FREQUENCY HOPPING SEQUENCE

The random frequency hop sequence was created using the random sequence generator found at http://www.random.org/sform.html , which generates true random numbers using atmospheric noise measurements.

"The way the random.org random number generator works is quite simple. A radio is tuned into a frequency where nobody is broadcasting. The atmospheric noise picked up by the receiver is fed into a Sun SPARC workstation through the microphone port where it is sampled by a program as an eight bit mono signal at a frequency of 8KHz. The upper seven bits of each sample are discarded immediately and the remaining bits are gathered and turned into a stream of bits with a high content of entropy. Skew correction is performed on the bit stream, in order to ensure that there is an approximately even distribution of 0s and 1s.

The skew correction algorithm used is based on *transition mapping*. Bits are read two at a time, and if there is a *transition* between values (the bits are 01 or 10) one of them - say the first - is passed on as random. If there is no transition (the bits are 00 or 11), the bits are discarded and the next two are read. This simple algorithm was originally due to Von Neumann and completely eliminates any bias towards 0 or 1 in the data." (from http://www.random.org/essay.html)

A "smallest value" of 0 and "largest value" of 129 were entered, corresponding to the 130 different frequencies we use, and the following random sequence was generated:

61, 7, 112, 60, 102, 35, 0, 122, 6, 66, 117, 69, 110, 78, 107, 9, 91, 59, 44, 121, 50, 126, 8, 24, 94, 19, 46, 127, 72, 114, 73, 68, 111, 56, 29, 86, 54, 120, 58, 118, 28, 125, 93, 52, 49, 115, 36, 129, 20, 3, 27, 74, 21, 113, 90, 106, 89, 47, 77, 57, 18, 75, 40, 80, 76, 17, 119, 11, 37, 105, 83, 48, 13, 82, 1, 10, 109, 4, 79, 2, 12, 43, 103, 32, 108, 67, 25, 45, 38, 53, 14, 34, 22, 116, 55, 26, 62, 99, 81, 71, 98, 70, 95, 128, 64, 88, 16, 84, 5, 41, 97, 23, 100, 31, 96, 51, 65, 104, 30, 101, 123, 87, 124, 42, 92, 63, 39, 15, 33, 85 .

The active frequency is set sequentially from the above table. This results in a channel hop sequence of [61], [7], [112], [60], etc. where [xx] denotes a channel number. The resultant frequency hop sequence in MHz is 914.3, 903.5, 924.5, 914.1, etc. The sequence wraps around so that when on frequency [85], the NEXT frequency will be [61]. The raw table was scanned for adjacent frequencies, and if/when one was found, that index was moved further in the sequence until indices were no longer adjacent.

The first and last five (5) channels in the table are not used by the hardware to avoid potential out of band interference levels. This allows for 120 total channels available for the hop sequence. When a blanked channel is selected in the table software will automatically step to the next valid channel on the list.

This sequence is coded into a fixed HOP TABLE which is used by the software. This table is used to set frequencies, and index to the NEXT frequency in the sequence:

Frequency (MHz)	Channel Number	Next Channel in Hop Sequence
902.100	0	122
902.300	1	10
902.500	2	12
902.700	3	27
902.900	4	79
903.100	5	41
903.300	6	66
903.500	7	112
903.700	8	24

Frequency (MHz)	Channel Number	Next Channel in Hop Sequence
903.900	9	91
904.100	10	109
904.300	11	37
904.500	12	43
904.700	13	82
904.900	14	34
905.100	15	33
905.300	16	84
905.500	17	119
905.700	18	75
905.900	19	46
906.100	20	3
906.300	21	113
906.500	22	116
906.700	23	100
906.900	24	94
907.100	25	45
907.300	26	62
907.500	27	74
907.700	28	125
907.900	29	86
908.100	30	101
908.300	31	96
908.500	32	108
908.700	33	85
908.900	34	22
909.100	35	0
909.300	36	129
909.500	37	105
909.700	38	53
909.900	39	15
910.100	40	80
910.300	41	97
910.500	42	92
910.700	43	103
910.900	44	121
911.100	45	38
911.300	46	127
911.500	47	77
911.700	48	13
911.900	49	115
912.100	50	126
912.300	51	65
912.500	52	49
912.700	53	14
912.900	54	120
913.100	55	26
913.300	56	29
913.500	57	18
913.700	58	118
913.900	59	44

