TI-RSLK *MAX*

Texas Instruments Robotics System Learning Kit

User guide

TEXAS INSTRUMENTS

Robot Systems Learning Kit (TI-RSLK) User Guide

Introduction

The TI-RSLK (robotics system learning kit) 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 newest addition to the TI-RSLK 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 up and running in less than 15 minutes. The new kit includes the industry-leading SimpleLink MSP432P401R LaunchPad™ Development Kit, easy-to-connect sensors, and a versatile chassis board that turns the robot into a mobile learning platform.

The TI-RSLK MAX – The Solderless Maze Edition curriculum comes with 20 learning modules that have been upgraded to support the new kit. New and supplemental content has been added to this comprehensive curriculum. Through advanced modules, wireless communications and Internet of Things capabilities can be added to the TI-RSLK MAX to control the robot or even establish robot-to robot communication. You can monitor the robot's environment with sensors and learn to send data to the cloud. Encourage team work and collaboration with the newly added challenges and have your robots communicate with each other through audio commands.
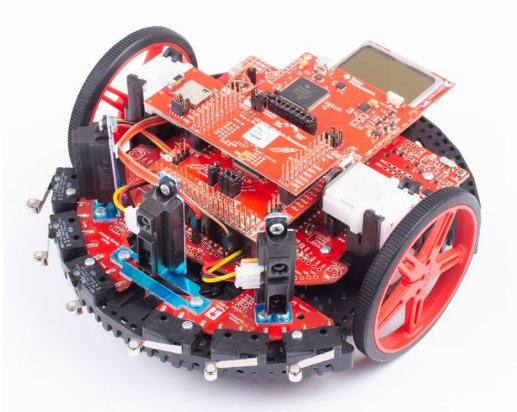

Figure 1. TI-RSLK MAX robot with optional BLE and LCD.

Each module is complete with lecture videos and slides, lab documentation and active lab demonstrations. Included to further enhance the learning experience are quizzes and classroom activities.

TI-RSLK MAX kit box contents:

1. Modified TI's MSP432 LaunchPad with 2 x19 stackable* female headers and 1x2 female header soldered and ready
2. TI-RSLK kit with Black Romi Chassis which includes:
   - Black Romi chassis kit with red wheels
   - TI-RSLK chassis board assembly
   - 8-Channel QTRX Sensor array for ROMI/TI RSLK MAX
   - Left bumper switch assembly for TI-RSLK MAX
   - Right bumper switch assembly for TI-RSLK MAX
   - Gear motor and encoder assembly (2)
   - 400-point breadboard with special mounting holes and four 1"-long #2-56 M-F aluminum standoffs (with screws and nuts for mounting)
3. Cable USB-A to Micro USB-B 0.3M to connect your LaunchPad to PC
4. Male/Female Wires (10 pieces)
5. Male/Male wires (10 pieces)
6. Electronic components for lab experiments
   - LED RED DIFF 5MM ROUND T/H 10mA (1)
   - LED RED DIFF 5MM ROUND T/H 2mA(1)
   - RESISTOR 220 OHM 1/6W 5% AXIAL (1)
   - RESISTOR 470 OHM 1/6W 5% AXIAL(1)
   - RESISTOR 22K OHM 1/6W 5% AXIAL(1)
   - RESISTOR 33K OHM 1/6W 5% AXIAL(1)
   - RESISTOR 10 ohm Wire wound 10W, 5%, Axial
   - CAPACITOR Ceramic, 0.47 µF, 50 V, ± 5%, Radial (2)
   - CAPACITOR Tantalum, 10 µF, 20V, 10%, Radial (3)
   - Tactile push button Switch (3)

Not included in the kit:
   - Six rechargeable, Nickel Metal Hydride,1300mAH, 1.2V, AA (required to power the robot or six non-rechargeable, standard Alkaline, 1.5V, AA battery cells

- Black masking tape, maze for competition (several modules)

- TI SimpleLink™ Bluetooth® low energy CC2650 Module BoosterPack™ Plug-in Module (BOOSTXL-CC2650MA) (module 19)
- SimpleLink™ Wi-Fi® CC3100 wireless network processor BoosterPack™ plug-in module (CC3100BOOST) (module 20)
- Three Sharp GP2Y0A21YK0F analog distance sensors (distance sensor kit (not included) (module15)
- Nokia 5110/3310 monochrome LCD (module 11)
- Monochrome1.3" 128 x 64 OLED graphic display (module 11)
- Audio kit for robot to robot communication (module 15)
  o Microphone, TI TLV9004 on the chassis board or TLC2272C
  o TI TPA731 (Audio amplifier)
  o Resistors :1k, 10k, 20k,22k, 200k
  o Capacitors : 100nF ceramic, 220nF ceramic,1uF ceramic,2.2uF tantalum,4.7uF tantalum,
  o SOIC to DIP, 8 by 1 male header

Figure 2a. TI MSP432 LaunchPad with headers pre-soldered .

In addition to the kit you will need some tools for assembly. For example, the Sharp GP2Y0A21YK0F distance sensors and the TPA731 audio amplifier in the Lab 15 will require soldering. Please use proper precaution and follow lab safety rules.

*WARNING – If you have a LaunchPad that did not come with the TI-RSLK MAX robot kit. Please assemble the MPS432 LaunchPad with a 2 X 19 stackable female header and 1 x2 female header so that it can plug into the TI-RSLK chassis board for this MAX robot. The 1x2 female header must be placed on the LaunchPad (see Figure 2a) and the LaunchPad 5V jumper must be removed (see Figure 2b) prior to use with TI-RSLK MAX in order to avoid shorting different power rails and potentially damaging the chassis board.

Figure 2b. TI MSP432 LaunchPad with headers pre-soldered and jumper removed.

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TI-RSLK MAX Software:

The TI-RSLK utilizes several software packages and coding environments to help students at different levels of programming experience. The main code editor or Integrated Development Environment (IDE) for all students using the TI-RSLK is called Code Composer Studio (CCS).

You can download CCS from this mirror:
http://www.ti.com/tool/ccstudio

The MSP432P401R LaunchPad supports many other IDE options including CCS Cloud, Energia IDE, IAR Workbench, Keil IDE but those are not included in the curriculum resources. They can be used as part of your exploration beyond the curriculum according to your preferences.

The main software package for the TI-RSLK is the starter code, which can be downloaded here:
http://users.ece.utexas.edu/~valvano/arm/tirslk_max_1_00_00.zip

This zip file containing many CCS projects will need to be imported into Code Composer Studio and that is described fully in Module 1 of the curriculum.

tirslk_max is a set of software components that includes about 50 CCS example projects, html documentation, data sheets, and a Windows application called **TExaSdisplay**.

Some of the example projects run out of the box and are intended to illustrate various functionalities of the MSP432. However, some of the projects have names beginning with "Lab", and these are starter projects for your labs. You will be developing code in these projects as part of the lab assignments in this curriculum. Furthermore, the folder **inc** has files you develop in one lab that will be used in subsequent labs. Additional software options for exploration beyond the curriculum include Energia, TI Driver Library for MSP432, TI-RTOS, and more
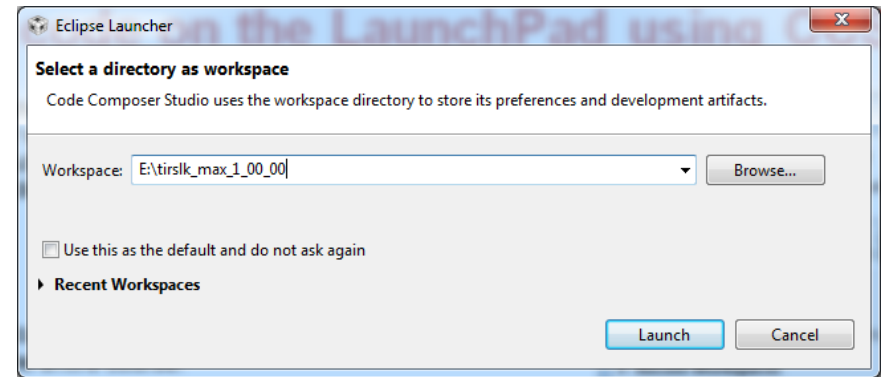

Figure 3. Folder download for sample projects.

