TI Designs
Sub-1 GHz Wireless Remote Control for Servo and DC Motors Design Guide

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TI Designs provide the foundation that you need including methodology, testing, and design files to quickly evaluate and customize the system. TI Designs help *you* accelerate your time to market.

Design Resources

TIDM-WIRELESSRC	Tool Folder Containing Design Files
MSP-EXP430G2	Design Folder
MSP-EXP430F5529LP	Tool Folder
DRV8833EVM	Tool Folder
430BOOST-CC110L	Tool Folder
DRV8833EVM	Tool Folder
BOOSTXL-EDUMKII	Tool Folder
BOOSTXL-BATTPACK	Tool Folder
MSP430G2553	Product Folder
MSP430F5529	Product Folder
DRV8833	Product Folder
CC110L	Product Folder
TPS63002	Product Folder
BQ27510-G2	Product Folder
BQ24210	Product Folder

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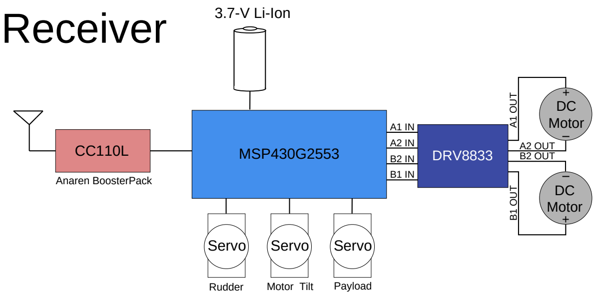
Design Features

- Low Power Sub-GHz Wireless Data Transmission
- Wireless Remote Control of Servo and DC Motors
- Low Battery Indicator on Transmitter
- Battery Charging for Lithium Polymer Battery

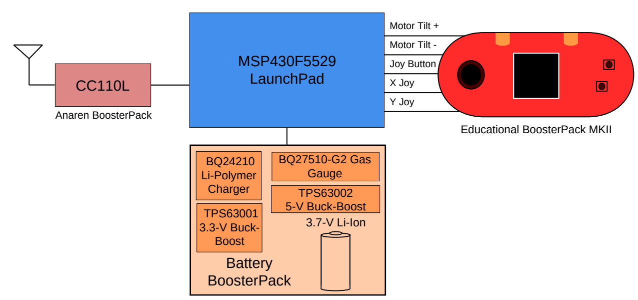
Featured Applications

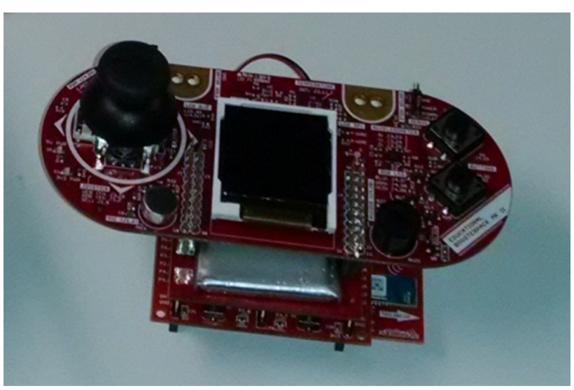
- Remote Control Toys

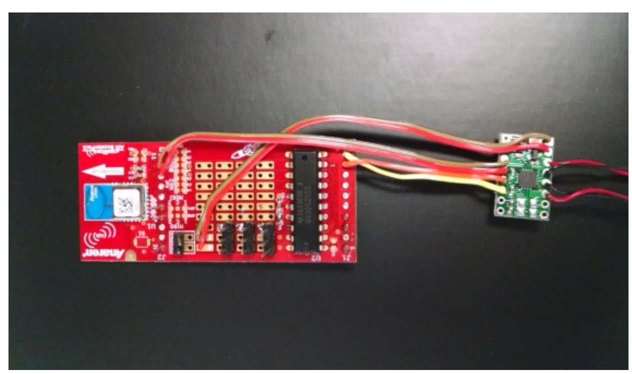
Receiver



Transmitter







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1 System Description

The TIDM-WIRELESSRC reference design describes the implementation of a sub-1 GHz wireless remote control with the following characteristics:

- Low power wireless communication
- Remote wireless control of brushed DC and servo motors
- Lithium polymer battery charging

1.1 MSP430G2553

The Texas Instruments™ MSP430G2553 is an ultra-low-power microcontroller from the MSP430 family of devices. The architecture is optimized to achieve extended battery life in portable applications.

