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Section 2.0 – Overview of Digital vs. Analog ENG Operation

ENG Analog Operation in a 12 MHz Channel Plan

Broadcasters have become accustom to the methods by which they successfully operate analog 2 GHz ENG systems in the current 1990 – 2110 MHz (17 MHz channel bandwidth) BAS ENG band. This legacy band plan consists of seven discrete channels that provide known levels of adjacent channel isolation from interfering signals. In addition, this band plan supports full NTSC video deviation of +/- 4 MHz and audio subcarrier frequencies as high as 8.3 MHz @ 75 KHz deviation.

A typical 2 GHz ENG operation consists of one video and two audio subcarriers, although the band plan channel bandwidth will accommodate up to four audio subcarriers. The amount of channel bandwidth also permits the use of "split channel" operation where two adjacent channel users can produce even greater isolation from one another by off setting their respective channel operating frequencies to the "low" side (- or A) or "high" side (+ or B) of their respective ENG channels by 4.25 MHz.

Employing certain techniques such as receiver narrow IF bandwidth filtering, antenna cross polarization discrimination, and RF power output control can also enhance adjacent channel isolation.

The new 2025 - 2110 MHz BAS reduced band plan supports seven contiguous 12 MHz wide channels. This reduction of channel bandwidth brings with it certain performance degradation in an analog operating environment. There are also several operational drawbacks when reducing the channel bandwidth from 17 MHz to 12 MHz. The following is a list of the performance and operational considerations.

1) Video deviation must be reduced from 4 MHz to 3 MHz. This reduction in deviation decreases the overall video S/N of the microwave link by 2.5 dB and also impacts the available link margin.

2) The highest audio subcarrier frequency that can be used in a 12 MHz channel is 5.8 MHz. This will permit a maximum of two audio subcarriers that can be operated simultaneously.

3) Should two audio subcarriers be required they will need to be configured closer in frequency to video modulation. A likely pairing for two audios is 4.83 MHz and 5.8 MHz. The following suggested pair (4.83 MHz & 5.2 MHz) should be considered for use in highly congested ENG environments.

4) The amount of adjacent channel interference isolation will be reduced by approximately
21 dB. Further, the use of split-channel (channel offset) operation will no longer be possible.

5) In-band (2 GHz) ENG repeater (relay) systems will require greater channel separation or
additional channel filter isolation.

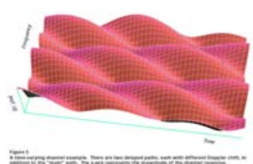
ENG Digital Operation in a 12 MHz Channel Plan

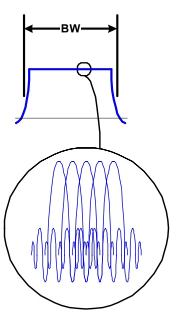
Digital modulation systems for ENG purposes provide a significant amount of operational benefit that legacy analog systems cannot support. There are also some operational differences between analog and digital systems that the ENG operator will need to become accustomed to.

One of the first considerations is that analog video and audio content will need to be encoded into a digital transport stream, typically as an ASI (asynchronous serial interface) format. MPEG-2 encoding algorithms have become the defacto standard for this purpose, either in a 4:2:0 chroma encoding profile or 4:2:2 profile.

The next step is to modulate the digitally encoded ASI transport stream. There are a number of digital modulation systems available for DENG (Digital Electronic News Gathering). It is not the intent of this paper to weigh the pros and cons for each of these systems, but rather focus on the characteristics of one of the most widely used and accepted formats, which is COFDM (coded orthogonal frequency division multiplex).

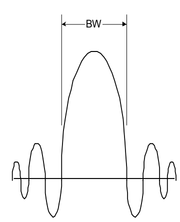
What is CODFM ?





CODFM is a multi-carrier RF digital modulation format where the digitally encoded "payload" is equally divided among it's carriers.

The benefit of this scheme over that of single carrier systems is that it is more reliable and robust. Each carrier is independently modulated, has user defined FEC (forward error correction) and GI (guard interval) applied to it, dependant upon operating path conditions.



