The Spread Spectrum Radio Operation

The radio transceiver is controlled by a microprocessor which performs the hopping, data transmit and data receive functions.

Eight hop sets are programmed into the microprocessors non-volatile memory at the factory. The hop set number used by the transmitter, is programmed by the user.

One unit communicates with another unit using data packets that have a maximum size of 300ms. Each packet sent to another unit is acknowledged by the receiving unit. If an acknowledge message is not received within the timeout period then the transmitter will retry the message.

Each data packet comprises of 30ms of training data reversals and synchronization words, which allows the receiver to lock onto a valid data packet.

The hop sets used by the transceiver have been calculated using a random number generator and selected so that they are mutually orthogonal (have a very low cross correlation). Each hop set contains 50 frequencies.

The hop set is listed in memory in its random order, so that the transmitter simply uses the next value in the hop set list, when it is required to make a transmission.

So each time the transmitter wants to transmit it selects the next frequency in the hop set that it is using, programs the transceivers PLL to that frequency, starts the RF PA and then modulates the transmitter with the data required to be sent.

So each transmission is on a different frequency in the list (even retries) and hence all frequencies are used equally. The other receiving unit which acknowledges the transmission is using the same hop set, but its transmission are not synchronized (it will be in a different position in the same hop set) with the sending unit.

For example if the hop set list was 21,83,115,81,113,65,105,61 (8 channel hop set). Each of these numbers is a channel number using a spacing of 125kHz (we only use odd channel numbers because we use a 250kHz channel spacing) and starting from 902MHz. The sequence of transmissions would be as follows:

1st transmission ---> channel 21
good acknowledge received <-----
2nd transmission ---> channel 83
bad acknowledge received <------
3rd transmission (retry of 2nd transmission) ----> channel 115
good acknowledge received <-----
4th transmission ----> channel 81
….
….
….
8th transmission ----> channel 61
good acknowledge received <-----
9th transmission ----> channel 21 (goes back to start of sequence)

The hop set frequencies used are listed below:

Hop set 1 – 8

#1	21	83	115	81	113	65	105	61
#2	21	83	115	67	107	77	47	97
#3	21	83	51	99	81	49	97	57
#4	21	113	105	103	61	119	69	111
#5	147	211	145	209	193	189	167	171
#6	121	183	151	191	155	219	207	163
#7	147	163	165	219	197	169	139	207
#8	147	211	171	121	197	127	159	217
#1	902.625	910.375	914.375	910.125	914.125	908.125	913.125	907.625
#2	902.625	910.375	914.375	908.375	913.375	909.625	905.875	912.125
#3	902.625	910.375	906.375	912.375	910.125	906.125	912.125	907.125
#4	902.625	914.125	913.125	912.875	907.625	914.875	908.625	913.875
#5	918.375	926.375	918.125	926.125	924.125	923.625	920.875	921.375
#6	915.125	922.875	918.875	923.875	919.375	927.375	925.875	920.375
#7	918.375	920.375	920.625	927.375	924.625	921.125	917.375	925.875
#8	918.375	926.375	921.375	915.125	924.625	915.875	919.875	927.125

Hop set 9 – 16

#1	103	71	45	95	69	107	77	111
#2	69	43	31	89	117	75	111	65
#3	101	59	103	61	39	29	87	117
#4	65	93	71	45	117	109	73	95
#5	133	203	137	205	169	183	123	159
#6	177	147	133	181	149	173	145	189
#7	137	153	213	145	161	217	131	203
#8	131	175	133	203	193	135	153	163
#1	912.875	908.875	905.625	911.875	908.625	913.375	909.625	913.875
#2	908.625	905.375	903.875	911.125	914.625	909.375	913.875	908.125
#3	912.625	907.375	912.875	907.625	904.875	903.625	910.875	914.625
#4	908.125	911.625	908.875	905.625	914.625	913.625	909.125	911.875
#5	916.625	925.375	917.125	925.625	921.125	922.875	915.375	919.875
#6	922.125	918.375	916.625	922.625	918.625	921.625	918.125	923.625
#7	917.125	919.125	926.625	918.125	920.125	927.125	916.375	925.375
#8	916.375	921.875	916.625	925.375	924.125	916.875	919.125	920.375