As Figure 1 shows, the devices in the MSP430G2xx3 family have two 16-bit timers, an optional 10-bit ADC with eight input channels (G2x53 devices), one Universal Serial Communications Interface (USCI), a comparator, and up to 24 I/O pins. This reference design uses the MSP430G2553 in the MSP-EXP430G2 LaunchPad, which is the superset of the G2xx3 family of devices, with 16KB flash, 512 bytes RAM, and 16 I/Os in a dual in-line package (DIP). The MSP430G2553 device processes incoming wireless data into control signals for three servo motors and two DC brush motors. The control signals are pulse-width modulated to the input of the servos and the DRV8833.

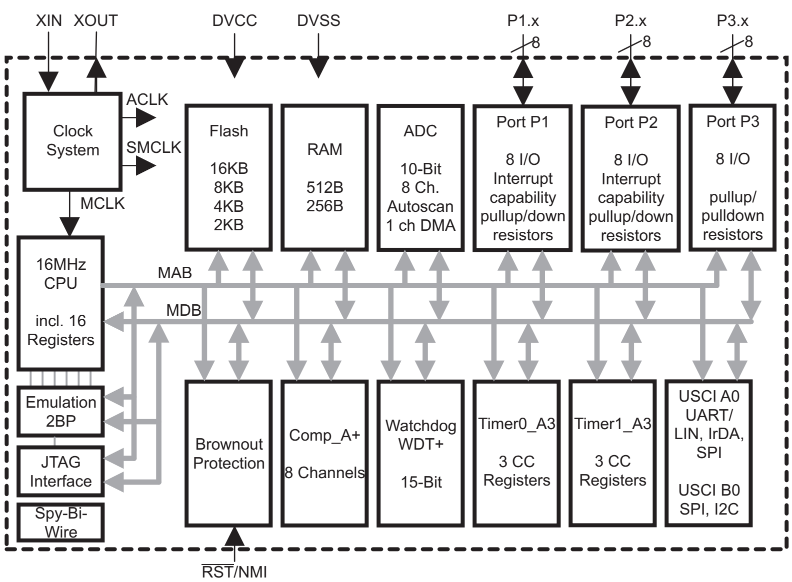

Figure 1. Functional Block Diagram – MSP430G2553

1.2 CC110L

The CC110L is a cost optimized sub-1 GHz RF transceiver for the 300- to 348-MHz, 387- to 464-MHz, and 779- to 928-MHz frequency bands. The circuit is based on the popular CC1101 radio frequency (RF) transceiver and the RF performance characteristics are identical. The two CC110L transceivers in this design are used together to enable a low-cost bidirectional RF link.

This reference design uses the CC110L transceivers in the 430BOOST-CC110L BoosterPack to transmit the control inputs between the transmitter and the receiver.

1.3 DRV8833

The DRV8833 provides a dual-bridge motor driver solution for toys, printers, and other mechatronic applications. The device has two H-bridge drivers and can drive two DC brush motors, a bipolar stepper motor, solenoids, or other inductive loads. The output driver block of each H-bridge consists of N-channel power MOSFETs configured as an H-bridge to drive the motor windings. Each H-bridge includes circuitry to regulate or limit the winding current.

This reference design uses the DRV8833 in the DRV8833EVM to control the speed and direction of two brushed DC motors.

