Expanding ENG Central Receive Sites to include COFDM

Using new technology to keep the cost down

The application of COFDM to ENG is becoming much more the Modulation of choice. Several reasons driving the switch to COFDM include:

1 – Superior reception from sites not accessible using analog modulation methods.

2 - Superior reception from moving vehicles such as helicopters and moving ENG vans.

3 – Reduced bandwidth requirements for a high quality picture; 6, 7 or 8 MHz.

4 – Price of COFDM systems is now at more affordable levels and still coming down.

The first steps in the installation of a COFDM system are two-fold. The Digital Ready Transmitter and COFDM Modulator must be installed in the ENG van or helicopter. At the same time, the Central Receiver Site must be replaced or up-graded to receive the digital transmission. If the system is operated at 7 GHz, then a Digital Block Converter must also be installed or replaced. Also attention must be given as to how the resultant signal is to be returned from the Central Receive site to the Studio.

The purpose of this paper is to examine four different alternatives for returning the COFDM digital signal from the Central Receive site back to the Studio. In the fourth alternative, a new low cost product is introduced that can reduce the cost of the digital conversion. This product is the Analog Coder. The Analog Coder converts an Analog link into a digital link.

Returning the Digital Signal from the Central Receiver to the Studio:

The second step, in the switch to digital operation, is the return of the received Digital Video/Audio signal from the Central Receive site back to the studio. Four System options or choices on how to accomplish this are discussed below.

There are advantages and disadvantages with each of the four system configurations depending on the overall objectives, including cost and the quality and reliability of the returned signal to the studio. The following paragraphs will detail each method in detail and discuss the advantages and disadvantages. A new product development known as the Analog Coder will be introduced as System 4. This new product technology helps to minimize the conversion cost while providing an all-digital solution for getting the digital COFDM signal back to the studio.

For the discussion to follow it is assumed that all systems have the same RF front-end receiver configurations. That is, the received RF signal is down-converted to 70 MHz by the Newscoder CR Central Receiver. The Newscoder CR is a 2 GHz Digital/Analog Central Receiver. If the received RF signal is at 7 GHz, it is first down-converted to 2 GHz by a Digital Ready Block Down Converter, then inputted to the Central Receiver. After the RF signal is received by the Central Receiver Newscaster CR, two outputs are available (assuming that an analog Demodulator is installed in the Central Receiver). One output is for receiving analog signals and outputting the demodulated analog video and audio. The other output is the 70 MHz IF signal. The IF carries both the analog and the digital signal.

System 1, as shown in Figure 1, is the most popular as well as the most cost-effective configuration. For COFDM reception, the 70 MHz is inputted to the Newscoder RX1 COFDM Receiver/Decoder. The COFDM signal is demodulated, error corrected and the MPEG2 is decoded. The output is analog composite video, SDI digital video, analog audio or digital audio. The resultant composite video and audio are relayed back to the studio over an existing analog link. For combined analog and digital operations, the CR Central Receiver typically contains an analog demodulator. When analog operation is required, the analog output from the CR is easily switched to the analog microwave.

The disadvantage of this system is that the digital quality of the video and audio may be degraded by the analog link. In most case's this is not a disadvantage as the resultant video signal quality at the studio is no worse than the fully analog system would have yielded. If the studio is all-digital, then the SDI output from the COFDM receiver is not available at the studio. If multiple receive sites exist, then multiple 70 MHz COFDM demodulator/decoders are required. This would increase the overall system cost.

