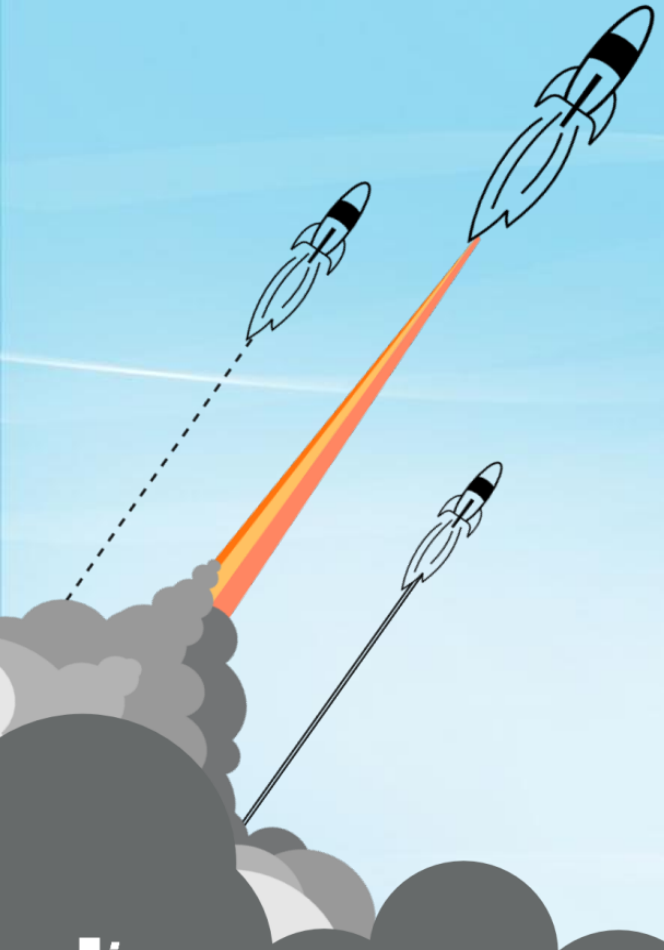


TI LaunchPad™ Ecosystem: Modular and affordable microcontroller development tools for rapid prototyping

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

Wi-Fi Internet of Things Workshop

Texas Instruments

January 2017

Texas Instruments

For the greatest crash course on IoT and electronics you've ever done?

The Rise of Electronics

From large desktop computers to tiny battery powered devices, EVERY innovation is all part of the same technology revolution

1800s-1900s

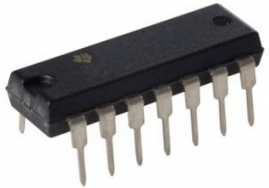
Edison & Tesla

- It pretty much always starts with the lightbulb, harnessing electricity for human applications, took lots of famous people to get to this point

1900s-1960s

Tubes, Transistors & Radio

- Electric computation and communication becomes possible and mainstream with the creation of the basic building blocks



1958

The Integrated Circuit

- Jack Kilby, a TI engineer, changed the world by inventing a practical way to shrink the size of electronics

The Rise of Electronics

From large desktop computers to tiny battery powered devices, EVERY innovation is all part of the same technology revolution

1970s-1990s

The PC Age

- Personal computers change business and productivity in every aspect of life worldwide

1990s-2010s

The Internet Age

- Computers and electronics can talk to each other creating a whole new world of applications

2000s-2030s

The IoT Age

- Affordable connectivity and processing gives all electronics additional capabilities for new data driven and world changing behavior

This tech wave will have lasting effects on EVERY industry

Government Transportation Industrial Aviation

Agriculture Manufacturing Energy Retail / Ecommerce

Medical Automotive Military Marine / Aquaculture

Food Real Estate Finance Construction

Opportunity to Disrupt

Join the IoT revolution!

See the World!

Build a new industry!

IoT will change your life!

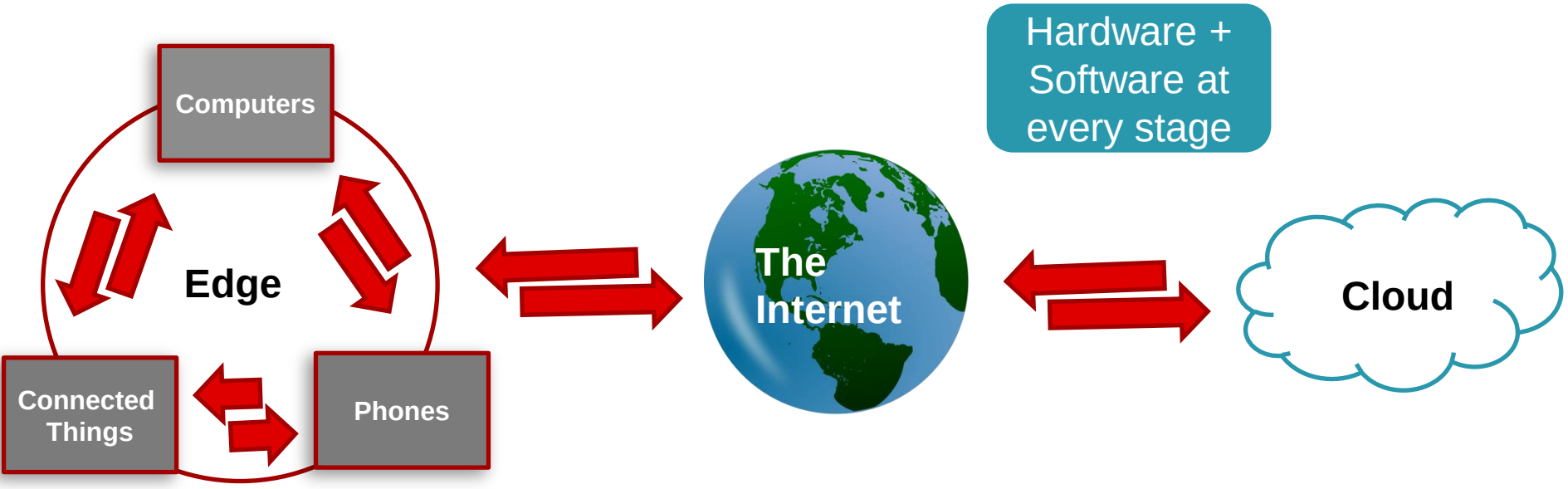
Can you make the next Great Product or Service?

WE WANT YOU!

Calling all Engineers, Makers, Entrepreneurs

The Internet of Things
a birds eye view

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



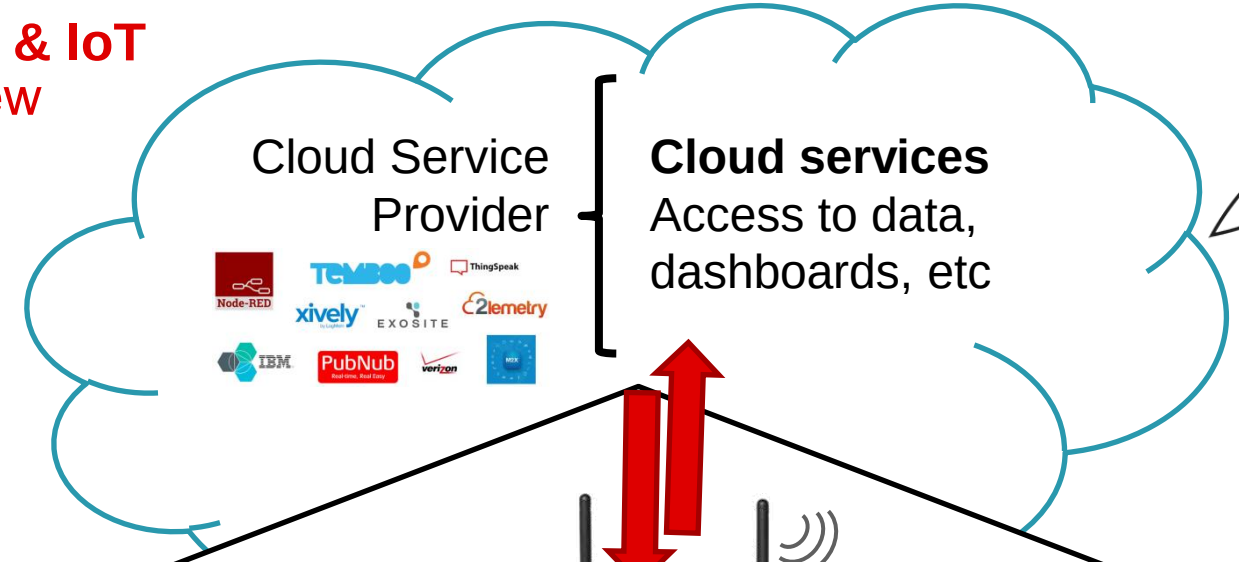
Think products
- Anything that can talk to the internet or connect to something else that can talk to the internet

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

TI LaunchPad & IoT
a bird's eye view



MCU + Ethernet LaunchPad

RF Booster Pack

Ethernet

IoT Gateways
Your portal to the cloud

MCU + RF SoC LaunchPad

RF Booster Pack

Wi-Fi

LaunchPads
- MSP430
- MSP432
- TM4C
- C2000
- Hercules

MCU LaunchPad

BoosterPack

RF BoosterPacks
- Zigbee / Zwave
- 6LoWPAN / Thread
- Bluetooth / Wi-Fi
- SubGHz RF / NFC
- LTE / Satellite

Wireless Nodes
Connecting your devices

MCU + RF SoC LaunchPad

MCU + RF SoC LaunchPads
- CC3200 MCU + WiFi
- CC2650 MCU + BLE
- CC1310 MCU + SubGHz RF
- CC1350 MCU + SubGHz/2.4GHz

Easily add RF for wireless applications!

Which wireless?

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

CONNECT MORE WITH TI

Wi Fi®

- Ubiquitous
- High bandwidth
- Higher power usage

Bluetooth®

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

NFC™

- 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

- Wide range
- High bandwidth
- Expensive

THREAD

6LoWPAN

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

ZigBee®

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

Infrared

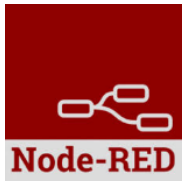
- Line of Sight
- Low power
- Very low cost

Satellite

- Global range w/ Sat available
- Expensive

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.

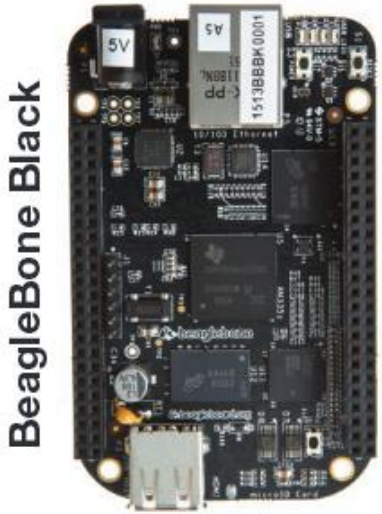


Microprocessors: Microcontrollers vs Single Board Computers
a comparison

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?

beagleboard.org



Microprocessors: Microcontrollers vs Single Board Computers
a comparison

Considerations:
- Power
- Integration
- Performance

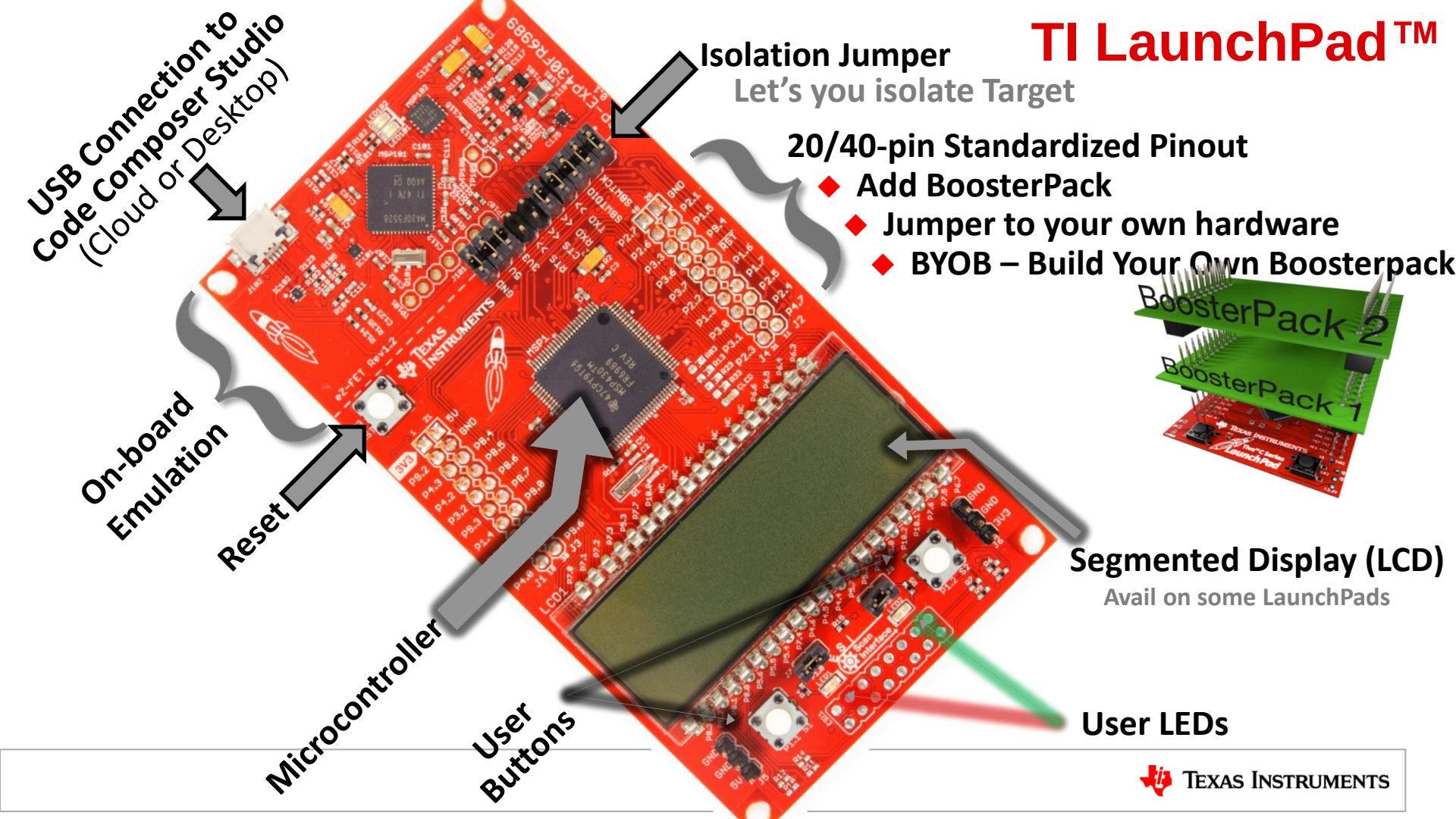
Advantages
- Overall less complex
- Overall less cost
- Overall lower power consumption
- Real-time capable

