Appendix B - GOES DCS Pseudo-Binary Data and Other Definitions

General

This standard specifies a standard format for Data Collection Platforms (DCP's) transmitting on random reporting channels. The format has been structured so as to also be compatible with many self-timed (in particular) and interrogated DCP's. The standard is based heavily on two assumptions: First, the proper interpretation and utilization of random data requires a data processing element within the data flow. Second, that the format of all transmissions from a complying platform can be decodable through the use of a properly constructed data base which is to be contained within the data processing facility.

This standard defines the necessary attributes of both a DCP and a data base to make the data processible and useful. The manner in which a DCP can be described by the data base determines both the format and the operating characteristics of the DCP.

DCPRS Message Format

The DCPRS transmission format is set forth in paragraph 3.1 for the pre-amble (carrier, clock, and FSS), the GOES ID code, and Flag Word (see Figure 1). The sensor or message data shall consist of a single 8-bit header word, followed by data from one or more sensors. As shown in Figure 2, the header word is always a number between 0 and 63 and represents the entry number in a DCP information file which describes the format being used for that message. Thus, a DCP is capable of transmitting up to 64 different formats and each format can be determined fully by knowing the header word and accessing a data base for that particular DCP.

PRE-AMBLE	GOES ID 31-BIT ADDRESS	FLAG WORD	MESSAGE 1	SP	MESSAGE 2	SP	MESSAGE N	EOT

Figure 1. DCPRS Transmit Format

EIGHT BIT HEADER WORD	SENSOR 1 DATA	SENSOR 2 DATA	SENSOR N DATA

Figure 2. DCPRS Message or Sensor Data Format

The sensor data after each header word must adhere to the following requirements:

1. Pseudo Binary Data Format

   All header and sensor data will be converted to pseudo binary, regardless of its format from the sensor (analog, BCD, grey-coders, events, etc.). All data will be transmitted in a "modified ASCII" format utilizing 6- bits of an 8-bit character to represent part of each binary number. For data requiring 12-bit precision, two consecutive modified ASCII characters are needed as shown in the example below:

P	1	2^{11}	2^{10}	2^9	2^8	2^7	2^6	P	1	2^5	2^4	2^3	2^2	2^1	2^0

1st DATA CHARACTER 2nd DATA CHARACTER

12-Bit Precision Data

For 18-bit precision, three characters are required:

P	1	2^{17}	2^{16}	2^{15}	2^{14}	2^{13}	2^{12}	P	1	2^{11}	2^{10}	2^{9}	2^{8}	2^{7}	2^{6}	P	1	2^{5}	2^{4}	2^{3}	2^{2}	2^{1}	2^{0}

1st DATA CHARACTER 2nd DATA CHARACTER 3rd DATA CHARACTER

18-Bit Precision Data

Note that bits 7 and 8 of each character are a *"one" and an odd parity bit, respectively*. Thus, data is always expressed by N characters, each character representing N x 6 bits of information. Data within a character is transmitted least significant bit first.

*The 6-bit binary data sequence of all ones may be transmitted as 01111111 (an ASCII "DEL" character) or 10111111 (an ASCII “?” character).

2. Signed Parameters

Many parameters, temperatures in particular, may be expressed with negative values. In addition, the direction of change in a reading is often useful information and similar such parameter-related flags should also be handled efficiently. Therefore, data may be expressed in one of three ways:

a) as a positive fixed point value of precision (N x 6);

b) as a signed value in two's complement form having a precision of (plus or minus) (N x 6 -1); or

c) as a positive fixed point number of precision (N x 6 -1) with the high order bit used as a flag.

As an example of a negative value, a temperature value of 17 degrees below zero could be expressed with six bits as 101111. Whereas, a signed value of *+17 degrees would be expressed as 010001. See "Definitions" for an explanation of two's complement arithmetic.

For parameters not having negative values, but designated as being a parameter with a f lag, the high order bit is the f lag and the remaining bits are data in binary form. The precise interpretation of the flag bit is to be defined in the DCP's associated data base. As an example, the 11 bit precision accumulated precipitation value of 000001111011 (123) could indicate both the value of 1.23 inches (accumulated) and the fact that it is raining at the time of the measurement. Conversely, a value of 100001111011 indicates the same reading but signifies that no perceptible change has occurred since the last sensor update.

3. Order of Reporting

The most current data will be reported first within the DCP message.