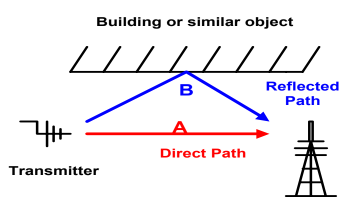
The amount of FEC and GI employed will either increase or decrease the robustness (aka reliability) of the digital ENG signal. The reflective path environment or topography will determine the best FEC and GI combinations to maximize reliability while maintaining data throughput needs. The more FEC and GI used, the lower the data payload will be. Table T-1 identifies the different data throughputs that can be realized based upon FEC and GI combinations.

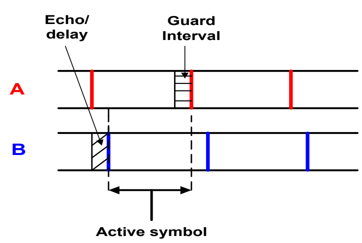
	1 /4 Guard			1/8 Guard			1/16 Guard			1/32 Guard		
Code Rate	QPSK	16 QAM	64 QAM	QPSK	16 QAM	64 QAM	QPSK	16 QAM	64 QAM	QPSK	16 QAM	64 QAM
1/2	4.98	9.95	14.93	5.53	11.06	16.59	5.85	11.71	17.56	6.03	12.06	18.10
2/3	6.64	13.27	19.91	7.37	14.75	22.12	7.81	15.61	23.42	8.04	16.09	24.13
3/4	7.46	14.93	22.39	8.29	16.59	24.88	8.78	17.56	26.35	9.05	18.10	27.14
5/6	8.29	16.59	24.88	9.22	18.43	27.65	9.76	19.52	29.27	10.05	20.11	30.16
7/8	8.71	17.42	26.13	9.68	19.35	29.03	10.25	20.49	30.74	10.56	21.11	31.67

Table T-1

All of the operating considerations that apply to create a successful analog ENG "shot" also apply to that for a digital (COFDM) ENG system. There are several additional benefits that digital systems provide beyond that of conventional analog ENG systems. They are:

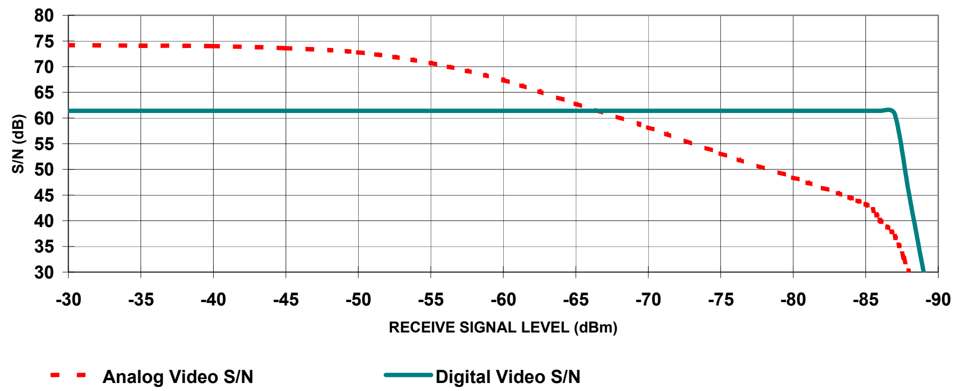
1) **Non-line of sight reception** – Due to the coding technology and multi- RF carrier format employed, COFDM systems are able to use and reconstruct the reflected energy of an ENG transmission that would otherwise mitigate a successful analog ENG shot.