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

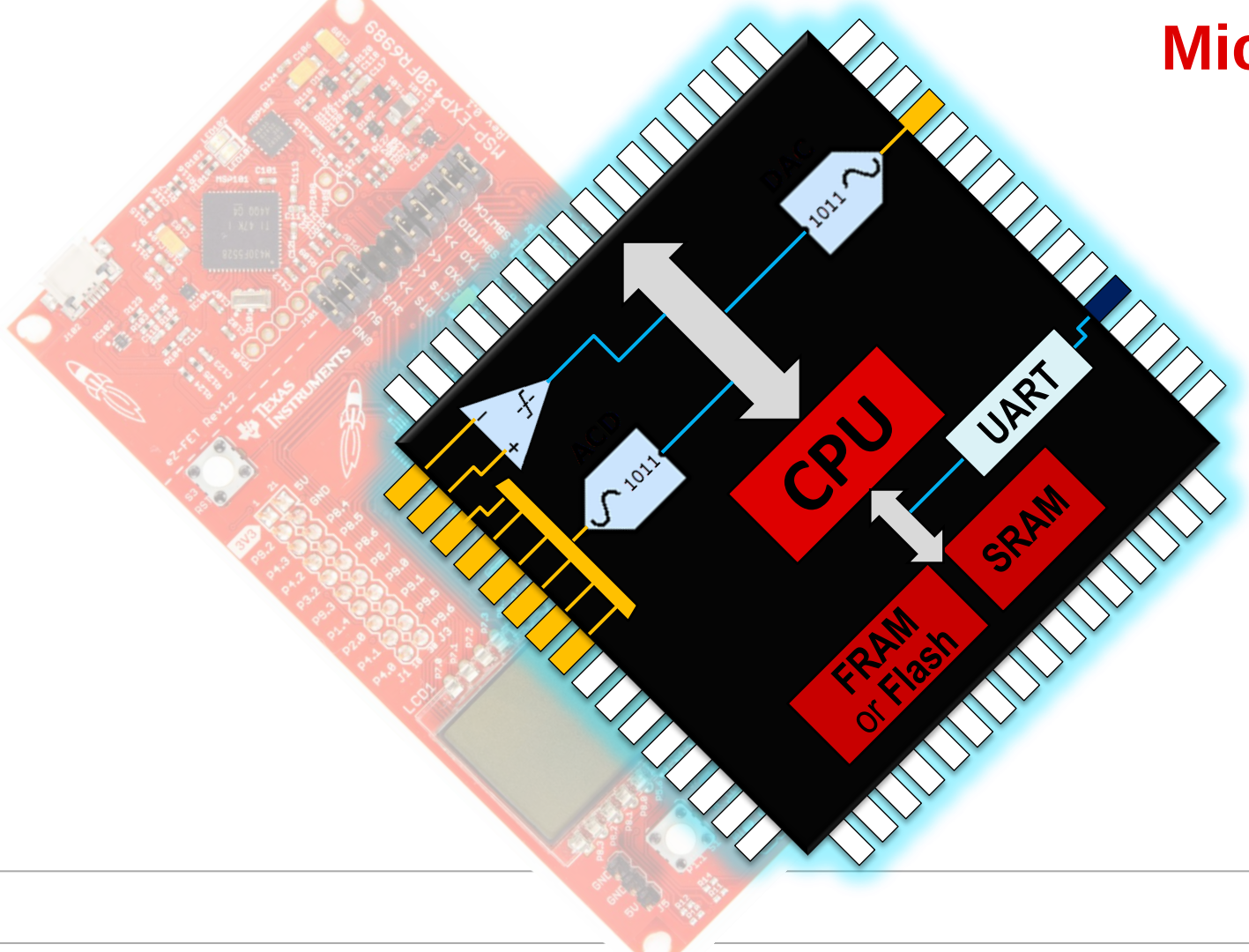
Advantages
- Overall higher performance
- Overall more peripheral capabilities
- More flexible software options and the ability to run Linux OS

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

TI LaunchPad™



Microcontroller



Making MADE simple

With the BeagleBone

Hardware & Software

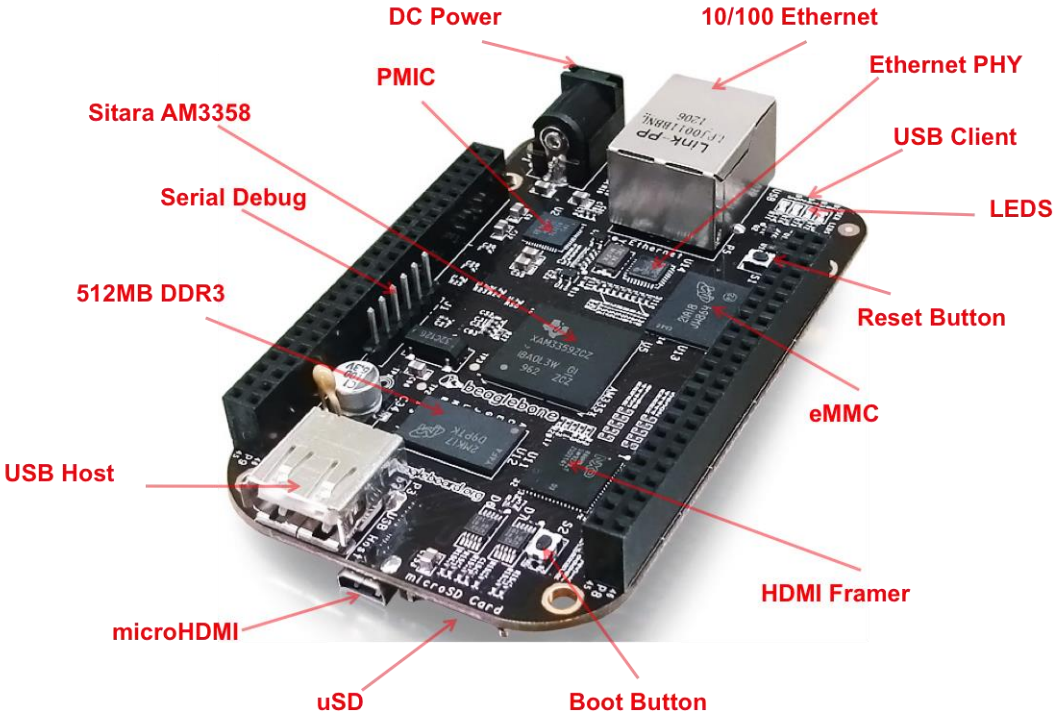
Rapid Prototyping

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



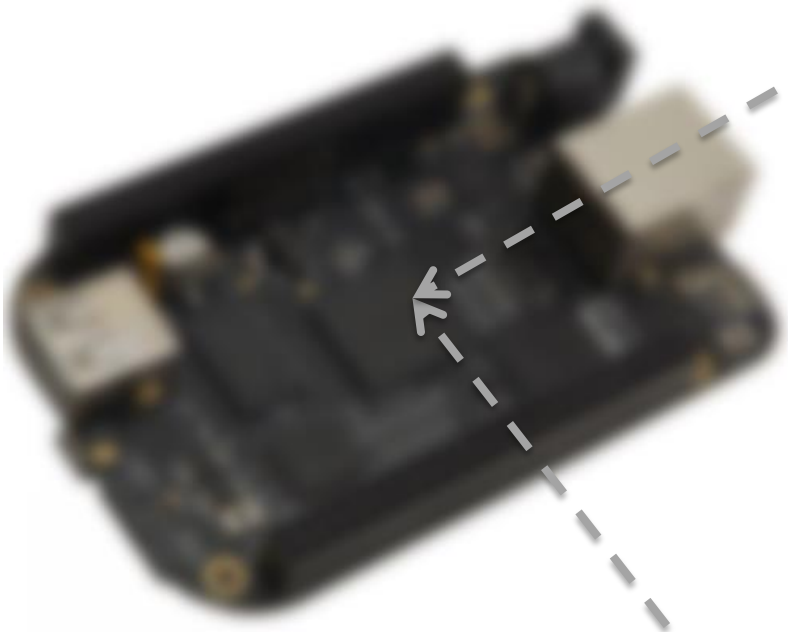
BeagleBone Black

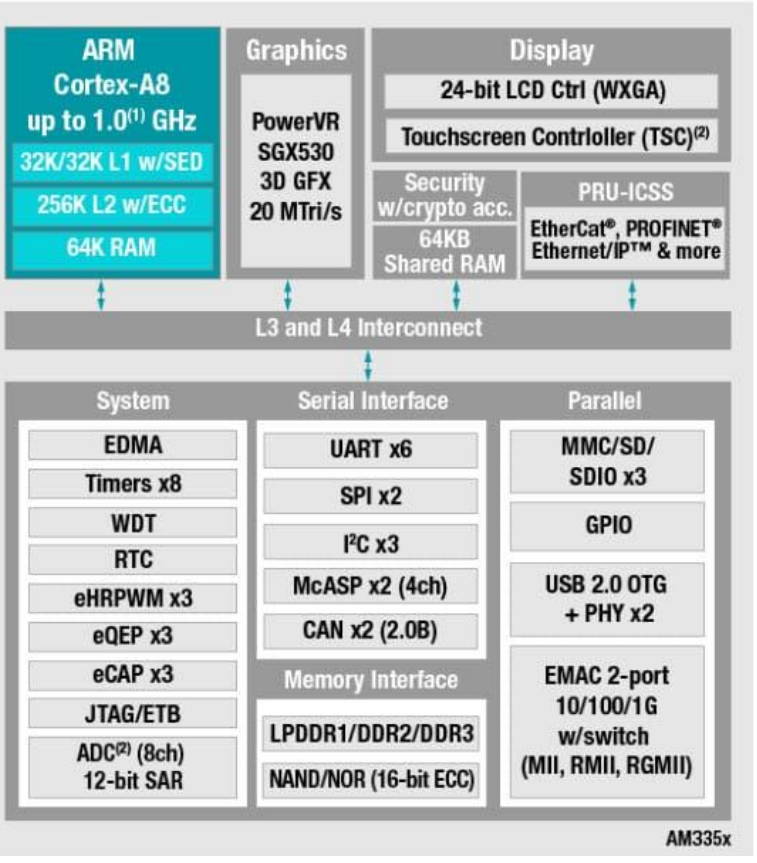
Processor: AM335x 1GHz ARM® Cortex-A8
- 512MB DDR3 RAM
- 4GB 8-bit eMMC on-board flash storage
- 3D graphics accelerator
- NEON floating-point accelerator
- 2x PRU 32-bit microcontrollers

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

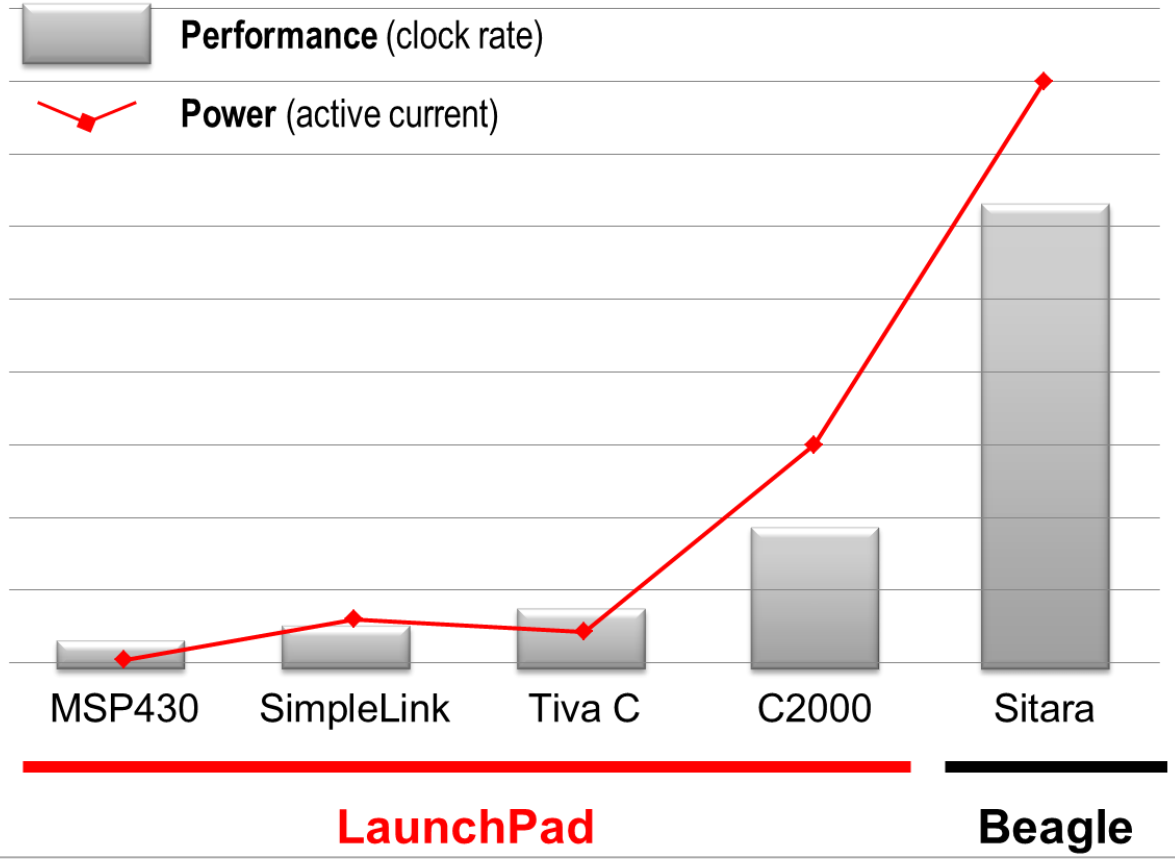
Software Compatibility
- Debian
- Android
- Ubuntu
- Cloud9 IDE on Node.js w/ BoneScript lib
- plus much more

AM3358 Microprocessor





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?