4. Limitations on Data Content

This standard per se, places no restriction on the number of parameters being sensed, the accuracy of the measurements, or the number of readings within a message. The format of the message must, however, be describable by a data base (located in the receive system's computer) containing, as a minimum, the following elements:

a) For each parameter being reported;

1) Precision of the measurement being reported. This will always be a multiple of 6 (6, 12, 18, 24, etc.) unless it is a signed parameter or has a high-order flag bit (than it is 5, 11, 17, 23, etc.).
2) A flag indicating whether or not the data signed, or has a flag bit.

3) Calibration coefficients which will be applied to the data (if necessary).

b) For each possible format to be transmitted;

1) The message format number (0-63) which corresponds to the 8-bit header word beginning each message.

2) Parameter cycle time (in seconds or minutes) - an N/A (not appropriate) flag may be used to indicate data is not reported in cycles.

3) Cycle offset (in minutes) -- the time delay from the end of the last complete up-date cycle, reported, to the beginning of transmission. If this value is N/A, the data is assumed to be transmitted in real-time, or the time delay between measurement and reporting is to be reported as a parameter within the message. This value will be *N/A for random or interrogated transmissions.

4) A list of parameters contained within the message (or parameter cycle, if the data is reported in cycles): along with the time of the sensor update relative to the beginning of the message. If any given parameter is updated (reported) several times within a cycle, that parameter (with the corresponding time) will be listed for each update.

   If time delay is itself a reported parameter, it will be listed in the data base--the *DCP will transmit this value immediately before all parameters associated with it.

5) Cycles per message (if appropriate). This value indicates the number of times the listed parameters are repeated. An N/A flag would indicate either no repeats, or an indeterminate number of parameter groups (a time delay value, with one or more data values).

6) Multiple Messages Within A Transmission. A transmission may contain more than one message. Generally, multiple messages will be used when two or more formats (as defined in the data base) are needed to transmit all the desired data. Multiple massages can also be utilized to transmit new data along with previously transmitted data --- where possible, multiple parameter cycles should be utilized in lieu of multiple messages.

   Transmissions containing multiple messages will have a single ASCII space character (00100000 - LSB first) between each message. Note: the seventh bit (underlined) is a zero and thus is not a valid data character.

7) Bad Data. If a sensor fails, or if for some reason the DCP is unable to transmit, proper data, an ASCII (/) character (00101111) may be substituted for each data character. Note, the 7th bit of this character is not a one, and cannot therefore be a valid data character.

Other DCPRS Definitions

Transmission The combination of clear radio carrier and all bits of identification, data and any special sequences sent by a DCP.

Message — Relates to all or a portion of the data segment of a transmission; the message is a segment of data that is fully defined in a DCP management data base; a transmission will contain one or more messages.

Header Word — An 8-bit character whose low order 6 bits make up a binary number that identified a format retry stored in a DCP management data base for a specific DCP. A header word begins each message.

DCP — Contains one record per DCP that includes Data Base the Management characteristics of each parameter measured, plus a list of format entries that will identify each potential data message that the DCP can formulate and transmit.

Parameter — Data element measured by a sensor. Common hydrometeorology parameters include stream stage, precipitation and temperature.

Parameter Cycle — A procedure used by a DCP in acquiring and formatting multiple readings obtained over a period of time. Generally a cycle consists of specific measurements taken at prescribed times within a defined interval. A DCP may acquire and report data for several such time intervals by precisely repeating the prescribed cycle for each consecutive interval.

Parameter Update — Entry of a value (composite or point) for into a parameter DCP message. The value may be an instantaneous value or a computed value based on many sensor values measured since the last message update.

Two's Complement — A method of expressing negative numbers so that subtraction may be performed by a simple fixed-precision binary accumulator (adder). The negative value of a binary number is computed by complementing each bit and then adding one. (Example: The equation 4-6=-2 is computed as 4+(-6)=-2, which in 6-bit binary is 000100 + 111001 = 111101). The magnitude of a negative value is determine by taking its two's-complement. (i.e., -(-2)=+2 or -(11101)=000010).

Appendix C - Interrogate DCP Receive Requirements

3.1 Received Frequency Characteristics - The DCP received radio-frequency (RF) shall be as follows:

a. The Geostationary Operational Environmental Satellite (GOES) East frequency - 468.8375 MHz.
b. The GOES West frequency - 468.8125 MHz or 468.825 MHz.
c. Furthermore, these frequencies shall be selectable without requiring realignment.