Goals of the TI-RSLK MAX

The ultimate goal of the learning kit is to learn, build, and test a robot system capable of solving complex tasks. Example challenges using the robot include exploring a maze, racing autonomously, finding an object, navigating through an obstacle and following a line. Some advanced challenges include robot-to-robot communication via audio commands; transmitting and receiving robot information to and from the cloud. Lastly, the goal for you is to have fun while you are aggregating knowledge along the way. We have created some new challenges that we hope you will enjoy while learning how to get your RSLK MAX robot to Barrel race using principles from odometry.

However, it is not the final robot that matters, but the educational journey that discovers a wide range of engineering principles along the way. We have two options that the robot curriculum can follow a) Top-down b) Bottom's up

The top-down approach allows you to pick a challenge and gather all the necessary learning modules you need to follow. You can use pre-compiled object code solutions for the low-level software drivers allowing you to learn the robot from a systems-level or top-level perspective. The challenges are part of Module 21.

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The second approach is bottom-up such that you can start from module 1-20 building up components from simple to complex.

You can start with fundamentals such as voltage, current, power, energy, batteries, resistors, capacitors, transistors, diodes, and DC motors. You can learn how to use a voltmeter, an ohmmeter, a current meter, and an oscilloscope.

Since this is targeted at embedded systems courses; hence you will interface numerous devices to the TI MSP432 microcontroller and various application boards and components.

In particular, you will interface LEDs, switches, a line sensor, DC motors, tachometers which are part of the TI-RSLK MAX robot kit (base). Included in the kit is the versatile TI-RSLK chassis board which is customized to the robot chassis and provides power to your robot. This board also includes motor drivers and gear and motor assembly so you can control your motor and robot. Besides providing an easy plug-in interface to the MSP432 LaunchPad headers, it also provides many connections to your sensors and even an OLED to display what your robot is doing.

Additional hardware (such as BLE, Wi-fi, and Audio kit) can be added to this kit to further enhance your knowledge on technology used in industry to solve real problems.

Your microcontroller hardware/software skills will include pulse-width modulation (PWM), flash read-only memory, periodic timers, edge-triggered interrupts, digital to analog converter (DAC), analog to digital converter (ADC), synchronous serial communication, and asynchronous serial communication.

A significant component of the curriculum involves software development. You will develop software skills in multithreading, data structures, debugging, linked lists, semaphores, and first in first out (FIFO) queues. You will learn how to use a logic analyzer for interface testing, and thread profiling.

In the end you will be able to integrate software and hardware knowledge to build your own challenge and dream up your own robot tasks. This is a lab-based curriculum. However, there are numerous fundamental concepts to master, such as the Nyquist Theorem, the Central Limit Theorem, digital filtering, Little's Theorem, and trigonometry to implement odometry.

Outcomes

Although robotics is the central theme of the curriculum, the educational outcomes can be best categorized as engineering design in general and embedded systems in specific. A system is essentially a collection of components and the interfaces between the components. You will learn interfacing to the microcontroller, which includes concepts like voltage, current, resistance, capacitance, and inductance. You will develop skills for designing components to meet specifications. You will learn an integrated approach to design including mechanical, electrical, digital, and software components. Your software skills will improve along a wide range of topics including computer architecture, assembly language, modular design in C, abstraction, concurrent multithreading using interrupts, data structures, and testing. You will learn abstractive design methods like finite state machines, data flow using FIFO queues, and digital control systems.

Getting started

Course prerequisites: Algebra, College Physics, basic knowledge of computers and architecture, C programming.

You will need to follow the instructions in Module 1 Lab document to set up your computer for the software development with Code Composer Studio. Follow the instructions carefully.

Each module is relatively independent and you can thread the modules to create a particular learning experience. The modules can be accessed online at **ti.com/rslk**
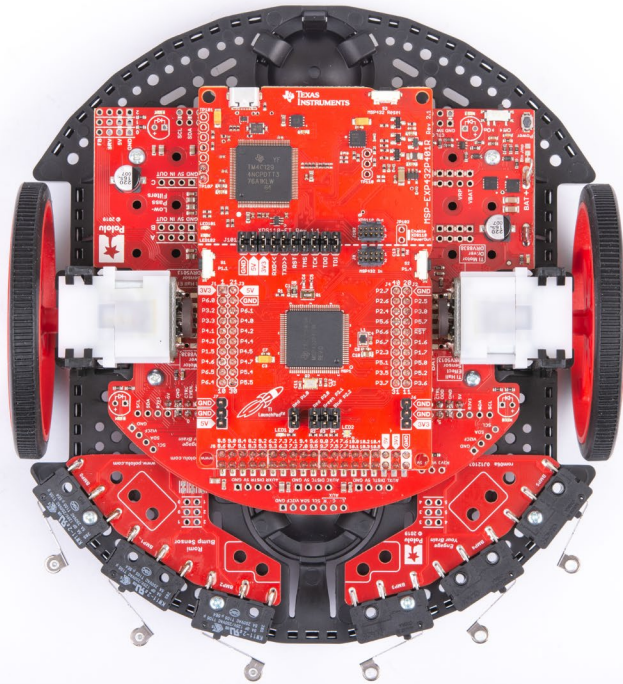
Reference textbook
Embedded Systems: Introduction to Robotics,
Jonathan W. Valvano, ISBN: 9781074544300, copyright © 2019

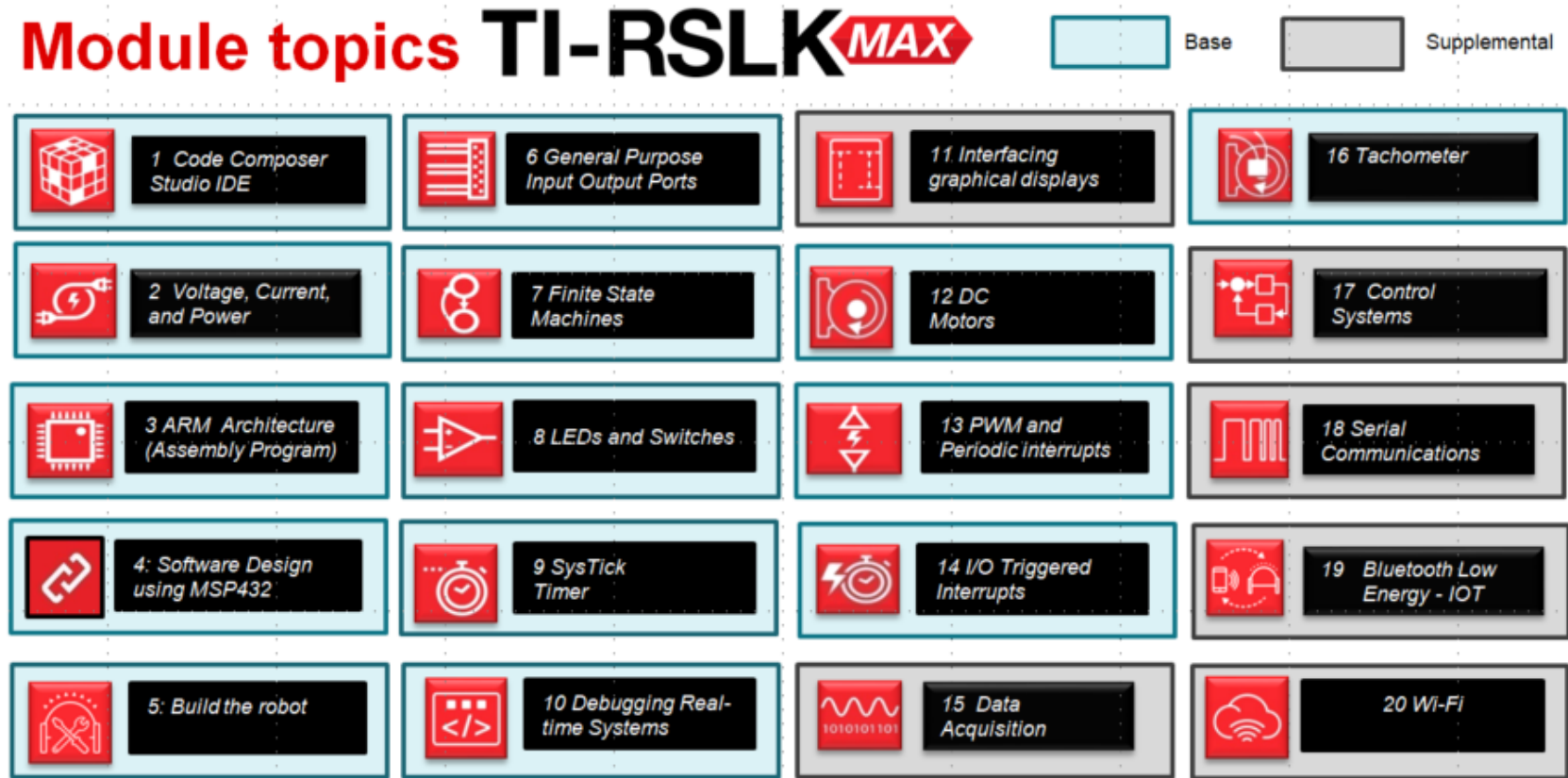# Robot Systems Learning Kit (TI-RSLK) User Guide