Microcontrollers (MCU)

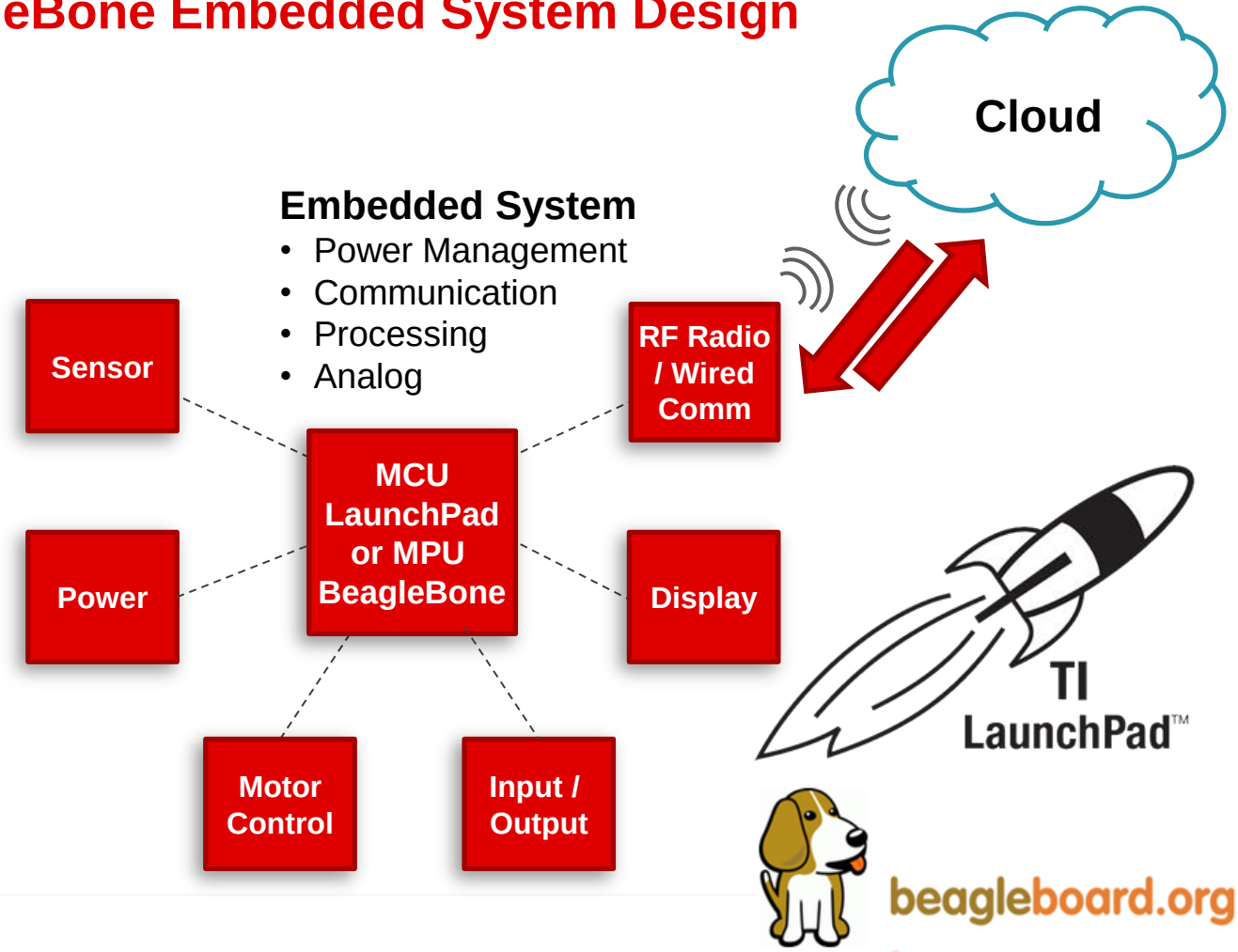
Application (MPU)

MSP	C2000	Tiva C	SimpleLink	Sitara	DSP	Keystone
16-bit/32-bit **Ultra Low Power & Cost**	32-bit **Real-time**	32-bit **Connectivity**	32-bit **Wireless**	32-bit **Linux Android**	16/32-bit **All-around DSP**	32-bit **Massive Performance**
• **MSP430 16-bit RISC** • **MSP432 32-bit ARM**	• **Real-time C28x MCU** • **ARM M3+C28**	**ARM Cortex-M4F**	**ARM Cortex-M3 Cortex-M4**	**ARM Cortex-A8 Cortex-A9 Cortex-15**	**DSP C5000 C6000**	• **C66 + C66** • **A15 + C66** • **A8 + C64** • **ARM9 + C674**
• Low Pwr Mode ▪ 250nA (RTC) ▪ 770nA (LCD) • Smart Analog • EnergyTrace++	• Motor Control • Digital Power • Precision Timers/PWM	• 32-bit Float • Massive I/O • Ethernet (MAC+PHY)	• M4 w/ WiFi • M3 w/ 2.4GHz • M3 w/ Sub-1GHz	• $5 Linux CPU • 3D Graphics • PRU • Industrial I/O	• C5000 Low Power DSP • 32-bit fix/float C6000 DSP	• Fix or Float • Up to 12 cores 4 A15 + 8 C66x • DSP MMAC's: 352,000
Flash: 512K FRAM: 128K	512K Flash	1MB Flash	256K to 3M Flash	L1: 32K x 2 L2: 256K	L1: 32K x 2 L2: 256K	L1: 32K x 2 L2: 1M + 4M
48 MHz	300 MHz	120 MHz	220 MHz	1.35 GHz	800 MHz	1.4 GHz

Rapid Prototype with
TI LaunchPad Ecosystem

Get Started with
BeagleBoards

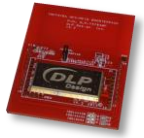
TI LaunchPad & BeagleBone Embedded System Design
a bird's eye view



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

Quick demo recipes

Enable customers to experience TI differentiation

WiFi-enabled Meat Probe “iGrill”. Send a tweet when temp exceeds threshold.	=	MSP430F5529 LaunchPad 	+	WiFi CC3100 BoosterPack 	+	Thermocouple BoosterPack (ADS1118) 
Create a battery-powered WiFi-connected NFC/RFID tag reader	=	CC3200 Wi-Fi LaunchPad 	+	NFC/RFID (TRF7970A) 	+	LiPo Battery BoosterPack (BQ fuel gauge) 
Create a multi-point SubGHz RF wireless temperature sensor network	=	MSP430G2553 LaunchPad 	+	Sub-1GHz (CC110L) 	+	MEMS Temp Sense BoosterPack (TMP006) 
		TI Microcontroller		*TI Wireless*		*TI Analog*

Human Machine Interaction

Does it feel responsive?
Does it feel like magic?

Active Control

- Human physically interacts with machine or system
  - Buttons
  - Touch screen
  - Wired or wireless Controller
- Has to be responsive
  - Quick reactions to input
  - Graphical indicators
  - Light, sound, or haptic indicators

Passive Control

- Machine or system automatically performs tasks
  - Requires minimal Human input
  - Leverages real world sensors or incoming data to make decisions
- Leads to poor user experience if interaction model is broken
  - E.g. Automatic door doesn't open

Which philosophy is
Amazon Echo? Xbox?
Nest Thermostat?

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

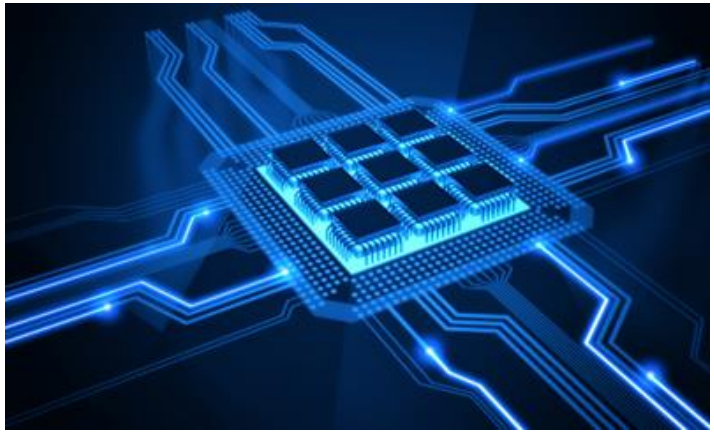
7 Marketing

8 Production

9 Distribution

10 Support

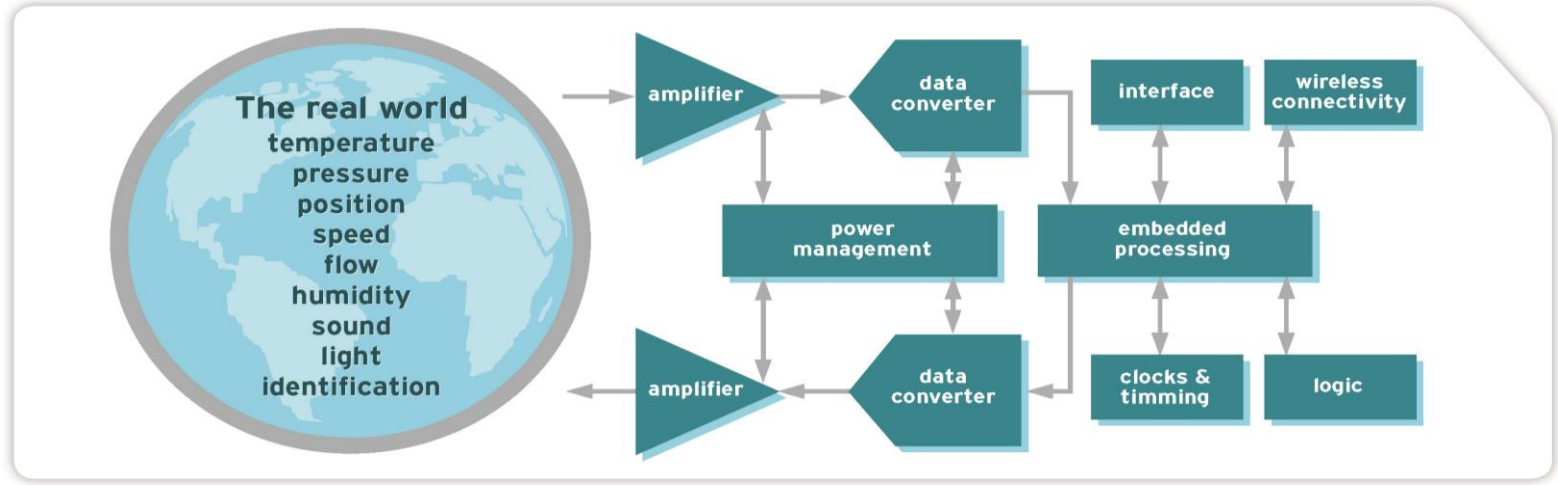
What does TI do?



What we've done
for over 85 years…

We connect electronics customers to devices and technology that will help them build amazing products!

Everyday electronics that use TI technology



TI builds technology that connects the signal chain from the real world to the digital realm

university.ti.com

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





www.ti.com/students

www.ti.com/careers

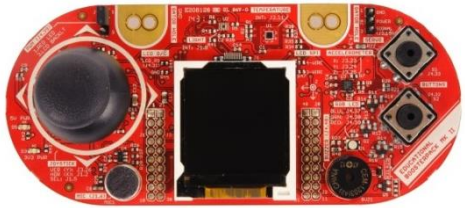
Want to work for TI?

- Internships
- Rotation Programs
- Full-time positions

change the world, love your job.

