P1110-EVAL-PS

PowerSpot® RF Wireless Power Development Kit for Battery Recharging

User Manual

Overview

The PowerSpot® RF Wireless Power Development Kit for Battery Recharging is a complete demonstration and development platform for recharging batteries in consumer devices wirelessly from RF energy (radio waves) using the PowerSpot transmitter. It is designed to be used at a higher RF power level using the PowerSpot TX91503 RF Wireless Transmitter. For higher power recharging, a charging distance of 5 ft. or less between transmitter and evaluation board is recommended, but this board can be used at a distance of up to 20ft. It can be used with or without a mobile app and is configured for out-of-the-box operation.

The battery recharging P1110-EVB-PS board utilizes the P1110B Powerharvester® Receiver, which converts RF energy into DC power. The PowerSpot TX91503 transmitter is the source of RF energy, operating at 915MHz. The battery recharging EVB receives the RF energy, converts it to DC, and charges the onboard batteries.

The battery recharging P1110-EVB-PS evaluation board includes the circuitry necessary to activate the PowerSpot transmitter via BLE communication. It can keep it transmitting once its TxID (the ID of the PowerSpot transmitter) has been received. If a valid TxID signal is not received, or the measured RSSI value falls below a value defined at 20 feet for more than a 30 second duration, the transmitter will automatically turn off. Circuitry on the P1110-EVB-PS will also monitor the voltage of the battery being recharged, the level of current being supplied to recharge the battery, and Received Signal Strength Indication (RSSI) of the RF field received from the PowerSpot or other RF sources. All of this data is transmitted via Bluetooth to a mobile device and can be displayed in the free PowerSpot Dev app. A switch on the EVB (S1) allows the user to select from three on board batteries. This enables the user to test RF charging capabilities on various battery types / chemistries included on the EVB.

At the press of a push button (PB1), an on-board LED gives visual charging / done status indication without the use of the app. Also integrated onto this board is circuitry that will allow the discharge of the selected battery at various discharge rates (jumper selectable – J3). A separate LED indicates when the discharge mode is active.

This P1110-EVB- contains many features and functions. For the simplest reference design for a potential application, please contact Powercast directly.

Table of Contents

Kit Contents

The contents of the kit are shown in the image and table below. The kit includes a TX91503 PowerSpot RF transmitter with power adaptor and quickstart guide, an RF energy harvesting evaluation board (P1110-EVB-PS) which includes a Li-iON 2032 size rechargeable cell, a Li-Mn cell in the shape similar to a single "AA", and three (3) NiMH cells "AAA" size in series. It comes with a patch antenna with SMA connector, a dipole antenna with SMA connector, and two (2) PS915 RF field detecting light sticks. The PowerSpot Dev app can be downloaded for free on the Apple or Google Play store.

Fig. 1 – Photo of Kit Contents

Qty	Item	Description
1	PowerSpot Transmitter (TX91503) (with power adaptor and quickstart guide)	3-watt, 915 MHz transmitter for power and data transfer with integrated 6dBi antenna and power jack. Comes in consumer packaging with power supply and quickstart guide.
1	PowerSpot Evaluation Board (P1110-EVB-PS)	Evaluation board with P1110B Powerharvester Receiver. This board has an SMA connector to attach the antennas and various test points.
1	Patch antenna (PA-915-01)	915MHz directional antenna with 120-degree reception pattern. (included with the P1110-EVB-PS evaluation board). Gain = 4.1 (6.1 dBi)
1	Dipole antenna (DA-915-01)	915MHz omni-directional antenna with 360-degree reception. (included with the P1110-EVB-PS evaluation board). Gain = 1.25 (1.0 dBi)
2	RF Field Detecting Light Sticks (PS915)	RF field detecting light stick (operates at 850-950MHz)
3	NiMH batteries	Rechargeable NiMH batteries to be used in series
1	Li-iON coin cell battery	Rechargeable Li-iON coin cell battery
1	Li-Mn battery	Rechargeable Li-Mn battery

Table 1 – Kit Contents

Set-up and Operation

Installation Overview Summary
The following basic steps are required to operate the kit and are provided as an overview.
Detailed installation instructions are provided immediately after this summary.