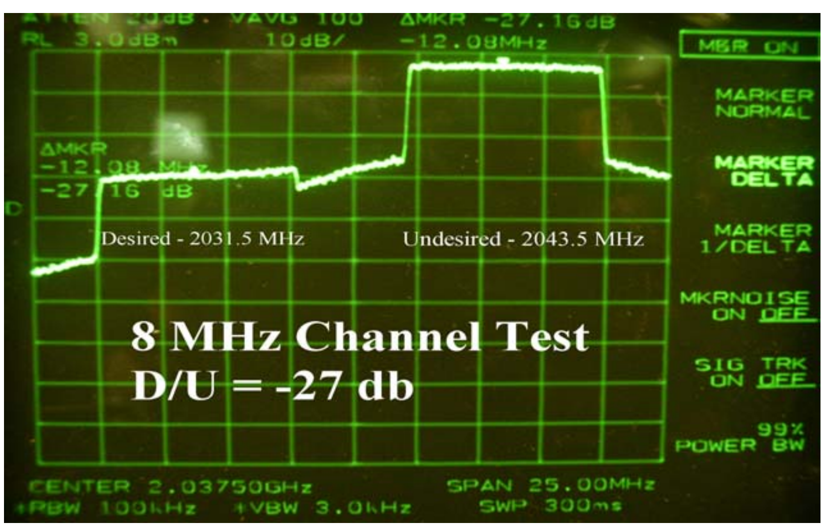
2) **Moving ENG transmission** – Digital COFDM technology will permit the user to transmit video, audio and data while in motion with negligible signal break-up due to multi-path. This can be either from a high-speed airborne platform, and ENG truck, or a cameraman on foot. An example of this performance enhancement is pictured below.

3) **Consistent Video/Audio Quality** – In analog systems, as receive signal levels diminish so does video and audio performance. This is not the case with digital COFDM systems. Video and audio quality are consistently maintained until the digital system looses "lock", at which point the signal completely disappears. The following graph represents the relative video S/N (signal to noise) performance of both an analog and digital system.



4) **Co-Channel Operation** – Digital COFDM systems will permit frequency reuse at the same receive site. Approximately 10 – 20 dB of co-channel rejection is required to provide interference free operation, all dependent on the combination of FEC and Guard Interval selected (Table T-1) and prevailing microwave path conditions. This 10 – 20 dB of isolation can be achieved in several different ways, but the easiest is by employing antenna cross polarization. Most central ENG receive sites have antenna systems that are capable of remotely selectable polarization (i.e. H, V, CW, CCW). Many existing ENG Van transmit antennas are also capable of dual polarization operation (i.e. CW/CCW, or H/V). An ENG operating system that includes matching dual polarization capability at both receive and transmit sites will be able to take advantage of this frequency re-use capability. Legacy analog systems, on the other hand, require approximately 50 dB of co-channel rejection. This has never been practical to achieve.

5) **Improved Adjacent Channel Interference Operation** – Adjacent channel operation in the analog domain typically requires approximately 0 to + 5 dB of desired to undesired (D/U) signal separation to achieve interference free reception. Digital COFDM systems reduce this level of separation to approximately – 27 dB as illustrated on the waveform plot below.



6) **FCC Digital Emission Bandwidth Requirements** – FCC Part 74.637 (a) (2) currently governs the emission bandwidth requirements for Broadcast Auxiliary Service (BAS) operations using digital modulation transmissions. The chart below illustrates the FCC spectral mask requirements for a 12 MHz channel bandwidth.

The use of digital COFDM modulation employing the DVB-T 8 MHz pedestal format will comply with FCC spectral mask requirements for digital modulation operation.