1.4 MSP430F5529

The MSP430F5529 microcontroller features an integrated universal serial bus (USB) and physical layer (PHY) supporting USB 2.0, four 16-bit timers, a high-performance 12-bit analog-to-digital converter (ADC), two USCIs, a hardware multiplier, direct memory access (DMA), a real-time clock module with alarm capabilities, and 63 I/O pins.

This reference design uses the MSP430F5529 in the MSP-EXP430F5529LP LaunchPad to translate user inputs from real-world analog signals into wireless digital packets and transmit the information to the receiver.

1.5 BQ24210

The BQ24210 device is a highly-integrated lithium-ion (Li-Ion) linear charger targeted at space-limited portable applications. The battery is charged in three phases: conditioning, constant current, and constant voltage with an integrated circuit (IC) thermal protection and safety timer. The charge current value is programmable through an external resistor. The high input voltage range with input overvoltage protection supports low-cost unregulated adapters.

This reference design uses the BQ24210 device to charge the lithium polymer batteries used in both the receiver and transmitter with a USB cable.

1.6 BQ27510-G2

The Texas Instruments BQ27510-G2 system-side Li-Ion battery fuel gauge is a microcontroller peripheral that provides fuel gauging for single-cell Li-Ion battery packs. The device requires little system microcontroller firmware development.

This reference design does not use the BQ27510-G2 device.

1.7 TPS63001

The TPS6300x devices provide a power supply solution for products powered by either a two-cell or three-cell alkaline, nickel-cadmium (NiCad) battery, or nickel-metal hybride (NiMH) battery, or a one-cell Li-Ion or Li-polymer battery. Output currents can go as high as 1200 mA while using a single-cell Li-Ion or Li-polymer battery and discharge the battery voltage down to 2.5 V or lower.

This reference design uses the TPS63001 device to regulate the lithium polymer battery voltage down to 3.3 V for the microcontroller.

1.8 TPS63002

The TPS6300x family of devices provide a power supply solution for products powered by either a two-cell or three-cell alkaline, NiCad or NiMH battery, or a one-cell Li-Ion or Li-polymer battery. Output currents can go as high as 1200 mA while using a single-cell Li-Ion or Li-Polymer Battery and discharge it down to 2.5 V or lower.

This reference design uses the TPS63002 device to regulate the lithium polymer battery voltage up to 5.0 V for the high drive I/O pins on the microcontroller. The TPS63001, TPS63002, BQ27510-G2, and BQ24210 devices are all a part of the BOOSTXL-BATTPACK BoosterPack.