P1110-EVB-PS
Battery Recharging
1. Install the PowerSpot Dev app on your Android or iOS device.

   NOTE: The use of the PowerSpot Dev app is **NOT required** to use this evaluation board. The app adds additional functionality to monitor the battery and set a power transmission schedule for the transmitter.

2. Select the battery you want to recharge (switch S1).
3. Connect the desired antenna to the EVB evaluation board (J1).
4. If desired, attach test equipment to desired test points on EVB evaluation board.
5. Install the jumper J2 to connect the battery.
6. Enable the PowerSpot transmitter by plugging it in. Its status LED will initially be RED. Once communication is established with the EVB, the status LED on the PowerSpot transmitter will turn GREEN.
7. Press button PB1 if desired (short button press < 2 seconds) to "activate" the charging data transmission to the PowerSpot Dev app.
8. Measure data.

NOTE: The Lithium-Ion batteries on the PowerSpot-EVB need to be recharged every 3 months to prevent damage to the battery. Jumper J2 should be removed for long term storage.

P1110-EVB-PS

Fig. 2 – Photo of P1110-EVB-PS

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Important Components on the P1110-EVB-PS
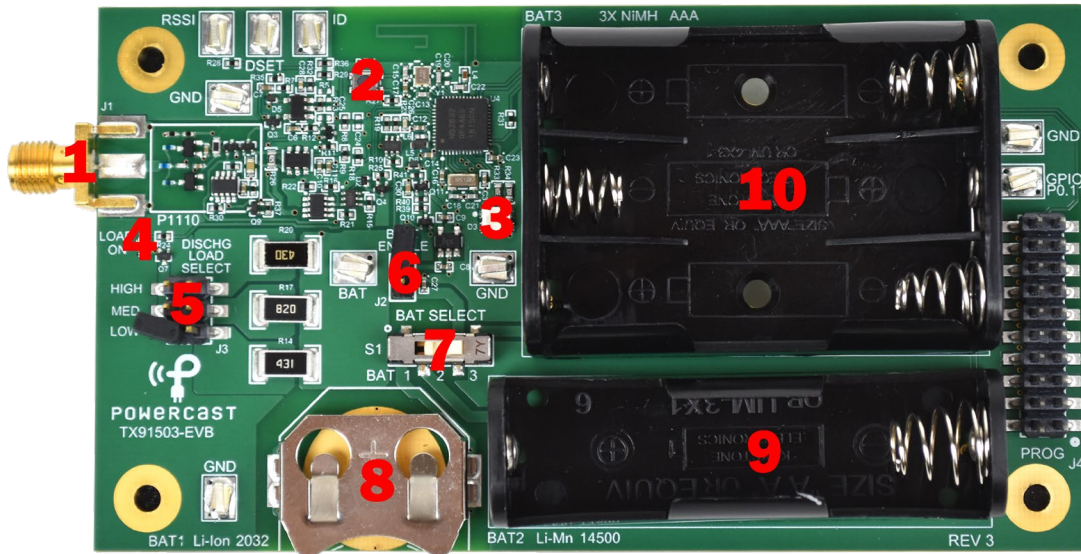
Fig. 3 – Component Identification on the P1110-EVB-PS

#	ID	Description
1	J1	SMA Connector for antenna
2	PB1	Push Button for controlling various states
3	D3	LED status indicator
4	D4	LED battery discharge status indicator
5	J3	Discharge load selector
6	J2	Battery connection jumper
7	S1	Battery selection switch
8	BAT 1	Li-iON coin cell battery holder
9	BAT 2	Li-MN battery holder
10	BAT 3	(3) NiMH battery holder

Table 2 – EVB Components

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Step-by-Step Installation and Use

1. Select the battery you wish to charge

SW1 is a 3 position slide switch. The three batteries can be selected (only one type at a time) with this switch. See the table below for more information.

SW1 SWITCH POSITION	LOCATION NAME	BATTERY TYPE SELECTED
Left	BAT 1	Single coin cell size Li-iON battery
Middle	BAT 2	Single Li-Mn battery, similar to "AA" size
Right	BAT 3	(3) NiMH 1.2V batteries in series, equivalent to "AAA" size.

