VERSION 1.0B

of the

300 / 1200 BPS GOES Data Collection Platform Radio Set (DCPRS) CERTIFICATION STANDARDS

NOAA / NESDIS

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Appendices

GOES DCS 300/1200 BPS DCPRS CERTIFICATION STANDARDS
FOR SELF-TIMED, RANDOM REPORTING, and INTERROGATE OPERATION

Introduction

DCPRS Certification is achieved by demonstrating that a radio set (transmitter and/or receiver) fulfills each of the requirements set forth in the respective portions of this document. NESDIS certification is "type certification", wherein a representative production unit is tested and found to fulfill all stated requirements. NESDIS certification of individual production units (those having the same model number) is not required. **As a standard, this document represents mandatory requirements--waivers will not be accepted.**

To obtain "Type Acceptance" the manufacturer shall submit the DCPRS schematics, data flow chart. electronics parts design data, unit and system test data, and perform tests to demonstrate that each requirement herein is met. This includes but is not limited to analysis of the DCPRS' design and performance characteristics, performing unit tests t room temperature, and over a range of temperature and power supply (battery voltage) variations. For clarity the certification requirements have been grouped into related areas. For example, all EIRP requirements are included in one section.

Certification testing shall be ran with standard laboratory test equipment and with a NOAA supplied Test Receiver/Demodulator. This test unit includes a computer output port from the demodulator for test data extraction points from the unit under test. The output port is accessed by the use of a "dumb" terminal which is obtained by running a terminal emulation programs such as BitCom, COMMIT, etc. through an IBM desktop or laptop PC. The test demodulator has other access points for "I" and "Q" phase detector measurements. Test guidelines, procedures, etc. are described in the appendix of this document. The NOAA Test Receiver/Demodulator will be loaned for a period of up to sixty (60) days to manufacturer's after the required documentation and design data requirements in Section 1 have been accepted and/or approved by the NOAA NESDIS Certification Official.

Manufacturer's are required to supply all other test equipment needed to demonstrate compliance with the certification requirements. All test equipment to be used must be identified in the manufacturer's initial request for DCP certification and have verified calibrations to an established test laboratory. A list of the recommended test equipment, a typical test set up, and some of the capabilities of the NOAA provided test set are included in Appendix A . The manufacturer test channels for the GOES DCS are as follows: 151 for 100/300bps and 76 for 1200bps (see Appendix D).

Document Organization

The GOES DCPRS certification requirements are set forth in the following four sections. The first section identifies the DCPRS certification documentation required. The second section defines the DCPRS certification reporting mode requirements. The third section focuses upon the DCPRS transmit data format requirements which are not considered to be temperature dependent. The fourth section involves requirements for which performance may vary over temperature and power supply variation such as output power, frequency stability, modulation stability, carrier phase noise, transmit spectrum, etc.

SECTION 1 - DCPRS Certification Documentation Requirements

Manufacturer's shall submit the following documentation at least 60 days prior to beginning the formal DCPRS certification testing. While NESDIS may review and comment on this documentation, all documentation is considered 'PROPRIETARY' for government eyes only and not available, unless so identified by the manufacturer, to any other party.

a) DCPRS Model Number with its respective data and/or specification sheet(s)
b) DCPRS electrical and electronic circuit schematics.
c) DCPRS software flow-charts that identify how the DCPRS reporting method(s) - random, self-timed, interrogated, message formatting/generation, frequency and time stability functions, Fail-safe operation, other functions are fulfilled.
d) DCPRS antenna gain, polarization, axial ratio, and VSWR data. This data shall be used with the power amplifier output to determine the DCPRS EIRP (Equivalent Isotropic Radiated Power).
e) Manufacturers Proposed Test Procedures including test data sheets.
f) DCPRS oscillator aging analysis data to demonstrate that the specified aging requirements are met.
g) Preliminary DCPRS Transmit Spectrum (see paragraph 4.5)

SECTION 2 - DCPRS Data Rate and Operating Mode Requirements

For High Data Rate (HDR) operation a DCPRS may be designated for either 300 bps or for 1200 bps. Further the DCPRS manufacturer shall clearly state the reporting mode(s) for the Model/unit (i.e. Self-timed, Random, or Interrogate). A combination of two operating modes is permitted providing this is so identified and that all applicable mode requirements are met. The DCPRS certification official will identify specific channels, GOES ID/DCP Address, and time slots as needed for any 'on-the-air' or 'GOES testing.'

2.1 DCPRS Self- Timed Reporting Mode Requirements

All DCPRS designated for self-timed operations shall fulfill the timing requirements identified below.

2.1.1 300 BPS Reporting Time Accuracy

Manufacturer's shall demonstrate that self-timed reporting will have a drift of no more than ± 30 seconds per year. Manufacturer's may use a combination of analysis with oscillator drift data and DCP software utilized.

The DCPRS shall be demonstrated to operate for 48 hours on a NOAA/NESDIS assigned channel and time slot. The timing accuracy shall not exceed a prorated ± 30 seconds per year.

2.1.2. 1200 BPS Reporting Time Accuracy

All 1200 BPS DCPRS transmissions shall be within ± 0.5 seconds of the assigned reporting time with a probability of 99.9% within any one year period and at any temperature over a range of -40EC to +50EC. This shall include any inaccuracies associated with the initial setting of the clock by the user as specified in paragraph 2.1.5 below.

2.1.3 DCPRS Time Reference

DCPRS reporting time shall always be with respect to Coordinated Universal Time (UTC).

2.1.4. Inhibiting Transmissions

Should that the DCPRS clock differs by more than ± 0.5 seconds from the Coordinated Universal Time (UTC) at time of transmission, transmission (including RF carrier) shall be inhibited (i.e. shall be canceled). After an inhibited transmission should the DCPRS clock be restored to less than ± 0.5 seconds from Coordinated Universal Time (UTC), the DCPRS may resume normal transmissions.

2.1.5 Setting and Verifying the DCPRS Clock

Manufacturer's shall provided a method to enable a user to set the DCPRS clock to an accuracy of within ± 0.1 seconds of Coordinated Universal Time (UTC). The needed equipment and software must be available from the DCPRS vendor to verify the accuracy of the DCPRS clock after it has been set.

NOTE: The requirements in paragraphs 2.1.4 and 2.1.5 are mandatory for the 1200 BPS DCP and are optional for the 300 BPS DCP.

2.2 DCPRS Random Reporting Mode Requirements

For random reporting certification manufacturer's shall demonstrate that the DCPRS transmits at a maximum message length of 3 seconds for 300 BPS and 1.5 seconds for 1200 BPS. The same algorithm and/or processes used for 100 bps certification may be used. Definitions of pseudo binary and other concepts are included in Appendix B. Random reporting certification testing requires that manufacturer's demonstrate random message generation on an approved NESDIS channel and transmit DCP messages in the random mode for eight (8) or more hours with an average repeat interval of every 15 minutes. One of the data values to be transmitted in this testing shall be a message number counter.

2.3 DCPRS Interrogate Reporting Mode Requirements

For DCPRS interrogate mode certification the unit shall be tested as a transmit/receive system. Thus not only the DCPRS transmit but also the GOES Command Receiver requirements must be demonstrated. The DCPRS command receiver requirements are as set forth in Appendix C.

For 'on the air' testing a reply message must be generated when the interrogate command is received on the appropriate interrogate DCP GOES ID and a data transmission must be sent on the proper channel.

