Banner Engineering RF Module Implementation Guide

Purpose: This guide is intended as an internal guidance document to ensure that the radio module identified is installed in Banner Engineering equipment in an appropriate manner so as to comply with the conditions of the original FCC grant and IC certificate.

Applicability: RF module FCC ID.: UE3RM7023, IC: 7044A-RM7023

Antennas: The module was certified with the following antennas. These antennas or antennas of the same design but lower gain may be used in the final installation.

Gain dBi	Type
7.2	Dipole
8.2	Monopole
12.2	Yagi

Antenna connection: The rf module has a non-standard antenna connection such as a reverse gender connector. The equipment must be professionally installed.

Final assembly labeling: The final assembly must contain a label notifying the user that the device contains a certified rf module that is identified by the following product approval numbers:

FCC ID.: UE3RM7023

IC: 7044A-RM7023

Human exposure to Radio Frequency (RF) energy: The module referenced in this document was evaluated to determine compliance with ANSI C.95 (USA) and Safety Code 6 (Canada). This module can only be used in final assemblies that are used in a mobile environment where the radiating element is located a minimum of 20 cm. from the user or nearby persons. This module must not be used in a final product that is used in an environment where the radiated element may be expected to be closer than 23 cm. from the user or nearby persons. Professional installation is required.

Unintentional emission requirements: The final product must be tested for unintentional emissions in accordance with the following regulations.

USA – CFR 47, Part 15, Subpart B

Canada – ICES-003, Issue 4

Modification: The rf module referenced in this document must not be modified in an manner.

Final Product User Guide Statements: The user guide for the final product must have the following statements to inform the user of proper operation and implementation of the product.

FCC specific statements:

- This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:
  - Reorient or relocate the receiving antenna.
  - Increase the separation between the equipment and receiver.
  - Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
  - Consult the dealer or an experienced radio/TV technician for help.

- FCC Caution: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.
- This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2)this device must accept any interference received, including interference that may cause undesired operation.
- RF Exposure warning: This device must be operated with a maximum eirp of 4 watts and a minimum separation distance of 23 cm between the radiating elements and the user or nearby persons.

Industry Canada specific statements (**in both English and French**):

- This device has been designed to operate with the antennas listed below, and having a maximum gain of 12.2 dBi. Antennas not included in this list or having a gain greater than 12.2 dBi are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

Gain dBi	Type
7.2	Dipole
8.2	Monopole
12.2	Yagi

- To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.
- This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.
- RF Exposure warning: This device must be operated with a minimum separation distance of 23 cm between the radiating elements and the user or nearby persons.

Cet appareil a été conçu pour fonctionner avec les antennes énumérées cidessous, et ayant un gain maximal de 12.2dBi. Les antennes non inclues dans cette liste ou ayant un gain supérieur à 12.2dBi sont strictement interdites pour une utilisation avec cet appareil. L'impédance d'antenne requise est de 50 ohms.

Gain dBi	Type
7.2	Dipole
8.2	Monopole
12.2	Yagi

Pour réduire le risque d'interférence avec d' autres utilisateurs, le type d'antenne ainsi que son gain doivent être choisis afin que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Cet appareil est conforme la norme d'Industrie Canada exempts de licence RSS (s). Son fonctionnement est sous réserve des deux conditions suivantes: (1) cet appareil ne doit causer aucune interférence, et (2) cet appareil doit pouvoir accepter toute interférence reçue, y compris une interference pouvant causer une opération indésirable

Avertissement d'exposition aux fréquences radio (RF) : Cet appareil doit être utilisé avec une distance de séparation minimale de 23cm entre les éléments rayonnants et l'utilisateur ou personnes proches.

Overview

The Banner RM7023 device is a frequency hopping spread spectrum transceiver operating in the 902 – 928 MHz band. When mounted to a carrier board containing a microcontroller and voltage regulator, the pair is known as the DX180.

The DX180 employs a time-slotted architecture to support point to point, point to multipoint, peer to peer and TDMA network topologies. Some operational parameters (number of hop table frequencies, power levels, TDMA "slot times") are configurable at the system level to provide maximum flexibility for particular applications and network topologies, but for a given architecture the parameters will not change in the field. This document will discuss fixed and configurable parameters and their relation to meeting the FCC specifications. Such parameters include the frequency plan, the time sharing architecture, power control, and approved antennas. Also discussed will be the partitioning of radio functions as pertaining to the limited Modular Approval for the device.

Frequency Plan

The radio is capable of transmitting or receiving on any of 64 equally spaced, non-overlapping channels available in the 902-928 MHz band. (902.4, 902.8…927.6 MHz) From this set of 64, a subset of M (M <= 64) unique frequencies will be chosen to populate the hop table. The subset of M frequencies will be configured at the factory and will not be field adjustable. The radio hops through each successive entry in the hop table in pseudorandom order and then repeats, never truncating the list and starting over. The receiver is a direct conversion type (zero-IF) meaning there are no additional intermediate frequency oscillators.