Table 3 – SW1 Switch Position

2. Connect the antenna

Included in the kit are two different styles of antennas. Connect your choice of antenna to the SMA jack (J1). This is where the received RF is fed to the EVB. Orient the antenna in the proper polarization in relation to the transmitter being used as described in the note below:

Orientation of the EVB in relation to the transmitting source is extremely important. Properly aligning the transmitting and receiving antennas will give the best performance. Both antennas - dipole (shown) and patch (not shown) – have the same polarity and should be oriented in the same manner as the photos below:
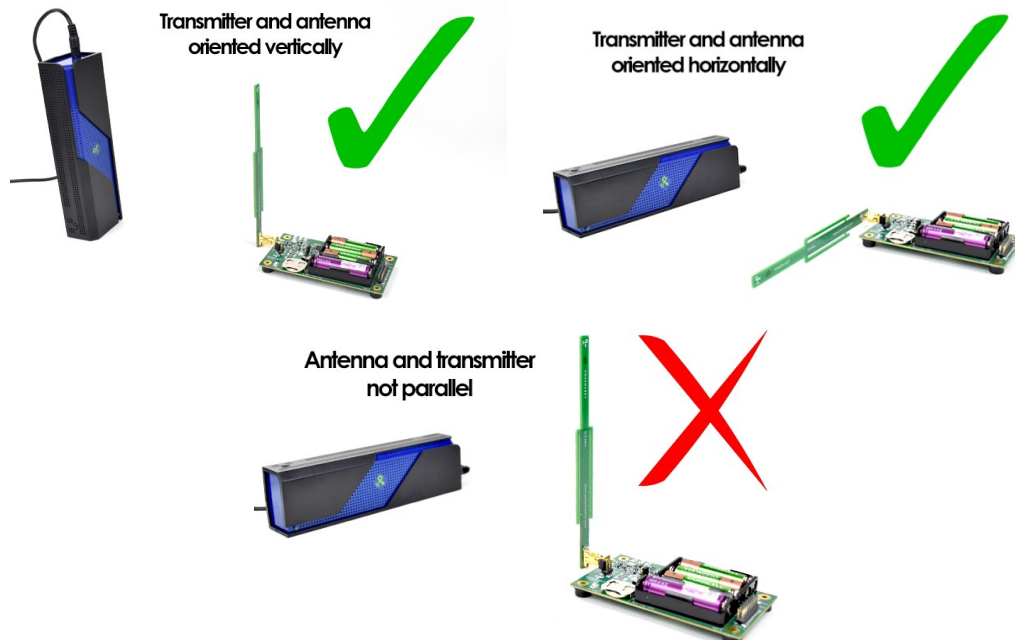

Fig. 4 – Correct Antenna Orientation

Note: As a precaution, do not operate the transmitter within 4 inches of the evaluation board when the patch antenna is attached. Please see the transmitter's user manual for operating details.

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3. Connect any test equipment

Testpoints are included on the EVB to provide access to various connections to the circuitry on the PCB. These include BAT, GND, RSSI, TxID, DSET, and GPIO11 – see table below for more detail.

GPIO11 can be used for any purpose the end user desires, but firmware would need to be generated, compiled and programmed to the Nordic device through J4 programming header. Contact Powercast directly for custom GPIO11 usage.

