RF Source Transmitter Board

User Guide

SUMMARY: This document provides information on the Atmosic RF Source Transmitter Board which is used to assist customers in evaluation of RF energy harvesting with the ATM3 and ATM33e Solution.

Atmosic™

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Table of Contents

List of Figures

List of Tables

Acronyms and Abbreviations

Acronyms	Definition
ATM3	ATM3202 ATM3221
ATM33e	ATM3330e
EVK	Evaluation Kit
RF	Radio Frequency
SDK	Software Development Kit
SMA	Subminiature version A
xPA	External Power Amplifier

1. Overview

Atmosic provides an RF Source Transmitter Board to assist customers evaluating RF energy harvesting with the ATM3 and ATM33e solutions, as shown in Figure 1. The RF Transmitter Board is available separately from Atmosic and is ordered as part number ATMRFS-M22xx-02.

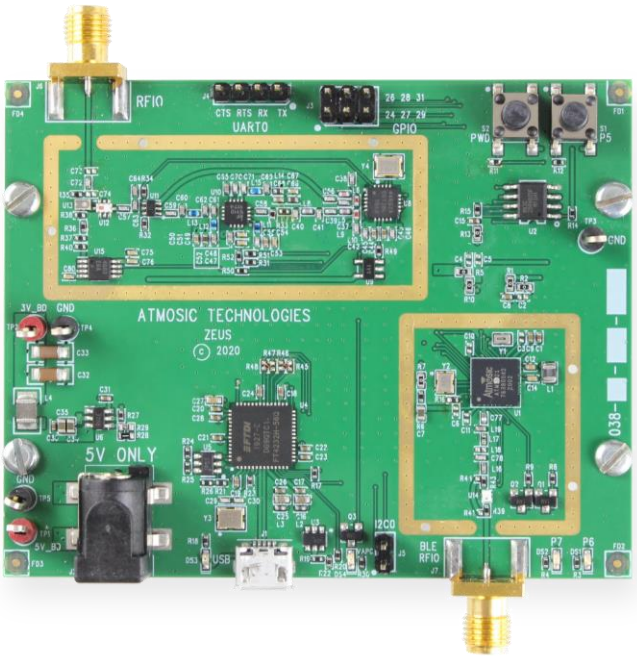

Figure 1 - RF Source Transmitter Board

RF Source Transmitter Board provides a 900 MHz signal for RF energy harvesting, a wider output power range, full USB host interface, and separate ATM2 Bluetooth LE from Atmosic for communication with target devices and phone applications.

2. RF Source Transmitter Board

The RF Source Transmitter Board updates the RF energy source for energy harvesting applications. Although the frequency range of the RF transceiver can be configured from 850 MHz to 1050 MHz, the board is designed to best work at 915 MHz. It supports testing and evaluation of RF Energy Harvesting and is designed with a 900 MHz xPA to boost the output power of the RF signal to 29 dBm (maximum).

The default configuration of the board is shown in Table 1.

Duty Cycle	Output Power	Frequency
100%	29 dBm	915 MHz

Table 1 - Board Default Setting

Note: *Do not continuously operate the transmitter board at full TX power while its antenna is closer than 6 inches to the harvesting antenna of the evaluation board.*

The main components of the RF Source Transmitter Board are shown in Figure 2. Figure 3 is the block diagram showing the connections between the main components of the boards.