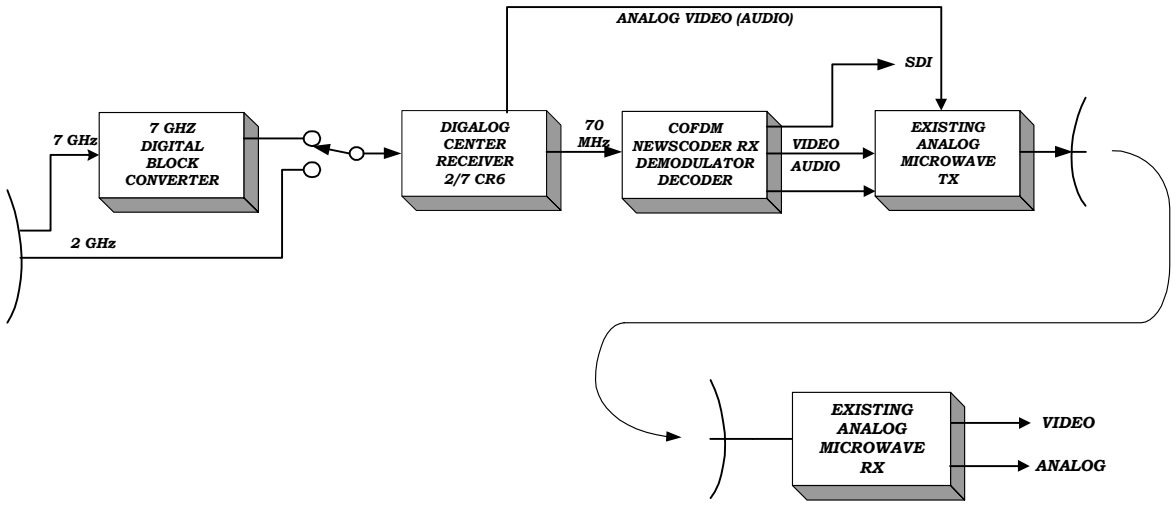

Figure 1
BLOCK DIAGRAM of a COFDM RECEIVER SYSTEM using an ANALOG MICROWAVE RETURN LINK

