

# Eleven Engineering HT700 System Regulatory Operational Description

In order to achieve regulatory compliance in the USA and Europe, the regulatory bodies require an operational description of the unit under test. This description describes how HT700 systems satisfy frequency hopping, BW, and other requirements.

The descriptions below may be applied to the following: Ginseng and Ginger hardware

## FCC Rules:

### 2.1(c) Terms and Definitions of Frequency Hopping Systems

15.247(a)(1) "...The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter."

15.247(a)(1)(iii) "Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed."

## Operational Description:

These solutions are a pure frequency hopping system according to the definition located in the section 2.1. A channel palette of 49 channels, which are spaced by 1.536 MHz starting at 2403.585 MHz. From this palette, 20 channels are used by the system at any given moment. Upon startup the system beings to hop on 20 random channels. The hopping sequence is a pseudo random ordered list of the 20 channels, and is 20 elements long. During operation, the performance of a given channel is monitored. If the performance is deemed poor, the channel is removed from the hopping list and is replaced by another channel from the palette. The new channel is then entered into the pseudo random sequence and the system hops according to the new list. The system also maintains a pseudo-random ordered list of 30 unused channels.

20 hopping channels are always used at any given point in time. The system has a regular hopping rate of ranging from 100 hops per second to 1000 hops per second, and has a dwell time ranging between 1 ms to 10 ms. During normal operation all channels are used equally and transmissions never span more than 1 hop time. Every hop cycle contains a single transmission from the transmitter and receiver and no channels in the current list of 20 are skipped. This guarantees that all 20 channels are used equally on average, and that the total dwell time on any channel within the hop set is less than 0.4 s in any 8 s period.

The channel palette of 49 channels is given below in MHz.

-	2417.409	2432.769	2448.129	2463.489
2403.585	2418.945	2434.305	2449.665	2465.025
2405.121	2420.481	2435.841	2451.201	2466.561
2406.657	2422.017	2437.377	2452.737	2468.097
2408.193	2423.553	2438.913	2454.273	2469.633
2409.729	2425.089	2440.449	2455.809	2471.169
2411.265	2426.625	2441.985	2457.345	2472.705
2412.801	2428.161	2443.521	2458.881	2474.241
2414.337	2429.697	2445.057	2460.417	2475.777
2415.873	2431.233	2446.593	2461.953	2477.313



**FCC Rule:**

15.247(a)(1) "...The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals."

**Operational Description:**

The RF section uses a complete integrated circuit as the RF transceiver. The receiver is a single conversion heterodyne, with a low IF frequency. All IF and base band filters are contained within the integrated circuit. The IF filter restricts the receive bandwidth to the hopping channel bandwidth.

Since the receiver is a single conversion heterodyne receiver. Changing the receiver channel is achieved by changing the frequency of the PLL controlled local oscillator. The signal from the local oscillator is fed to one mixers which convert the received signal to the IF frequency. The incoming signal is then filtered and demodulated.

Upon startup the receiver searches for a transmitter on all 49 channels. When the receiver captures a packet sent by the transmitter, it extracts the current hopping channels table and matches the hopping sequence. At this point the transmitter and receiver have a connection and are now synchronized to the hopping sequence. If a the hopping sequence adaptation is needed, the change request is sent by the transmitter to the receiver on several channels. The hop set change does not occur until the receiver has acknowledged the change. This way all transceivers within the system maintain synchronization.

**FCC Rule:**

15.247(h) "The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hop sets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted."

**Operational Description:**

A system is defined as 1 audio transmitter and up to 4 audio receivers. Each audio transmitter or audio receiver actually contains an RF transceiver. There is no coordination of hopping frequencies between systems. The decision to adapt the hopping sequence is based purely on the performance of the current hop set, and is determined by the single audio transmitter. Transmissions from any other like system are regarded as interference. Poor performing channels are simply replaced with a new channel in the current hop set. Multiple systems do not coordinate their hopping channels or hopping times.



**ETSI Rule:**

EN 300 328 v1.7.1

**4.3.5 Medium access protocol****4.3.5.1 Definition**

A medium access protocol is a mechanism designed to facilitate spectrum sharing with other devices in a wireless network.

**4.3.5.2 Requirement**

A medium access protocol shall be implemented by the equipment.

**Operational Description:**

The requirement above states that a medium access protocol must be used. There are no performance or other technical requirements, other than the fact that it must be present.

Eleven's HT700™ solution uses a "Collision Detect with Acknowledge" protocol. If collisions occur and cause a packet error rate above a predetermined threshold are detected on a currently used channel, that channel is removed from use and another is selected. The removed channel is then placed at the end of the list of unused channels, and will not be attempted again until all other unused channels have been attempted.

**Document History**

Version 1.00	Creation	Jason Gosior	12/20/10
Version 1.1	Add description of the charge Cable	Jason Gosior	6/17/11
Version 1.2	Corrected the total maximum hoping time.	Jason Gosior	6/22/11
Version 1.3	Corrected number of channels in channel palette. Allocated Document Number: DO5586	Ryan Baron	8/19/11
Version 1.4	Changed to Support HT700	Ryan Baron	2012-09-19

