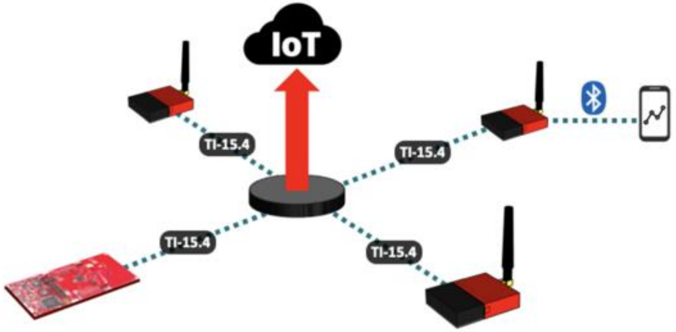




Unparalleled flexibility to connect your applications.

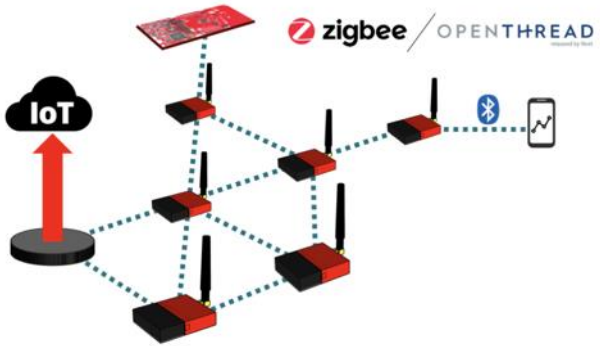
Easily create a multi-node star sensor network

Quickly evaluate a complete star topology, featuring low-power, long-range sensors using TI's TI-15.4 stack over Sub-1GHz. Over 1 mile of range possible.



Create a scalable mesh network with Thread or ZigBee

The LPSTK is based on the multi-protocol SimpleLink CC1352R MCU, which support ZigBee and Thread. Developers have multiple mesh options that support multi-hop & self-healing networks.

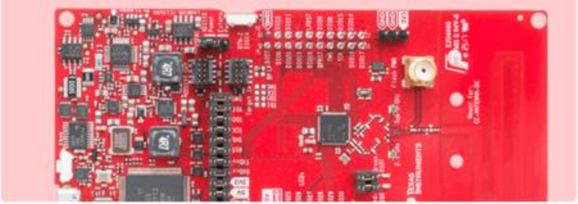


Flexible hardware kits for prototyping & development

Multiple points of entry

Open-ended hardware — Hardware tools you need to innovate. — Ready-to-go hardware

LaunchPad Development Kits

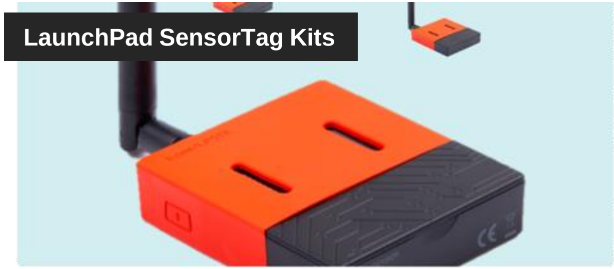


LaunchPad Development Kits are open-ended hardware development platforms. These kits offer developers unrestricted development access to SimpleLink MCUs & can be used as a blank slate for creating the next big thing.

Key Features

- On-board debugger with EnergyTrace™ capability
- USB-powered
- Available for all SimpleLink families
- User LEDs & pushbuttons
- Access to all MCU pins
- BoosterPack-compatible

LaunchPad SensorTag Kits



LaunchPad SensorTag Kits are a fully-enclosed, battery-operated wireless prototyping platform, featuring ready-to-go hardware. Developers can jumpstart their development with out-of-the-box battery-operation & on-board sensors.

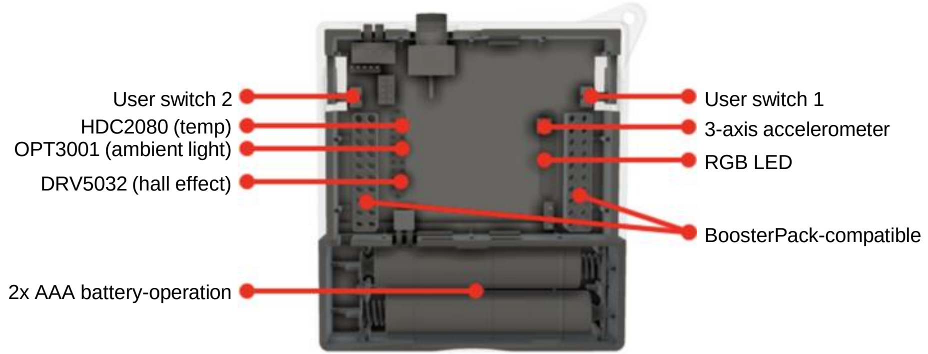
Key Features

- Battery-operated with remove-able enclosure
- On-board sensors (Temp, humidity, light, hall effect, motion)
- Featuring SimpleLink CC1352R MCU
- User LEDs & pushbuttons
- Access to all MCU pins
- BoosterPack-compatible

Hardware flexibility facilitates rapid prototyping.