3.0 DCPRS Data Format Requirements

3.1 DCPRS Data Format. The figure below defines the required message format. For each of the blocks a "0" = represent 0 degrees and a "1" represents 180 degrees.

*0.5s / 0.25s Carrier	3 '0 -1' Clock States	15 bit FSS	31 bit GOES ID 4 - 8 bit Bytes	Flag Word 8 Bits	DCP DATA Up to 126,000 bits (maximum)	EOT	Encoder Flush 16 bits

↑ Start of Scrambling, Coding, and Interleaving

NOTES: ASCII EOT used for ASCII and Pseudo Binary formats
International EOT used for Binary Format
Actual Message Length may not Exceed Fail-Safe Limits

***Carrier**: 0.50 seconds for 300 BPS
0.25 seconds for 1200 BPS

Clock: 3 "0 and 180" degree phase transitions (0-1, 1-0, 0-1)at the respective symbol data rate

Frame Synchronization Sequence (FSS) - Three possible 15 bit Patterns:

	No Interleaver	Short Interleaver	Long Interleaver
Binary	MSB 000001011001110	000100011101001	001111100110101
Hexadecimal (implied ("0" as MSB)	02CE	08E9	1F35

GOES ID/DCP address: 31 bits plus LSB assumed as a "0" to form 4 - 8 bits Bytes

Flag Word: (LSB) Bit 1 spare, undefined
Bit 2 Clock updated since last transmission = 1, not = 0
Bit 3 Data Compression on =1, off = 0 Possible Future Enhancement
Bit 4 Reed Solomon on = 1, off = 0 Possible Future Enhancement
Bit 5 spare, undefined
Bits 6 & 7 ASCII = 10, Pseudo Binary = 11, Binary = 01
(MSB) Bit 8 Odd parity for ASCII formatted data

The FSS consists of three possible 15 bit words where 0 degrees = "0" and 180 degrees= "1" transmitted at the symbol rate. The left most bit is transmitted first.

After the FSS is transmitted the remainder of the format is presented as eight (8) bit bytes. If an interleaver is enabled the respective FSS word shall be generated. After the FSS is transmitted the GOES ID and all data shall be scrambled, trellis encoded, and interleaved as defined in paragraph 3.5 below.

The GOES ID is a 31-bit Bose-Chaudhuri-Hocquenghem (BCH) address with a zero implied as the 32^{nd} LSB. This address shall be transmitted as the first 4 bytes of the data in the message in exactly the same manner as all the other data bytes in the message. For example, given the hex ID of **CE 12 00 B8**, the first byte transmitted is **CE** hex, followed by **12** Hex, followed by **00** hex, followed by **B8** hex or **11001110 00010010 00000000 10111000.**

3.2 Data Scrambling

At the beginning of the GOES ID all DCP data must be scrambled. Each data byte is scrambled by "exclusive ORing" (XOR) the byte with a byte from the following 40 byte table. The first byte is XORed with the first byte in the table (53 hex). The next byte is XORed with the second byte in the table (12 hex), and so on. After the 40^{th} byte has been scrambled the next scramble byte to be used is the first byte (53 hex). The below table is to be used in a circular fashion throughout the message.

53	12	72	B2	54	62	AA	E4	DB	A7	56	08	A8	09	B4	BF	61	DC	50	E3
AB	7F	00	87	6D	F5	58	CC	CF	3E	E7	2A	7E	9B	5C	4D	CE	A5	3C	0A

This array is treated as a single binary string where each data binary pair generates one symbol. BAD hex is the first scrambled symbol output and recycles after 160 input symbols. This array shall be cycled through as many times as required for the duration of the message data.

3.3 Convolutional or Trellis Encoding

Figure 3 provides a Functional Block Diagram of the convolutional/Trellis encoder required. This

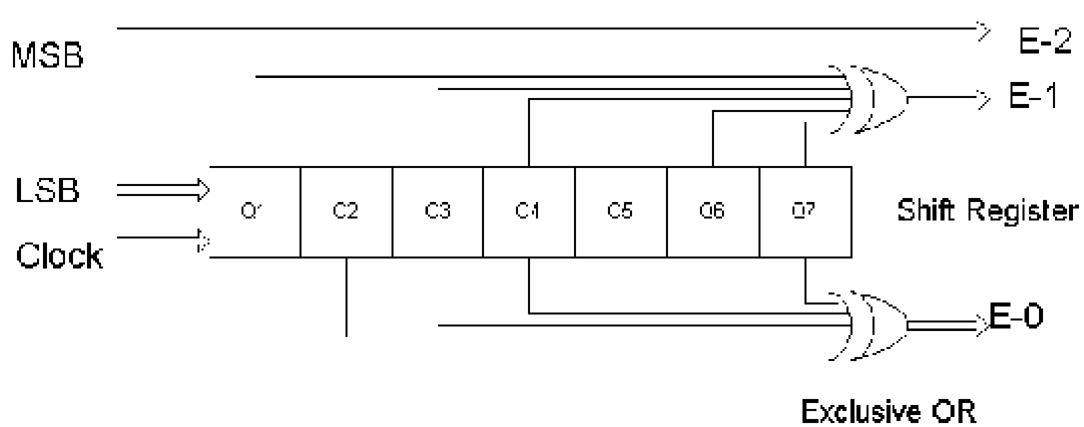


Fig. 3 TRELLIS ENCODER LOGIC

hardware logic generates the 3 tri-bits, which are used to generate each eight (8) PSK symbol to be modulated. Each data byte contains 8 bits. These bits are split into four 2 bit pairs as shown in the table below. Each 2-bit pair is fed into the trellis encoder in order. Pair 1 is fed into the encoder,

MSB			LSB
Bits 7 & 6	Bits 5 & 4	Bits 3 & 2	Bits 1 & 0
Bit Pair 4	Bit Pair 3	Bit Pair 2	Bit Pair 1

then pair 2, etc. The trellis encoder takes a 2-bit pair and encodes it to a 3-bit symbol. This 3-bit symbol is then mapped to one of the eight phases for transmission as shown in Table 3.6. The initial state of the encoder shall be all zeros.

3.4 Encoder Flush

At the end of the message after transmitting the EOT an additional 16 zero (0) data bits shall be provided to flush the encoder. After the 16th flush bit is transmitted, the interleaver, if used, shall be unloaded per para. 3.5.2, the phase should be brought to zero and the carrier power shall be turned off.

3.5 DCRPS Interleaver Requirements

The DCPRS shall contain two types of interleavers that are users selectable from the DCPR test menu. The type is identified by the MLS word selected. The interleavers compile the symbols to be sent into a matrix of fixed size. If the EOT and flush symbols do not fill out the interleaver matrix block then data zeros (0) shall be used to complete the data block.

Short interleaver. A data block which is 16 columns wide and 24 rows deep with a total of 384 symbol positions.

Long interleaver. A data block which is 24 columns wide and 32 rows deep with a total of 768 symbol positions.

3.5.1 Interleaver Loading

When the interleaver is enabled, the first symbol loaded shall be the first scrambled and encoded symbol of the GOES ID or DCPRS address word. The interleaver shall be loaded in a column major fashion. For example, the first symbol of the scrambled and encode BCH coded address word will be placed in column 1, row 1. The second symbol will be placed in column 1, row 2, until the first column is full. The next symbol will be placed in column 2, row 1, and so forth.