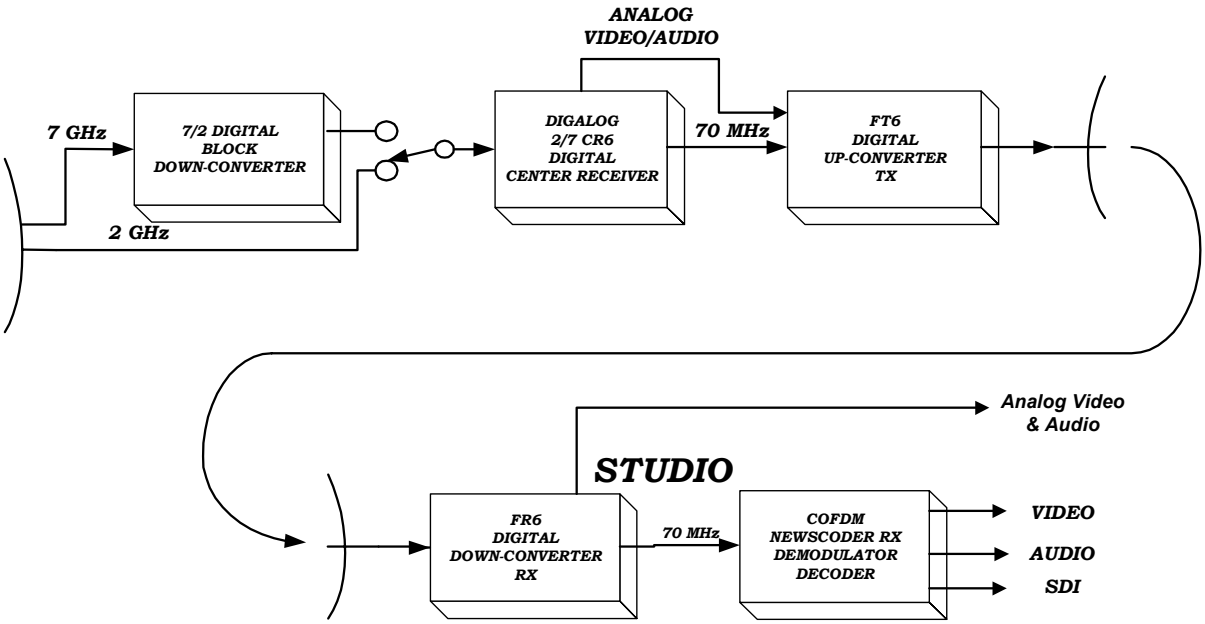

Figure 2
BLOCK DIAGRAM OF COFDM RECEIVER SYSTEM WITH 70 MHz IF REPEAT RETURN LINK

System 2, as shown in Figure 2, preserves the digital quality of the video and audio signals as well as makes available a SDI output at the studio. Here the 70 MHz output from the Digital Newscoder Central Receiver CR is inputted to the 70 MHz input of a digital transmitter such as the Nucomm FT6 Digalog digital ready transmitter and outputted through the Nucomm FR6 digital ready receiver. The digital transmitter and receiver must be designed to have very low phase-noise, low microphonics as well as good linearity in order to transport the 70 MHz COFDM signal. In most cases this would require a new digital microwave system to replace the existing analog link. At the studio the digital microwave receiver outputs the signal to 70 MHz which in turn feeds the Nucomm Newscoder RX1 70 MHz COFDM receiver demodulator/decoder. The Newscoder RX1 provides a high quality analog Video/Audio output as well as a digital SDI signal for those all-digital studios.

Additionally, this system provides for an all-analog backup operation in two ways. First, the 70 MHz output from the Central Receiver carriers both analog and digital modulation that will pass through the system with equal performance. Adding a 70MHz analog demodulator to the microwave links studio receiver, FR6, provides the analog video/audio output. The second option uses the analog output from the CR6 Central Receiver, which comes standard with a built in analog demodulator. By adding a 70 MHz analog modulator to the FT6 transmitter as well as a 70 MHz demodulator to the FR6 receiver, the system will be capable of passing both analog and digital signals.

The advantage of this system is that the COFDM demodulator/decoder outputs the composite video and audio signal as well as a SDI digital signal at the studio. In this configuration, only a single 70 MHz COFDM demodulator/decoder is required at the studio. The digital quality of the signal is maintained back to the studio. In an all-digital plant, the SDI output enables continued digital processing. If multiple Central Receive sites exist, then multiple COFDM demodulator/decoders are not required. The result is lower overall cost since only a single unit is required. By the addition of analog modulator/demodulator to the microwave link at a minimum additional cost, a full analog backup is provided.

The disadvantage of this system arises from the fact that most ENG receive sites have only analog links back to the studio, an increase cost at each site would result from the replacement of the analog link with a digital link. A further disadvantage of this system is that, in digital operation, errors encountered in the central receive process due to low signal levels and low signal to noise ratios as well as other interference can be further corrupted through the microwave link. This later corruption will depend on the quality of the microwave link. Since the 70 MHz to 70 MHz IF repeater link only transports the RF signal, no error correction is performed at either the Central Receiver or through the microwave link until the digital COFDM signal is received at the studio. If the microwave link encounters fades or adjacent channel interference additional errors would be produced. In most cases the relay of the COFDM signal over a microwave link will produce a minimum of additional errors and the COFDM receiver would correct all of the errors and produce a perfect picture. The point is that to relay the 70 MHz output from the Central Receiver by an IF repeater can degrade the COFDM under certain condition and this is not the ideal way to get the signal back to the studio. System-3 presents a better method for moving the digital signal from the ENG receive site back to the studio.

System 3. Using Nucomm's V-Stream Digital Link Provides full Digital Capability and error correction plus analog backup. This system is shown in Figure 3. In this configuration the Central Receivers 70 MHz output feeds a 70 MHz COFDM Newscoder Demodulator. A block Diagram of the Newscoder Demodulator is shown in Figure 4. Unlike the Newscoder Receiver Demodulator/Decoder, the Newscoder Demodulator outputs the MPEG2 transport stream only as DVB-ASI. No output MPEG2 decoding to Video/Audio occurs. The 70 MHz COFDM Demodulator is, in effect, half of a COFDM Receiver Demodulator/Decoder. The first part is the 70 MHz demodulator section that receives the 70 MHz output from the Central Receiver and demodulates the signal as well as corrects any errors that may have occurred in the receiving process. The demodulators output is a MPEG-2, DVB-ASI, transport stream. The DVB-ASI error corrected digital signal is inputted to the V-Stream digital microwave link. The V-Stream digital modulator adds new FEC to the DVB-ASI input.