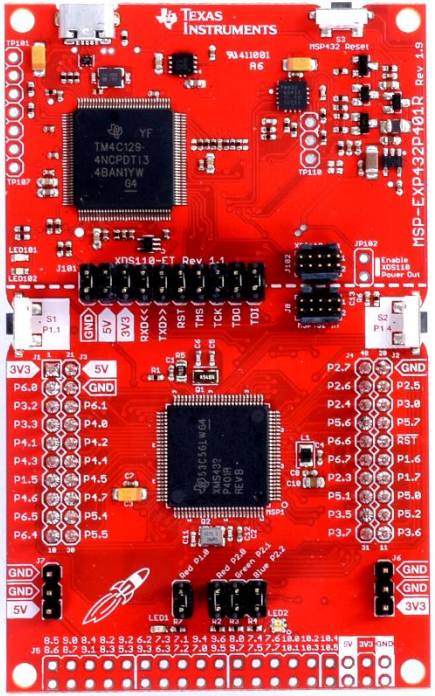
Workshop Materials

- MSP432 LaunchPad (MSP-EXP432P401R)
  - Alternative: MSP-EXP430FR5994, MSP-EXP430F5529LP, EK-TM4C123GXL
- CC3100 Wi-Fi BoosterPack (CC3100BOOST, CC3100MODBOOST)
- Educational BoosterPack MK II (BOOSTXL-EDUMKII)



MSP432 LaunchPad

Introducing the MSP432 processor for Low Power + Performance



$12.99

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

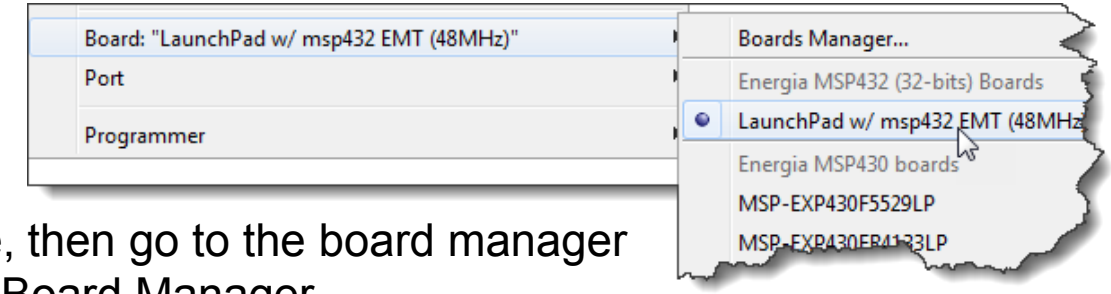
MSP-EXP432P401R

Pre-work

We will break here and get started with the hardware!

Lab: https://goo.gl/**VbymuW**

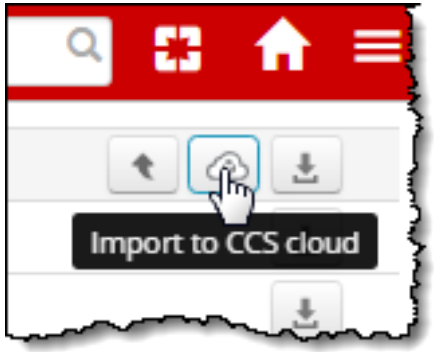
1. Download Energia from www.energia.nu
2. Unzip Energia to “install” it
3. Start Energia and select your LaunchPad “LaunchPad w/ msp432 EMT (48MHz)” from *Tools* menu.



4. If LaunchPad isn’t available, then go to the board manager to install – Tools > Board > Board Manager…
5. Create your free accounts at: my.ti.com and temboo.com

Lab 1 CCS Cloud & MSP432 LaunchPad Out of Box

1. Open TI Resource Explorer Cloud from dev.ti.com Lab: https://goo.gl/**VbymuW**
2. Find the *Out-of-Box Experience* (OOBE) for **MSP-EXP432P401R – Rev 2.x (Red)**
3. Import OOBE into CCS Cloud
   (You will need to log into
   my.ti.com to access the IDE)

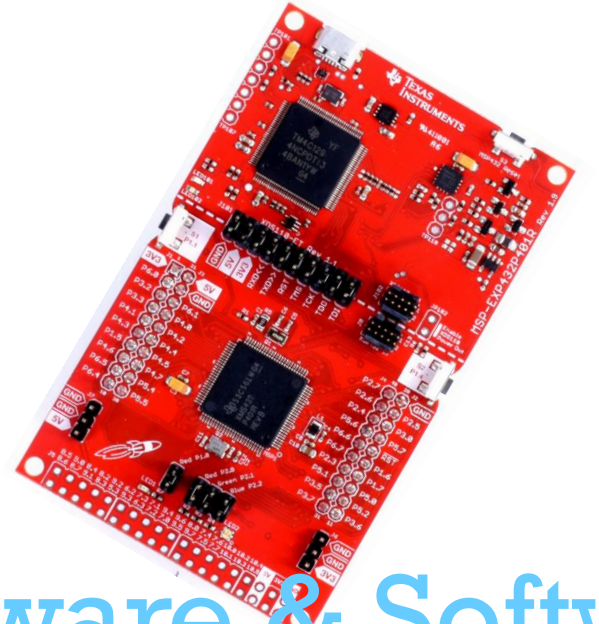


4. Build the OOBE project (using hammer icon)
   and then click on “Run” to download the program to the LaunchPad (see LED blink)
5. Click back over to the TI Resource Explorer window and select:
   Out-of-Box Experience GUI
6. Connect the GUI to the LaunchPad (“Connect” button)

Making MADE simple

With the TI LaunchPad

TI LaunchPad™



Hardware & Software

The LaunchPad Concept

Rapidly Prototype

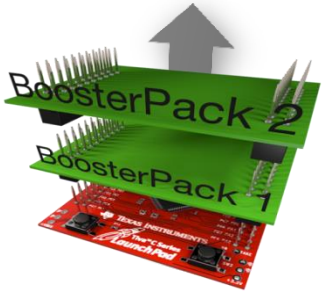
TI Solutions with

Modular Hardware,

Intuitive Software,

& Community Support

This overview shows why TI LaunchPad™ is the highest value microcontroller development tool on the market



Modular & Affordable

Hardware

Energia | IAR SYSTEMS | KEIL Tools by ARM

Intuitive & Flexible

Software

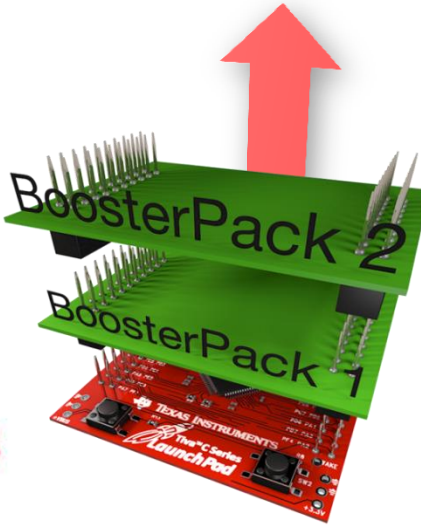
TI E2E™ Community | 43oh.com | hackster.io

Accessible & Engaged

Community Support

Rapid Prototyping

with TI LaunchPads & BoosterPacks



Why TI LaunchPad™ is better?

- Price ($10-$30)
- HW Debugger
- TI online resources
- Focus on Prototype to Production
- Performance and Variety
- Multiple supported SW paths

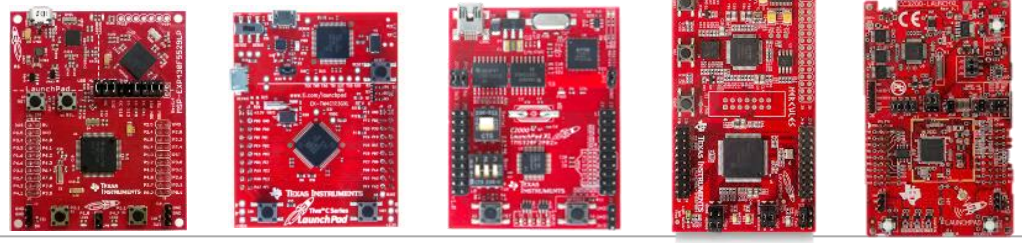
LaunchPad is TI's Common Denominator

Modular hardware enables developers to explore new ideas quickly

TI Wireless: Sub-1GHz, NFC/RFID, Wi-Fi, ZigBee, BLE, Bluetooth

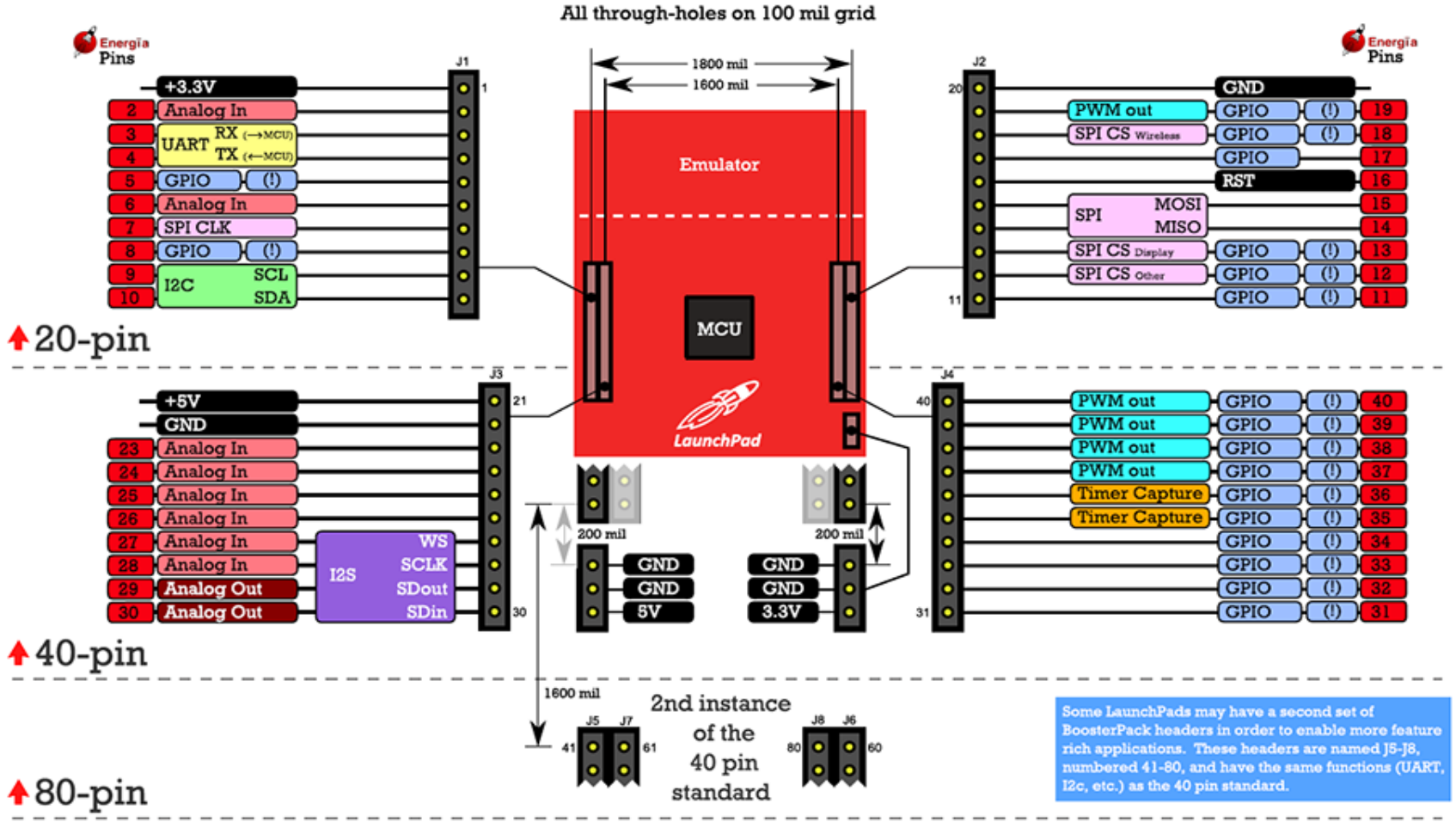
Analog, sensors, displays & more from TI, 3rd parties & Maker community

LaunchPads featuring TI MCUs & BoosterPack interface



MSP430	TM4C	C2000	Hercules	CC3200
(Ultra-Low Power)	(ARM Cortex M4F)	(Real-time Control)	(Safety)	(MCU + WiFi)

BoosterPack pinout standard (ti.com/byob)