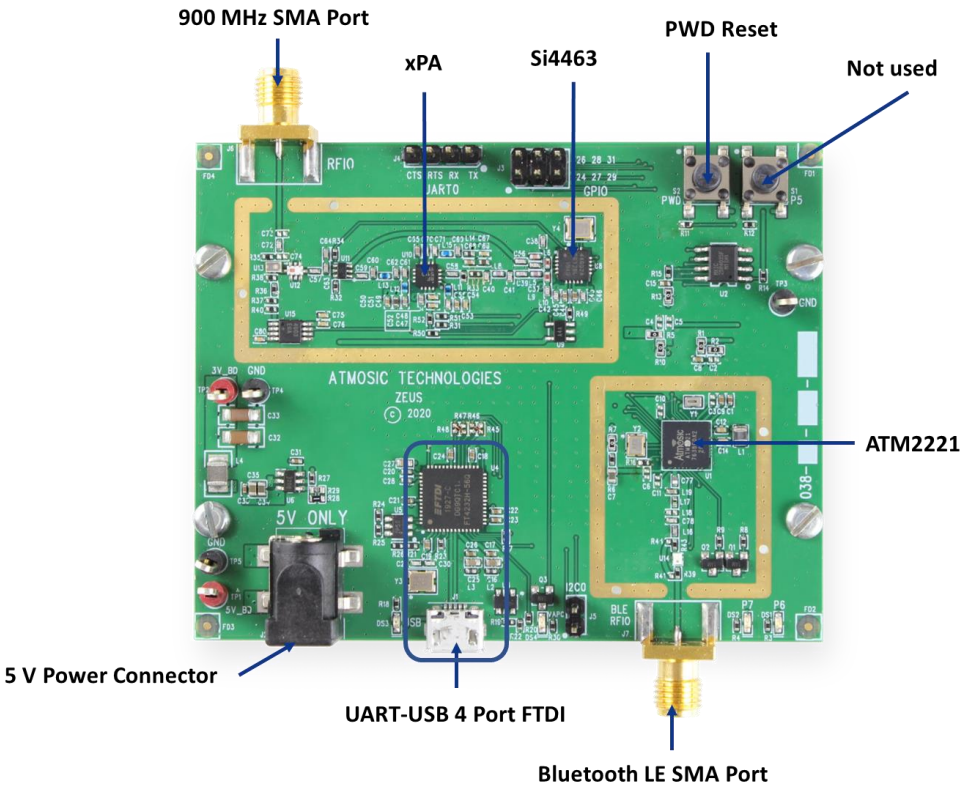

Figure 2 - RF Source Transmitter Board Description

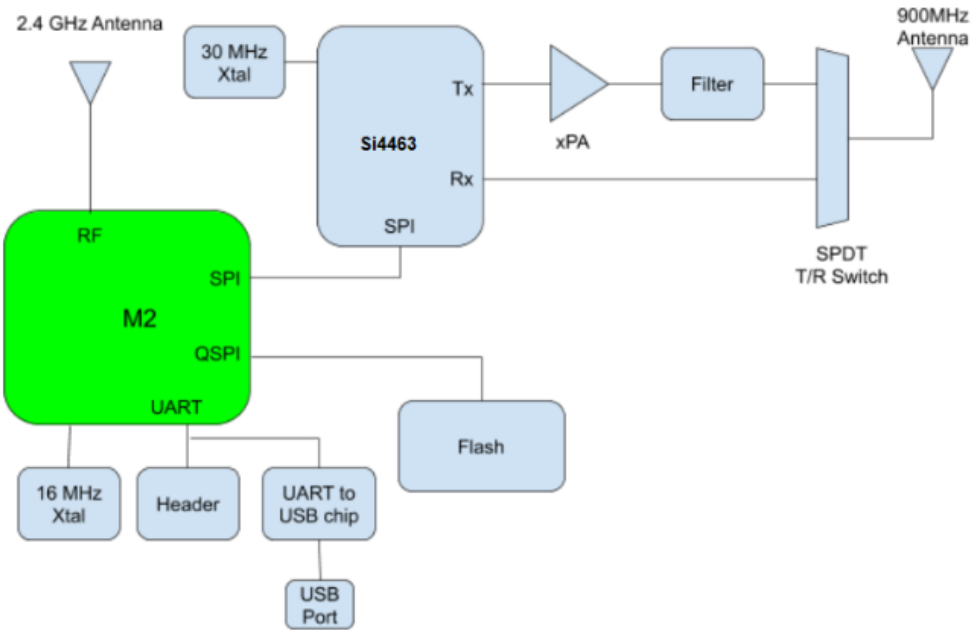

Figure 3 - RF Source Transmitter Board Block Diagram

3.2 Antennas

Two antennas are included with this kit. The longer one is to be attached to the 900 MHz SMA connector and the shorter one to the Bluetooth LE SMA connector. It is strongly recommended that the antennas be properly attached before power is applied to the board through the 5 V plug and remain attached as long as the board is powered to avoid damaging the board.

