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To: Mario de Aranzeta (Timco Engineering)

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Subject: GW-900T FCC Data

Modulation Parameters

Modulation Type:	Binary FSK
Modulation Rate:	10,932 bits per second
Modulation Frequency Deviation:	$2f_d$ = 16 kHz (peak-to-peak deviation)

Pseudorandom Frequency Hopping Sequence

Random Number Generator

The frequency hop algorithm is generated from a **maximal-length pseudo-random linear feedback shift register (LFSR).** The LFSR is also known as the **random number generator (RNG).** In this design, the RNG shift register is 6 bits in length and generates a pseudo-random number from 1 to 63. The RNG used in the GW-900T is shown in **Figure 1**. The RNG taps were selected based on a well-known LFSR design with good statistical properties that is free of long sequential runs.

Each new value of the RNG is generated by the following steps:

1. Logically add b_5 to b_4 and save the result in a delay register, D.
2. Shift the bits in the shift register to the left such that $b_4 > b_5$, $b_3 > b_4$, …
3. Shift the delay register, D, into b_0.

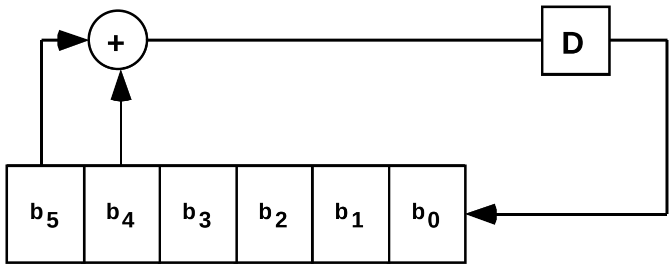

Figure 1. Random Number Generator.

An example of the random number generator output is shown in **Table 1**. Here the initial value of R, that is R_1, was set to 31. The second value of R, that is R_2, is computed to be 63. The third computed value of R, R_3, is 62. The 64th time the RNG is updated, the value of R is computed to be 31 and the sequence starts over.

Table 1. Random Number Generator Output.

Number of Times R is Computed	Value of R
R_1	31
R_2	63
R_3	62
…	…
R_{62}	23
R_{63}	47
$R_{64} = R_1$	31
$R_{65} = R_2$	63

Hop Frequencies

Each hop period, a new value R, from 1 to 63, is computed from the RNG. The hop frequency for the current hop is computed by the following equation:

$$f_h = 905.700 + 0.100 * (N-1) + 0.300R \qquad [MHz]$$

Here, N is a net number from 1 to 3 which is set at the time of manufacture and gives additional frequency diversity to radios nets that are deployed. **Table 2** shows examples of the hop frequency calculation.

Table 2. Hop Frequency, f_h, in MHz.

	Net Number, N		
Value of R	1	2	3
R = 1	906.000	906.100	906.200
R = 2	906.300	906.400	906.500
…	…	…	…
R = 63	924.600	924.700	924.800

Equal Hopping Frequency Use

Each message sent from a transmitter is divided into 10 separate parts. Each of the 10 parts is sent on a separate frequency (hop). The duration of a single hop is greater than 4.5 msec and less than 20 msec. There is a 10 second delay between each hop. At the beginning of each hop, a new value, R, from random number generator is computed in accordance with Figure 1. When a new message is to be sent, the process is continued where the next value of R is computed in accordance with Figure 1. The initial value of R is set only once and occurs only when the radio is installed or when the battery requires replacement. **Table 3** shows an example of how the hop pattern is distributed among sequential messages. Here R_1 is the first random number computed from the RNG, R_2 is the second number computer from the RNG, etc. Note that the value of R_1 is not 1 and the value of R_2 is not 2. The **values** of R are determined as shown in **Table 1**.

Table 3. Distributions of Hops Across Multiple messages.

	Msg Part 1	Msg Part 2	Msg Part 3	Msg Part 4	Msg Part 5	Msg Part 6	Msg Part 7	Msg Part 8	Msg Part 9	Msg Part 10
Message 1	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}
Message 2	R_{11}	R_{12}	R_{13}	R_{14}	R_{15}	R_{16}	R_{17}	R_{18}	R_{19}	R_{20}
• • •										
Message 6	R_{51}	R_{52}	R_{53}	R_{54}	R_{55}	R_{56}	R_{57}	R_{58}	R_{59}	R_{60}
Message 7	R_{61}	R_{62}	R_{63}	R_1	R_2	R_3	R_4	R_5	R_6	R_7

System Receiver Input Bandwidth

The associated receiver uses a digital signal processor to implement a 3rd order CIC[i] filter to match the receiver bandwidth to the transmitted signal.

System Receiver Hopping Capability

The associated receiver uses a digital quadrature tuner to shift frequencies in synchronization with the transmitted signal. A 32-bit unique-word synchronization sequence is used to detect initial synchronization.

[i] CIC – Cascade-Integrator-Comb filter. This is an efficient class of finite impulse response (FIR) digital filters that operate without the use of digital multipliers. This is a common technique used in modern communication systems such as digitally implemented cell phone receivers. Reference: Hogenauer, Eugene, "An Economical Class of Digital Filters for Decimation and Interpolation", IEEE Transactions on Acoustics, Speech and Signal Processing, Vol. ASSP-29 No. 2, April 1981.