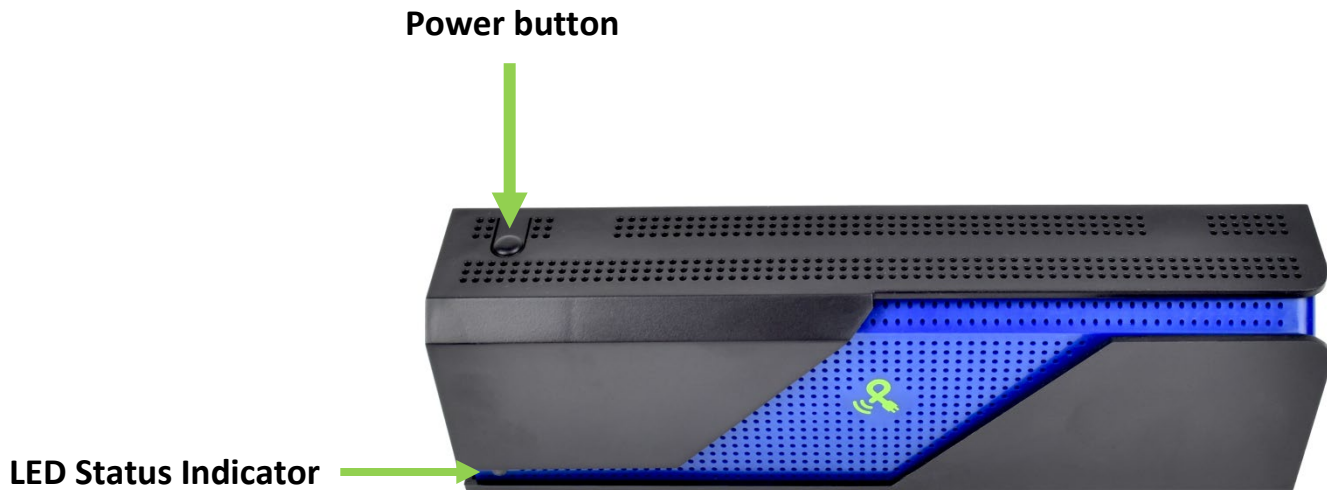| Test Point Label	Function
BAT	Selected BATTERY connection point, while jumper J2 is installed
GND(s)	DC Ground. Connected to analog and RF ground plane. 4x
RSSI	Analog Output. Provides an analog voltage level corresponding to the harvested power.
DSET	Digital output that when set (by the microprocessor), enables measurement of harvested power (RSSI) and TXID read hardware
ID	Digital output. When DSET is high, TxID is present on this pin
GPIO P0.11	I/O to the control processor. User must reprogram the device to take advantage of this pin

Table 4 – Testpoint Functions

4. Turn on the P1110-EVB-PS power

Install jumper J2. When the evaluation board powers up the first time, the on-board discharge LED D4 will blink momentarily. This is to provide feedback that the unit has successfully turned on. Since the EVB monitors voltage, if the battery is too low, it will not be able to transmit any beacons to turn on the transmitter or provide data to the app. If the battery is **full**, the evaluation board will stop sending beacons to the app and transmitter, allowing the transmitter to turn off and the evaluation board to preserve any charge that was just received. Pressing the PB1 button while fully charged will turn the app beacons on for less than 1 minute and then go back to sleep.

5. Turn on the transmitter and point towards P1110-EVB-PS

Plug in the PowerSpot Transmitter and point it towards the evaluation board and receiving antenna, making sure to orient both as in the figures above in step 3. Place the P1110-EVB-PS at an initial distance of 1 to 2 feet from the transmitter. The line-of-sight range when using the included patch antennas is around 20 feet maximum, and less for the dipole antenna.

Note: Operating the evaluation board on a ground plane such as an anti-static protection mat on a lab bench may cause significant signal attenuation.

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Power button

LED Status Indicator

Fig. 5 – PowerSpot Power Button and LED Status Indicator

The status LED on the front of the PowerSpot transmitter will be RED until a "turn on" beacon is received from the evaluation board or other device with a valid TxID.

This original beacon momentarily activates the transmitter, and turns the LED on the PowerSpot Tx GREEN. As soon as the evaluation board reads the valid TxID from the transmitter, it sends the same TxID back for verification. This beacon exchange keeps the transmitter on for 1 minute intervals until the RSSI drops below a certain threshold. Decreased RRSI could be due to signal obstruction, complete discharge of batteries, complete charging of batteries, separation of the transmitter and receiver, etc. For further details on this operation, see the PowerSpot user manual located in the included PowerSpot packaging or on Powercast's website at: https://www.powercastco.com/products/powerspot/

If the battery voltage on the EVB is too low, it will **NOT** beacon to turn on the PowerSpot transmitter. In this case you can manually press the button on the top of the PowerSpot. This single button press will turn on the transmitter for a period of 30 minutes to allow charging to take place. If the battery voltage rises past the low voltage level (approximately 3.3 Volts) during one of these manual button press cycles, depending on how low the battery was the EVB may automatically start to beacon to the transmitter thus keeping it on until charge is complete. This manual button press can be done as many times as necessary to bring the EVB/battery out of this low voltage state. Pressing the button a second time before the 30 minute time period expires will turn the transmitter back off.