3.3 Energy Source Signal

The RF energy source is transmitted via the 900 MHz SMA port at a maximum power level of 29 dBm. There is a feedback mechanism, via a coupler and power detector, built into the transmitter chain to allow the power level to be read and adjusted. The RF signal is modulated to meet FCC spectral density requirements and is filtered by a 900 MHz low pass ceramic filter to prevent spurious and harmonic emissions from interfering with other receivers and to meet FCC radiated emission limits.

The modulated signal is produced by the Si4463 transceiver IC (M2) and is amplified by a fixed gain RF5110 Power Amplifier IC. The transmitted power level at the antenna is adjusted by programming the output level of the Si4463. Since the xPA outputs about 1 Watt of power, the board can become warm if the energy source is on continuously for an extended period of time, and this is expected.

3.4 Bluetooth LE Receiver

The RF Source Transmitter Board also includes a Bluetooth LE IC to control the RF source according to demand of the harvester. It is the ATM2221 IC from Atmosic, capable of receiving and decoding the Bluetooth LE beacons from the energy harvester and controlling the Si4463 accordingly.

The Bluetooth LE receiver front-end includes a 2400 MHz ceramic bandpass filter to block the strong 900 MHz energy source signal and thus enabling the receiver to maintain its -94 dBm sensitivity to the beacons from the harvester.

3.5 Power

The RF Source Transmitter Board is powered by the AC power adapter included with the board. This adapter provides a regulated 5 V to the board and will source enough currents needed by the board at full transmit power. It is needed for both programming and operation. Once plugged into the 5 V plug, the board transmitter will immediately turn on.

3.6 Programming and Debug Interface

The UART-USB 4-port FTDI IC provides a USB interface for programming and operating the RF Source Transmitter Board. The 5 volts from the USB interface is not used to power the board.

Microsoft by default installs the FTDIBUS driver for the FTDI device on the board. This makes the device show as a COM port in the Windows Device Manager.

To program the device, the FTDI driver must be replaced with WinUSB in order for it to become available as a USB device and usable by OpenOCD. This can be done using the Zadig tool (available at https://github.com/pbatard/libwdi/releases).

Note: *Windows Administrator privileges are required for replacing a driver.*

Driver replacement instructions:

1) From the `Options` menu of Zadig, click `List all devices`
2) From the drop-down menu, find Quad RS232-HS (Interface 0). It should show `FTDIBUS (v...)` as the current driver on the left.
3) Select `WinUSB (v...)` as the replacement on the right.
4) Click `Replace Driver`

Verify the successful installation of WinUSB by going to the Windows Device Manager and confirming that the board now appears as a Quad RS232-HS device rather than a COM port. (In Device Manager, expand category `Universal Serial Bus devices` and look for `Quad RS232-HS`.) Also, verify that the driver provider is libwdi. (Right-click on `Quad RS232-HS`, go to `Properties`, go to the `Driver` tab, and check the `Driver Provider` line.) Restart Windows if necessary.

3.7 Operating the RF Source Transmitter Board

The board comes pre-programmed with the default settings outlined below. The source code is available through the RFsource_scan example application provided with the Atmosic SDK.

The Zeus RF default parameters:

- Frequency: 915 MHz
- Duty cycle: 100%
- Tx power: 29 dBm
- RF source transmitter enabled

3.8 Debug Messages

To see the debug messages connect the UART-USB cable to your laptop. In the Windows Device Manager, 3 COM ports will be displayed. The second port (displays as COM19 in the example below) is the UART0 interface and the third port is the UART1 (COM20) interface.

The firmware configures UART1 as the debug output. Open the UART1 COM port and configure the baud rate to 115200. See Figure 4 for an example of the debug messaging.