TDMA Plan

The radio is intended for operation in deterministic and ad-hoc networks. The communications channel is shared in these networks using a time domain multiple access protocol. The underlying structure to this protocol is a frame made up of N time slots, each of length T_{slot}. During each time slot, a given radio could spend part of its time transmitting (T_{on}), receiving, or idle to conserve energy. For this system, the time spent transmitting per time slot, T_{on}, is limited in software to be between 7.8125 ms and 62.5 ms. Obviously, if the Time Slot Duration T_{slot} is less than 62.5 ms, then that would be the maximum on-time per slot (by definition a transmission can not occupy more than 100% of T_{slot}.) The relationship between T_{slot}, T_{on} and transmit and receiving is illustrated graphically in Figure 1, below.

$$7.8125 \text{ ms} < T_{on} < \text{the lesser of (62.5 ms OR } T_{slot}.)$$

Equation 1

The actual duration of the slot (T_{slot}) is not explicitly constrained, but is governed by practical limitations. At minimum, T_{slot} must be long enough for the radio circuitry to stabilize on a given channel. At maximum, Tslot must be short enough to allow networks to form and communicate expediently. From **Equation 1**, it can be seen that T_{slot} in this system will always be greater than 7.8125 ms.

$$7.8125 \text{ ms} < T_{slot} < (\text{infinity})$$

Equation 2

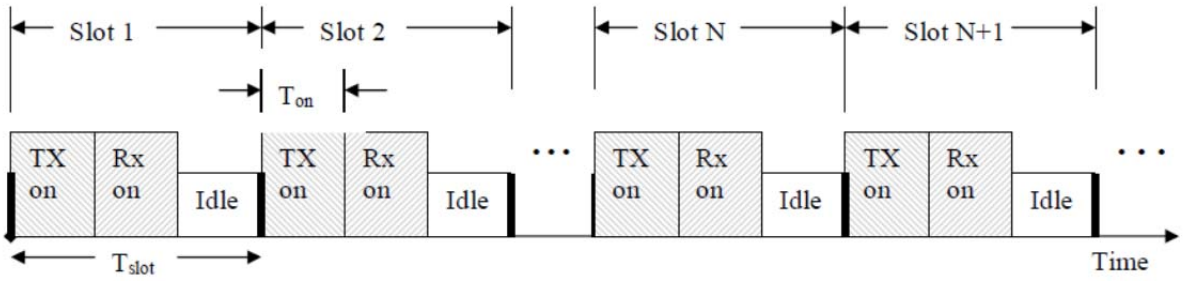

Figure 1

Average time of occupancy

Under no circumstances will this scheme result in violation of the FCC maximum for average time of occupancy on a given channel. The period of interest for the FCC is 10 seconds. Average time of occupancy on a channel may be calculated as follows.

1. Let T_{FCC} be the period of interest for the FCC rules. (T_{FCC} = 10 seconds.)
2. Calculate the # of hops, N_{hops}, of the hop table in the period of interest. $N_{hops} = T_{FCC} / T_{slot}$
3. Divide the number of hops through the table, N_{hops}, by the number of unique frequencies in the hop table (M), to find the average number of hops on a given channel. $N_{onechannel} = N_{hops} / M$.
4. Multiply the number of hops on a given channel by the transmitter ON time, T_{on} , to find the average Time of Occupancy (T_{occupy})on a given channel in the period of interest. $T_{occupy} = N_{onechannel} * T_{on}$

Taken together,

$$T_{occupy} = (T_{FCC} / T_{slot}) * (T_{on} / M)$$

Equation 3

In the limiting case of streaming data $T_{on} = T_{slot}$, the terms cancel, and **Equation 3** reduces to

$$T_{occupy} = (T_{FCC} / M)$$

Equation 4

To meet the requirements of section 15.247 (a)(1)(i) off the FCC requirements, it is required that systems in the band 902-928 MHz with bandwidths >= 250 kHz shall not occupy a given channel any more than an average of 0.4 seconds in a 10 second window.

In the table below, the Average Time of Occupancy is calculated for representative numbers of channels. For the DX180 system, the minimum number of channels is 26 (lower numbers of channels being worst case for Average Time of Occupancy), and the maximum available pool of channels is 64.

Number of hopping channels	Period for Average Time of Occupancy Determination (s)	Average Time of Occupancy from Equation 4 (ms), (for worst case - streaming data)	Compliance: <400 ms in 10 s
26 (minimum)	10	385	PASS
50	10	200	PASS
64 (maximum)	10	156	PASS

Output power control

For output power regulation as described in 15.247(b)(2), permitted output power vs. hopping channels is as follows:

Number of hopping channels	Maximum output power (W)	Maximum output power (dBm)	Maximum output EIRP (dBm)
25-49	0.25	24	30
50+	1	30	36

The control firmware limits output power to less than 24 dBm when utilizing less than 50 channels, and less than 30 dBm when utilizing 51-64 channels.

Antenna Choices

The following classes of antennas (**Table 1**) were tested and approved for use with the RM7023.

Approved antennas	
Antenna style	**Gain**
¼ wave monopole	1 dBi
½ wave dipole	2 dBi
High gain helical loaded omnidirectional monopole	<= 7.2 dBi
High gain omnidirectional dipole	<= 8.2 dBi
High gain Yagi directional	<= 12.2 dBi)

Table 1

The device is always professionally installed and uses unique connectors. Installation instructions dictate that power must be attenuated with some antenna choices to comply with the EIRP limit of 36 dBm (4 Watts).

Statement of End Product Control

Banner will control end products in two primary ways. The first way is through the business model: the RM7023 will not be for sale on the open market. The business model that the RM7023 will be produced under is one of reusing the RM7023 across multiple versions of Banner's own internal products, or with close co-development efforts with trusted Banner partners, which could culminate in Banner-manufactured devices being sold under another brand. The second way that control will be maintained is more practical. The partitioning of functions on the RM7023 and its carrier board keeps all the important intellectual property in the microcontroller on the carrier board.

And because the profitability of the RM7023 doesn't lie in licensing the manufacturing of the modules, but rather in the IP that makes it a useful, networkable radio, it is safe to assume that Banner will always retain control of the host systems. In summary, Banner has strong regulatory, operational, and fiscal reasons for maintaining control over the products that the RM7023 appears in. Full compliance of the end products will always be ensured.