3.5.2 Loading the Last Interleaver of the Message

Once all the scrambled and encoded data (sensor, EOT, and encoder flush bits) have been loaded into the interleaver, the DCPRS shall continue to input pairs of “0”s into the scrambler/encoder until the interleaver block is full.

3.5.3 Unloading the Interleaver

The interleaver shall be unloaded in a row major fashion. This means that the symbol in column 1, row 1 will be transmitted first, followed by the symbol in column 2, row 1. After the entire row has been transmitted, the DCP shall begin transmitting the symbols from row 2 in the same manner.

3.6 DCPRS Modulation Encoding (N X 45 degrees, +/- 2.5 degrees)

The transmitted data shall be phase mapped from the trellis encoder as shown in Table 3.6.

E-2	E-1	E-0	Phase Symbol
0	0	0	0
0	0	1	45
0	1	0	135
0	1	1	90
1	0	0	180
1	0	1	225
1	1	0	315
1	1	1	270

Table 3.6 Phase Encoding

3.7 DCPRS Data Formats

Three data formats shall be demonstrated ASCII, Pseudo Binary and Binary. HDR pseudo binary shall be the same as for 100 bps DCPRS certification (see Appendix B).

3.7.1 Prohibited Characters

For ASCII or Pseudo Binary format the following control characters are prohibited: DLE, NAK, SYN, ETB, CAN, GS, RS, SOH, STX, ETX, ENQ, ACK, and EOT. For DCPRS certification testing a set of five messages of at least 500 characters in length shall be sent in a pre-defined ASCII character set. The test demodulator output will be capable of extracting this transmitted text.

For binary mode certification a fixed set of binary values is sent five times. The string should be at least 256 bytes long. The precise format and error checking for HDR binary transmissions is TBD.

3.7.2 End Of Transmission (EOT)

ASCII and Pseudo Binary Format Mode - An EOT code word, bit pattern 00000100 - LSB first, shall be sent immediately after the last symbol of sensor data. This bit pattern is an ASCII EOT with odd parity.

Binary Mode - An (EOT) code word, bit pattern 11000111100101011110100000100 - LSB first, shall be sent immediately after the last symbol of sensor data. This bit pattern is identical to that required for international DCPRS certification.

3.8 DCPRS Maximum Message Length (MML)

The MML for any 300 bps or 1200 bps High Data Rate transmission shall be 126,000 bits (see paragraph 4.6 for DCPRS fail-safe requirements).

3.9 DCPRS Transmit Frequency Adjustment

The manufacturer shall demonstrate at room temperature that DCPRS output frequencies are adjustable to within 25 Hz of the nominal channel center frequency.

SECTION 4 - DCPRS Performance Requirements

DCPRS performance requirements shall be demonstrated over a -40°C to 50EC temperature range and over a power supply voltage variation of 15 per cent of nominal (e.g. 12 $\pm$ 1.8 volts).

4.1 DCPRS Effective Isotropic Radiated Power (EIRP)

4.1.1 RF Power Output

For 300 bps the DCPRS shall have a nominal EIRP of 48 dBm - Carrier only and a maximum EIRP of 50 dBm under any combination of power supply or temperature variation.

For 1200 bps the DCPRS shall have a nominal EIRP of 51 dBm - Carrier only and a maximum EIRP of 53 dBm under any combination of power supply or temperature variation.

Note: During the random modulation portion of the message the output power will be 1 dB less (See Appendix E paragraph 1- test notes for a discussion of RMS transmitted power).
DCPRS EIRP testing shall include a test to show the transmit amplifier 1 dB compression point. The DCPRS phase noise measurement shall be made with the transmitter operated at or above the 1 dB compression point.

4.1.2 DCPRS Antenna

4.1.2.1 Antenna Polarization

DCPRS antenna polarization shall be right-hand circular, according to IEEE Standard 65.34.159 and have an axial ratio or equal to or less than 6 dB on axis.

4.1.2.2 DCPRS Antenna Gain

The DCPRS antenna transmit gain shall be such that in combination with the DCP output power the maximum EIRP is not exceeded.

4.2 GOES DCS Operating Frequency Requirements

The GOES domestic DCS operates at UHF from 401.7 MHz to 402.0 MHz with either 200- 1.5 kHz channels @ 100/300 bps, 100 - 3.0 kHz channels @ 1200 bps or a combination thereof. The GOES international DCS operates from 402.0 MHz to 402.1 MHz with 33-3kHz channels. Although the 300 bps and 1200 bps DCPRS has not been adopted or approved for use in the international DCS, 3 kHz tuning from 402.0 MHz to 402.1 MHz is required for all HDR DCPRS.

4.2.1 Operating Channels and Frequencies

The assigned DCPRS operating channels and frequencies for 300 bps and for 1200 bps operations are set forth in Appendix D. For certification testing manufacturer's shall to demonstrate the synthesis of each of these over the entire range of the possible operation and at a minimum of five frequencies for 300 bps and five for 1200 bps selected at random by the NESDIS Certification Official.

4.2.2 Frequency Stability, Long Term

The DCPRS output frequency shall maintain a long term aging stability of ± 0.5 PPM and be permitted an additional ± 0.5 PPM of drift under any combination of power supply variation or temperatures set forth in paragraph 4.0 on any channel frequency defined in Appendix D. The output frequency shall be maintained to within ± 425 Hz of the channel center.

4.2.3 Short Term Frequency Stability

The DCPRS output frequency shall maintain a short term stability of ± 1 Hz/s under any combination of power supply variation or temperature as set forth in paragraph 4.0. For certification testing the frequency shall be measured over 10 - ten second sample windows and the difference over 100 seconds shall be recorded.

4.3 DCPRS Modulation Requirements

4.3.1 Output Symbol Rate

For 300 bps certification the output symbol rate shall be 150 symbols per second ± 0.025%.
For 1200 bps certification the output symbol rate shall be 600 symbols per second ± 0.025%.

For certification testing the DCPRS is to be set to transmit 0.5 second of carrier and then a continuous stream of "0-1" or 0E and 180E clock transitions at the respective symbol rate. The symbol period is to be measured at the "I" output of the test demodulator.

4.3.2 DCPRS 8-ary Modulator Stability

The 8-ary modulator shall maintain a stability/accuracy of $\leq \pm$ 2.5 degrees under any combination of power supply or temperature variation as defined in paragraph 4.0 (See Appendix E - GOES DCS Certification Test Notes Paragraph 3.0 Phase Measurement).

4.4 DCPRS Phase Noise

4.4.1 DCPRS Carrier Phase Noise

The DCPRS carrier phase noise shall be < 2.5 degrees RMS under any combination of power supply or temperature variation as defined in paragraph 4.0.

DCPRS RMS phase noise is to be measured during transmission of carrier only. First the test set up residual noise from the receiver and signal generator shall be measured. This should be < 0.2 degrees. Then measure the DCPRS phase noise. Subtract the residual set up phase noise from the DCPRS phase noise.

The DCPRS phase noise measurement is to be made at the "Q" output of the test demodulator. While making this measurement the test signal should be observed on an oscilloscope. Test data can be extracted from the test demodulator program or by using RMS voltmeter with a 2000 Hz response at the 1200 BPS data rate.