Note: If the battery is severely low (<3.1V), then it must be partially charged by the pressing the button on the transmitter, and then once a voltage above 3.2-3.3Volts is achieved turn the transmitter off and cycle the power on the EVB by removing and then reinstalling jumper J2.

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6. Enable data transmissions over Bluetooth.

To activate the radio transmissions to the app, press button PB1 for approximately 1 second (short button press). This will activate the radio data beacon to the app for 30 minutes. The app will automatically update with the new charging values. If charging is complete or battery level falls below a minimum value (from lack of RF field as described in step 6), the radio transmissions will automatically stop.

7. Install the App on your Android or iOS device

Battery recharging will take place regardless of the state of the communication to the app. An LED on the evaluation board will indicate the charge level (by monitoring charging current) and will also give a "charge full" indication (by monitoring voltage). If you choose not to pair the board with the PowerSpot Dev App, you may proceed directly to step 2.

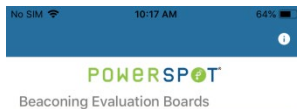<p align="center">How to use the PowrSpot Dev App</p>

Fig. 6.1 – App Icon

1. Install the PowerSpot Dev App. On the Apple or Google Play app store, search for Powercast. Find and install the PowerSpot Dev app.

2. Make sure Bluetooth is enabled on your device. Launch the App. Your screen should look like the image to the left.

   Click [⟳ Scan Bluetooth] on the bottom right of the screen to search for beaconing boards if none automatically appear. See step 3 for instructions on how to enable beacons on the P1110-EVB-PS.

Fig. 6.2 – App with no boards beaconing
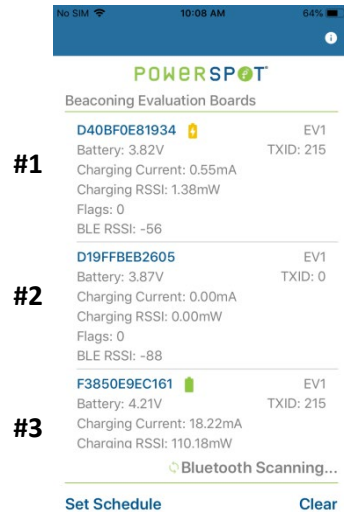
Fig. 6.3 –App communicating with evaluation boards

3. Make your board(s) visible to the app. With the EVB powered up (J2 installed) Press PB1 on the P1110-EVB-PS momentarily (2 seconds or less). The green status LED (D3) will blink green. This will start the transmitting of the charging data to the app. The app will automatically receive the data. No pairing is required. Your screen should now look like the image on the left. (Fig 4.2) Multiple devices will show their data on the next line.

Devices that are actively receiving wireless power and recharging an on-board battery will show a yellow recharging battery icon 🔋 such as board #1 on the figure to the left. Boards that are not charging will appear with no battery icon next to them, such as board #2 on the left. A board that has fully charged the chosen battery (chosen using S1) will appear with a green full battery icon 🔋 such as board #3 to the left.
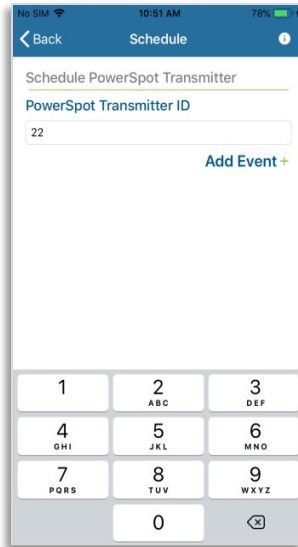
A board could be not charging because the transmitter it is paired with is in an OFF state, or because the board is too far from a transmitter to connect and charge.

The device ID (MAC address) for each device appears in blue bold text. The charging information including battery voltage level, the charging current, and received signal strength indicator (RSSI) of the transmitter (strength of the 915MHz signal being harvested) and RSSI strength of the Bluetooth signal all appear beneath their associated P1110-EVB-PS board ID. The TXID of the transmitter that board is paired with appears to the right of the device ID.