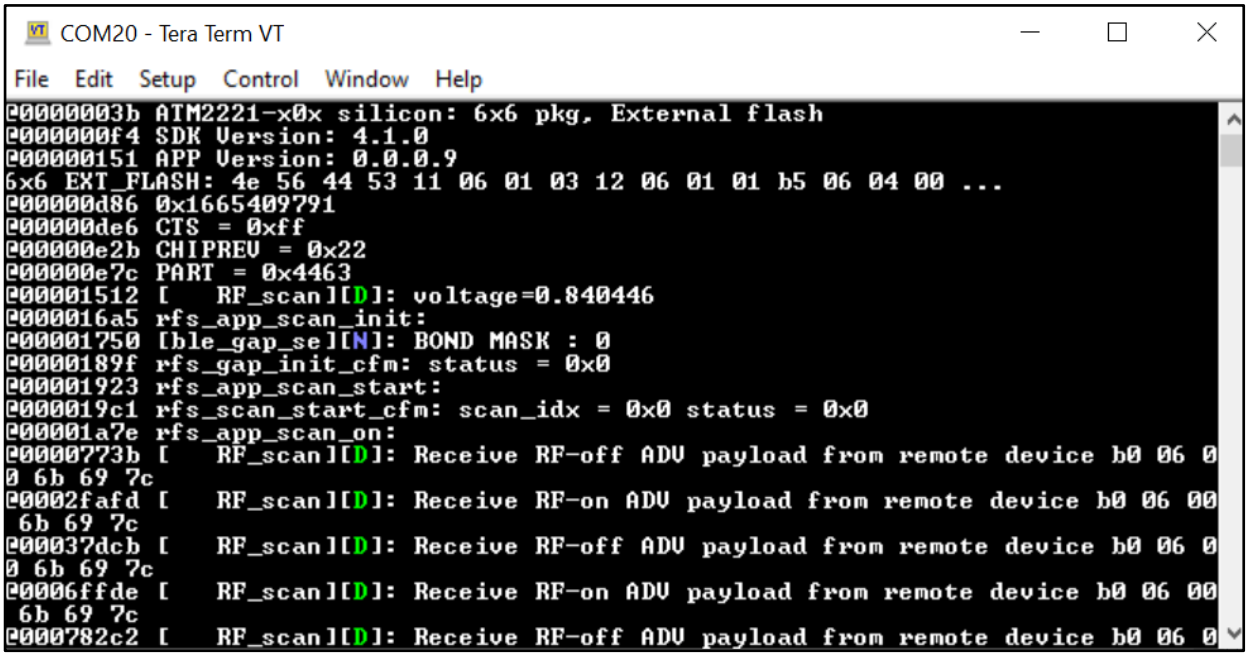

Figure 4 - Example Debug Messaging

3.9 RF Parameter Configuration

The RF parameters can be configured via AT commands on the UART0 port. See Figure 5. Any UART terminal application can be used with the following settings:

- Baud Rate: 460800
- Data Bits: 8
- Parity: None
- Stop Bits: 1
- Flow Control: Hardware

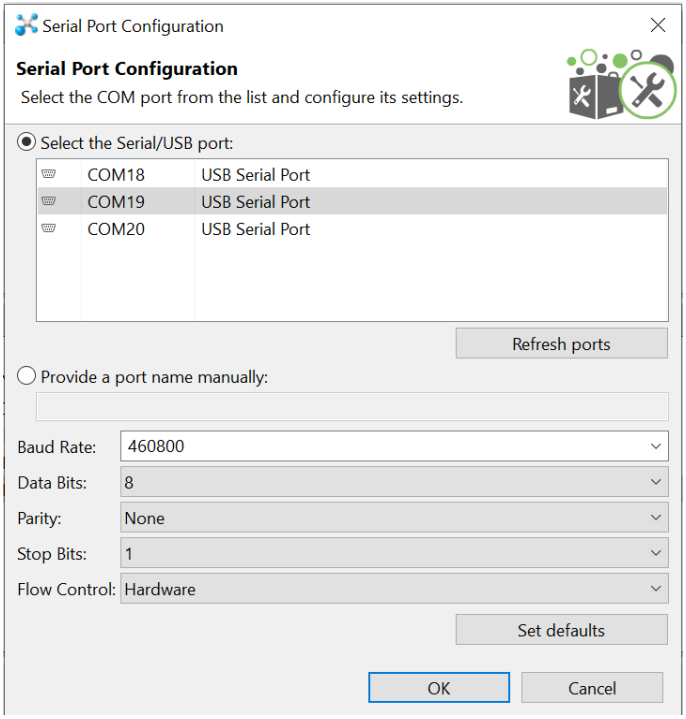

Figure 5 - UART COM Port Configuration

There are four commands to configure the RF parameters and behavior. After typing the command, press `Enter` to send the command and initiate the parameter change. Examples of the commands entered in the UART console window are shown in Figure 6.