3.2. Interrogate Receive Signal Characteristics

a. Data Format - The DCP shall be capable of receiving and demodulating the following sequence:
   1) 4 bit Binary Coded Decimal (BCD) time code followed by,
   2) 15 bit MLS sync word (bit pattern 100010011010111) followed by,
   3) 31 bit BCH interrogate address word (e.g. bit pattern 0011010010000101011101100011111--MSB first in Hexadecimal. The DCPRS shall respond to one or more assigned addresses with 1 second. The DCPRS shall respond whenever the received sequence is exact or within two bits of the assigned address(es).

b. Acquisition Time

The receiver shall acquire lock-on to the interrogation signal format in two minutes or less, from standby conditions when the interrogation signal carrier is within $\pm$ 100Hz. The acquisition shall be accomplished in the presence of modulation.

c. Level

The DCP shall lock-on and demodulate the interrogation signal over the range of -100 dBm maximum to -130 dBm minimum centered at the carrier frequencies identified in paragraph 3.1 above measured at the receiver antenna terminals.

d. Mean Time to Cycle Slip (MTCS)

The MTCS for the carrier tracking loop shall be equal to or greater than 1 minute.

APPENDIX D - GOES DCS TRANSMIT FREQUENCIES

100/300 bps channels	Frequency MHz	1200 bps Channels	Frequency MHz		100/300 bps channels	Frequency MHz	1200 bps Channels	Frequency MHz
1	401.701000	1	401.701750		44	401.765500		
2	401.702500				45	401.767000	23	401.767750
3	401.704000	2	401.704750		46	401.768500		
4	401.705500				47	401.770000	24	401.770750
5	401.707000	3	401.707750		48	401.771500		
6	401.708500				49	401.773000	25	401.773750
7	401.710000	4	401.710750		50	401.774500		
8	401.711500				51	401.776000	26	401.776750
9	401.713000	5	401.713750		52	401.777500		
10	401.714500				53	401.779000	27	401.779750
11	401.716000	6	401.716750		54	401.780500		
12	401.717500				55	401.782000	28	401.782750
13	401.719000	7	401.719750		56	401.783500		
14	401.720500				57	401.785000	29	401.785750
15	401.722000	8	401.722750		58	401.786500		
16	401.723500				59	401.788000	30	401.788750
17	401.725000	9	401.725750		60	401.789500		
18	401.726500				61	401.791000	31	401.791750
19	401.728000	10	401.728750		62	401.792500		
20	401.729500				63	401.794000	32	401.794750
21	401.731000	11	401.731750		64	401.795500		
22	401.732500				65	401.797000	33	401.797750
23	401.734000	12	401.734750		66	401.798500		
24	401.735500				67	401.800000	34	401.800750
25	401.737000	13	401.737750		68	401.801500		
26	401.738500				69	401.803000	35	401.803750
27	401.740000	14	401.740750		70	401.804500		
28	401.741500				71	401.806000	36	401.806750
29	401.743000	15	401.743750		72	401.807500		
30	401.744500				73	401.809000	37	401.809750
31	401.746000	16	401.746750		74	401.810500		
32	401.747500				75	401.812000	38	401.812750
33	401.749000	17	401.749750		76	401.813500		
34	401.750500				77	401.815000	39	401.815750
35	401.752000	18	401.752750		78	401.816500		
36	401.753500				79	401.818000	40	401.818750
37	401.755000	19	401.755750		80	401.819500		
38	401.756500				81	401.821000	41	401.821750
39	401.758000	20	401.758750		82	401.822500		
40	401.759500				83	401.824000	42	401.824750
41	401.761000	21	401.761750		84	401.825500		
42	401.762500				85	401.827000	43	401.827750