At this point in the system, the received COFDM signal has been demodulated and all errors corrected unlike that in System 1 or 2 above.

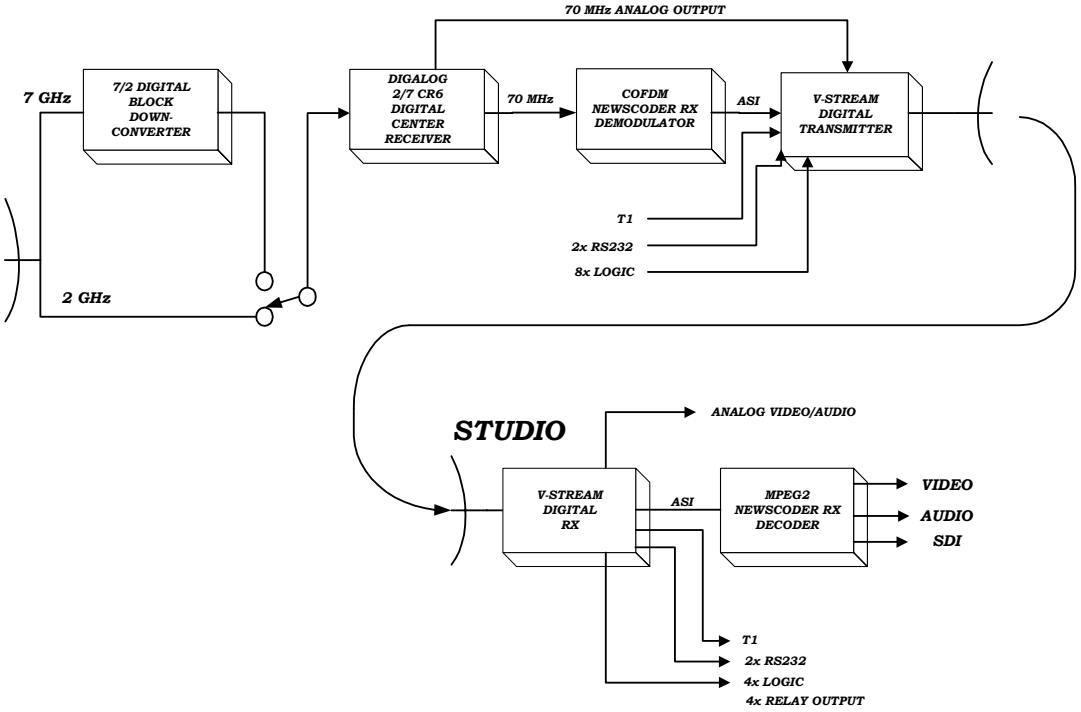

Figure 3
Block Diagram of COFDM Using the V-Stream Microwave Link

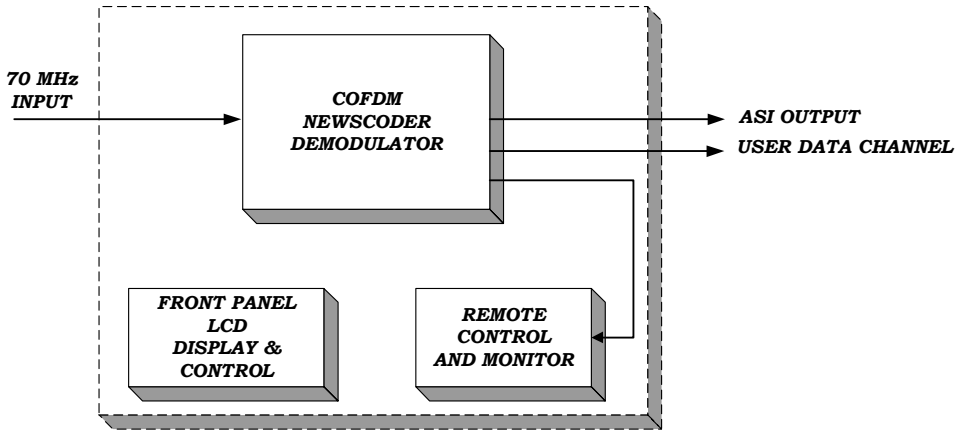

Figure 4
Newscoder COFDM Demodulator

Let us look at the studio receiver end. The V-Stream receiver now corrects any errors introduced by the microwave link and outputs the DVB-ASI digital signal to the Newscoder MPEG2 Decoder that converts the MPEG-2 transport stream to composite analog video, SDI digital video, analog audio or digital audio.

A block diagram of the Newscoder MPEG2 Decoder is shown in Figure 5.

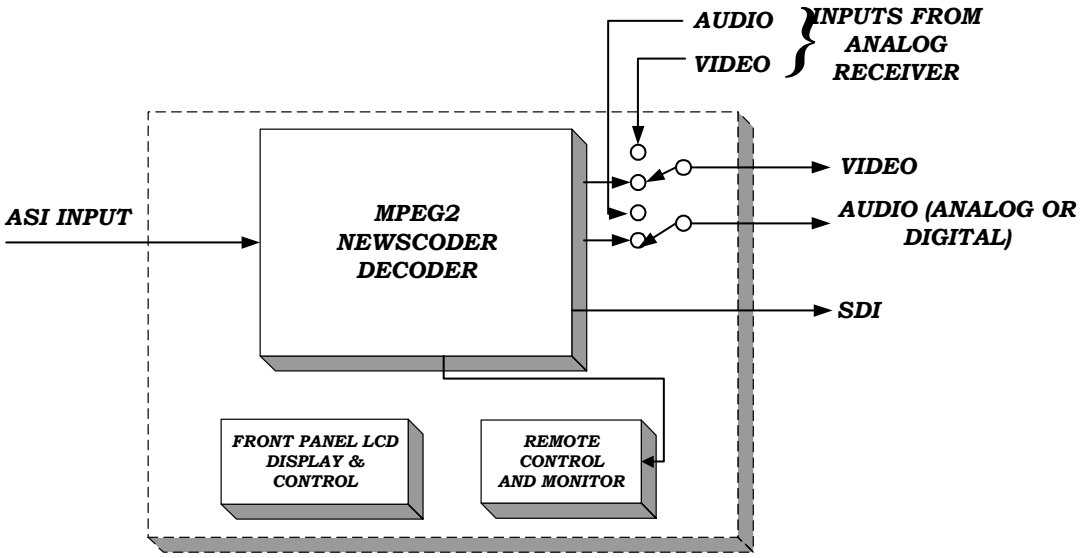

Figure 5
Newscoder MPEG2 Decoder

The V-Stream digital microwave transmitter link accepts DVB-ASI as digital inputs and adds forward error correction. At the receive end of the V-Stream link the receiver demodulates the digital signal and error corrects any errors that were introduced in the link. In addition the V-Stream receiver has a powerful adaptive equalizer that adjusts for path variations as well as imperfections in the antenna and transmission lines. The V-Stream outputs the DVB-ASI. The ASI output is inputted to the Newscoder MPEG-2 Decoder that outputs analog composite video, analog audio and SDI.

The V-Stream digital link also includes a T1 Data channel, two RS-232 ports and 8 logic channels for command and control that includes 4 Form C relay closures. An additional feature of the V-Stream is that the RF microwave signal occupies only 6.5 MHz of bandwidth. Multiple carriers can be placed side by side. In order to better utilize the channel spectrum.

Introduction of the "Analog Coder™". (Reduces Overall Cost and Provides Full Digital Capability plus Analog Backup.)

When a Central Receive site is upgraded to include COFDM, an Analog microwave link already exists. In System 1 the analog link was used to return the video and audio to the studio. In System 2 and 3 the Analog link had to be replaced with a digital link. The addition of a digital link significantly increases the up-grade cost.