Frequency (MHz)	Channel Number	Next Channel in Hop Sequence
914.100	60	102
914.300	61	7
914.500	62	99
914.700	63	39
914.900	64	88
915.100	65	104
915.300	66	117
915.500	67	25
915.700	68	111
915.900	69	110
916.100	70	95
916.300	71	98
916.500	72	114
916.700	73	68
916.900	74	21
917.100	75	40
917.300	76	17
917.500	77	57
917.700	78	107
917.900	79	2
918.100	80	76
918.300	81	71
918.500	82	1
918.700	83	48
918.900	84	5
919.100	85	61
919.300	86	54
919.500	87	124
919.700	88	16
919.900	89	47
920.100	90	106
920.300	91	59
920.500	92	63
920.700	93	52
920.900	94	19
921.100	95	128
921.300	96	51
921.500	97	23
921.700	98	70
921.900	99	81
922.100	100	31
922.300	101	123
922.500	102	35
922.700	103	32
922.900	104	30
923.100	105	83
923.300	106	89
923.500	107	9
923.700	108	67
923.900	109	4
924.100	110	78

Frequency (MHz)	Channel Number	Next Channel in Hop Sequence
924.300	111	56
924.500	112	60
924.700	113	90
924.900	114	73
925.100	115	36
925.300	116	55
925.500	117	69
925.700	118	28
925.900	119	11
926.100	120	58
926.300	121	50
926.500	122	6
926.700	123	87
926.900	124	42
927.100	125	93
927.300	126	8
927.500	127	72
927.700	128	64
927.900	129	20

FREQUENCY HOPPING DWELL TIMES

The dwell time for the UHF Reader is designed for a range between 150 and 350 mS, based on the following software characteristics:

1. A millisecond counter is used to track time since the last hop. That is, at each hop, a counter is loaded with a constant number of milliseconds. At each millisecond time tick, the counter is decremented as long as it remains nonzero. The counter is preloaded with a value of 300.
2. When the reader has its field on but is not actively searching for tags, the software will hop whenever the counter becomes zero. A consistent time of 300 mS between hops in this situation has been verified.
3. When the reader is actively searching for tags, service delays and the need of tags for a stable field make it impractical to hop at precise time intervals. For this case the software follows a number of rules to ensure compliance with the 400 mS average dwell time rule:
   a) Before initiating a search for tags, the software checks the value of the hop time counter. If the counter has fallen to below half its initial value (i.e., 150 mS), the reader hops frequencies before initiating a search for tags.
   b) During certain operations that take a long time, the software checks the value of the hop time counter. If the counter has fallen to zero (i.e., 300 mS), the reader hops frequencies before continuing the operation.
   c) In no case is any service delay long enough to cause a violation of the 400 mS limit.

RECEIVER SELECTIVITY

The operation of the RFID tag reading system supported by the UHF Reader requires the transmitter and receiver to operate simultaneously on the same frequency. The Transmitter provides activation energy to the tags through a CW RF field transmitted from the reader to the tag during the reader receive process. This energy is reflected back to the reader by the tag. Information is modulated onto the reflected carrier by varying the radar cross sectional area of the tag. The result is an AM modulated return signal. Since the tag does not generate its own RF field the return signal is on the same frequency as the transmitter.

The transmitter does not modulate its signal during the receive process making the communication simplex in nature.

ANTENNA SELECTIONS

Manufacturer	Model	Frequency (MHz)	Omi/Directional	Polarization	Nominal Gain (dBi)
Cushcraft	S888P12NF	880-960	Directional	Linear	8
	S9028PC12NF	902-960	Directional	Circular	7.5 dBic
	S9026P12NF	902-960	Directional	Linear	6
	S8963-B	896-960	Omni	Linear	3
Poynting Antennas Ltd.	PA-P-900-L-8/CELL	820-1000	Directional	Linear	8
	PA-P-900-C-7/RFID	902-928	Directional	Circular	5.5
	PA-P-900-L-8/TDMA	902-928	Directional	Linear	8
Seavey Engineering and Associates	9394-818	902.8	Directional	Linear	16
	9718-820	902.8	Omni	Linear	7
Maxrad Inc.	MP9159PT	902-928	Directional	Linear	8.9