2 Block Diagram

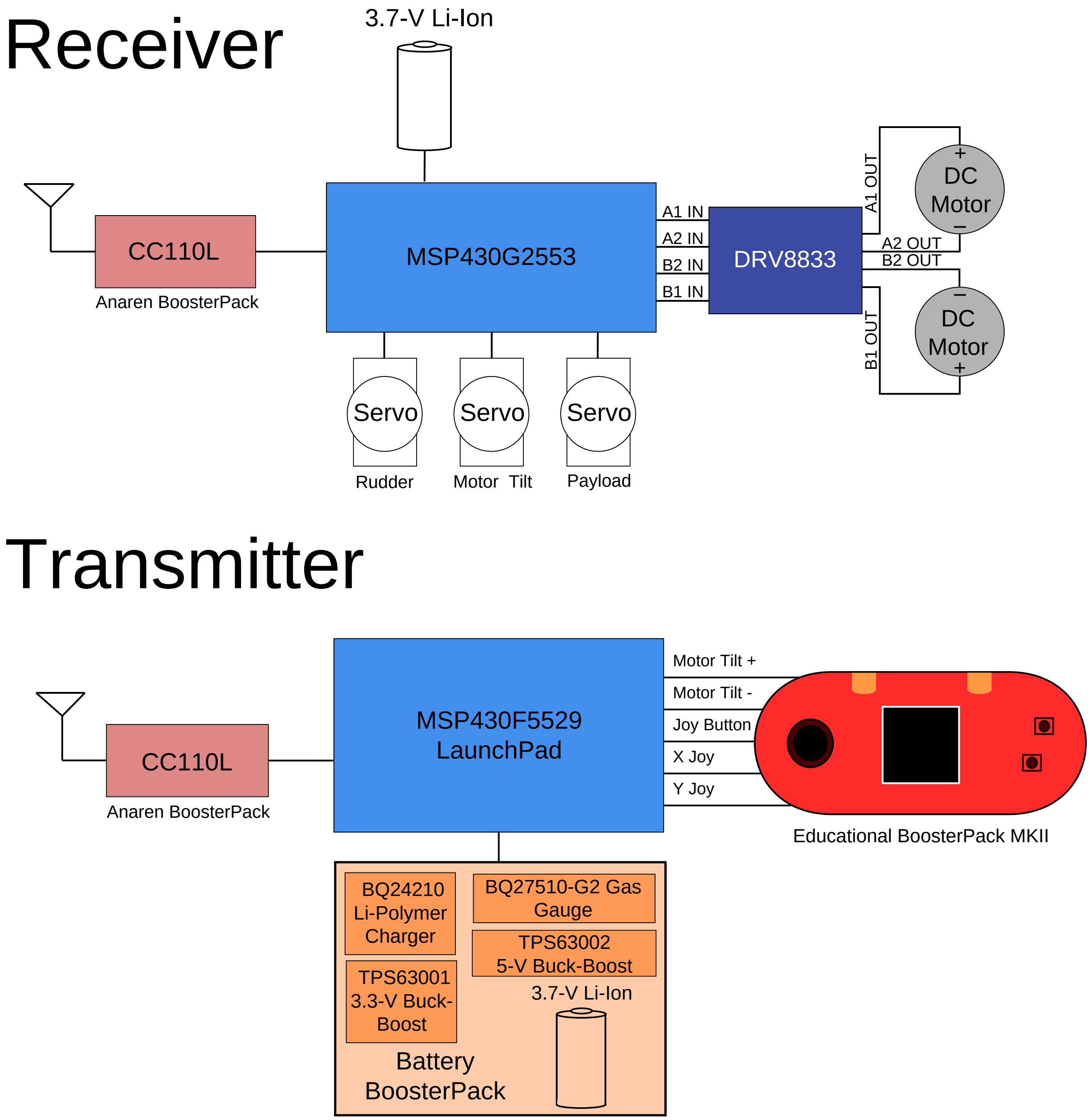

Figure 2. TIDM-WIRELESSRC Block Diagram

3 System Design Theory

3.1 User Input

The BOOSTXL-EDUMKII provides a simple interface for the user in the form factor of a game controller with two push buttons, a two-axis joystick, and a select button. The joystick axis inputs of x and y vary from 0 to 4096. These inputs are divided evenly into two bands each: the “forward/right” position (2048-4096) and the “reverse/left” position (2048-0) of the joystick based on the axis. Each of these positions is then mapped from 0 to 254 for a corresponding pulse width modulation (PWM) value. A direction variable is used to define how the DC motors and rudder are triggered. This direction variable is determined by the value of the joysticks y-position first and then the x-position. Additionally a rudder variable is created and mapped from 0 to 180 to mix control of the rudder with the x-position of the joystick.

The joystick select button is programmed to trigger the payload servo to actuate and drop whatever cargo the payload servo happens to be carrying.

The two push buttons are programmed to increment and decrement the angle of the two brushed DC motors by two degrees to provide additional lift or forward thrust as required in flight.

The MSP-EXP430F5529LP LaunchPad takes the user inputs and translates them into control signal values and sends them to the CC110L BoosterPack to be transmitted to the receiver.

3.2 Receiver Control

The variables transmitted to the CC110L are received by the MSP430G2553 device which then processes the variables to control the blimp servos and motors. The joysticks direction and PWM values are written to the DRV8833 device using analogWrite() statements to control the motor speed and direction.