1) Set Transmitter Frequency : AT+TRXFREQ=param1
   Param1 is the frequency to be set. The range is from 850 to 1050 MHz.

2) Set Output Power Level : AT+TRXOUTPUTPWR=param1
   Param1 is the output power level. The 11 power levels supported are listed below.
   For example, the command `AT+TRXOUTPUTPWR=8` will set the Tx power to be in the 27~28 dBm range.

   Tx_Power_L0, // 10dBm ~ 13dBm
   Tx_Power_L1, // 15dBm ~ 17dBm
   Tx_Power_L2, // 18dBm ~ 20dBm
   Tx_Power_L3, // 20dBm ~ 22dBm
   Tx_Power_L4, // 22dBm ~ 24dBm
   Tx_Power_L5, // 23dBm ~ 25dBm
   Tx_Power_L6, // 24dBm ~ 26dBm
   Tx_Power_L7, // 26dBm ~ 27dBm

Tx_Power_L8, // 27dBm ~ 28dBm
Tx_Power_L9, // 28dBm ~ 29dBm
Tx_Power_MAX, // 29dBm ~ 30dBm

3) Set Duty Cycle: AT+TRXDUTYCYCLE=param1, param2
   Param1 is the duty cycle, ranging from 0% to 100%
   Param2 is the period of the entire cycle, ranging from 1 to 10000. The unit is 100 μs.
   For example the command `AT+TRXDUTYCYCLE=80, 10000` will set the duty cycle to 80% with a period of 1 second.

4) Transmitter Enable: AT+TRXENABLE=param1
   Setting param1 to 1 enables the transmitter and 0 disables it.