Module topics and structure

*Figure 4. TI-RSLK MAX curriculum modules
(available on www.ti.com/rslk).*

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Introduction document
Provides educational objectives, pre-requisites, lists linking modules, references

Class Lecture slides (1-3 files) along with training videos ~20mins/video
Provides material covering topics that can be expanded or modified for class

Lab document along with demo videos of completed lab (1-3 videos, 2-4 mins)
Reinforces theory with hands on experience, system thinking, extended learning

Quiz document for testing students
Quiz solution only available to faculty on request

Class Activity document
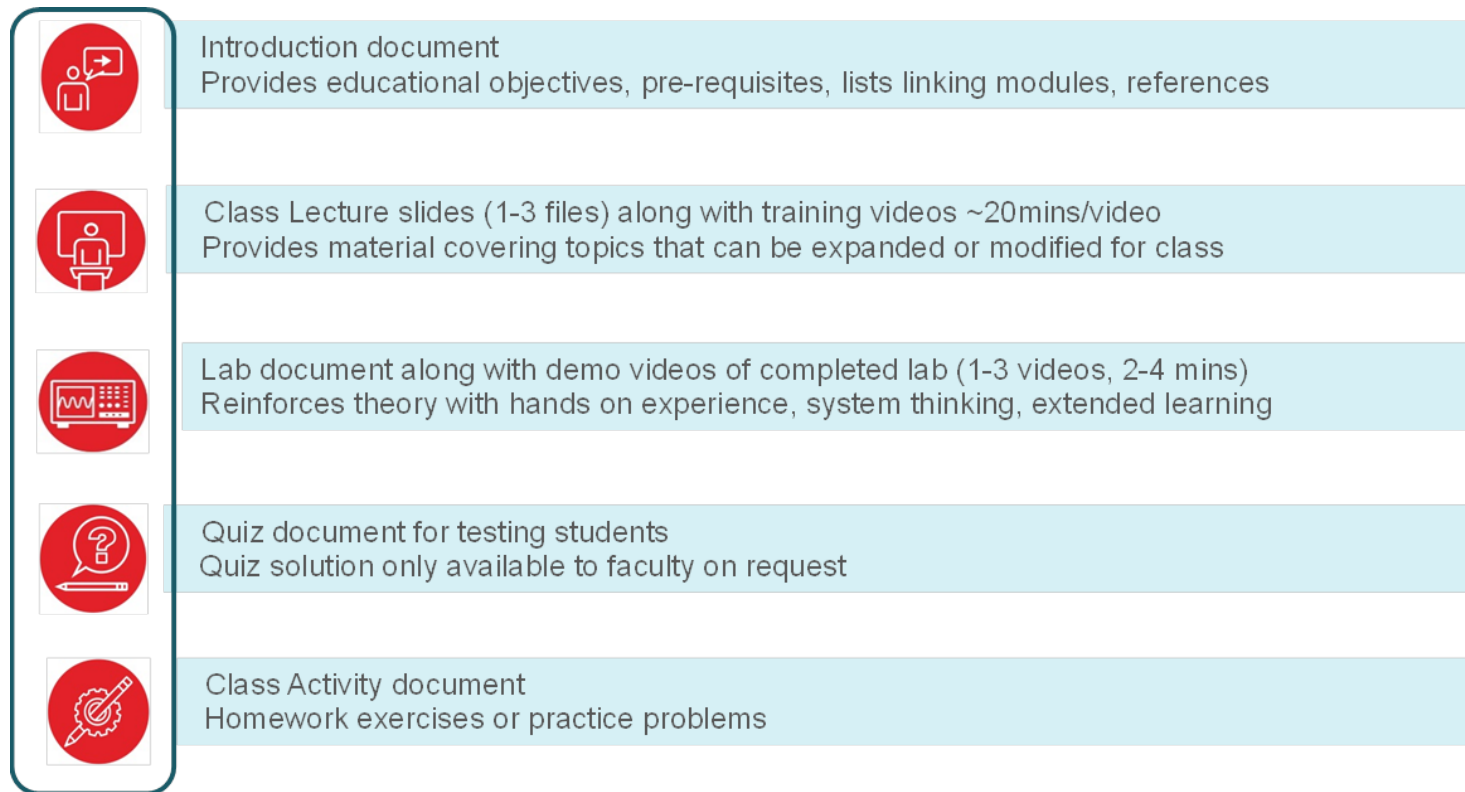Homework exercises or practice problems

Figure 5. Module structure.

The most important document in each module is the lab document.
Module 5, "Build the robot" lab provides details on how to build the robot
and also test it with executable code. TI-RSLK MAX construction guide
document and construction videos will also help with assembly,
disassembly, installing optional accessories to your robot such as the
LCD, OLEDs that can be purchased separately.
Performing labs for each module can help you in learning and
implementing your robotic system that is ready for challenges Included in
Module 21.

To find the circuit diagrams, create an account in Circuit maker. Launch
the application, under projects select Tags, and search MSP432. You will
find starter circuits for each lab that has hardware.

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Build your robot:

[TI-RSLK MAX construction guide document](#) will cover the instructions to build your robot using the parts associated with the TI-RSLK MAX Robot. The instruction video is also included in Lab 5 (lab demo videos).
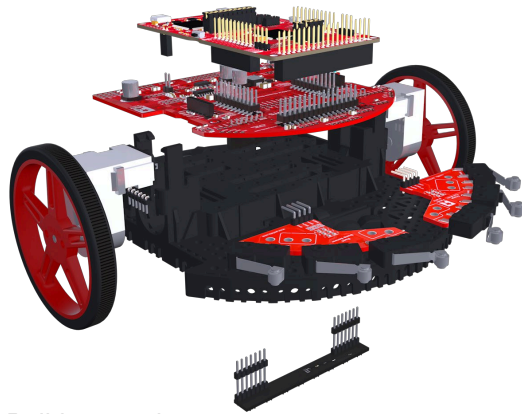

Figure 6. Build your robot.