If more than one EVB board is used, the app will populate the next line with the other board's ID and charging information.

The charging data will be sent to the app for a period of 30 minutes before going to sleep. If the 30 minute timer expires, press PB1 again (2 seconds or less) to restart another 30 minute period of data transmission. If you wish to end the data transmission earlier than 30 minutes, simply press the button PB1 again. The integrated radio will go back to sleep.

Note: The gathering, processing and transmitting of power data to the app will consume a small amount of the energy.

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4. If you wish to set a schedule on your transmitter, press the Set Schedule button and input your PowerSpot's TXID. This number can be found on the back of your transmitter(s), and is circled in red in the image below. Type in the ID number of the transmitter you wish to schedule for, then move on to step 5.


Fig. 6.4 – Syncing App with Transmitter
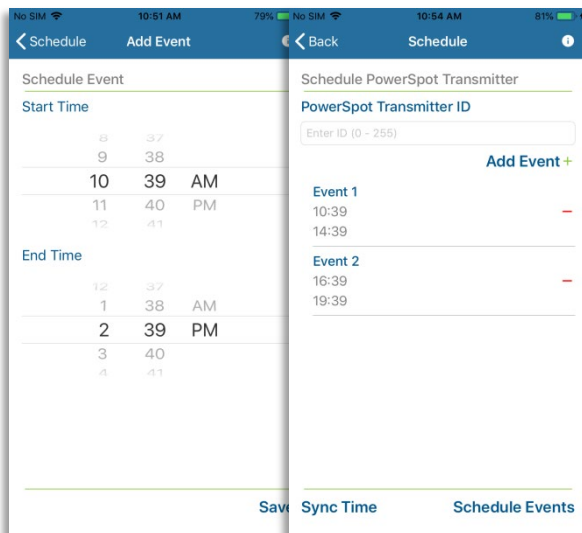
5. Schedule events. Each event you schedule is an event for the transmitter to turn **OFF**. By default, the transmitter will automatically turn on when there is a device in its field requesting power (such as the P1110-EVB-PS).

Select   Add Event +   , choose a start time and end time for the event, then hit   Save   in the lower right hand corner. Each event you create will queue on this page. You may only queue up to four events at a time.

Fig. 6.5– Creating Events

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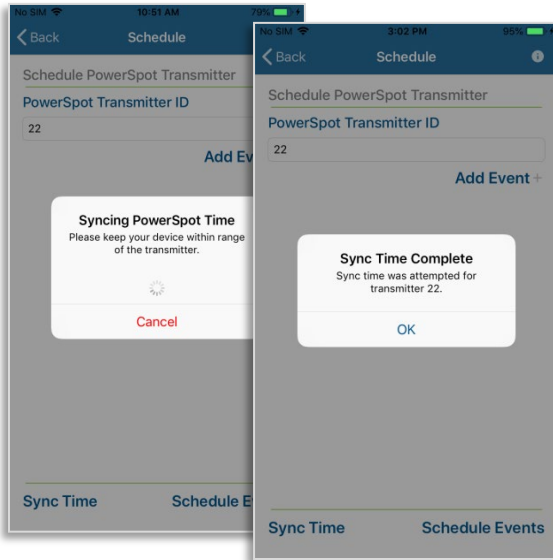
Fig. 6.6– Syncing Time

NOTE:
Each time you schedule events using this app, the PowerSpot will automatically sync with the time on your local device. In some events (such as daylight savings time), you may want to re-sync your PowerSpot and local device.

To do this, simply click the [Sync Time] button at the bottom left of the screen after inputting the TXID of the device you'd like to sync. You can only sync one transmitter at a time.
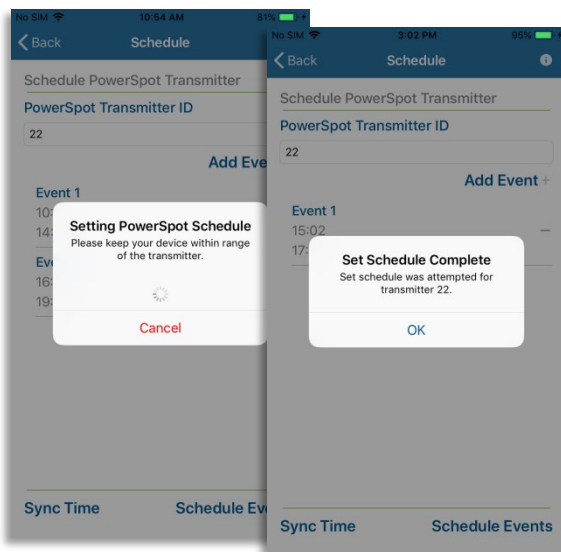
Fig. 6.7– Setting Schedule