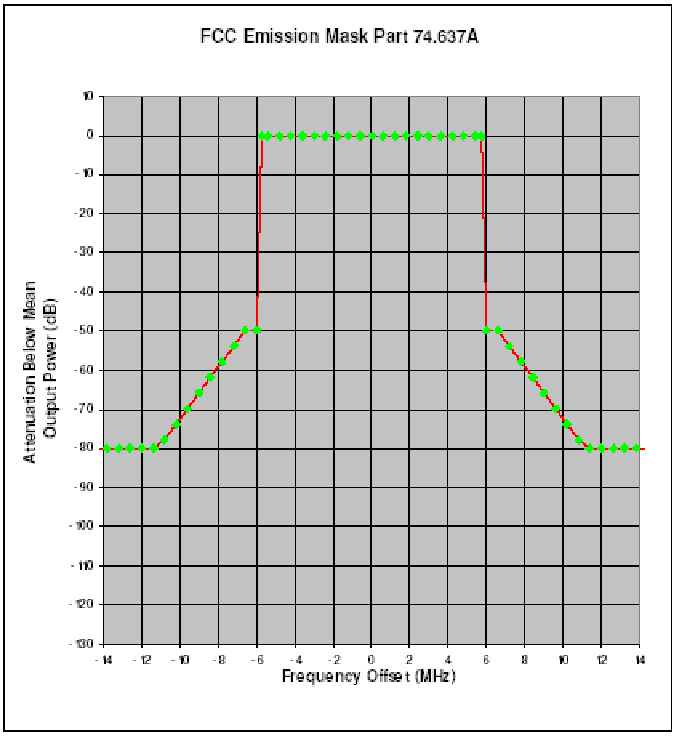


Figure 1 – Spectral Mask Points

7) **Split-Channel Digital Operation in a 12 MHz Channel Bandwidth** – DVB-T COFDM compliant digital equipment will support both 8 MHz, 7 MHz, and 6 MHz pedestal bandwidth formats. Reducing the COFDM pedestal bandwidth from 8 MHz to 6 MHz potentially allows for two discrete RF signals occupying a single 12 MHz channel.

One of the major trade-offs in reducing from an 8 MHz to a 6 MHz bandwidth is that the amount of data throughput is reduced by approximately 25%. This translates into either lower video quality signal transmissions, or less robust transmission as digital modulation rates are increased to compensate for consistent data through-put (i.e. from QPSK to 16 QAM).

Another factor regarding "split-channel" operations is that of the FCC emission mask compliancy requirements. The RF output power for 6 MHz bandwidth split-channel operation will need to be reduced by an additional 3 dB from RF levels typically used for 8 MHz bandwidth operations. This requirement further degrades the reliability of the digital transmission, and in practice may not be possible, dependant on data throughput requirements.

8) **Digital COFDM Operating Considerations** – There are several operating aspects relating to digital ENG operations that need to be considered.

a) *Encoding delay* – Digital transmissions will typically experience signal delays somewhere between 60 and 450 msec. The major factor that affects encoding delay is the selection of the chroma profile 4:2:0 versus 4:2:2 video processing and the data rate required. The use of higher bit rates leads to an overall lower processing delay when used with the 4:2:0 chroma profile. Encoding delay performance will vary between encoder manufactures.

b) *RF receive signal overload* – Very strong digital RF receive carrier levels (RCL) will cause COFDM IRDs to break "lock". The operator will have a difficult time distinguishing this situation as there will be no signal present to ascertain this condition.

c) *Bit error rate degradation due to low RCLs* – As previously discussed, digital COFDM receive signal levels produce consistent video and audio performance as receive carrier levels (RCL) degrade. There is virtually no warning as to when the digital IRD breaks "lock" and the signal disappears (known as the "cliff effect"). A few ENG equipment manufacturers are addressing this issue through product enhancements or external monitoring devices.

d) *IRD signal acquisition time* – Signal acquisition time is the amount of time it takes for a COFDM IRD to "lock up" on a digital transmission. If the acquisition time is too great it becomes difficult to "pan" in a digital ENG transmission. The digital ENG user should seek out COFDM IRD equipment that provides for the lowest amount of signal acquisition time.

9) **High Definition (HD) Digital COFDM ENG Transmission** - Compression technology for high definition video encoding has improved significantly over the past few years. MPEG-2 encoding is still the industry's defacto standard, and as such will be the basis for this discussion.

Digital HDTV ENG transmissions using DVB-T compliant COFDM systems are possible at data rates as low as 18 – 19 Mbps, depending on the transmission operation (stationary or mobile). 16 QAM is the lowest modulation rate that will support this level of data throughput. There are a number of FEC and Guard Interval combinations that will successfully transport this level of data rate. Actual field tests have shown that FECs of 5/6 & 7/8 and guard intervals (GIs) of 1/8th produce the most reliable HDTV transmissions.

It should be noted that HDTV COFDM transmissions are less reliable than SDTV (standard definition) transmissions due to the higher order modulation architectures needed, increased FEC and lower GI required to support the higher HD data rates. In addition, HDTV MPEG-2 encoders and IRDs (integrated receiver decoders) are presently much more expensive and bulkier than their SDTV counterparts.