If the user applies any left or right turn then the rudder value is written to the rudder servo, allowing for greater turning control while the blimp is in motion. While the blimp is stationary, the motors provide greater control for turning than the rudder. Mixing the rudder with the motor control provides greater turning control for the user.

If the user depresses one of the two motor push buttons, the MSP430 increments the motor servo forwards or backwards by two degrees depending on the transmitted value.

If the user presses the joystick select button, the MSP430 triggers the payload servo to move 180 degrees forward, hold for one second, and then move back 180 degrees to dispense the payload that the servo is carrying.

4 Getting Started Hardware

This section covers the steps required to prepare the hardware for this application.

4.1 Hardware Setup

4.1.1 The Receiver

The receiver source code requires a MSP430G2553 from the MSP-EXP430G2 Rev 1.5 LaunchPad, 430BOOST-CC110L BoosterPack, and DRV8833EVM Rev A. This reference design used the following modifications:

- Unsolder R27 and C14 from the MSP430 LaunchPad and solder them onto the CC110L BoosterPack at R1 and C2, respectively.
- Remove the MSP430G2553 from the MSP430 LaunchPad and solder it to the CC110L BoosterPack in the U2 position.
- Solder the BoosterPack header pin 10 to the DRV8833EVM pin AIN1.
- Solder the BoosterPack header pin 9 to the DRV8833EVM pin AIN2.
- Solder the BoosterPack header pin 12 to the DRV8833EVM pin BIN1.
- Solder the BoosterPack header pin 13 to the DRV8833EVM pin BIN2.
- Solder the DRV8833EVM pin AOUT1 to the left motor positive lead.
- Solder the DRV8833EVM pin AOUT2 to the left motor negative lead.
- Solder the DRV8833EVM pin BOUT1 to the right motor positive lead.
- Solder the DRV8833EVM pin BOUT2 to the right motor negative lead.
- Solder the 3 x 3-pin headers in the breadboard area of the CC110L BoosterPack as servo connectors.
- Solder the 1x 2-pin header in the GND and VDD location as a battery connector.
- Solder a wire on the bottom of the BoosterPack connecting VDD from the 2-pin header to all of the 3-pin headers.
- Solder a wire on the bottom of the BoosterPack connecting GND from the 2-pin header to all of the 3-pin headers.
- Solder the BoosterPack header pin 11 to a 3-pin header available pin to create the rudder servo.
- Solder BoosterPack header pin 2 to a 3-pin header available pin to create the motor servo.
- Solder the BoosterPack header pin 5 to a 3-pin header available pin to create the payload servo.
- Solder the VDD and GND of the BoosterPack to the VDD and GND of the DRV8833EVM.
- Place Jumpers J1, J2, J3, and J4 on the DRV8833EVM in position 1.
- Remove the switches on DRV8833EVM (optional).

4.1.2 The Transmitter

The transmitter source code requires any 40-pin LaunchPad such as the MSP-EXP430F5529LP Rev 1.4, BOOSTXL-EDUMKII Rev A1 Educational BoosterPack, BOOSTXL-BATTPACK Rev 1.0 FuelTank BoosterPack, and the 430BOOST-CC110L BoosterPack. Please verify the following jumper settings:

- Remove the “I_2C PULLUPS” jumper from the FuelTank BoosterPack
- Place both the “5 V Out” and “3.3 V Out” jumpers on the FuelTank BoosterPack

Plug the CC110L BoosterPack into the bottom header of the MSP-EXP430F5529LP. Next, plug the FuelTank BoosterPack into the top header on the MSP-EXP430F5529LP. Then plug the Educational BoosterPack into the top header on the FuelTank BoosterPack.

4.2 Software Setup

The software includes sketch files for the Energia 0101E0014 software and can be imported into the Code Composer Studio™ software version 6 (CCSv6) or greater.