4.4.2 DCPRS Dynamic Phase Noise (Inter Symbol Interference (ISI))

The DCPRS dynamic phase noise or ISI shall be $\leq$ 1.5 degrees RMS (see Appendix E - GOES DCS Certification Test Notes Para. 2.0 Phase Error Budget) which provides a recommended measurement process.

4.5 DCPRS Transmit Spectrum

4.5.1 Narrow Band Transmit Spectrum

The first modulation sideband is defined as the energy around the carrier frequency extending to the theoretical first spectral nulls on both the positive and negative sides of the carrier. For NRZ-PSK modulation this is from F_C - R_S to F_C + R_S, where F_C is the carrier frequency and R_S is the symbol rate. The second sideband is defined as the frequency band from $F_C + R_S$ to $F_C + 2R_S$ and from $F_C - R_S$ to $F_C - 2R_S$. Third and higher sidebands are defined in a similar manner using $3R_S$, $4R_S$, etc.

The first sideband is the desired signal, all other sidebands are undesired.

When modulated with a random data stream, the 300 and 1200 bps signals shall produce sidebands with peak energy equal to, or less than, the following values.

Second sideband	-15 dBc
Third sideband	-25 dBc
Fourth sideband	-35 dBc
Fifth and higher sidebands	-45 dBc

Note: The sideband levels measured shall be referenced to the level of the unmodulated carrier.

Recommended Test Process:

The transmitter under test shall be operated into a 50 ohm load and at its maximum rated output power level. All measurements of the carrier and sideband levels shall be made with the spectrum analyzer controls set as follows:

Residual Bandwidth	30 Hz
Video Bandwidth	10 Hz
Sweep time	50 seconds
Level Sensitivity	5 dB per division

The frequency span shall be 5000 Hz for 1200 bps and 1250 Hz for 300 bps measurements.

These measurements will require the use of test data sequences that are longer than normally permitted to provide sufficient sweep time for accurate measurement.

NOTE: See Appendix E Test Notes for Random Data plots of the above transmit spectrum with the HDR Improved Test Transmitter

4.5.2 Mid-Band Transmit Spectrum

With the transmitter set with a random 8 PSK modulation the Mid-Band and Harmonics shall be as set forth below:

For the 300 bps data rate at $F_o \geq \pm$ 1500 Hz	$\leq$-60 dBc
For the 1200 bps data rate at $F_o \geq \pm$ 10000 Hz	$\leq$-60 dBc

4.5.3 Combined Spurious

The combined spurious within + /- 500 kHz of the carrier (excluding the modulation side bands) < -50 dBc. (This would be the equivalent to the sum of 10 side bands of – 60 dBc each.)

4.6 Fail-safe Operating Requirements

An independent or separate fail-safe circuit shall be provided to prevent a DCPRS from operating in an uncontrolled fashion. This independent circuit must “permanently ” shut off the transmitter if any of two conditions are violated. These two conditions are:

- Message is too long. For 300 BPS a DCP message length of $\geq$ 270 seconds shall trip the fail-safe. For 1200 BPS a DCP message length of $\geq$ 105 seconds shall trip the fail safe.

- Message sent is too soon. There shall be a minimum of 30 seconds off-time between successive transmissions. If a second message is transmitted before 30 seconds has expired, then the fail-safe shall be tripped.

The fail-safe capability must be demonstrated for all conditions over the defined operating a -40° C to 50EC temperature range and over the required power supply voltage variation. Removal of DC power from the DCPRS shall not affect the operation of this function.

Note: The above term "permanently" requires a manual intervention or reset of the DCPRS in order to restore the unit for operational use in the DCS.

APPENDIX A - Recommended Test Equipment and Test Set Up

The following test equipment or approved equal are recommended:

Spectrum Analyzer (SA) - The SA is needed to perform for spectrum tests. The SA must be able to measure to the third harmonic at 1206 MHz with sufficient Resolution Bandwidth.

Frequency Meter (FM) - The FM is needed to measure transmit frequencies (401.7 to 402.1 MHz) and to measure the transmit symbol rate. The FM shall be accurate to 0.01 PPM (parts per million).

Digital Multi-Meter (DMM) - The DMM may be used for power supply voltage, RMS response to measure phase noise, and other measurements as deemed appropriate. NOTE : DCP phase noise may also be measured using the Demodulator programs.

RF Power Meter (RFPM) - The RFPM is used to measure the RF power amplifier output power. The response needs to be to RMS power. A Bird Wattmeter Model 43 with a 50-watt element with a ± 3 per cent accuracy at full range or approved equal is acceptable for these measurements.

Signal Generator (SG) - The SG is to be used for mixing the 402 MHz signal to the 5 MHz IF of the test demodulator. The SG phase noise shall be < 0.1 degree RMS. An HP 8660C or approved equal is acceptable for this testing.

Environmental Test Chamber (ETC) - The ETC is used to control the ambient test temperature of the DCP unit under test. A –40EC to 50EC range or greater is required.

General Purpose Oscilloscope - To measure and/or observe the relationship of "I" and "Q" data signals.

Laptop or IBM PC - To interface with the NOAA provided Demodulator Test Set.

Low Frequency Signal Controller/Modulator - An HP 33120A or equivalent. Used to generate modulation patterns and IF signals.

DCPRS Test Capabilities Required

During certification testing manufacturers must be able to disable or enable the DCP fail-safe circuitry as needed. Further a number of test sequences must be available on the unit to test various DCP functions. These include the following:

a) Carrier only	carrier phase noise, frequency
b) Clock pattern "0-1"	spectrum and clock pattern check, symbol rate
c) Repeating short message sequence	format checks
d) Longer message, repeating pattern	modulation and Inter-symbol Interference check, power measurement, spectrum

The typical test set up is shown in Figure 1.

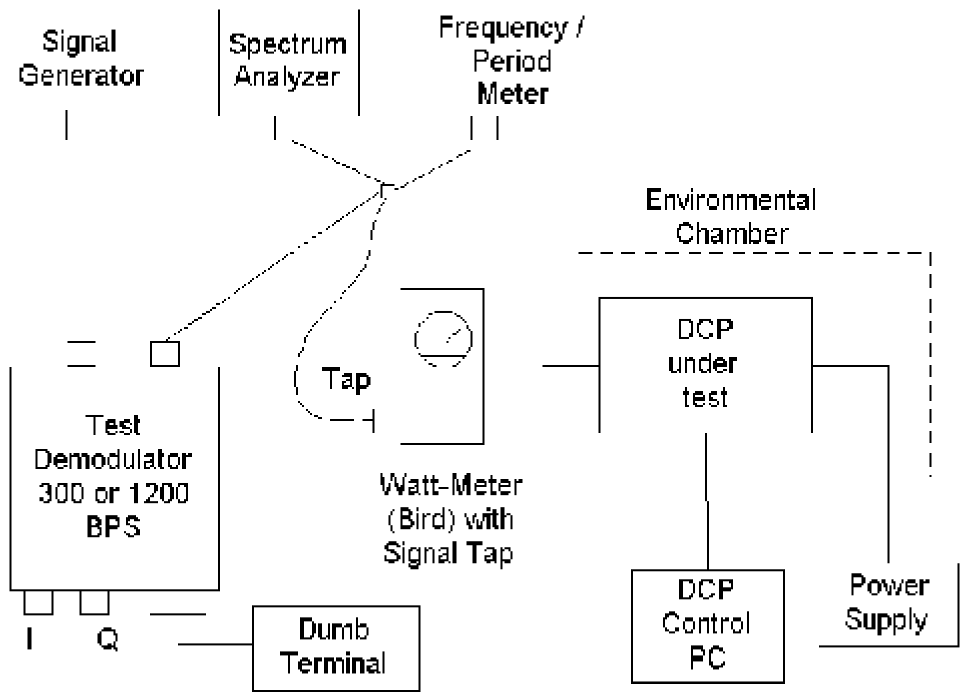


Fig. 1 TYPICAL DCP CERTIFICATION TEST SETUP

Some of the capabilities/features of the Test Demodulator are highlighted below:

Hardware Input

Input is direct from the manufacturer's DCP power amplifier. An internal wattmeter (50 watt load) with a coupler tap provides the low power level input required by the demodulator. A 0.01 PPM reference oscillator (with a single VCO loop) provides the LO and frequency measurement stability.