Section 1: This will cover the assembly of the robot.
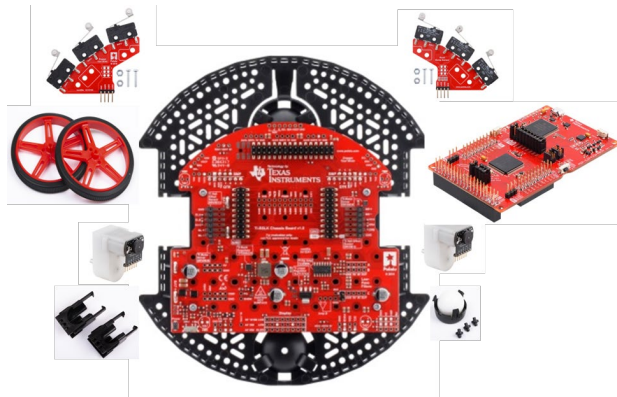You will also learn how to install the MSP432 Launchpad on the robot.

Figure 6a. Build your robot – Assembly.

Section 2: You will prepare the MSP432 LaunchPad kit in case you already had one or had to replace with a new one.

Figure 6b. Build your robot – Preparing the MSP432-LaunchPad.

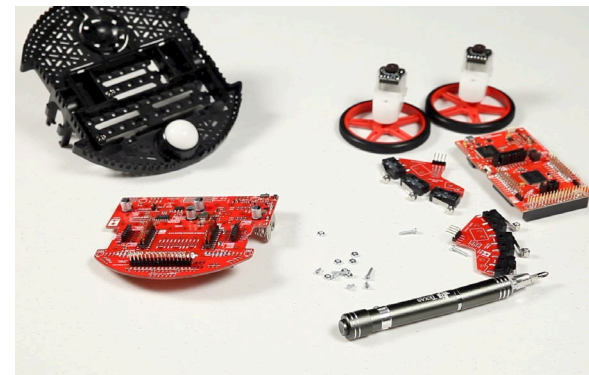**Section 3:** You will learn how to disassemble the robot.

Figure 6c. Build your robot – Disassembling the robot.

Section 4: Your chassis board should already be constructed but this section will go over how to disassemble the TI-RSLK chassis board or add options like the LCD, OLED, Distance sensors, robotic arm etc. You can also watch the construction videos on **www.ti.com/rslk.**

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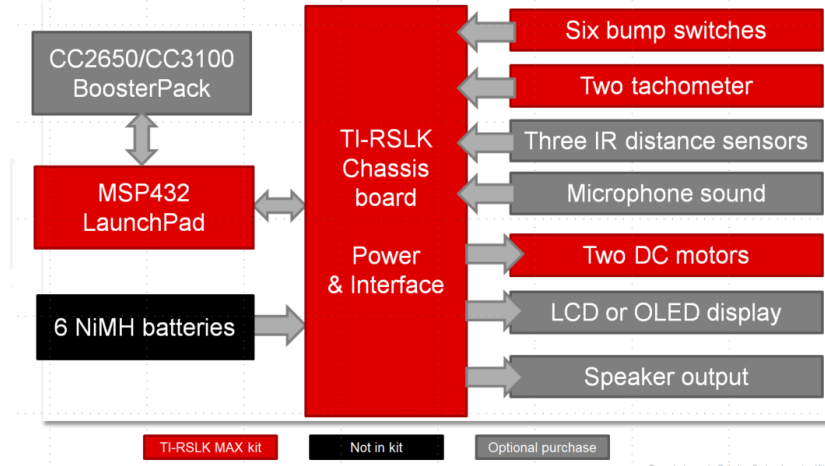**System Block diagram:**

Figure 7 TI-RSLK MAX system overview

Hardware Description:

The TI-RSLK MAX robot kit system consists of many components, but two main boards make up the heart of this system; they are the TI-RSLK Chassis board and the TI MSP432 LaunchPad development board (your kit comes with the modified version with headers already soldered) for ease of plugging on to the top of the TI-RSLK chassis board.

TI's LaunchPad Development Kits are low-cost, modular, consistent and open-source hardware tools. The variation used in the TI-RSLK contains the TI MSP432P401R 32-bit Microcontroller, which has a built-in ARM Cortex-M4F core running at 48MHz along with 256KB of programmable Flash and 64KB of SRAM for storing and running your code. Importantly, the board also includes a debug probe, allowing you to program and debug your code using just a micro-USB cable; no additional hardware required. For detailed information please review the MSP432 user guide and datasheets,

The jumpers placed along the dotted line are what separate the debug probe upper section from the Microcontroller lower section. These jumpers connect the power, ground, and data lines between the two sections.
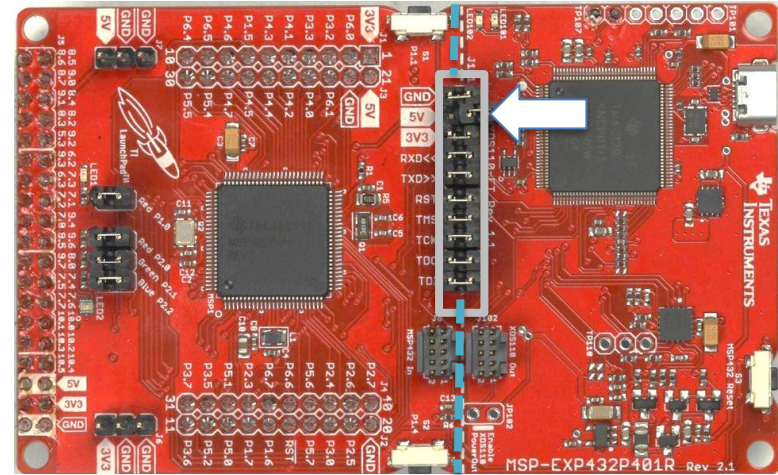

Figure 8. TI MSP432 LaunchPad.

However, as mentioned early on, the 5V jumper **MUST be removed** before connecting it to the robot or you **WILL damage** it and the chassis board. Below the dotted line, the MSP432 microcontroller sits in the middle of the section of the board, surrounded by some additional components that are needed to connect more devices to the LaunchPad, such as the TI-RSLK robot chassis. Two 20-pin headers and one 38-pin header allow us to connect to all of the circuitry that's on the TI-RSLK chassis board, and to add more features (such as Wi-Fi, Bluetooth, or a robotic arm) in the future.

The MSP432 board also includes 2 push button switches and LEDs as basic input and output components. These can be used to get your board up and running without needing any other connections.
When not being powered by the USB port, it will need to get its power from another source. This is one of the many functions being performed by the TI-RSLK chassis board.

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The first thing to notice on the TI-RSLK chassis board highlighted in orange, are the connectors that are used to mate with the MSP432 LaunchPad board. These connections provide power to the MSP432, along with all of the sense and control lines required for using the various features of the robot.
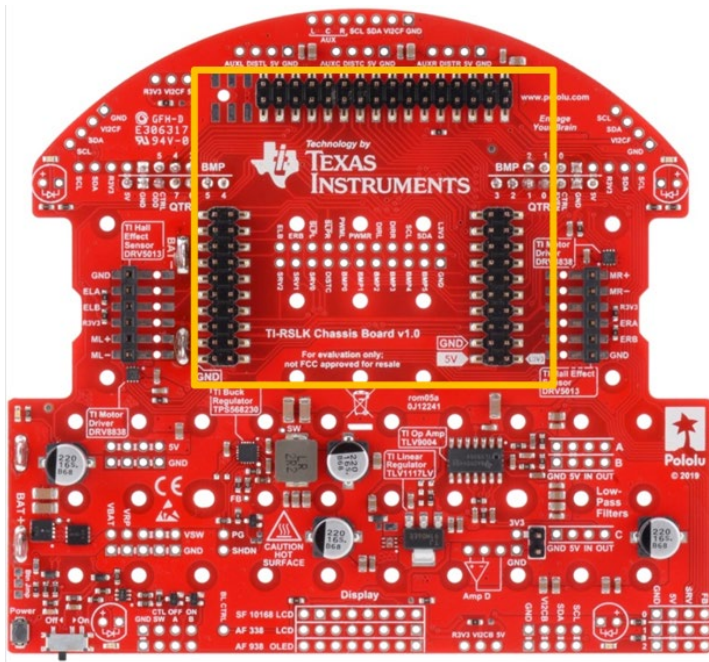

Figure 9. TI-RSLK chassis board showing the MSP432 interface pins.