4.2.1 The Receiver

To program the receiver, plug the CC110L BoosterPack into the MSP-EXP430G2 LaunchPad if the goal is to not remove the headers; otherwise, a jumper to the following pins is required:

- VDD, RXD (universal asynchronous receiver/transmitter (UART)), TXD (UART), RST, TEST, and GND pins from the MSP-EXP430G2 LaunchPad to pins 1, 3, 4, 16, 17, and 20 on the BoosterPack respectively

After connecting the BoosterPack, plug in the USB cable provided with the LaunchPad. Open the Energia integrated development environment (IDE), navigate to the sketch labeled *BlimpReceiver.ino*, and open the sketch. Verify the following settings before proceeding:

- Navigate to the file menu under Tools → Board → then select “LaunchPad w/ msp430g2553 (16MHz)”
- Navigate to the file menu under Tools → COM Port → then select the COM port associated to the desired LaunchPad

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NOTE: The programmer may require an update before the user can flash the microcontroller. Update the programmer if the prompt requests such by navigating to the file menu under Tools → select “Update programmer”.

After confirming the settings then upload the sketch to the microcontroller. If plugged in, the servos make noise as they center when the microcontroller initializes.

4.2.2 The Transmitter

To program the transmitter, plug in the provided USB cable into the MSP-EXP430F5529LP. Open the Energia IDE, navigate to the sketch labeled *BlimpController.ino*, and open the sketch. Verify the following settings before proceeding:

- Navigate to the file menu under Tools → Board → then select “LaunchPad w/ msp430f5529 (16MHz)”
- Navigate to the file menu under Tools → COM Port → then select the COM port associated to the LaunchPad

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NOTE: There are two COM ports available for the 5529 LaunchPad and they may require switching if the programmer does not properly upload the sketch.

NOTE: The programmer may require an update before the user can flash the microcontroller. Update the programmer if the prompt requests such by navigating to the file menu under Tools → select “Update programmer”.

After confirming the settings, upload the sketch to the microcontroller. The liquid-crystal-display (LCD) backlight on the Educational BoosterPack turns on when the transmitter powers up. If the serial monitor were open, then the print outs of the variables being transmitted would be visible.

5 Test Setup

The test setup for this reference design consists of placing the receiver into the gondola of a seven-foot blimp kit. The blimp is inflated with helium until it is just slightly negatively buoyant and can naturally sink to the floor very slowly under no power.

6 Test Data

This reference design transmits five control variables and one address with every communication. Table 1 shows the designations of the control variables and their descriptions.

Table 1. Control Variables Documentation

VARIABLE NAME	VALUES	DESCRIPTION
xPWM	int (0 – 254)	Mapped PWM value for x-axis joystick position
yPWM	int (0 – 254)	Mapped PWM value for y-axis joystick position
rud	int (0 – 180)	Mapped PWM value for rudder servo mixing
Dir	int (0 – 4)	Direction variable to define forward, reverse, stop, left turn, or right turn movement of the blimp
motor	int (0 – 3)	Motor variable used to increment or decrement motor angle as well as payload trigger

Table 2 is the table of operations based on the software sketch provided with this reference design:

Table 2. Blimp Operation

USER INPUT	CONTROL VARIABLE VALUES	DESCRIPTION
yPosition ≤ 2000	Dir = 2 yPWM = PWM	Motors move in reverse direction
yPosition ≥ 2040	Dir = 1 yPWM = PWM	Motors move in forward direction
xPosition ≤ 2010	Dir = 4 xPWM = PWM rud = PWM	Left turn : left motor reverse and right motor forward with mixed left rudder
xPosition ≥ 2040	Dir = 3 xPWM = PWM rud = PWM	Right turn: right motor reverse and left motor forward with mixed right rudder
2040 ≤ xPosition ≤ 2010 and 2040 ≤ yPosition ≤ 2000	Dir = 0 xPWM = 0 yPWM = 0 rud = 90	Stop : All motors stopped and rudder at 90 degrees
btn1 = 0	motor = 1	Increment motor angle 2 degrees
btn2 = 0	motor = 2	Decrement motor angle 2 degrees
btn3 = 0	motor = 3	Trigger payload servo
btn1 = btn2 = btn3 = 1	motor = 0	No action

Note the control inputs and outputs of the DRV8833 device used in this reference design in Table 3.