43	401.764000	22	401.764750		86	401.828500		

100/300 bps channels	Frequency MHz	1200 bps Channels	Frequency MHz		100/300 bps channels	Frequency MHz	1200 bps Channels	Frequency MHz
87	401.830000	44	401.830750		132	401.897500	67	401.899750
88	401.831500				133	401.899000		
89	401.833000	45	401.833750		134	401.900500	68	401.902750
90	401.834500				135	401.902000		
91	401.836000	46	401.836750		136	401.903500	69	401.905750
92	401.837500				137	401.905000		
93	401.839000	47	401.839750		138	401.906500	70	401.908750
94	401.840500				139	401.908000		
95	401.842000	48	401.842750		140	401.909500	71	401.911750
96	401.843500				141	401.911000		
97	401.845000	49	401.845750		142	401.912500	72	401.914750
98	401.846500				143	401.914000		
99	401.848000	50	401.848750		144	401.915500	73	401.917750
100	401.849500				145	401.917000		
101	401.851000	51	401.851750		146	401.918500	74	401.920750
102	401.852500				147	401.920000		
103	401.854000	52	401.854750		148	401.921500	75	401.923750
104	401.855500				149	401.923000		
105	401.857000	53	401.857750		150	401.924500	76	401.926750
106	401.858500				151	401.926000		
107	401.860000	54	401.860750		152	401.927500	77	401.929750
108	401.861500				153	401.929000		
109	401.863000	55	401.863750		154	401.930500	78	401.932750
110	401.864500				155	401.932000		
111	401.866000	56	401.866750		156	401.933500	79	401.935750
112	401.867500				157	401.935000		
113	401.869000	57	401.869750		158	401.936500	80	401.938750
114	401.870500				159	401.938000		
115	401.872000	58	401.872750		160	401.939500	81	401.941750
116	401.873500				161	401.941000		
117	401.875000	59	401.875750		162	401.942500	82	401.944750
118	401.876500				163	401.944000		
119	401.878000	60	401.878750		164	401.945500	83	401.947750
120	401.879500				165	401.947000		
121	401.881000	61	401.881750		166	401.948500	84	401.950750
122	401.882500				167	401.950000		
123	401.884000	62	401.884750		168	401.951500	85	401.953750
124	401.885500				169	401.953000		
125	401.887000	63	401.887750		170	401.954500	86	401.956750
126	401.888500				171	401.956000		
127	401.890000	64	401.890750		172	401.957500	87	401.959750
128	401.891500				173	401.959000		
129	401.893000	65	401.893750		174	401.960500	88	401.962750

130	401.894500				175	401.962000		
131	401.896000	66	401.896750		176	401.963500	89	401.965750

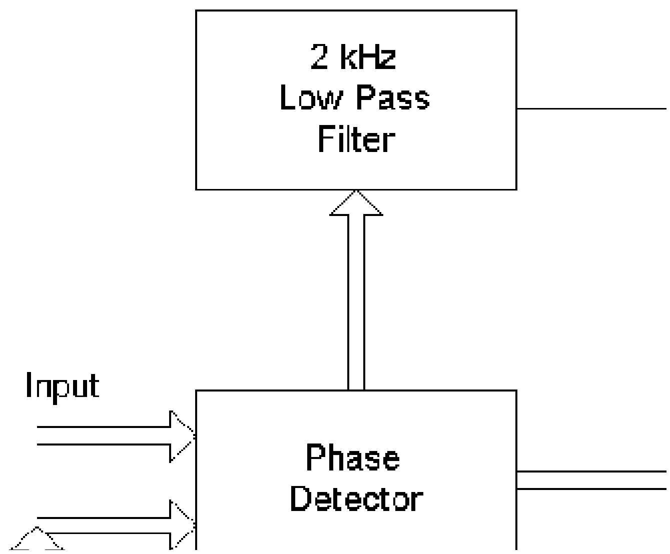
100/300 bps channels	Frequency MHz	1200 bps Channels	Frequency MHz		100/300 bps channels	Frequency MHz	1200 bps Channels	Frequency MHz
177	401.965000	90	401.968750		222	402.032500		
178	401.966500				223	402.034000	113	402.037750
179	401.968000	91	401.971750		224	402.035500		
180	401.969500				225	402.037000	114	402.040750
181	401.971000	92	401.974750		226	402.038500		
182	401.972500				227	402.040000	115	402.043750
183	401.974000	93	401.977750		228	402.041500		
184	401.975500				229	402.043000	116	402.046750
185	401.977000	94	401.980750		230	402.044500		
186	401.978500				231	402.046000	117	402.049750
187	401.980000	95	401.983750		232	402.047500		
188	401.981500				233	402.049000	118	402.052750
189	401.983000	96	401.986750		234	402.050500		
190	401.984500				235	402.052000	119	402.055750
191	401.986000	97	401.989750		236	402.053500		
192	401.987500				237	402.055000	120	402.058750
193	401.989000	98	401.992750		238	402.056500		
194	401.990500				239	402.058000	121	402.061750
195	401.992000	99	401.995750		240	402.059500		
196	401.993500				241	402.061000	122	402.064750
197	401.995000	100	401.998750		242	402.062500		
198	401.996500				243	402.064000	123	402.067750
199	401.998000	101	402.001750		244	402.065500		
200	401.999500				245	402.067000	124	402.070750
201	402.001000	102	402.004750		246	402.068500		
202	402.002500				247	402.070000	125	402.073750
203	402.004000	103	402.007750		248	402.071500		
204	402.005500				249	402.073000	126	402.076750
205	402.007000	104	402.010750		250	402.074500		
206	402.008500				251	402.076000	127	402.079750
207	402.010000	105	402.013750		252	402.077500		
208	402.011500				253	402.079000	128	402.082750
209	402.013000	106	402.016750		254	402.080500		
210	402.014500				255	402.082000	129	402.085750
211	402.016000	107	402.019750		256	402.083500		
212	402.017500				257	402.085000	130	402.088750
213	402.019000	108	402.022750		258	402.086500		
214	402.020500				259	402.088000	131	402.091750
215	402.022000	109	402.025750		260	402.089500		
216	402.023500				261	402.091000	132	402.094750
217	402.025000	110	402.028750		262	402.092500		
218	402.026500				263	402.094000	133	402.097750
219	402.028000	111	402.031750		264	402.095500		