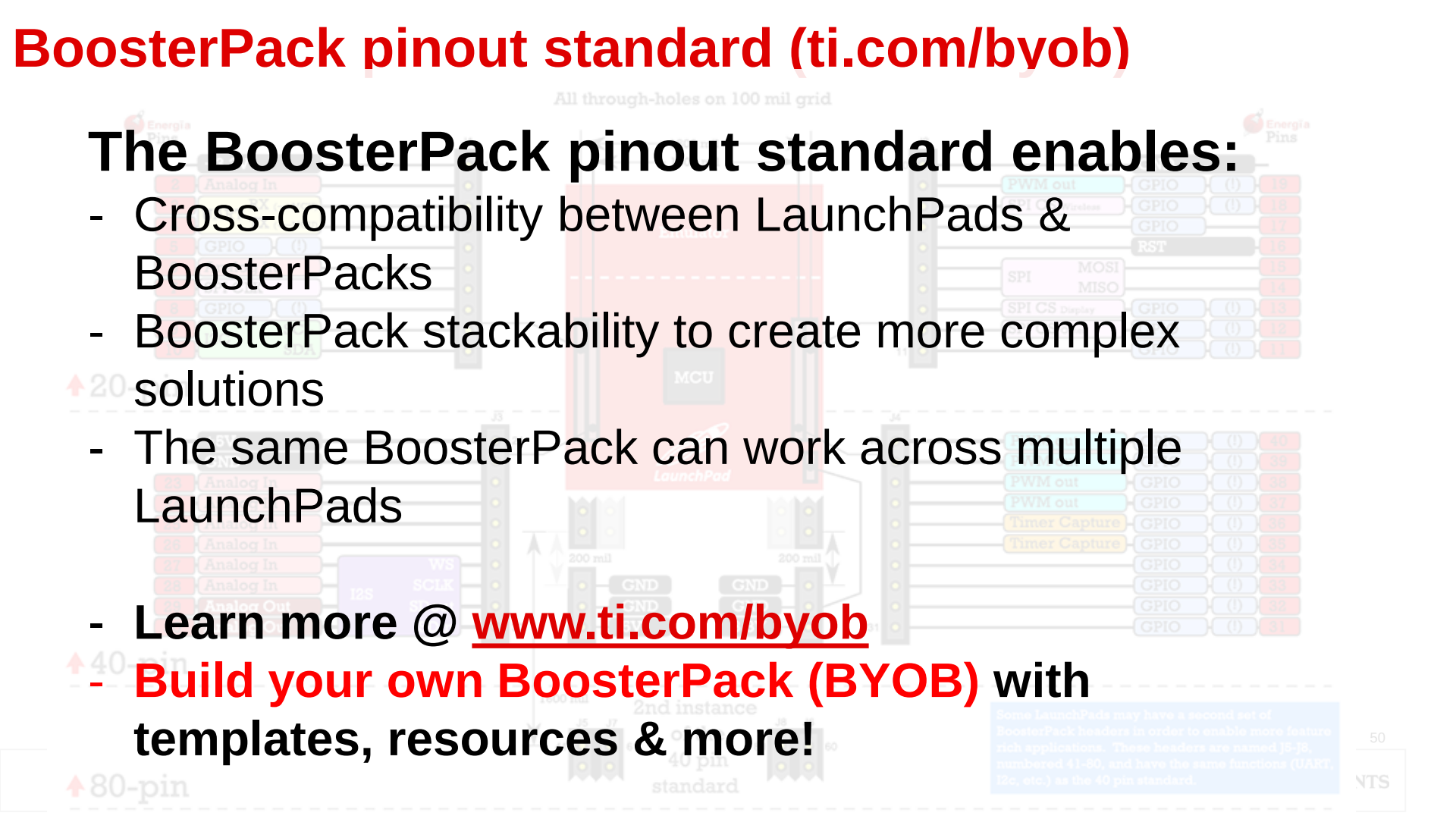


BoosterPack pinout standard (ti.com/byob)

The BoosterPack pinout standard enables:

- Cross-compatibility between LaunchPads & BoosterPacks
- BoosterPack stackability to create more complex solutions
- The same BoosterPack can work across multiple LaunchPads

- **Learn more @ www.ti.com/byob**
- **Build your own BoosterPack (BYOB) with templates, resources & more!**



The LaunchPad Ecosystem

Everything you need to start microcontroller development

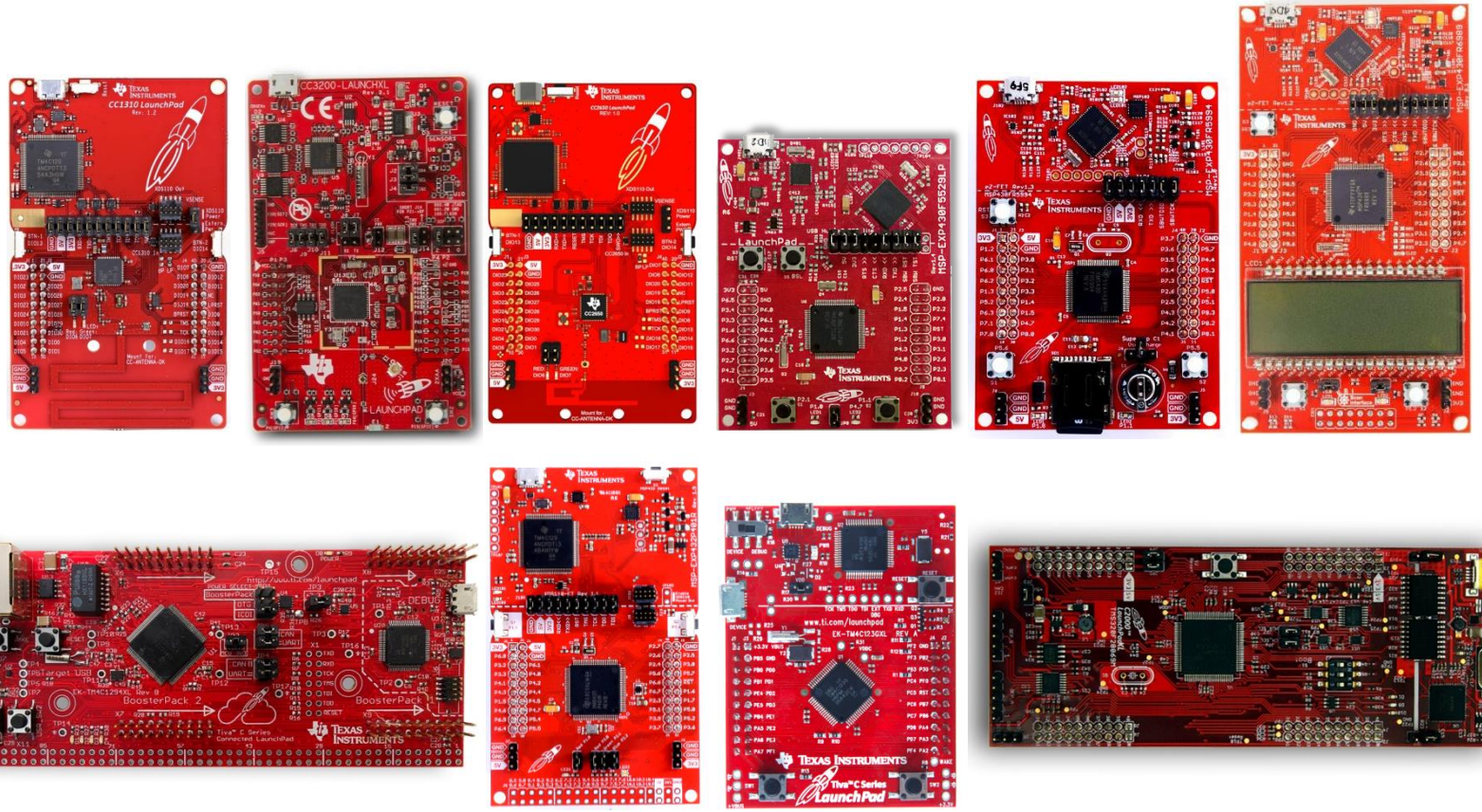
Hardware + Software + Community

Over 20 types of LaunchPads for different application needs!

Open Source Hardware

Works with TI LaunchPad™

The LaunchPad Ecosystem



General & Special Purpose MCUs

Full specs at www.ti.com/launchpad

Texas Instruments

The FRAM Advantage: At a Glance

www.ti.com/fram

Write More

Collect more data over time with 100x faster writes than Flash
Extend product life and ditch the EEPROM with infinite endurance

Decrease Power

Extend battery life with 250x lower energy writes vs Flash
Minimize wireless system power by shortening memory update times

Unified Memory

Simple to use with unmatched flexibility
Migration guides, code examples and application notes available!

The LaunchPad Ecosystem

Everything you need to start microcontroller development

Hardware + Software + Community

Many orderable BoosterPacks and open source designs available!

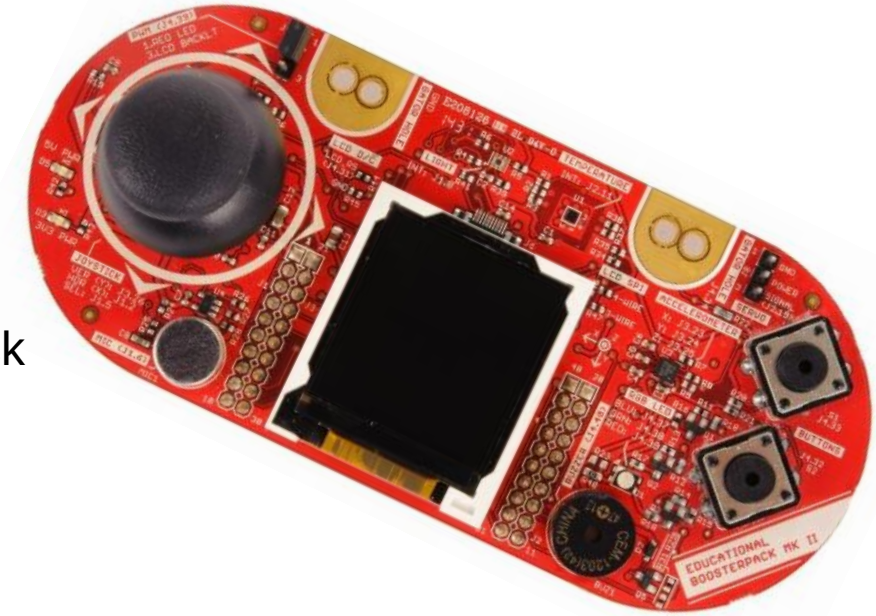
Open Source Hardware

Works with TI LaunchPad™

Educational BoosterPack Mk II

Create new projects with this useful add on!

- Manufacturer: Texas Instruments
- Part #: BOOSTXL-EDUMKII
- MSRP: $29.99
- Feature List:
  - 128x128 pixel color TFT display
  - 3 axis accelerometer, 2-axis joystick
  - TI TMP006 temp sensor
  - TI OPT3001 Light Sensor
  - Microphone, Buzzer, RGB LED
  - Servo connector, Push buttons

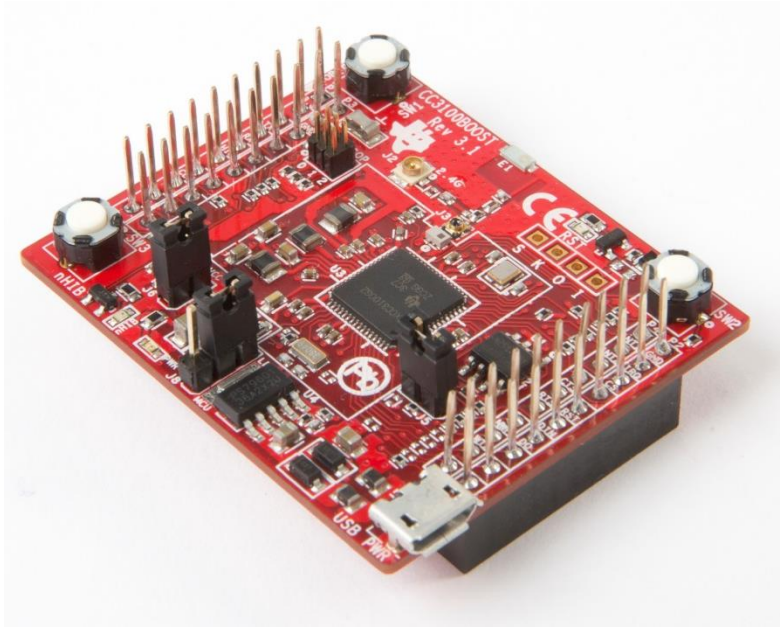


- Learn more @ www.ti.com/boosterpacks

CC3100 SimpleLink Wi-Fi BoosterPack

LaunchPad in the cloud

- Manufacturer: Texas Instruments
- Part #: CC3100BOOST
- MSRP: $19.99
- Feature List:
  - CC3100 WiFi Transceiver
    - IEEE 802.11 b/g/n
    - Embedded IPv4 TCP/IP stack
  - Small form factor
  - Complete software solutions & features
    TI's unique SimpleLink technology



- Learn more @ www.ti.com/boosterpacks

Sharp ® Memory LCD BoosterPack

Add capacitive touch and display capabilities with 1 board!

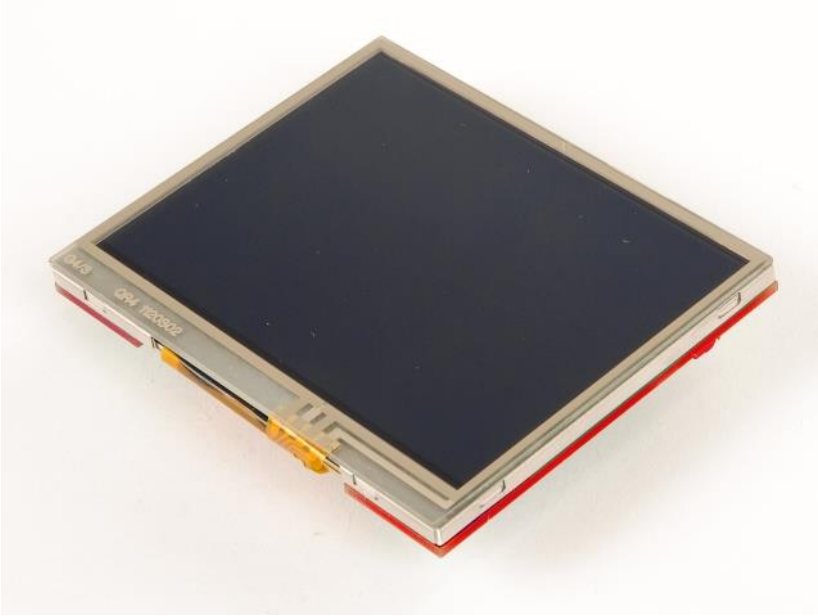
- Manufacturer: Texas Instruments
- Part #: 430BOOST-SHARP96
- MSRP: $19.99
- Feature List:
  - Sharp LS013B4DN04 Memory LCD
    - 1.3" inch screen offering 96 x 96 pixels
    - Ultra-Low-Power consumption
    - Display controlled serially using SPI
  - Software enabled by TI's software libraries
    - Graphics Library Support
    - Capacitive Touch Library Support

- Learn more @ www.ti.com/boosterpacks

Kentec QVGA TFT LCD BoosterPack

Add resistive touch and display capabilities with 1 board!