Unique Software Functions For the Test Set Demodulator

The demodulator makes signal quality measurements of all the signal variables of power, frequency, and phase. In the test case the measurements are required to be made in different sequences and accuracy. In the test case the noise floor is the base line phase noise of the system since the S/N typical of live signals is not applicable.

Power Measurement

Power is measured over a 27-dB range with an expected accuracy of +0.5 dB. The signal envelope inside of 180 Hz wide filter is measured for 300 bps and 800 Hz wide filter for 1200 bps. Power measurement can be made specifically at the carrier, clock, and 8 PSK modulation.

Frequency Measurement

The demodulator resolution is 1 Hz. The proposed LO has a 0.01-PPM stability. Accuracy of the measurement related to the reference and LO stability.

Phase Noise Measurement

Phase is measured with an eight bit Analog to Digital Converter. Resolution is 0.7 degree. Processing of many samples further improves resolution. Phase noise is measured during carrier only. Processing is over 1 second using 1000 samples with an expected accuracy of ± 0.2 degrees.

Modulation Measurement

A random set of symbols is sent by the test transmitter that has at least 1000 symbols. The phase is measured for each symbol and folded to 90-degree bins. The spread around the 45-degree nodes indicates any phase error. Phase spread is sent via the serial port to the demodulator terminal.

Symbol Rate

After carrier is sent clock symbols are sent continuously. There are two points of measurement for symbol rate on the front panel of the demodulator - the symbol strobe pulses and the "I" phase detector output. Time between pulses should indicate 150 or 600 symbol per second rate.

Message Format

The test transmitter sends a defined message to the test receiver, That same message should be repeated at the demodulator. This message will be sent for the three cases of the interleaver selections.

Carrier Length - Time between the detection of power level and first phase transition after phaselock.

Clock and MLS bits

Phase "1" or "0" sent to the output port. The exact transmission pattern is displayed.

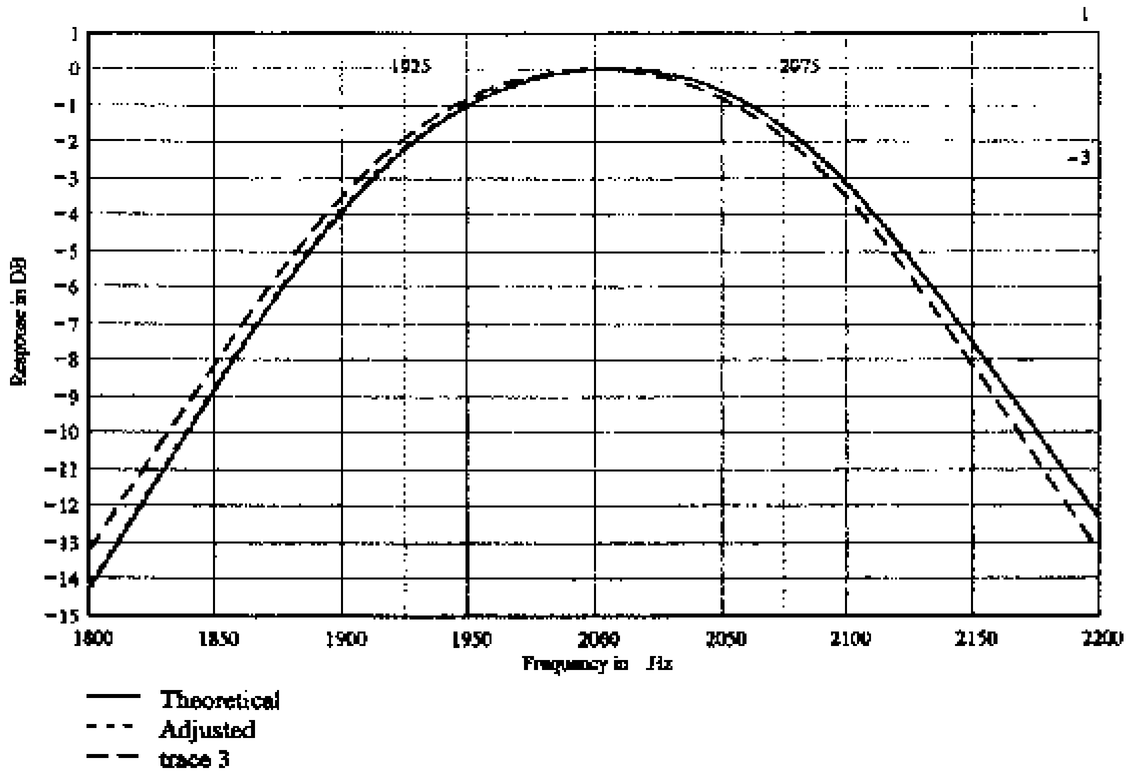
Scrambling and Trellis Encoding

If the correct encoding is followed the data sent to the output port will be intelligible. An incorrect pattern will provide a meaningless data string. A test mode is provided to print out the measured symbol phase in terms of phase bin. The phase bins are numbered 0 to 71. This is the raw data prior to any processing.

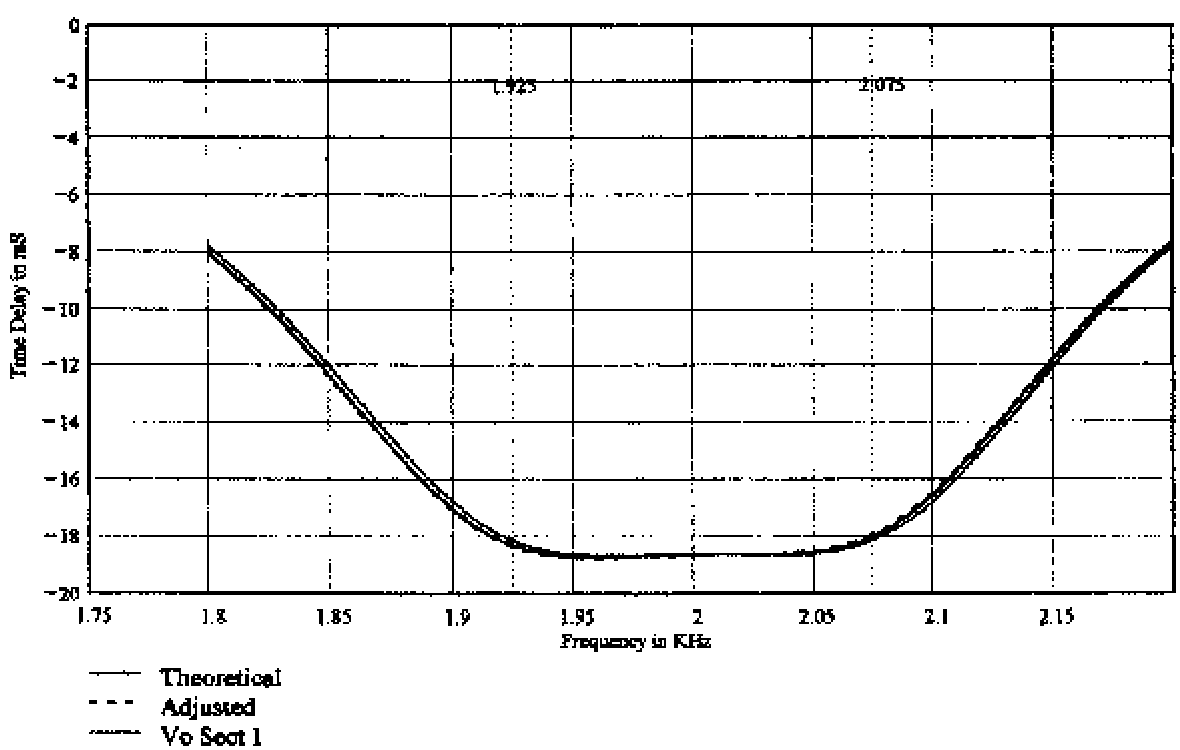
EOT Detection - This should be visible in the test mode and from the demodulator recognition mask.