Table 3. DRV8833 Control Parameters

xIN1	xIN2	xOUT1	xOUT2	DESCRIPTION
0	PWM	0	PWM	Motor spinning in reverse, speed is based on PWM value
PWM	0	PWM	0	Motor spinning forward, speed is based on PWM value

6.1 Pictures

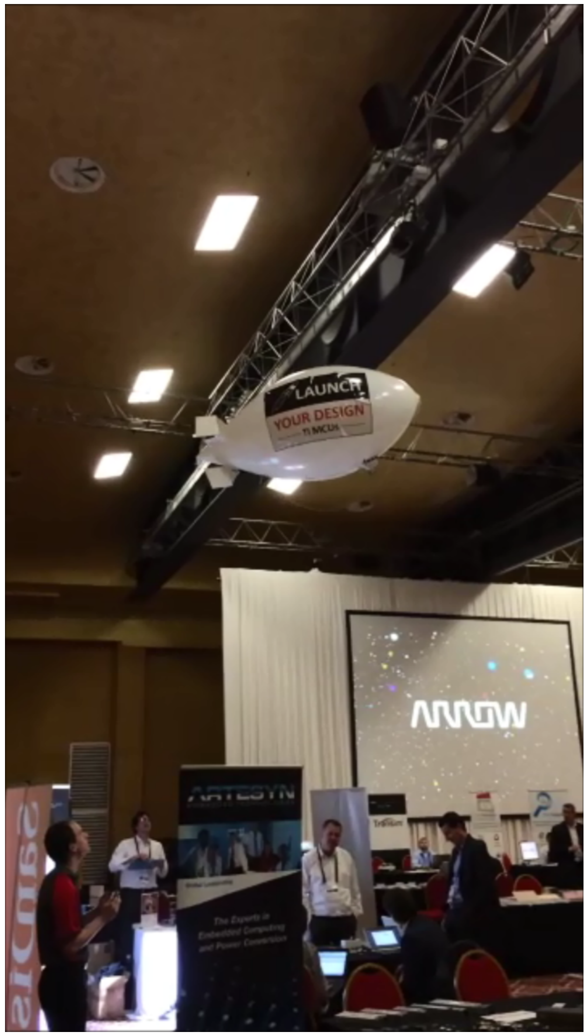

Figure 3. Blimp Test Flying at Trade Show

7 Design Files

7.1 Schematics

To download the schematics for each board, see the design files at http://www.ti.com/tool/TIDM-WIRELESSRC.

7.2 Bill of Materials

To download the bill of materials (BOM), see the design files at http://www.ti.com/tool/TIDM-WIRELESSRC.

7.3 PCB Layout

To download the layout prints for each board, see the design files at http://www.ti.com/tool/TIDM-WIRELESSRC.

7.4 Gerber Files

To download the Gerber files, see the design files at http://www.ti.com/tool/TIDM-WIRELESSRC.

7.5 Assembly Drawings

To download the assembly drawings, see the design files at http://www.ti.com/tool/TIDM-WIRELESSRC.

8 Software Files

To download the software files, see the design files at http://www.ti.com/tool/TIDM-WIRELESSRC.

9 About the Author

JOSHUA COLLINS is a Marketing & Applications Engineer at Texas Instruments, where he is responsible for developing marketing collateral and demos for TI’s microcontroller families. Joshua earned his Bachelors of Science in Electrical Engineering (BSEE) from Arizona State University in Tempe, AZ.

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