Banner RM7023 Transceiver
1 Watt, 900 MHz FHSS
Operational Description

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, which is being sought for the RM7023.

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.

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

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

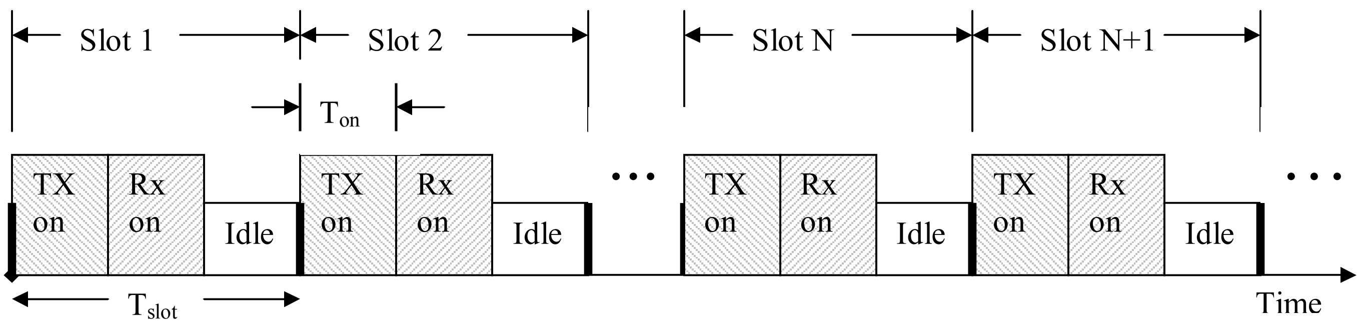

Figure 1

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 test report demonstrates that 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.