220	402.029500				265	402.097000		
221	402.031000	112	402.034750		266	402.098500		

Appendix E - GOES DCS Certification Test Notes

1.0 Carrier Phase Noise Test Loop

Carrier phase noise is measured as the RMS voltage at the output point. The value in degrees is proportional to the phase detector scale factor.



2.0 DCPRS Transmitted Power

The power transmitted by a linearly modulated signal is the same for any position on the unity phase circle. However since this is a dynamic case the power is not constant for various types of modulation, since the rate of change of phase is determined by the filtering which is necessary to control the spectral spreading. In the random 8 PSK case the power level is 1.2 dB less than carrier, and for the clock modulation it is 3 dB less than carrier. Since carrier and clock are for relatively short parts of the message the specification reflects the power at random modulated signal. The power measured at carrier only will be 1 dB higher than when a random modulated signal is transmitted. A 3-dB increase in EIRP is permitted for the 1200 bps DCPRS.

3.0 Phase Error Budget

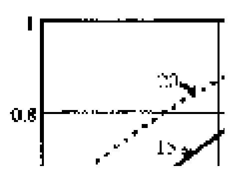
The transmission of an eight "8" phase signal has a phase decision window of ± 22.5 degrees, about 1/3 less than the previous 60 degrees. All elements of the system add phase uncertainty. The specification optimizes the system performance without placing technically impossible demands on any individual portion of the system.

The plot below shows the probability of error verses Signal to Noise Ratio for various values of phase error. Evident from these curves is that any phase error induced from any source degrades the over all performance.

Source of Error	Max. Error Value RMS degrees	Nominal
RECEIVER		
Static Carrier Noise	0.5	0.5
Dynamic Sampling	0.5	0.5
Reference Tracking	2.0 (@ 10 dB S/N)	1.0 (@ 15dB S/N)
TRANSMITTER		
Carrier Noise	2.5	1.5
Dynamic Noise, ISI (300 bps)	2.0	1.5
Dynamic Noise, ISI (1200 bps)	3.0	2.0
Frequency Drift	2.0	1.0 (bias)
Modulation Accuracy	2.5	1.0

The above curves show the effect of additive phase errors. Lower levels of operation are with an error probability of 0.9. From the curves it is clear that a 5-degree increase in phase error (i.e. going from 2.5 to 7.5 degrees) causes an equivalent overall link degradation of about 6 dB which has the same effect as decreasing the output transmit power from 10 watts to 2.5 watts.

4.0 Phase Measurement



The test demodulator incorporates a test program, which measures the phase and places the measurement in one of 18 phase bins within the first 90-degree quadrant. At the end of the message the demodulator prints out the number of symbols placed in each bin. An example is shown below.

Example Message

" *Message example* "

307 162 11 0 0 0 6 183 244 303 247 6 0 0 0 10 170 281
Good phases: 1897 of 1930 0.983

The line in bold Italics is the bin counts for phase measurements with all minus signs removed. The effect is to fold over the phase measurements as if all measurements are in the same quadrant. Each quadrant has the following bin values.