The TI-RSLK chassis board is responsible for taking power from the six AA batteries (installed under the robot) and safely providing power to the rest of the system. The light blue squares highlight the battery connection tabs protruding from the battery compartment. This power is then sent through an on/off switch and latching button, along with some additional protection and control circuitry, all highlighted in green.

Once the power passes through this stage, it's then ready to be used by the motors, and also by the two main voltage regulators that will provide

the required 5V and 3.3V levels to the rest of the robot system as shown in purple, the TI TPS568230 switching regulator provides 5V /8A (use caution: you cannot exceed 5A of load or you will be increasing the TI-RSLK chassis board PCB temperature beyond its operating range and safety guidelines), this section also includes TI's lower power TLV1117LV linear regulator which provides 3.3V at up to 1A for use by the LaunchPad and other components running on 3.3V. Once the batteries are installed and the switch is turned on, the LaunchPad will then have power to operate.
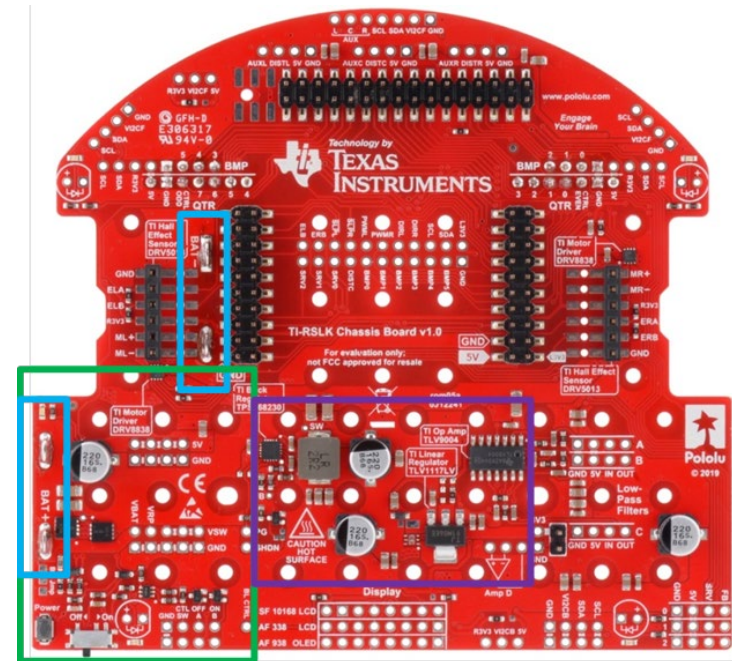

Figure 10 TI-RSLK chassis board showing the power section.

Now that the two boards are mated connected and the MSP432 LaunchPad is powered up, it's time to start adding more functionality.

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On each side of the board, circled in <mark>yellow</mark>, there is a connector and a TI DRV8838 motor driver; they are used to control each motor assembly independently in forward or reverse. There are three main control pins on each DRV8838: One pin controls direction (forward or backward), another pin controls speed using a pulse width modulated signal, and the third pin can put the part into a low power sleep mode.

Also notice the white text on the board with the words "TI Hall Effect Sensor DRV5013." These hall-effect sensors are used to detect the direction and speed of each motor and are attached to the circuit board that's on the motor itself. In green, you can see there are 4 LEDs located at the corners of the board which can be programmed and used as desired.
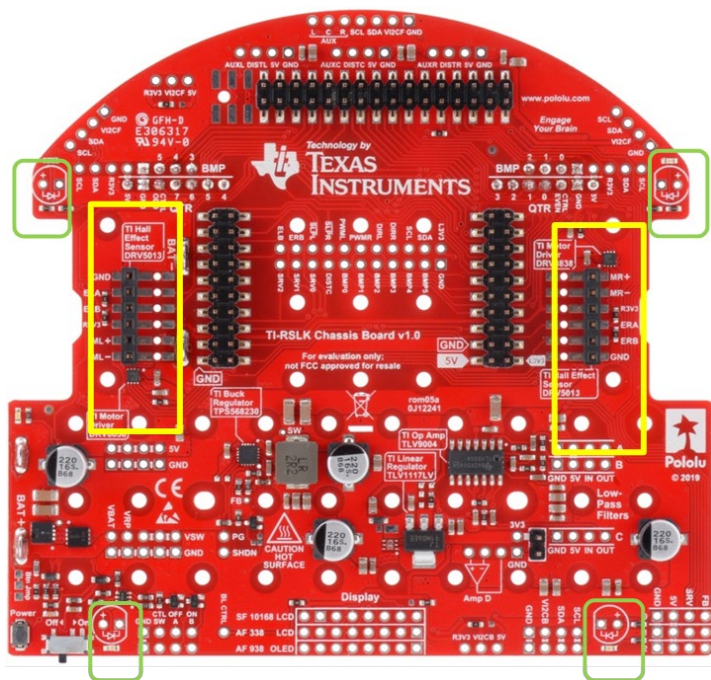
Circled in white, the TI TLV9004 is a four-channel operational amplifier that can be used as low pass filters for three optional IR distance sensors if used. Lastly, in blue, are header connections for adding a display if desired.

Before moving to the other side of the board, take a moment to notice all of the open and empty via holes. These provide multiple points for additional connections, which are useful when adding more parts to your robot. There are several power rails and ground points available throughout the board for more details refer to www.Pololo.com.
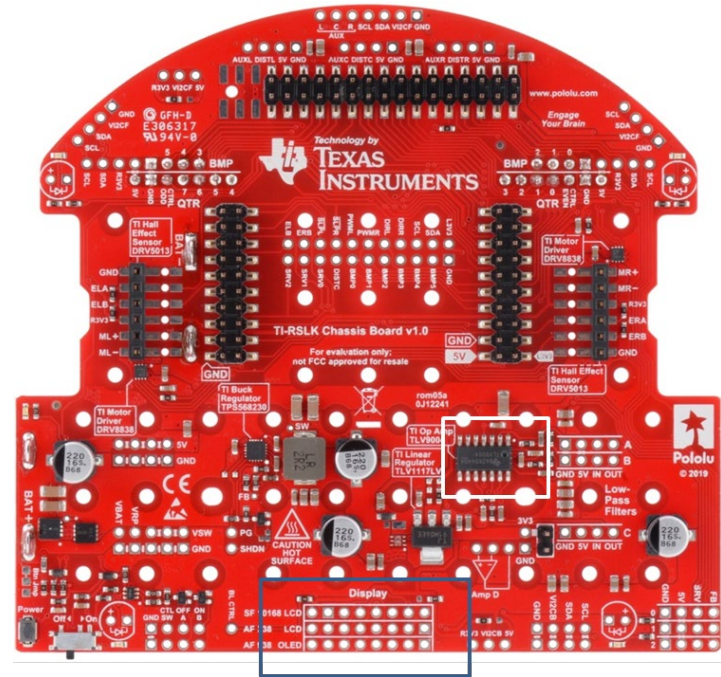

Figure 11. TI-RSLK chassis board showing the motor driver section.

Figure 12. TI-RSLK chassis board showing the opamp and display headers.