Ready-to-go hardware with on-board sensors & AAA battery operation

LPSTK | Cross Section



TI DRV5032 | Industry-leading ultra-low-power hall effect sensor
Featured use-case: Door/window sensors

TI HDC2080 | High-accuracy, interruptible temp & humidity sensor
Featured use-case: Environmental sensing for building & factory automation

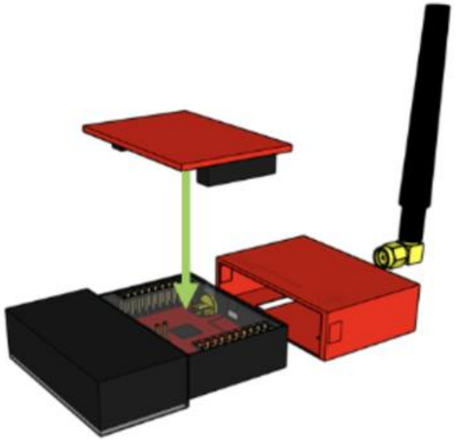
TI OPT3001 | Industry-leading “Eye-matching” light sensor with IR rejection
Featured use-case: Environmental sensing for building & factory automation

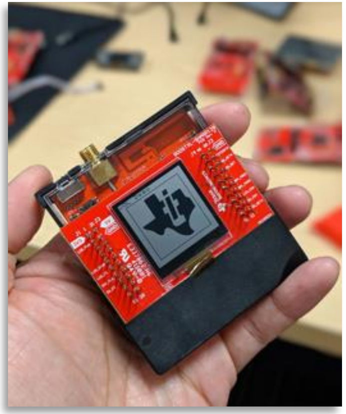
3-axis accelerometer| Paired with CC1352R integrated Sensor Controller
Featured use-case: Asset tracking, tilt-detection & motion tracking

Add your own sensors| Rapidly prototype your own connected sensor nodes
Leverage the BoosterPack ecosystem or interface your own components

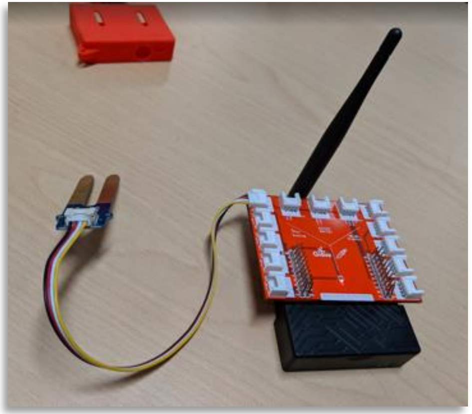
Customize-able, Extendable & Modular

Rapid prototyping with BoosterPack extendibility to add external hardware (sensors, displays & more)





SHARP LCD BoosterPack

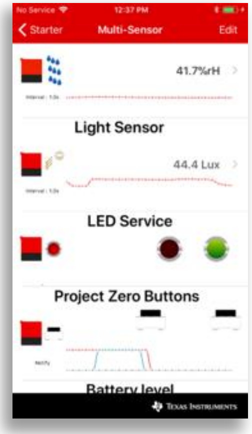


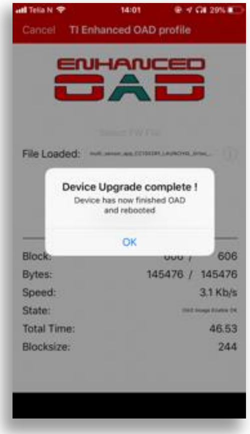
Seeed Studio Grove BoosterPack
+ soil moisture sensor

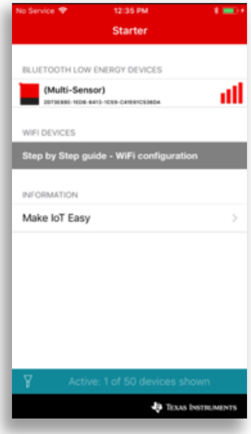
Mobile app provides fully-featured out-of-box experience.

Visualize sensor data & re-program LPSTK over-the-air

The SimpleLink Starter app is available for iOS and Android mobile devices to interface with the LPSTK over Bluetooth. Stream & visualize sensor data, or re-program the LPSTK with over-the-air download (OAD)







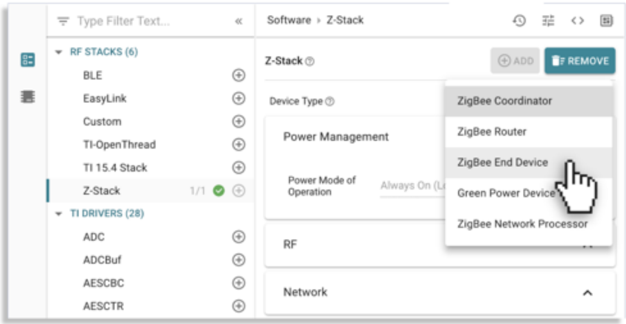
Go beyond the demo & iterate towards production.

Full debug support when paired with a SimpleLink LaunchPad kit

Full debug support is available when the LPSTK is connected to a SimpleLink LaunchPad kit debugger. An ARM JTAG 10-pin ribbon cable is provided with the LPSTK to allow full debug when needed.

Simply customize your LPSTK software with SysConfig

The SimpleLink SDK is configurable with an intuitive graphical interface called SysConfig. Change stack parameters, pin out configurations, driver capabilities and more through an easy-to-use interface.



Thanks!

Q&A

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