- Manufacturer: Texas Instruments
- Part #: BOOSTXL-K350QVG-S1
- MSRP: $24.99
- Feature List:
  - Kentec TFT LCD (P/N: K350QVG-V2-F)
    - 3.5 inch QVGA (320x240 resolution)
    - SPI Interface
    - 4-wire resistive touch screen
    - White LED Backlight + driver circuit
  - Complies with the BoosterPack standard for use with 20 and 40 pin LaunchPads



- Learn more @ www.ti.com/boosterpacks

Infrared (IR) BoosterPack Plug-in Module

Start developing remote control applications today!

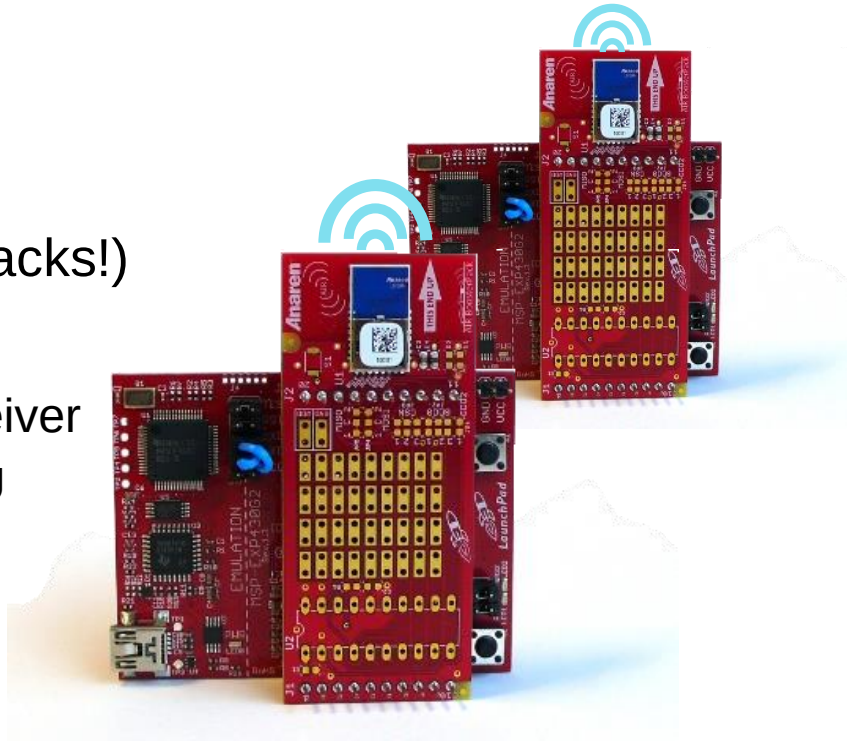
- Manufacturer: TI
- Part #: Boost-IR
- MSRP: $20
- Feature List:
  - IR LED transmitter
  - IR receiver + demodulator
  - 4x4 membrane keypad
  - 20-pin BoosterPack standard for use with any LaunchPad
  - Compatibility with different IR signal generation methods

- Learn more @ www.ti.com/boosterpacks

CC110L Sub-1GHz RF BoosterPack (433, 868, 915MHz)

Start developing wireless applications immediately!

- Manufacturer: Anaren / TI
- Part #: 430BOOST-CC110L
- MSRP: $19.99 (includes 2 RF BoosterPacks!)
- Feature List:
  - Based on TI CC110L SubGHz RF transceiver
  - SPI interface between RF module & MCU
  - FCC/IC certified module
  - Includes AIR BoosterPack Stack software
  - Enabling Star network & p2p topologies
  - Includes pre-programmed MSP devices

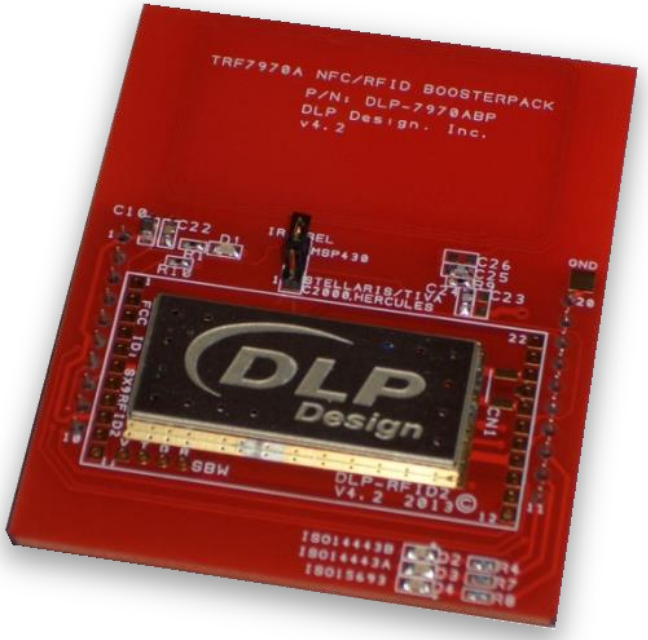


- Learn more @ www.ti.com/boosterpacks

TRF7970A NFC BoosterPack

Start developing with Near-Field Communication & RFID!

- Manufacturer: DLP Design
- Part #: DLP-7970ABP
- MSRP: $25
- Feature List:
  - 13.56MHz HF RFID Reader/Writer
  - Supported by the NFCLink software library
  - Supports various modes:
    - RFID/NFC Reader
    - NFC Peer
    - Card-Emulation Mode
    - FCC/IC approved design

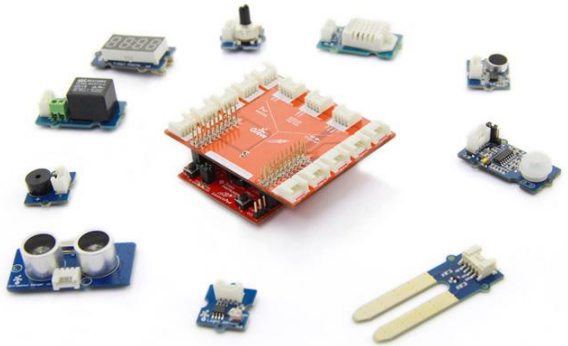


- Learn more @ www.ti.com/boosterpacks

Companion Kits: Seeedstudio

Must have LaunchPad accessories!

- Sidekick Basic Kit for TI LaunchPad™
  - **MSRP: $29.99**
  - Feature List:
    - 100+ commonly used breadboard components
    - 10+ example circuits and code
  - Learn more @ www.energia.nu/sidekick
- Grove Starter Kit for TI LaunchPad™
  - **MSRP: $59.00**
  - Feature List:
    - 10 sensor modules with example code
  - Learn more @ www.energia.nu/grovekit



Sidekick Basic Kit for TI LaunchPad™

Manufactured by Seeedstudio

Part List

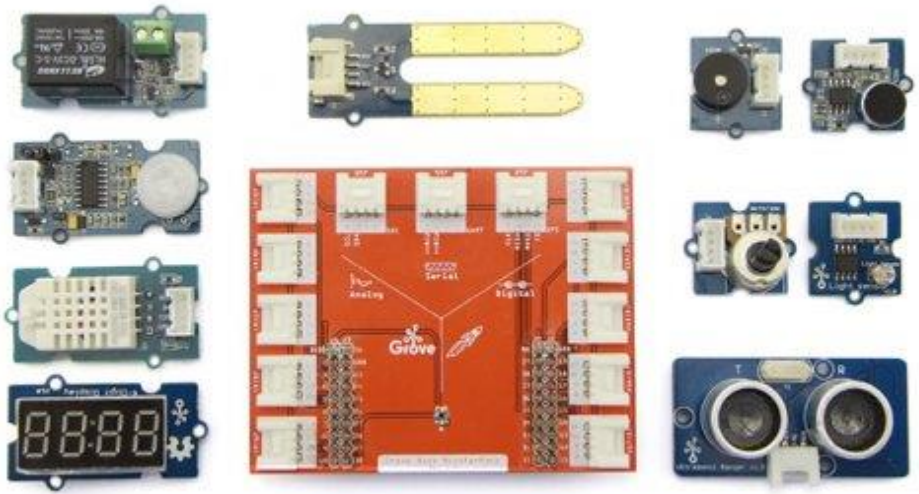
1x Breadboard
1x Breadboard Adapter BoosterPack
5x Green LED
5x Red LED
1x RGB Common Anode LED
10x Ceramic Capacitor 10nF
10x Ceramic Capacitor 100nF
5x Aluminum Capacitor 100uF
10x Resistor 330 ohm
10x Resistor 1K ohm
10x Resistor 10K ohm
1x Tilt Switch
1x Thermistor
1x Photoresistor (photocell)
1x Diode
1x Piezo Buzzer
5x Button
5x Switch
2x Potentiometer with knob
1x Small DC Motor
1x 7 Segment Single Digit Display
1x 8-bit Shift Register (SN74HC595N)
2x NPN Transistor (2N2222)
1x Analog Temperature Sensor (LM19CIZ/NOPB)
5x Jumper Wire Long
20x Jumper Wire Short
1x Sidekick Manual

Learning Over 100+ electronic components to build basic and complex circuits
Compatibility Useful with any TI LaunchPad or other digital / analog development kit
Completeness All the popular accessories for beginners to develop with microcontrollers

Learn more @ www.energia.nu/sidekick

Grove Starter Kit for TI LaunchPad™

Manufactured by Seeedstudio



Part List

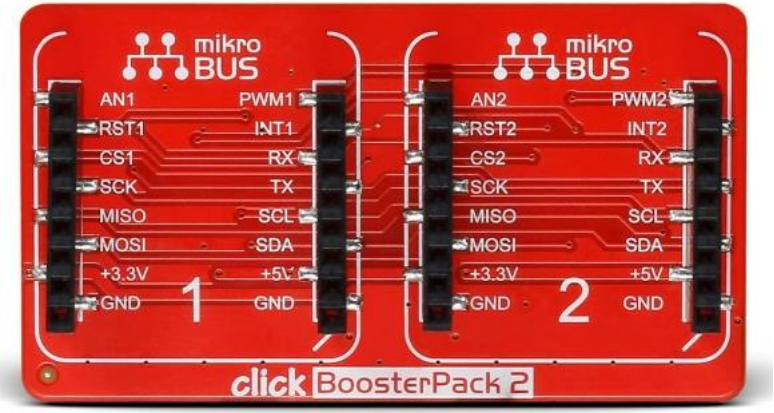
1x Grove Base BoosterPack
1x Grove Buzzer (Digital)
1x Grove Relay (Digital)
1x Grove 4-Digit-Display (Digital)
1x Grove Ultrasonic Range Sensor (Digital)
1x Grove PIR Motion Sensor (Digital)
1x Grove Light Sensor (Analog)
1x Grove Sound Sensor (Analog)
1x Grove Moisture Sensor (Analog)
1x Grove Temperature Humidity Sensor (Analog)
1x Grove Rotary Angle Sensor (Analog)
Grove Cables
Starter Guide Manual

Learning 10 different grove modules to build basic and complex systems
Compatibility Useful with any TI LaunchPad or other digital / analog development kit
Completeness All the popular accessories for beginners to develop with microcontrollers

Learn more @ www.energia.nu/grovekit

Click BoosterPack 2

Manufactured by MikroElektronika



Click BoosterPack 2 has two mikroBUS sockets onboard, for simple and easy integration of MikroElektronika click boards with a TI LaunchPad™.

Add new functionality to your LaunchPad within minutes. More than 250 click boards available from audio and voice to power management and wireless connectivity clicks.

All MikroElektronika compilers come with code examples, so you'll have a great base to start with.

Learning Click boards to build basic and complex systems
Compatibility Useful with any TI LaunchPad or other digital / analog development kit
Completeness All the popular accessories for beginners to develop with microcontrollers

Learn more @ www.energia.nu/click

LAUNCH YOUR DESIGN

IoT made easy

By 2020 there will be 50 billion IoT devices – Get yours today!

The SensorTag allows quick and easy prototyping of IoT devices. It simply works – Connect your sensor solution to the Cloud in three minutes. Get started with Wi-Fi®, *Bluetooth®* smart, or 6LoWPAN development for only U.S. $29.

www.ti.com/sensortag

TI SensorTag apps

Download the SensorTag apps for iOS or Android™ to connect to your SensorTag and explore the sensors in a few minutes. The SensorTag app is used to configure the sensors and set up the connection to the cloud interface.