Test Demodulator Front End Filter

Attached is a copy of the receiver front end filter response curves for the 300 bps case. The 1200 bps front end filter is the same but centered at 8000 Hz with a four times the bandwidth. The key characteristics is a 3 dB bandwidth of 180 Hz and phase linear at 150 Hz to within 3 per cent of band edge. The response is shown in the below Figures.



Full Response



Time Delay Response

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 ± 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

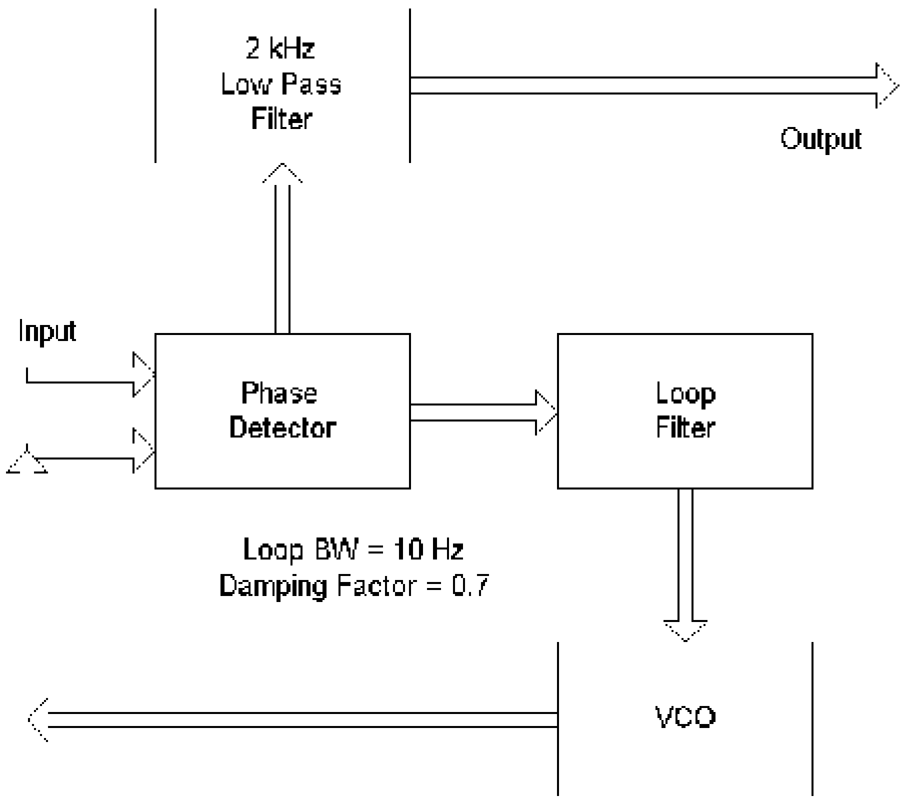
100/300 bps channels	Frequency MHz	1200 bps "A" Channels	Frequency MHz		100/300 bps channels	Frequency MHz	1200 bps "A" Channels	Frequency MHz
1	401.701000	1	401.701750		44	401.765500		
2	401.702500				45	401.767000	23	401.767750
3	401.704000	2	401.704750		46	401.768500		
4	401.705500				47	401.770000	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 "A" Channels	Frequency MHz		100/300 bps channels	Frequency MHz	1200 bps "A" Channels	Frequency MHz
87	401.830000	44	401.830750		132	401.897500		
88	401.831500				133	401.899000	67	401.899750
89	401.833000	45	401.833750		134	401.900500		
90	401.834500				135	401.902000	68	401.902750
91	401.836000	46	401.836750		136	401.903500		
92	401.837500				137	401.905000	69	401.905750
93	401.839000	47	401.839750		138	401.906500		
94	401.840500				139	401.908000	70	401.908750
95	401.842000	48	401.842750		140	401.909500		
96	401.843500				141	401.911000	71	401.911750
97	401.845000	49	401.845750		142	401.912500		
98	401.846500				143	401.914000	72	401.914750
99	401.848000	50	401.848750		144	401.915500		
100	401.849500		DCS Pilot		145	401.917000	73	401.917750
101	401.851000	51	401.851750		146	401.918500		
102	401.852500				147	401.920000	74	401.920750
103	401.854000	52	401.854750		148	401.921500		
104	401.855500				149	401.923000	75	401.923750
105	401.857000	53	401.857750		150	401.924500		
106	401.858500				151	401.926000	76	401.926750
107	401.860000	54	401.860750		152	401.927500		
108	401.861500				153	401.929000	77	401.929750
109	401.863000	55	401.863750		154	401.930500		
110	401.864500				155	401.932000	78	401.932750
111	401.866000	56	401.866750		156	401.933500		
112	401.867500				157	401.935000	79	401.935750
113	401.869000	57	401.869750		158	401.936500		
114	401.870500				159	401.938000	80	401.938750
115	401.872000	58	401.872750		160	401.939500		
116	401.873500				161	401.941000	81	401.941750
117	401.875000	59	401.875750		162	401.942500		
118	401.876500				163	401.944000	82	401.944750
119	401.878000	60	401.878750		164	401.945500		
120	401.879500				165	401.947000	83	401.947750
121	401.881000	61	401.881750		166	401.948500		
122	401.882500				167	401.950000	84	401.950750
123	401.884000	62	401.884750		168	401.951500		
124	401.885500				169	401.953000	85	401.953750
125	401.887000	63	401.887750		170	401.954500		
126	401.888500				171	401.956000	86	401.956750
127	401.890000	64	401.890750		172	401.957500		
128	401.891500				173	401.959000	87	401.959750
129	401.893000	65	401.893750		174	401.960500		
130	401.894500				175	401.962000	88	401.962750
131	401.896000	66	401.896750		176	401.963500		