Hop set 17 –24

#1	73	109	63	41	93	55	37	91
#2	105	81	113	73	109	63	41	29
#3	67	43	95	79	113	77	111	65
#4	57	91	55	37	75	47	33	85
#5	217	195	141	207	129	201	191	125
#6	199	159	193	213	205	203	161	139
#7	129	159	181	167	183	143	209	193
#8	219	149	179	187	189	125	199	169
#1	909.125	913.625	907.875	905.125	911.625	906.875	904.625	911.375
#2	913.125	910.125	914.125	909.125	913.625	907.875	905.125	903.625
#3	908.375	905.375	911.875	909.875	914.125	909.625	913.875	908.125
#4	907.125	911.375	906.875	904.625	909.375	905.875	904.125	910.625
#5	927.125	924.375	917.625	925.875	916.125	925.125	923.875	915.625
#6	924.875	919.875	924.125	926.625	925.625	925.375	920.125	917.375
#7	916.125	919.875	922.625	920.875	922.875	917.875	926.125	924.125
#8	927.375	918.625	922.375	923.375	923.625	915.625	924.875	921.125

Hop set 25 – 32

#1	119	75	47	33	89	53	99	79
#2	87	53	35	27	23	85	51	99
#3	105	71	109	63	41	93	119	69
#4	81	97	101	77	107	63	41	87
#5	199	127	173	165	155	215	131	153
#6	129	185	179	175	197	201	171	169
#7	189	151	179	123	199	141	177	133
#8	165	183	167	139	177	155	215	195
#1	914.875	909.375	905.875	904.125	911.125	906.625	912.375	909.875
#2	910.875	906.625	904.375	903.375	902.875	910.625	906.375	912.375
#3	913.125	908.875	913.625	907.875	905.125	911.625	914.875	908.625
#4	910.125	912.125	912.625	909.625	913.375	907.875	905.125	910.875
#5	924.875	915.875	921.625	920.625	919.375	926.875	916.375	919.125
#6	916.125	923.125	922.375	921.875	924.625	925.125	921.375	921.125
#7	923.625	918.875	922.375	915.375	924.875	917.625	922.125	916.625
#8	920.625	922.875	920.875	917.375	922.125	919.375	926.875	924.375

Hop set 33 – 40

#1	49	97	57	101	59	39	29	87
#2	71	45	95	57	101	59	103	61
#3	107	73	45	31	89	53	35	91
#4	53	79	49	89	99	59	39	29
#5	179	143	177	185	187	135	175	121
#6	143	131	125	215	209	211	165	141
#7	175	185	187	125	173	121	149	211
#8	191	151	213	145	209	137	205	129
#1	906.125	912.125	907.125	912.625	907.375	904.875	903.625	910.875
#2	908.875	905.625	911.875	907.125	912.625	907.375	912.875	907.625
#3	913.375	909.125	905.625	903.875	911.125	906.625	904.375	911.375
#4	906.625	909.875	906.125	911.125	912.375	907.375	904.875	903.625
#5	922.375	917.875	922.125	923.125	923.375	916.875	921.875	915.125
#6	917.875	916.375	915.625	926.875	926.125	926.375	920.625	917.625
#7	921.875	923.125	923.375	915.625	921.625	915.125	918.625	926.375
#8	923.875	918.875	926.625	918.125	926.125	917.125	925.625	916.125

Hop set 41 – 48

#1	117	67	43	31	25	85	51	35
#2	39	93	55	37	91	119	79	49
#3	55	37	27	23	85	115	75	47
#4	115	67	43	31	25	83	51	35
#5	197	157	163	219	139	161	181	151
#6	217	167	195	157	137	187	153	135
#7	195	127	201	191	135	205	157	215
#8	201	141	207	157	181	123	173	185
#1	914.625	908.375	905.375	903.875	903.125	910.625	906.375	904.375
#2	904.875	911.625	906.875	904.625	911.375	914.875	909.875	906.125
#3	906.875	904.625	903.375	902.875	910.625	914.375	909.375	905.875
#4	914.375	908.375	905.375	903.875	903.125	910.375	906.375	904.375
#5	924.625	919.625	920.375	927.375	917.375	920.125	922.625	918.875
#6	927.125	920.875	924.375	919.625	917.125	923.375	919.125	916.875
#7	924.375	915.875	925.125	923.875	916.875	925.625	919.625	926.875
#8	925.125	917.625	925.875	919.625	922.625	915.375	921.625	923.125

Hop set 49 and 50

#1	27	23
#2	33	25
#3	33	25
#4	27	23
#5	213	149
#6	127	123
#7	171	155
#8	143	161
#1	903.375	902.875
#2	904.125	903.125
#3	904.125	903.125
#4	903.375	902.875
#5	926.625	918.625
#6	915.875	915.375
#7	921.375	919.375
#8	917.875	920.125

Hop channel numbers are always greater than 20 and less than 220 in order to stay within the 902 to 928 MHz frequency ranges with guard bands at the band edges.

Only odd hops are used which gives a 250kHz channel plan.

Hop Frequency = 900MHz + (hop channel number x 125kHz)