Download on the App Store

GET IT ON Google play

Breakthrough Sensor Technology

www.ti.com/sensing

ULTRA SONIC SENSING

Inductive Sensing

Analog Temperature Sensors

CAPACITIVE Sensing

humidity

cap-to-dig (FDC)

Low Voltage, Low Power BUILDING BLOCKS

Sensor AFE | NANO Timer

Sensing Innovation

Delivering better solutions today and new possibilities for tomorrow

- Biosensing
- Humidity
- Position / motion
- Chemical
- Light
- Pressure
- Current / power
- Material composition
- Proximity
- Gas
- Occupancy
- Temperature

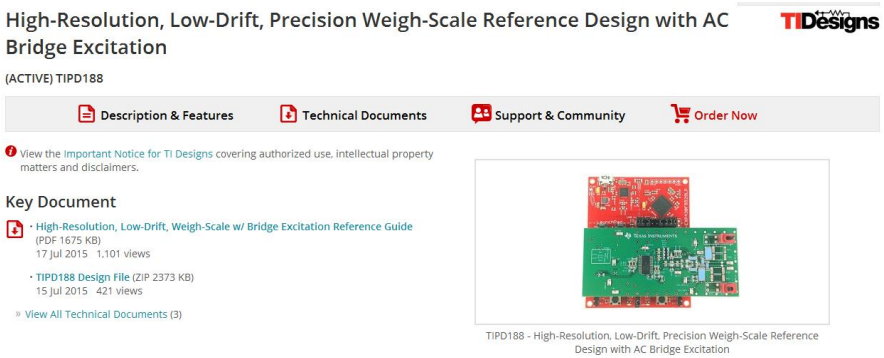
TIDesigns

www.ti.com/tidesigns

Reference Design Library

Jump start system design and speed time to market

- Comprehensive designs include schematics or block diagrams, BOMs, design files and test reports
- Created by experts with deep system and product knowledge
- Spans TI's portfolio of analog, embedded processor and connectivity products
- Supports a broad range of applications including industrial, automotive, consumer, medical and more



Energīa

We all can CODE!

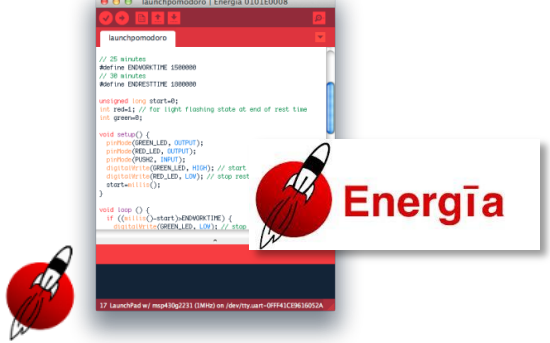
For FREE!

Intuitive & flexible software development paths speed up firmware creation for rapid prototyping

Rapid Prototyping

Energia

Light-weight, Community-driven, Wiring-based IDE for quick evaluation

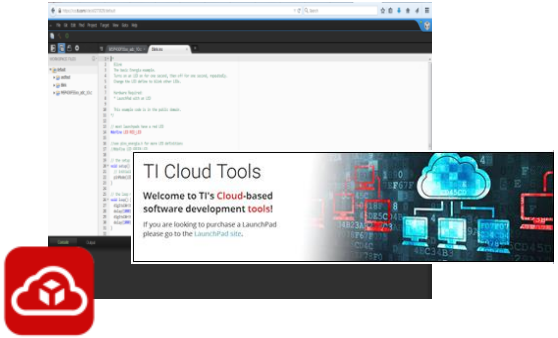


- **Intuitive coding environment**
- **Simplified interface**
- **Highly-abstracted API framework**
- **Open Source & Community-driven**

Evaluation

CCS Cloud

Browser-based code editor and Resource Explorer



- **Cross Platform**
- **Fast start & no installation**
- **Use Energia, TI-RTOS & more**
- **Resource Explorer integration**

Advanced

CCS & Pro Tools

Fully-capable dev environments from TI & third parties

- **Full debug capability & more**
- **Import Energia projects**
- **Access to third party compilers, features, and apps**

LaunchPad Software Tools - providing multiple points of entry

Texas Instruments

Energia Abstraction

Fly high above the bits & bytes

{ Boils it down to 1 line of code }

Abstraction

Energia

Highly-abstracted functional APIs

```
int sensorRead = analogRead(A0);  // Read analog channel A0
```

Peripheral Driver Library

Low level abstraction layer for populating peripheral registers

```
int analogRead(int pin)
{
  ROM_SysCtlPeripheralEnable(SYSCTL_PERIPH_ADC0);
  ROM_GPIOPinTypeADC((uint32_t) portBASERegister(port), digitalPinToBitMask(pin));
  ROM_ADCSequenceConfigure(ADC0_BASE, 3, ADC_TRIGGER_PROCESSOR, 0);
  ROM_ADCSequenceStepConfigure(ADC0_BASE, 3, 0, channel | ADC_CTL_IE | ADC_CTL_END);
  ROM_ADCSequenceEnable(ADC0_BASE, 3);
  ROM_ADCIntClear(ADC0_BASE, 3);
  ROM_ADCProcessorTrigger(ADC0_BASE, 3);
  while(!ROM_ADCIntStatus(ADC0_BASE, 3, false)) {
  }
  ROM_ADCIntClear(ADC0_BASE, 3);
  ROM_ADCSequenceDataGet(ADC0_BASE, 3, (unsigned long*) value);
  return value[0];
}
```

Low-level C Code

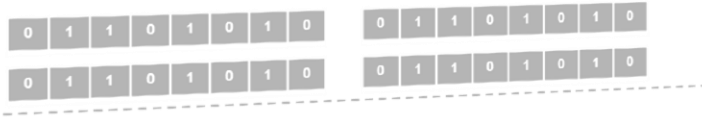
Each TI microcontroller peripheral is defined by a collection of registers

GPIO Registers:

- GPIODIR
- GPIOAFSEL
- GPIODR2R
- GPIOAMSEL

ADC Registers:

- ADCEMUX
- ADCSSPRI
- ADCSSMUX0
- ADCSSCTL0
- ADCSSOP0
- ADCACTSS
- ADCISC
- ADCPSSI
- ADCSSFSTAT0
- ADCSSFIFO0

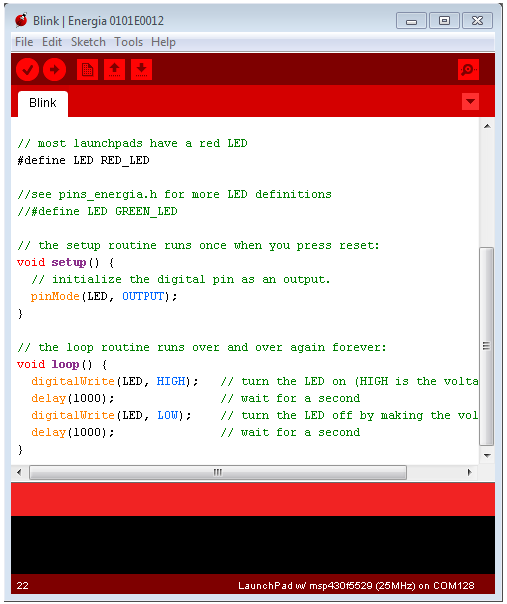


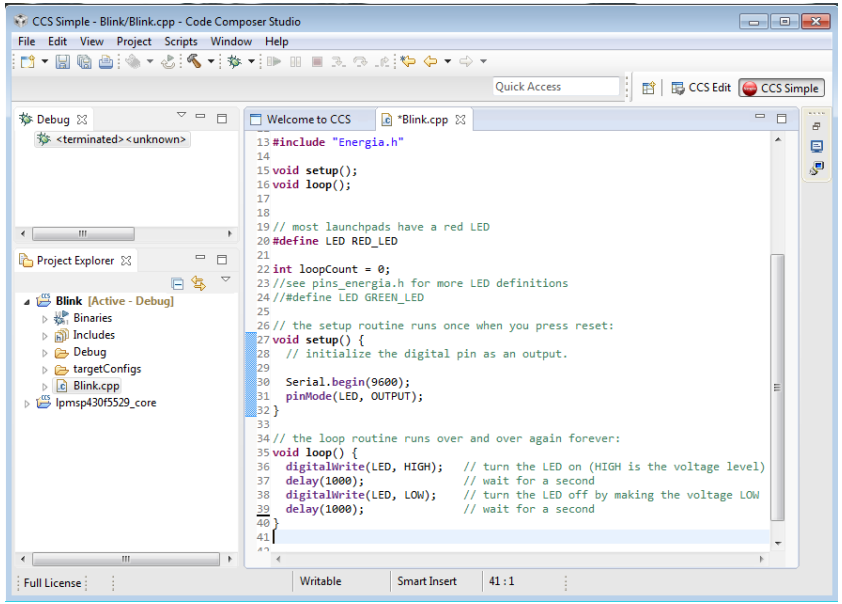
TI Microcontroller

Control MCU hardware & peripherals

Energia Import in CCSv6+ and CCS Cloud

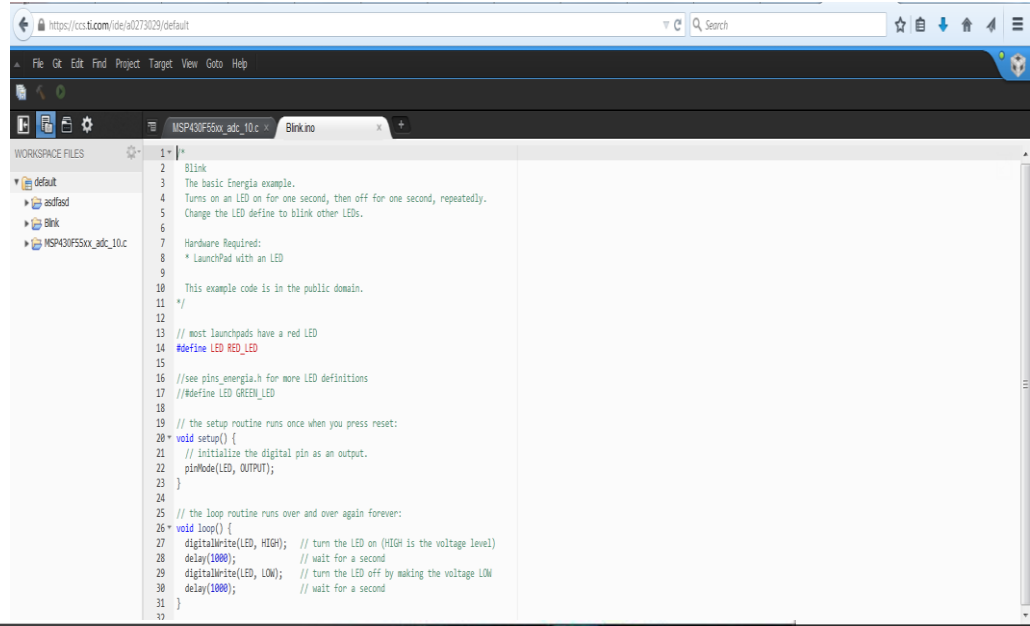
- Import an Energia sketch into Code Composer Studio v6 & pick up right where you left off.
- CCS introduces full debug capability & other professional features to further optimize your design.
- Modularize your code & leverage Energia APIs & libraries within CCS
- Enable “hybrid” projects that leverage low-level C, assembly & even abstracted Energia APIs enabling a developer maximum flexibility during code development.





Code Composer Studio Cloud

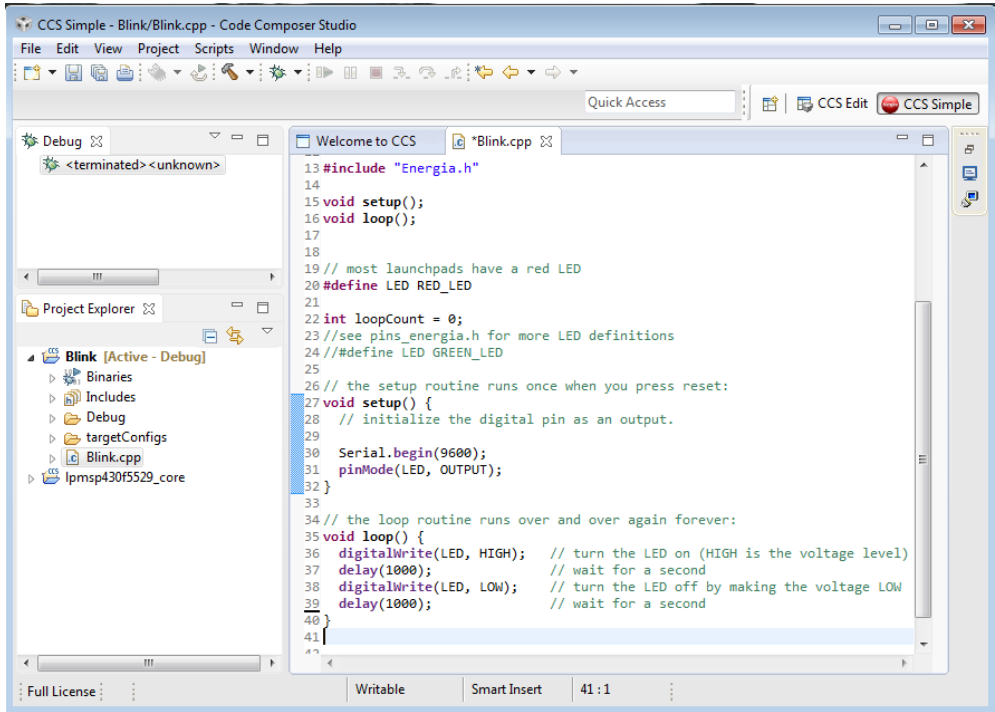
- **Browser based code editing tool to get your started quickly**
- **Access Resource Explorer to get the latest code examples, design files, and more.**
- **Cross Platform and allows you to upload firmware using TI Cloud Agent + Browser Extension**
- **Extended Debugging capability**



http://dev.ti.com

Code Composer Studio 7

- Eclipse-based IDE for professional firmware developers that supports all TI processors
- CCS App Center allows you to stay current with the latest plugins and updates
- Use tools such as Energy Trace, GRACE, and more to optimize your workflow and application
- Resource Explorer exposes thousands of code examples and technical materials