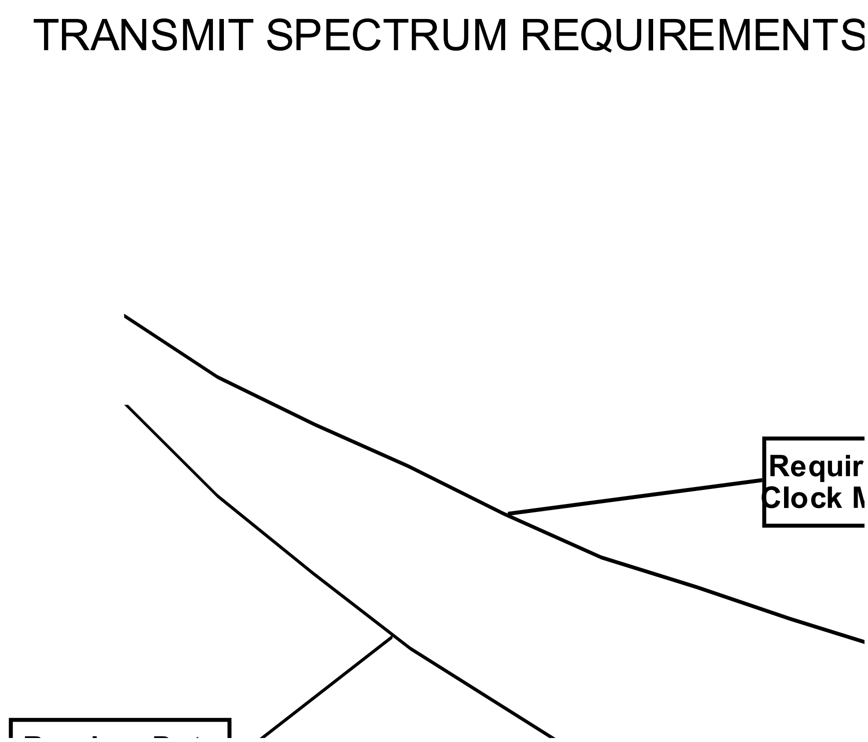
Bin No.	Bin Phase	No. Samples	Weighted Value	Square Values
1	0 / 2.8	307	+ 1.4	602
2	2.8 / 8.4	162	+ 5.6	5080
3	8.4 / 14.0	11	+ 11.2	1380
4	14.0 / 19.6	0	+ 16.8	
5	19. / 25.2	0	X	
6	25.2 / 30.8	0	- 16.8	
7	30.8 / 36.4	6	- 11.2	
8	36.4 / 42.2	183	- 5.6	
9	42.2 / 45.0	244	- 2.8	
10	45.0 / 47.8	303	+ 2.8	
11	47.8 / 53.4	247	+ 5.6	
12	53.4 / 59.0	6	+ 11.2	
13	59.0 / 64.6	0	+ 16.8	
14	64.6 / 70.2	0	X	
15	70.2 / 75.0	0	- 16.8	
16	75.0 / 81.6	10	-11.2	1254
17	81.6 / 87.2	170	- 5.6	5331
18	87.2 / 90	281	-1.4	551

The total number of symbols transmitted is 1930. Bins 1,2,8,9,10,11,17,18 are designated "good" bins. The ratio of "good" bin count to total sample numbers is an indication of the bit error rate or similarly the equivalent total system S/N of operation. If a Gausian distribution is assumed, the S/N ratio may be derived from the standard deviation.

The phase deviation is the separation between the center of bins 16, 17, 18, 1,2, 3 and 6,7,8,9,10,11,12,13. The example given has a difference in the two arithmetic centers of –0.07 degrees or 45-0.07=44.93 degrees average modulation deviation. The –0.07 indicates a small "Q" bias error on the I/Q modulator.

The second value, which is computed from these samples, is the RMS value in degrees of the phase spread. Bins 1,2,3,16,17, & 18 are used for this computation. The RMS value of this sample is 3.88 degrees. Since the carrier noise is 2 degrees then the dynamic noise is 1.88 degrees.

5.0 DCPRS Transmit Spectrum for “0-1" Clock and Random Spectrum



TRANSMIT SPECTRUM REQUIREMENT