100/300 bps channels	Frequency MHz	1200 bps "A" Channels	Frequency MHz		100/300 bps channels	Frequency MHz	1200 bps "A" Channels	Frequency MHz
177	401.965000	89	401.965750		222	402.032500		
178	401.966500				223	402.034000	112	402.034750
179	401.968000	90	401.968750		224	402.035500		
180	401.969500				225	402.037000	113	402.037750
181	401.971000	91	401.971750		226	402.038500		
182	401.972500				227	402.040000	114	402.040750
183	401.974000	92	401.974750		228	402.041500		
184	401.975500				229	402.043000	115	402.043750
185	401.977000	93	401.977750		230	402.044500		
186	401.978500				231	402.046000	116	402.046750
187	401.980000	94	401.980750		232	402.047500		
188	401.981500				233	402.049000	117	402.049750
189	401.983000	95	401.983750		234	402.050500		
190	401.984500				235	402.052000	118	402.052750
191	401.986000	96	401.986750		236	402.053500		
192	401.987500				237	402.055000	119	402.055750
193	401.989000	97	401.989750		238	402.056500		
194	401.990500				239	402.058000	120	402.058750
195	401.992000	98	401.992750		240	402.059500		
196	401.993500				241	402.061000	121	402.061750
197	401.995000	99	401.995750		242	402.062500		
198	401.996500				243	402.064000	122	402.064750
199	401.998000	100	401.998750		244	402.065500		
200	401.999500				245	402.067000	123	402.067750
201	402.001000	101	402.001750		246	402.068500		
202	402.002500				247	402.070000	124	402.070750
203	402.004000	102	402.004750		248	402.071500		
204	402.005500				249	402.073000	125	402.073750
205	402.007000	103	402.007750		250	402.074500		
206	402.008500				251	402.076000	126	402.076750
207	402.010000	104	402.010750		252	402.077500		
208	402.011500				253	402.079000	127	402.079750
209	402.013000	105	402.013750		254	402.080500		
210	402.014500				255	402.082000	128	402.082750
211	402.016000	106	402.016750		256	402.083500		
212	402.017500				257	402.085000	129	402.085750
213	402.019000	107	402.019750		258	402.086500		
214	402.020500				259	402.088000	130	402.088750
215	402.022000	108	402.022750		260	402.089500		
216	402.023500				261	402.091000	131	402.091750
217	402.025000	109	402.025750		262	402.092500		
218	402.026500				263	402.094000	132	402.094750
219	402.028000	110	402.028750		264	402.095500		
220	402.029500				265	402.097000	133	402.097750
221	402.031000	111	402.031750		266	402.098500		

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.



Carrier Phase Noise Test Phase Lock Loop

2.0 DCPRS Transmitted Power

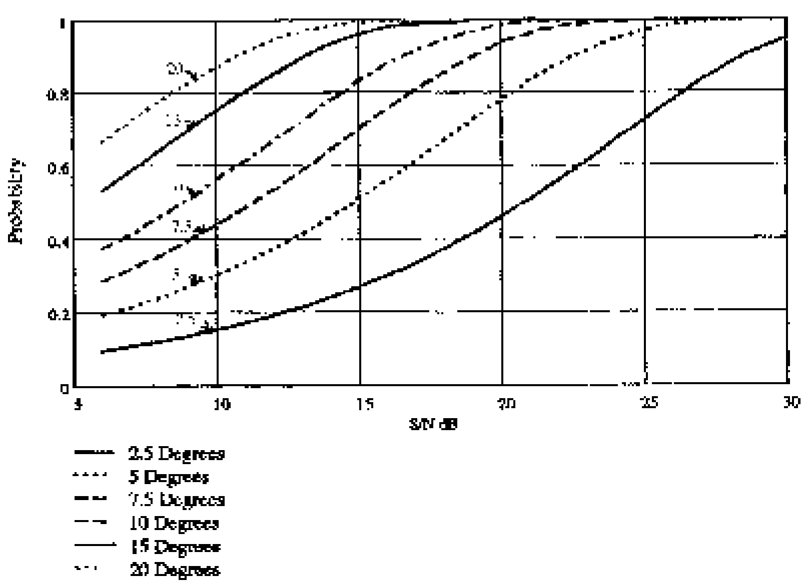
The power transmitted by a linearly modulated signal is the same for any position on the unity phase circle. However since this is a dynamic case the power is not constant for various types of modulation, since the rate of change of phase is determined by the filtering which is necessary to control the 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**



Phase Noise Probability vs S/N

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.

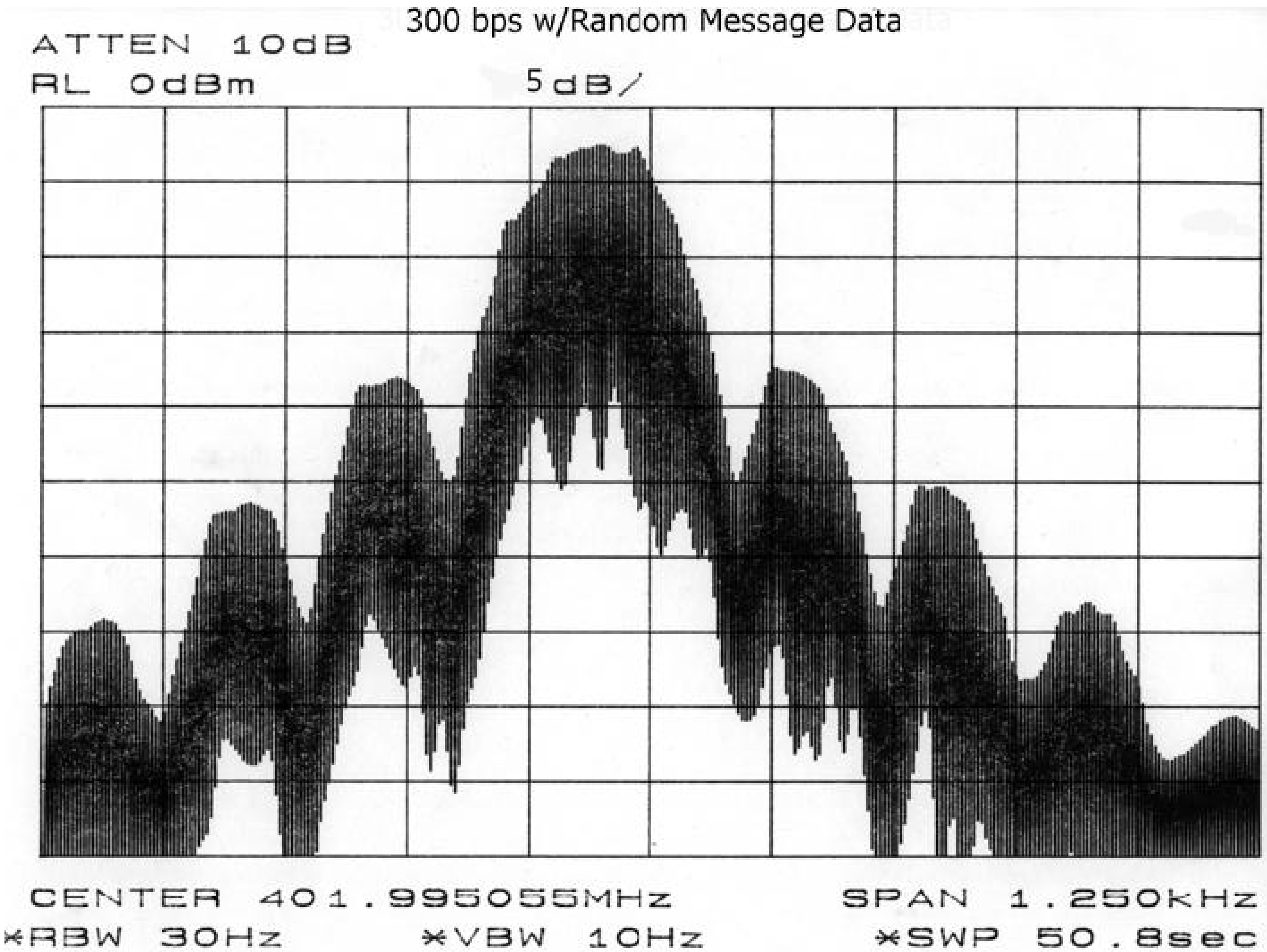
A sample output from the HDR Demodulator is provided below:

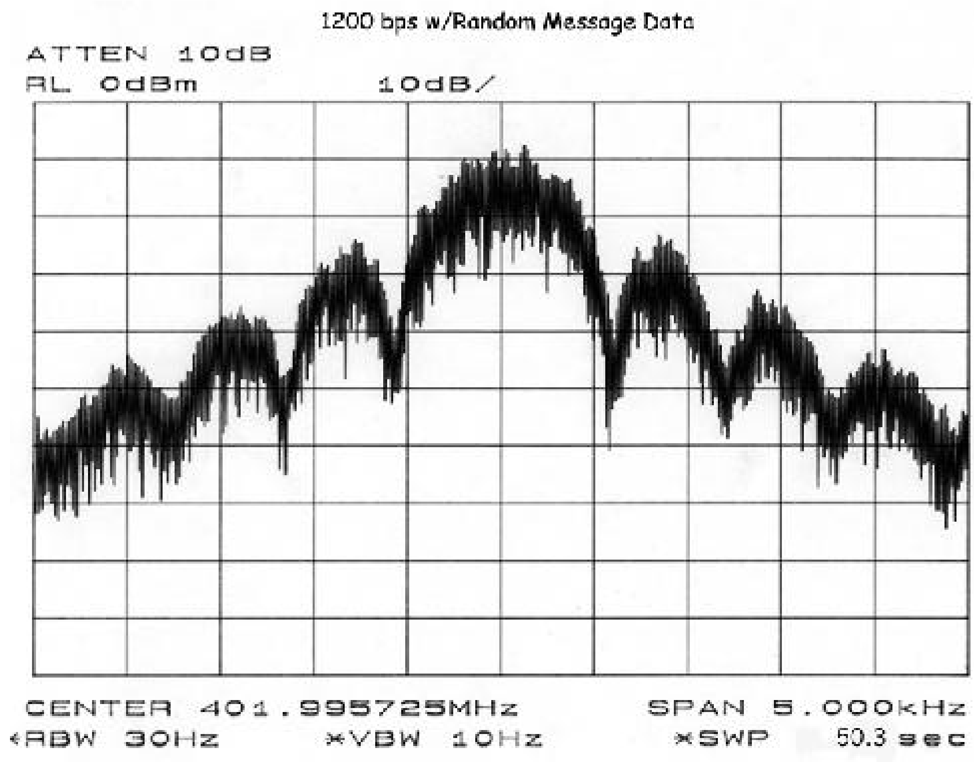
CS01000001011001110N15C94F4E *** THIS IS A TEST OF THE GOES DATA COLLECTION SYSTEM ***
P-ave: 50446 / 290 = 174 F: -38, -1
73 3 0 0 0 2 1 3 33 87 8 1 0 0 0 0 8 54

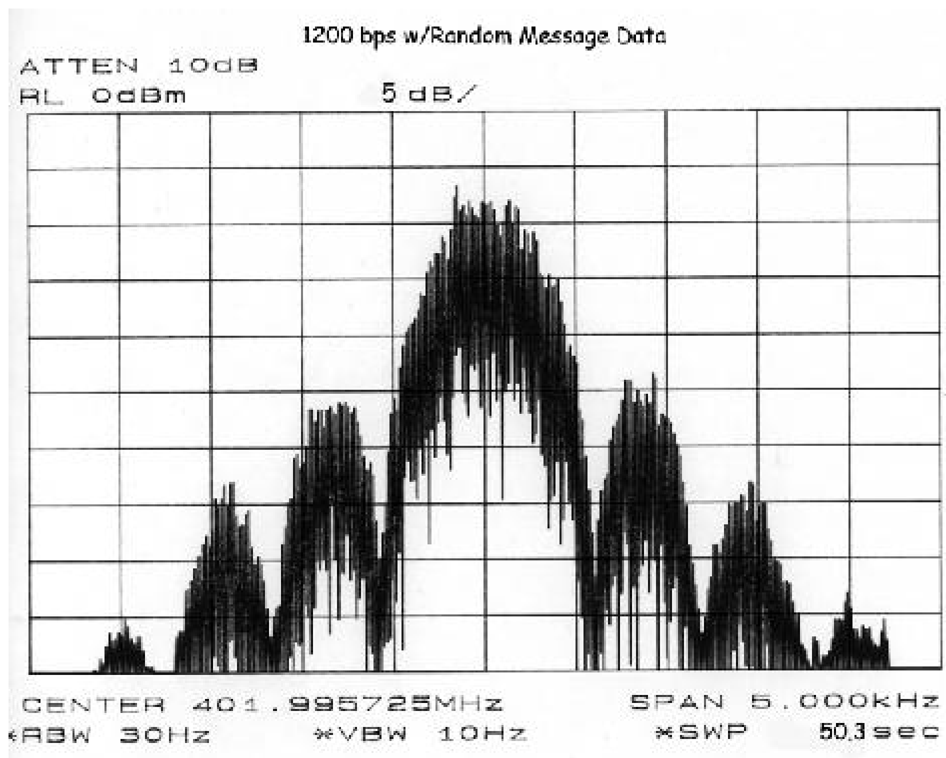
Branch Metrics, 360 Degrees
21 0 0 0 0 1 0 0 13 24 0 0 0 0 0 0 4 7
17 1 0 0 0 0 0 0 21 12 1 1 0 0 0 0 0 12
24 1 0 0 0 0 0 1 4 30 5 0 0 0 0 0 0 12
19 3 0 0 0 0 1 3 12 4 1 0 1 0 0 0 2 15

Good phases: 269 of 273 0.985
Parity Errors: 0
1693 / 38 = 44.6 => 0.4 => N
2nd Quadrant: 135.5, Err = 0.5
44-1NN

5.0 DCPRS Transmit Spectrum from HDR Improved Test Transmitter with Random Data:


300 bps w/Random Message Data
ATTEN 10dB
RL 0dBm
5dB/
CENTER 401.995055MHz
SPAN 1.250kHz
*RBW 30Hz
*VBW 10Hz
*SWP 50.8sec


1200 bps w/Random Message Data
ATTEN 10dB
RL 0dBm
10dB/
CENTER 401.995725MHz
SPAN 5.000kHz
RBW 30Hz
*VBW 10Hz
*SWP 50.3 sec


1200 bps w/Random Message Data
ATTEN 10dB
RL 0dBm
5 dB/
CENTER 401.995725MHz
SPAN 5.000kHz
RBW 30Hz
*VBW 10Hz
*SWP 50.3 sec