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On the back of the board, you'll find the connectors for two of the add-on boards included in the TI-RSLK kit: the two bumper switch assembly boards will connect to the 90 degree bent headers and the line following sensor board will connect to the standard headers.

You'll also see the spring tabs that get inserted into the battery compartment. When inserting battery tabs into the chassis, the springs should be depressed using your fingers to pass them through the battery tab slots.
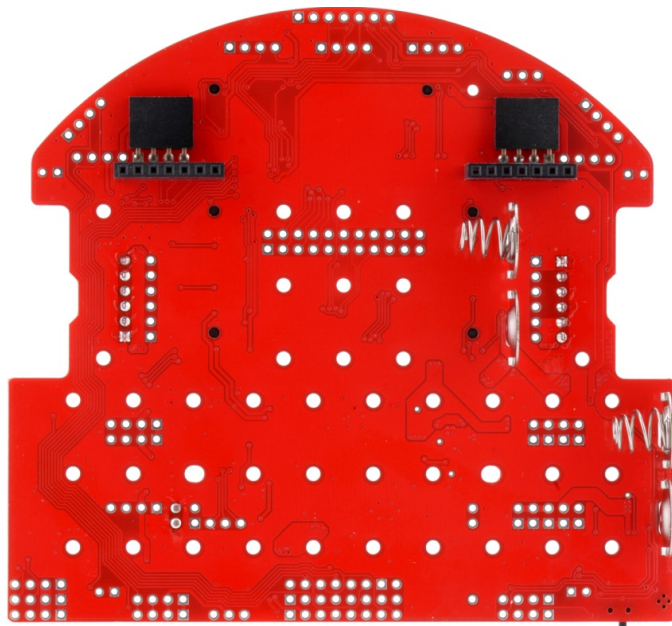
.

completed. Therefore, when the robot bumps into an object, the MSP432 can be programmed to see the signal change from a high of 3.3V down to 0V.

The QTRX line following sensor board contained in your kit is mounted to the underside of the robot so that it doesn't interfere with the battery compartment cover. The board has 8 separate sensors, and each sensor contains both an infrared light transmitter and receiver. The MSP432 turns on the transmitter side of all 8 elements to shine infrared light onto the surface below the robot. Then, the MSP432 can read the receiver side of each element to determine if that element is over a dark or light surface. This is very useful for detecting and following a dark line on a light surface underneath the robot.

Figure 13 TI-RSLK chassis board back view.

The two bumper switch boards included in your kit each contain 3 bumper switches. They're normally open and not electrically conducting, but when the switch is pressed the circuit gets
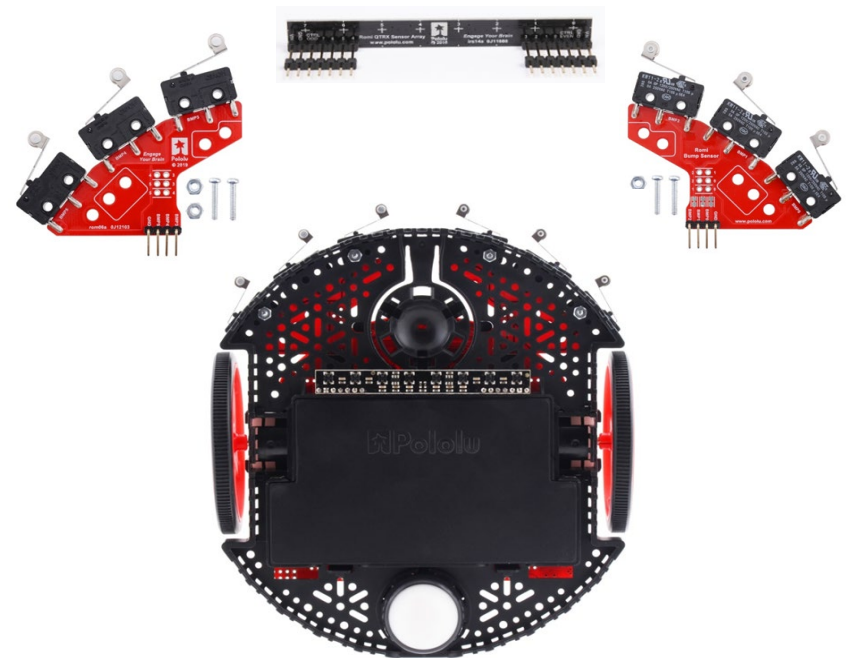
Figure 14. TI-RSLK MAX components with the sensors connected.

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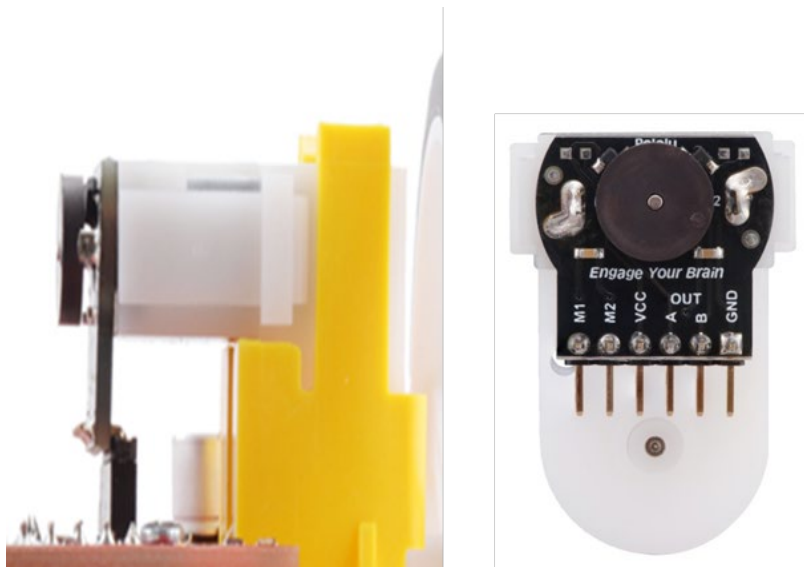SEKP166

Figure 15. Gear motor and Encoder Assembly for TI-RSLK MAX robot kit.

Back on the top side of the robot, you'll notice that each motor assembly has a board attached to it. Each board contains wire traces to control and power the motor, as well as a magnetic disc and two TI DRV5013 Hall effect sensors.
The hall-effect sensors can detect the six magnetic poles of the disc as it passes over them and when used together, can determine the speed and direction of the motor shaft. By combining the hall-effect sensor outputs with the 120:1 gearing ratio that's inside the motor assembly, it's possible to detect 1,440 incremental steps per revolution of the wheel. You can also learn more on www.Pololu.com.

The last component included in your kit is a 400-point solderless breadboard that can be used for adding more componentry to your kit and for additional experimentation.
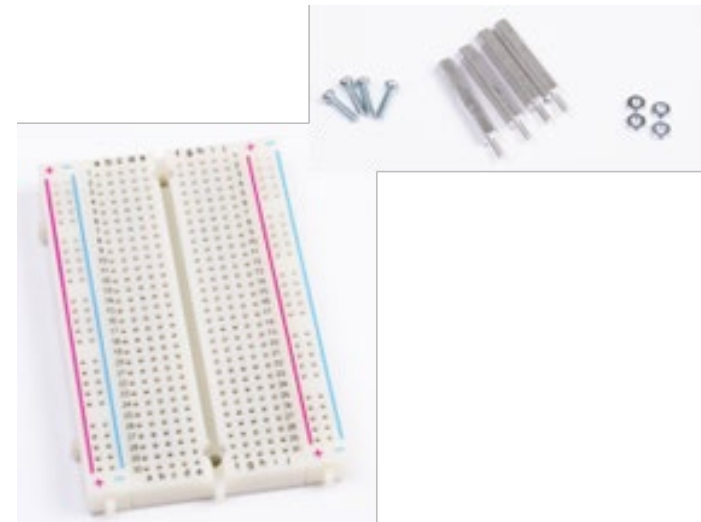

Figure 16. Solderless board and stand-offs part of TI-RSLK MAX kit.