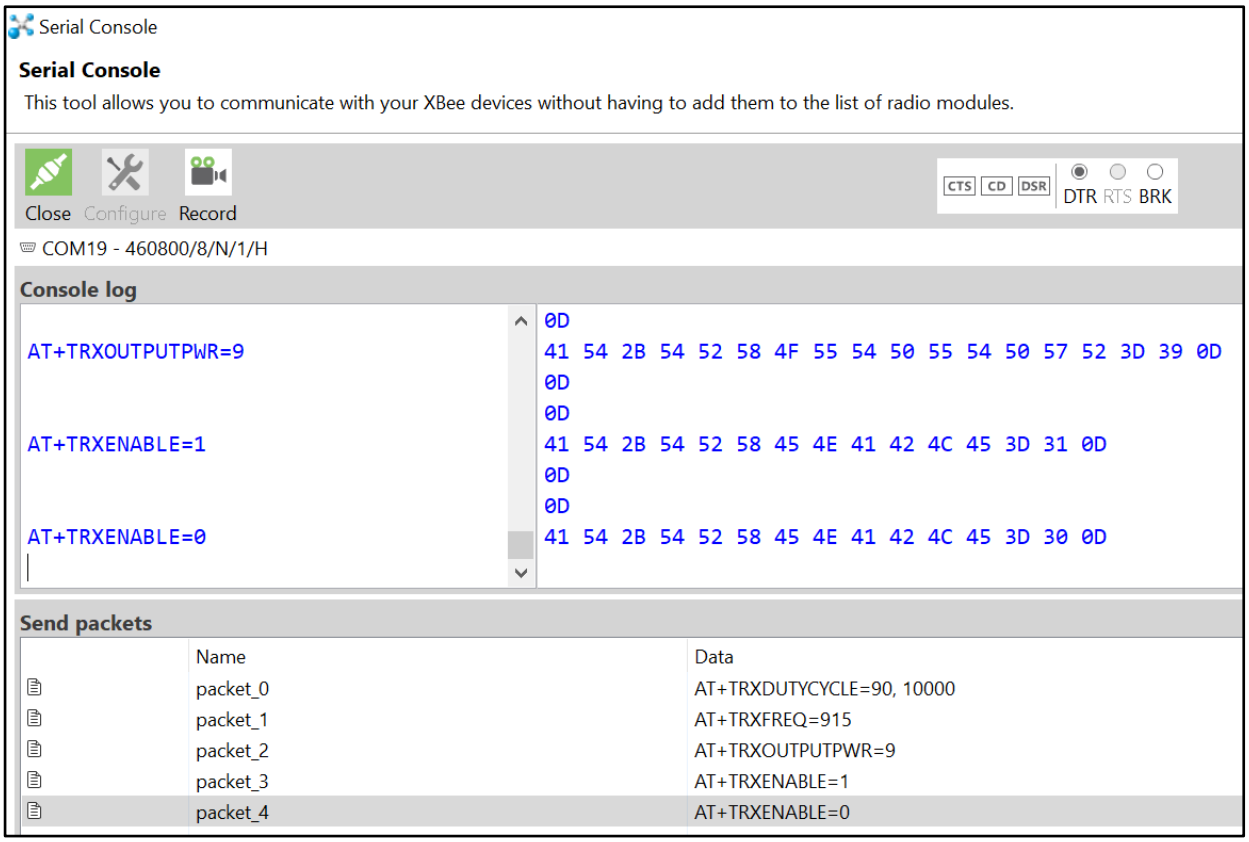

Figure 6 - UART Commands

3.10 RF Source Demonstration

The features of the RF transmitter can be demonstrated using the ATM3 Evaluation boards setup to harvest RF energy. The **ATM32xx EVK Energy Harvesting Application Note** (available on the Atmosic Support Website) provides instructions for evaluation board setup and operation.

During operation the RF source is transmitting power with 915 MHz and Bluetooth LE is also scanning. The scan is looking for specific advertising payload patterns to trigger starting or stopping the source transmitter.

- **Start-RF ADV payload**

```
static uint8_t adv0_data[] = {
0x11, // Length of complete 128 bit UUID
0x07, // type of complete 128 bit UUID
'A', 't', 'm', 'o', 's', 'i', 'c', 0x01, 0x02, 0x03, 0x04, 0x05, 0x06,
0x07, 0x08, 0x09, // 128 bit UUID
0x08, // Length of complete local name
0x09, // type of complete local name
'S', 'T', 'A', 'R', 'T', 'R', 'F' // local name
};
```

- **Stop-RF ADV payload**

```
static uint8_t  adv0_data[] = {
0x11, // Length of complete 128 bit UUID
0x07, // type of complete 128 bit UUID
'A', 't', 'm', 'o', 's', 'i', 'c', 0x01, 0x02, 0x03, 0x04, 0x05, 0x06,
0x07, 0x08, 0x09, // 128 bit UUID
0x08, // Length of complete local name
0x09, // type of complete local name
'S', 'T', 'O', 'P', '-', 'R', 'F' // local name
 };
```

If the RF source doesn't see the `Start-RF ADV payload` advertising payload for 10 minutes while the transmitter is on, it will turn off its transmitter.

3.11 Updating the Firmware

The firmware for RF Source Transmitter Board Is available in the Atmosic SDK. Look for the RFsource_scan application in the examples folder. The default parameters can be modified by editing #define statements in the RFsource_scan.c file:

```
#define TRX_FREQ 915 // Set frequency to 915 MHz
#define TRX_DUTYCYCLE 100 // Set duty cycle as 100%
#define TRX_PERIOD 10000 // Set period of the duty cycle as 10000, unit is 100 µs
#define TRX_POWER_LEVEL 10 // Set Tx power level.
#define TRX_ENABLE false // Set Initial Tx on or off.
#define ITVL_RF_TIMEOUT_CS 60000 // Set timeout to 10 minutes
```

The firmware can be built and loaded into the RF Source Transmitter Board with the following command:

```
make SWDBOARD=APT run_all
```

References

Title	Document Number
ATM32xx EVK Energy Harvesting Application Note	ATM32xx-ANHV
ATM2/ATM3 Evaluation Kit User Guide	ATM2_ATM3-UGEVK
ATM2/ATM3 EVK Power Consumption Evaluation User Guide	ATM2_ATM3-UGPCE
	Link
Zadig tool	https://github.com/pbatard/libwdi/releases

Revision History

Date	Version	Description
April 6, 2023	0.55	Changed format, no content change.
April 4, 2023	0.54	Updated Overview, Figure 1 - RF Source Transmitter Board, Figure 2 - RF Source Transmitter Board.
September 29, 2021	0.53	Updated Overview, added Zeus Transmitter Board.
April 14, 2021	0.52	Updated format, no content change
July 2, 2020	0.51	Updated with new title
March 5, 2020	0.50	Initial version created.

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