6. Set the schedule. Once you've queued your events, select [Schedule Events] in the lower right hand corner of the screen. Once your events have been communicated to the transmitter, the app will confirm with the "Set Schedule Complete" screen. While the events are being communicated to the transmitter, the LED on the transmitter will blink back and forth between green and red to indicate that the communication was successful.

You may only schedule events for one transmitter at a time.

To cancel all events in the queue, power cycle the transmitter.

NOTE: Each time the "Schedule Events" button is pressed, the previous schedule is deleted for that designated transmitter and replaced with the new schedule.

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Status LED's

The P1110-EVB-PS has a status indicating LED. During RF charging, the button can be pressed and held for 2 seconds then released immediately after the LED blinks GREEN. Next, the LED will blink RED to indicate the amount of charging current being delivered to the battery. See the table below for more information on determining charge status using the D3 LED indicator.

As soon as the battery is fully charged the LED will flash GREEN once every 10 seconds for 1 minute. After 1 minute, the LED will again flash GREEN once every 10 seconds for 1 minute if the button is pressed and the battery is still fully charged. At this point, it is necessary to discharge the battery in order to recharge (refer to page 14).

The LED will flash GREEN long when the mobile app data is enabled or disabled via a short button press. The LED will flash RED long after a button press if the battery is low (approximately 3.3V). See the chart below for a summary of LED blink descriptions:

D3 LED blink	Indication
Short button press (1s) - 1 long GREEN	Mobile app data enabled or disabled.
Short button press - 1 long RED	Battery low (approximately 3.3V)
2s button press – 1 short GREEN followed by 1 long RED	Current charging battery >1mA and < 5mA
2s button press - 1 short GREEN followed by 2 long RED	Current charging battery >5mA and < 20mA
2s button press - 1 short GREEN followed by 3 long RED	Current charging battery >20mA
Short or 2s button press - 1 GREEN every 10s for 1min	Battery fully charged

Table 5 – P1110-EVB-PS LED status

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Discharging the selected on board battery

To discharge the selected battery, press and hold PB1 button for approximately 4 seconds. A small green LED (D4) on the EVB near the RF input connector will illuminate. This LED acts as a load (about 15mA) and gives indication that the discharge mode is active. To increase the discharge rate, any combination of jumpers can be installed on J3. The "low" jumper will increase the discharge rate by adding ~10mA with a fully charged battery. The "med" jumper will increase the discharge rate by adding ~50mA with a fully charged battery. The "high" jumper will increase the discharge rate by adding ~100mA with a fully charged battery. If all three jumpers are installed, the discharge rate could be as high as 175mA.

During discharge mode BLE data is transmitted to the app until the battery is discharged to the minimum level (determined by hardware on the EVB, approximately 3.3V). Discharge mode may also be terminated by the user by pressing the PB1 button for approximately 4 seconds. If the EVB is in the presence of an RF field, charging will automatically resume upon termination of the discharge mode. To see recharging data in the app again, press button PB1 again for ~1 second and it will begin transmitting data for another 30 minute period.

Battery Information

This kit comes pre-packaged with all necessary batteries. **All batteries used with this board must be rechargeable.** See specifications below:

Battery Position	Battery Type	Part Number	Manufacturer	Nominal Voltage
BAT 1	Li-iON 2032 coin cell 85mAh 20mm x 3.2mm	PD2032C1	Route JD	3.7V
BAT 2	Li-MN 650mAh 14mm x 50mm	IMR14500	EFest	3.7V
BAT 3	(3) NiMH 3x 900mAh 10.5mmx44.5mm	DX2400	Duracell	1.2V each

Table 6 – Battery Specifications