To control the robot, you'll need to write the code for the MSP432 with an understanding of which LaunchPad pins are connected to each of the signals on the TI-RSLK Chassis Board. The pin maps providing this information can be found in the next section.

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MSP432 pin assignments and sensor interface

This section covers the pin assignments for your MSP432 and the chassis board connections to the sensors and other optional boards.

J1

3.3V	3.3V
P6.0	CC2650, MRDY
P3.2	CC2650/CC3100, TXD, UART1_TX
P3.3	CC2650/CC3100, RXD, UART1_RX
P4.1	CC3100, nHIB
P4.3	Bump 2 [3]
P1.5	CC3100, SPI_CLK
P4.6	Bump 4 [3]
P6.5	UCB1SCL [4]
P6.4	UCB1SDA [4]

J3

5V	5V
GND	GND
P6.1	Center IR Distance / OPT3101
P4.0	Bump 0 [3]
P4.2	Bump 1 [3]
P4.4	TExaS scope input
P4.5	Bump 3 [3]
P4.7	Bump 5 [3]
P5.4	DIR_L
P5.5	DIR_R

J4

GND	GND
P2.5	CC2650/CC3100, SRDY, IRQ
P3.0	CC3100, SPI_CS
P5.7	PWM Gripper Servo
!RST	RESET
P1.6	CC3100 SPI MOSI
P1.7	CC3100 SPI MISO
P5.0	ERB [1]
P5.2	ELB [1]
P3.6	nSLPR [2]

J2

P2.7	PWML, Left Motor PWM
P2.6	PWMR, Right Motor PWM
P2.4	PWM Arm Height Servo
P5.6	CC3100, UART1_CTS
P6.6	CC3100, UART1_RTS
P6.7	CC2650, NRESET
P2.3	CC3100, NWP_LOG_TX
P5.1	CC3100, WLAN_LOG_TX
P3.5	PWM Arm Tilt Servo
P3.7	nSLPL [2]

J5

P8.5	Yellow Front Right LED
P9.0	Right IR Distance / OPT3101
P8.4	Analog Arm Height Servo Feedback
P8.2	Analog Gripper Servo Feedback
P9.2	Reflectance LED Illuminate (odd)
P6.2	AUXR IR Distance / OPT3101
P7.3	Reflectance 3
P7.1	Reflectance 1
P9.4	Nokia5110/SSD1306 CS, SPI STE
P9.6	Nokia5110/SSD1306 CD
P8.0	Yellow Front Left LED
P7.4	Reflectance 4
P7.6	Reflectance 6
P10.0	UCB3CLK / OPT3101
P10.2	UCB3SDA
P10.4	ERA [1]
P8.6	Red Back Left LED
P8.7	Red Back Right LED
P9.1	Left IR Distance / OPT3101
P8.3	Analog Arm Tilt Servo Feedback
P5.3	Reflectance LED Illuminate (even)
P9.3	Nokia5110/SSD1306 RST

P6.3	AUXL IR Distance / OPT3101
P7.2	Reflectance 2
P7.0	Reflectance 0
P9.5	Nokia5110/SSD1306 Clock
P9.7	Nokia5110/SSD1306 MOSI
P7.5	Reflectance 5
P7.7	Reflectance 7
P10.1	AUXC IR Distance / OPT3101
P10.3	UCB3SCL
P10.5	ELA [1]

[1] This is encoder output.
[2] This disables a motor driver. 0 to sleep/stop.
[3] Use Port 4 for edge-triggered interrupts
[4] Primary I2C channel supported by Energia

IR Array:
reflectance even LED illuminate connected to P5.3
reflectance odd LED illuminate connected to P9.2
reflectance sensor 1 connected to P7.0 (robot's right, robot off to left)
reflectance sensor 2 connected to P7.1
reflectance sensor 3 connected to P7.2
reflectance sensor 4 connected to P7.3 center
reflectance sensor 5 connected to P7.4 center
reflectance sensor 6 connected to P7.5
reflectance sensor 7 connected to P7.6
reflectance sensor 8 connected to P7.7 (robot's left, robot off to right)

Nokia
Signal   (Nokia 5110) LaunchPad pin
3.3V   (VCC, pin 1) power
Ground   (GND, pin 2) ground
UCA3STE   (SCE, pin 3) connected to P9.4
Reset   (RST, pin 4) connected to P9.3
Data/Command (D/C, pin 5) connected to P9.6
UCA3SIMO   (DN, pin 6) connected to P9.7
UCA3CLK   (SCLK, pin 7) connected to P9.5
back light   (LED, pin 8)

Blue Adafruit 938 SSD1306 OLED (powered with 5V)
Signal   (SSD1306)   LaunchPad pin
UCA3SIMO   (Data, pin 1) connected to P9.7
UCA3CLK   (Clk, pin 2) connected to P9.5
Data/Command (DC,   pin 3) connected to P9.6
Reset   (Rst, pin 4) connected to P9.3
UCA3STE   (CS,   pin 5) connected to P9.4
3.3V   (3v3, pin 6) 3.3V out, not connected
5V   (Vin, pin 7) power in
Ground   (Gnd, pin 8) ground

Tachometer
Left Encoder A connected to P10.5 (J5)
Left Encoder B connected to P5.2 (J2.12)
Right Encoder A connected to P10.4 (J5)
Right Encoder B connected to P5.0 (J2.13)

Blinker LEDS
Front right P8.5 Yellow LED
Front left P8.0 Yellow LED
Back right P8.7 Red LED
Back left   P8.6 Red LED

Motors
Left motor direction connected to P5.4 (J3.29)
Left motor PWM connected to P2.7/TA0CCP4 (J4.40)
Left motor enable connected to P3.7 (J4.31)
Right motor direction connected to P5.5 (J3.30)
Right motor PWM connected to P2.6/TA0CCP3 (J4.39)
Right motor enable connected to P3.6 (J2.11)

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IR distance sensors
5V connected to all three Pololu #136 GP2Y0A21YK0F Vcc's (+5V)
ground connected to all three Pololu #136 GP2Y0A21YK0F grounds
MSP432 P9.0 (J5) (analog input A17 to MSP432) connected to right
GP2Y0A21YK0F Vout
MSP432 P6.1 (J3.23) (analog input A14 to MSP432) connected to center
GP2Y0A21YK0F Vout
MSP432 P9.1 (J5) (analog input A16 to MSP432) connected to left
GP2Y0A21YK0F Vout

Negative logic bump sensors
P4.7 Bump5, left side of robot
P4.6 Bump4
P4.5 Bump3
P4.3 Bump2
P4.2 Bump1
P4.0 Bump0, right side of robot

Robot Arm
PWM outputs for servos
P2.4/PM_TA0.1 (PMAP from TA1.1) connected to arm height servo
P3.5/PM_UCB2CLK (PMAP from TA1.2) connected to arm tilt servo
P5.7/TA2.2/VREF-/VeREF-/C1.6 connected to gripper servo

Analog inputs from servos (feedback)
P8.4/A21 connected to arm height servo
P8.3/TA3CLK/A22 connected to arm tilt servo
P8.2/TA3.2/A23 connected to gripper servo

What's next after TI-RSLK MAX?

TI-RSLK software will be developed in C running with Code Composer Studio. Each example is written from scratch in order to expose all the details. However, there are many other options for software development you could explore after RSLK.

Energia is a basic Arduino style programming experience for beginners. TI **DriverLib** is a C based functional programming API that is easy to understand.

TI-RTOS is suitable for managing more complex embedded projects. Resources will be linked online from TI and the community.