Download CCS Desktop at ti.com/ccstudio

Texas Instruments

TI-RTOS and FreeRTOS

- The use of Real-Time Operating Systems (RTOS) is getting more common for IoT firmware deployment
- A simple operating system can schedule tasks and do a variety of functions
- RTOS helps with maximizing power efficiency, implementing security, managing wireless communication, and other complex functions
- Improves software quality and portability
- Many free and open source options available today with TI RTOS and FreeRTOS recommended for TI devices

MSP Software Development

Pick a Coding Style…

Energia

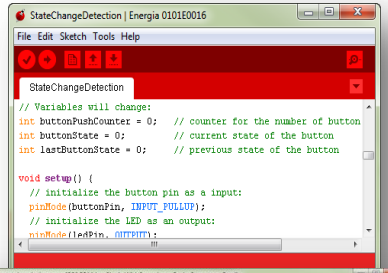
Driver Library
C coding / RTOS

Register-Based
C coding

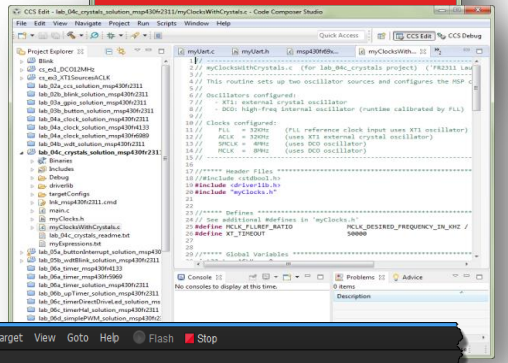
Low-Level
Hex programming

Choose a Tool…

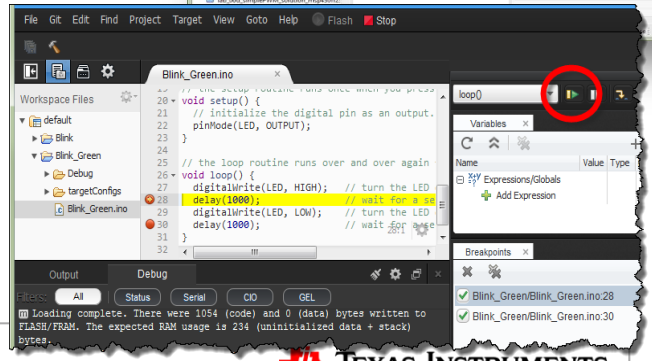
Energia IDE



CCS Desktop



CCS Cloud



Accessible & engaged community support gives new and experienced developers information to solve issues quickly

www.43oh.com

TI E2E™ Community

e2e.ti.com

hackster.io

www.hackster.io/ti-launchpad

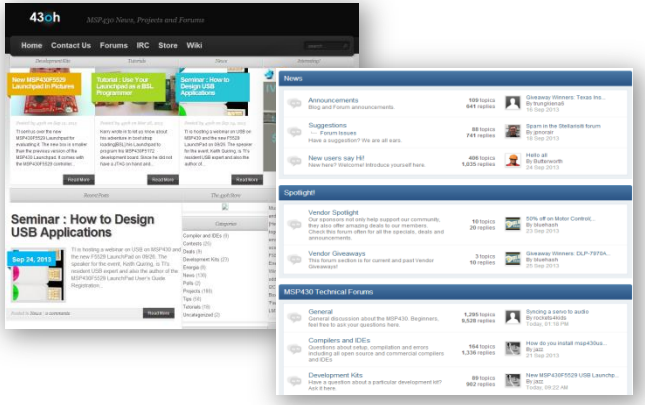
LAUNCH YOUR DESIGN

ti.com/lyd

The Community

Get support from TI & the online community!

- http://e2e.ti.com
- Supported 24/7 by TI engineers!
- Over 1 million Q&As available on-demand
- Get support on TI's complete portfolio from microcontrollers to analog to connectivity

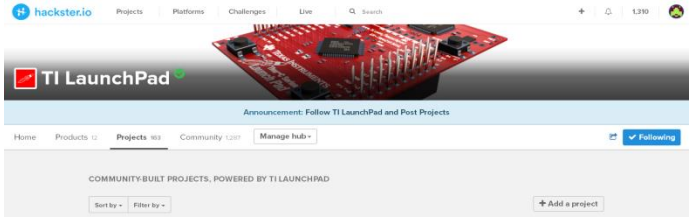


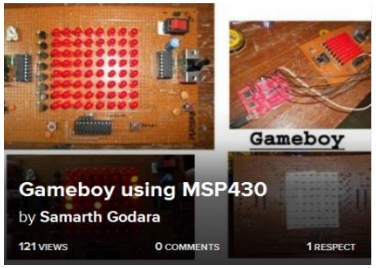
- www.43oh.com
- ~20,000 active members
- ~60 forum users online at any given time!
- Active & friendly online community & blog for the LaunchPad ecosystem!
- Home to much of the Energia community

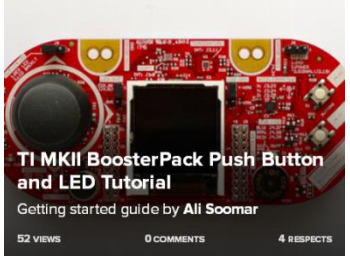
hackster.io - Share your electronics projects!

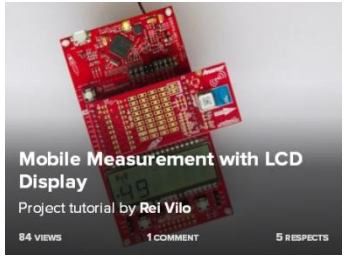
www.hackster.io/ti-launchpad

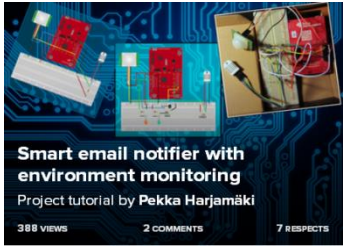
www.hackster.io/texasinstruments

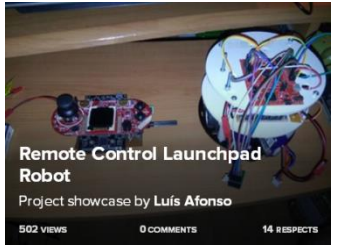






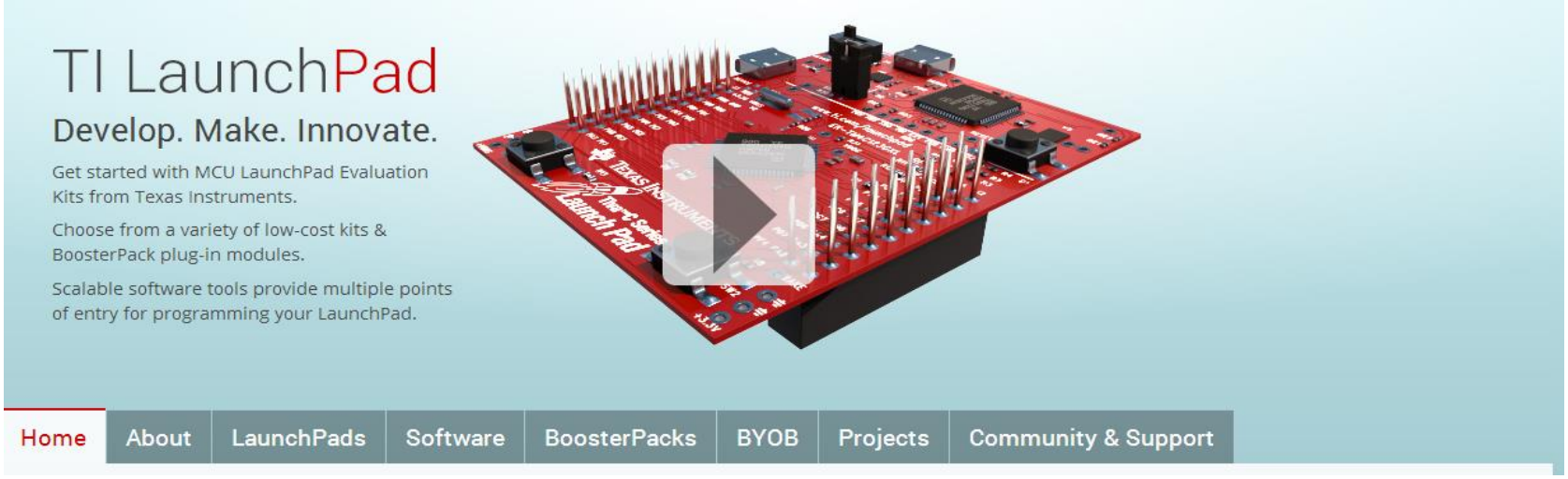






Where to go next: www.ti.com/launchpad

TI's official LaunchPad portal



Get specs, order hardware, find software tools, and download datasheets and design files

TI E2E™ Community

Sign up for a myTI account!

myTI

TI LaunchPad™ provides an ecosystem of hardware and software products, and community online resources that provides incredible value for rapid prototyping

Making MADE simple

With the TI LaunchPad

Questions?

www.ti.com/launchpad

Texas Instruments

Lab 2 Energia Introduction with Blink and the EduBP

We will break here and get started with the hardware! Lab: https://goo.gl/**VbymuW**

- Step 1: Install Energia IDE from www.energia.nu
  - Alternative use the CCS Cloud IDE from dev.ti.com
- Step 2: Install any OS specific drivers associated with your TI LaunchPad
- Step 3: Plug in your TI LaunchPad board with the included USB cable
- Step 4: Open Energia IDE and adjust your preferences as necessary
- Step 5: Open basic test example - click File > Examples > Basics > Blink
- Step 6: Select your LaunchPad board or install board package – click Tools > Board
  - If LaunchPad is not MSP430 then go to the board manager to install – Tools > Board > Board Manager… and install your package from the menu. Select your specific LaunchPad from the list after installation.

Lab 2 Energia Introduction with Blink and the EduBP

- Step 7: Click the upload button and make sure your Red LED is blinking
  - If not or you get errors during compile, your system is not properly setup and you will not be able to proceed, so seek assistance from instructor or neighbors
  - If yes, then you can now test the Educational BoosterPack
- Step 8: Open EDUBP example mentioned in the lab details
- Step 9: Click the upload button. You can use the joystick and see results on the LCD. Test it out!
- Step 10: There are additional examples for the BoosterPack that you can try if you have extra time, however we will be moving on quickly. They are documented at www.energia.nu/edumkii
- Examples are located in the IDE, click File > Examples > EducationalBP_MKII

Lab 3 Wi-Fi IoT with Temboo and Twitter

We will break here to get to the heart of the lab portion!

- Step 1: Navigate to the lab details or refer to handout
- Step 2: Create an account on www.temboo.com
- Step 3: Follow the lab details, no rude twitter shenanigans please
- Step 4: Raise your hand if you need assistance

Lab: https://goo.gl/**VbymuW**

SSID: **TEXINS3**

PASS: **launchpad**

Wi-Fi Connection for your LaunchPad, not your laptop, thanks!

Lab 4 More Wi-Fi IoT with Temboo

We will break here to get to the bonus lab portion!

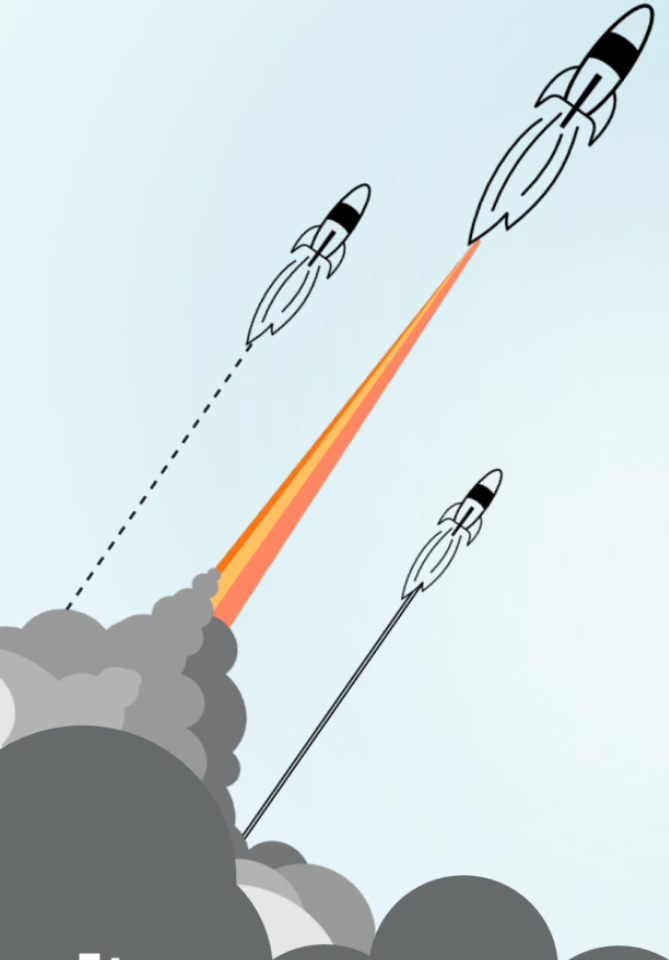
- Step 1: Navigate to the lab details or refer to handout
- Step 2: Follow the lab details
- Step 3: Raise your hand if you need assistance

Lab: https://goo.gl/**VbymuW**

SSID: **TEXINS3**

PASS: **launchpad**

Wi-Fi Connection for your LaunchPad, not your laptop, thanks!



Thank you!

www.ti.com/launchpad

Texas Instruments