A debugging tool is provided by TI that was built in GUI Composer, a utility to easily create dashboards and GUI interfaces online for your embedded projects. The **TI Cloud Tools** including GUI Composer, *Resource Explorer*, and CCS Cloud are located at dev.ti.com.
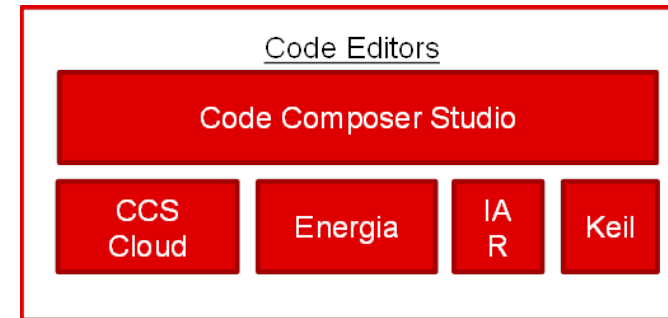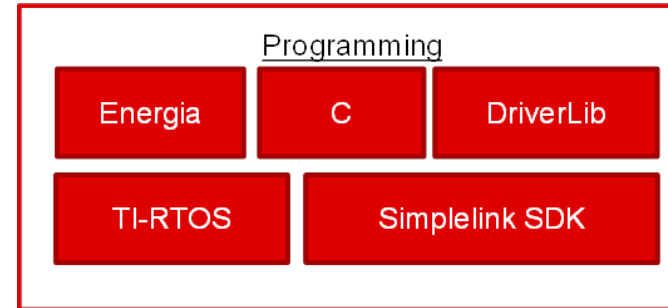
Operating and maintaining the TI-RSLK MAX

TI-RSLK is a robust platform for educational use and it may be used by multiple students over the course of many different activities. Therefore it should be a priority for users to take some measures to operate the TI-RSLK MAX with care.

It is extremely important that stalling of the motors be prevented as much as possible. Stalling that occurs by having an object or wall blocking the TI-RSLK MAX from moving can damage the gears of the motors or overload the circuitry of the motor board with current spikes. To prevent stalling, it is good to write the

software to make use of the bump switches for collision detection, so that the motors can be shut off when a collision occurs.

Excessive bumping or dropping of the robot should also be avoided as much as possible. While the TI-RSLK MAX has a chassis that can absorb some basic impacts that can occur during normal use, constant impacts will wear down the motor shafts, motor gears, electronics, and sensors. Damage can also occur if the TI-RSLK MAX is dropped or if it is driven off of a table, ramp, or other sharp height differential. Drop impacts can cause wear on the components, bend or short connector pins, or even displace critical components from the circuit boards, potentially damaging TI-RSLK MAX beyond basic repair.

TI-RSLK MAX is heavily customizable, but as more peripherals are added, the power dissipation gets more complex and closer to set limits. It is important to stick to recommended accessories for TI-RSLK MAX to avoid complications. The motors on TI-RSLK should not be altered. The DC motors put the most current load on the system and altering the motor selection will introduce current usage that may be out of the bounds of the motor drive and power regulation circuitry. While some protection circuitry is present to fail safe the electronics, modifying TI-RSLK MAX can still overwhelm the components or cause excessive heat that can lead to failure.

Some modification of the chassis may be required such as addition of screws and standoffs. Make sure screws are securely fastened so added components can operate optimally. Bump Sensor assemblies should be screwed down for proper resilience against impacts.

Certain components are susceptible to higher fragility and wear. This includes the capacitors, On/Off switch, power button, battery cover, battery tabs, battery springs on the motor board, USB connector, push buttons, BoosterPack connectors on the LaunchPad, gears, wheels on the motor assemblies, bump switches on bump sensor assemblies. Do note that attachment and detachment of the wheels to the motor shaft can cause a lot of force on the motor shafts, so handle with care and make sure the shaft is properly aligned with the wheel before applying force.

The motor mounts need to be fully locked in to avoid damage to the tab that secures it to the chassis. Make sure the motor mount is fully inserted and flush with the chassis before inserting the motor.

After classroom use is complete, it is good practice to disassemble the robot back to its original parts. This allows for individual inspection and testing for damage. Visual inspection of the bump switches, motor board, encoder assembly, and LaunchPad can often reveal any physical damage. Mechanical

inspection of the motor by hand turning the wheels can test if gearing is operating normally. If the motor feels stiff or cannot turn, then that is an indicator there could be damage or some kind of obstruction of the encoder magnet.

Ambient temperature also is a factor in long term operation. Use indoors and not at extreme temperatures will help the robot operate effectively.

TI-RSLK MAX can handle some load bearing, but as weight on the robot increases, it puts more wear on the motor shafts, motor gears, and electronics.

The connection of the LaunchPad to the TI-RSLK is very mechanically solid, so use caution when removing the LaunchPad and slowly apply upward force with minimal rocking to keep any pins from bending. When attaching the LaunchPad to the TI-RSLK MAX, make sure to align the pins with the connectors and apply even downward force to mate the two boards. The same applies for BoosterPack Plug-in Modules. When attaching a BoosterPack to the LaunchPad make sure to align the pins with the connectors and apply even downward force to mate the two boards. When removing a BoosterPack, slowly apply upward force with minimal rocking to keep any pins from bending.

Specifications and operating the TI-RSLK MAX

For detailed specs and use of the TI-RSLK MAX kit please refer to individual components specifications citied with their respective manufacturers. Not reviewing and understanding the proper use of the components, sub-assembles of the TI-RSLK MAX kit can lead to damage of components, malfunction of the robot and affect personal safety.

Resources and links:
For all TI products and devices, go to ti.com
For all information, schematic and specifications on robot parts in the kit from Pololu go to www.Pololu.com

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User Safety Guidelines

Always follow TI's set-up and application instructions, including use of all included components within their recommended **electrical rated voltage and power limits**. Always use electrical safety precautions to help ensure your personal safety and those working around you. Contact TI's Product Information Center http://support.ti.com for further information.

Warning! This kit is primarily for use in development laboratory environments and targeted at university students and instructors with knowledge of basic electronics and use of such components. Follow all instructions carefully. The assembled kit is compliant with Class B of CISPR 32 and can be used in residential environment.

Users should download ~~the~~ all the necessary documents to get started, set up the necessary project and code files as indicated in the lab manual at www.ti.com/rslk. The intent of the TI-RSLK curriculum is to understand the components used in the kit and assemble them up into a robot that can be autonomous and allow students to race and solve mazes. It is highly recommended to follow the curriculum, ~~and~~ experiments and lab setups used in the TI-RSLK curriculum. Before using the kit, users should carefully read and fully understand these instructions and those in the applicable lab manual including all accompanying warnings, cautions, safety statements, applicable industry safety practices, guideline and electrical codes.

When using this kit, appropriate safety practices must be used, including but not limited to the following:

Electrical Safety:

- Verify power supply inputs and other interfaces so that voltage, frequency and other current carrying capacities are compatible with published ratings. Exceeding such ratings can result in potential for personal injury or property damage.
- It is the user's sole responsibility to evaluate need, and implement any other protective means, including but not limited to thermal, impedance or other suitable electronic protective means to minimize unforeseen risks.

Work Area Safety:

- Keep work area clean and orderly.
- Use stable and non-conductive work surface. Normal ESD practices should be followed.
- Use adequately insulated clamps and wires to attach measurement probes and instruments.
- It is recommended to use parts that were included or accompanied the kit as TI does guarantee the same results.

Personal Safety:

- Keep extremities, hair, jewelry and clothing away from any associated moving parts.
- In case the robot kit is used in a non-laboratory setting, ensure all parts are stored and put away to avoid unsupervised use. The small parts can be a choking hazard.

Save all warnings and instructions for future reference.

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ti.com/rslk

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