Nucomm has developed a digital modulator and demodulator that enables digital signals such as DVB-ASI SMPTE-310 to be passed through an Analog microwave link with no loss of performance. This new modulator/demodulator system is referred to as an "Analog Coder". Figure 6 shows how the "Analog Coder" is incorporated into the System 1 configuration. With the addition of the "Analog Coder" to the System 1 configuration, the existing analog link can be used to return both analog and digital signals.

A block diagram of the Analog Coder Modulator is shown in Figure 7. The Analog Coder Modulator simultaneously receives the following input signals

1 – DVB-ASI	3 – Two RS-232
2 – T1	4 – Eight Logic inputs

The modulator multiplexes these four inputs into a single transport stream. Using the ATSC standard, forward-error-correction (FEC) is added to the transport stream. The forward-error-correction consists of Reed Solomon and Trelis coding as well as interleaving, the same as that used for 8VSB transmission. The resultant transport stream is converted to an eight level, one volt peak-peak analog base-band signal.

This signal is inputted to the base-band input of the analog microwave transmitter. The analog receiver outputs this same eight level, one volt peak-peak, base-band analog signal, which in turn is inputted to the Analog Coder Demodulator. A block diagram of the Analog Coder Demodulator is shown in Figure 8. The 8VSB demodulated transport stream is error corrected and de-multiplexed to produce the original input signals. The Analog Coder demultiplexer simultaneously outputs the following signals.

1 – One DVB-ASI
2 – Two RS-232
4 – Four Logic Outputs
5 – Four Form C Relay Closures

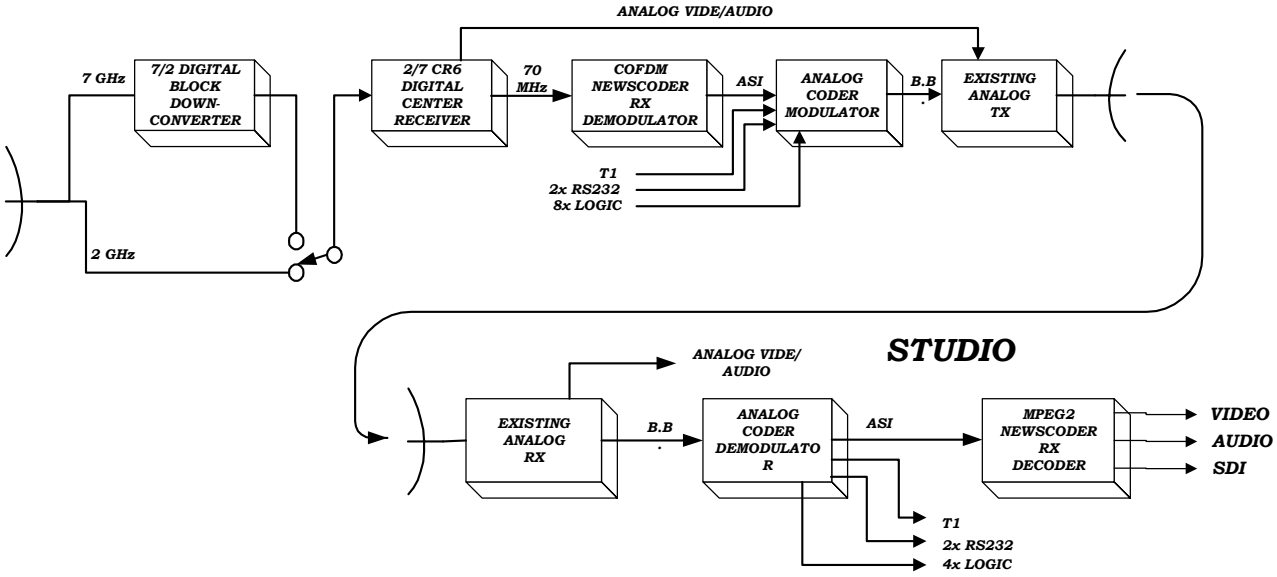

Figure 6
Block diagram of a COFDM Receive System using the Analog Coder and the Analog Microwave Return Link

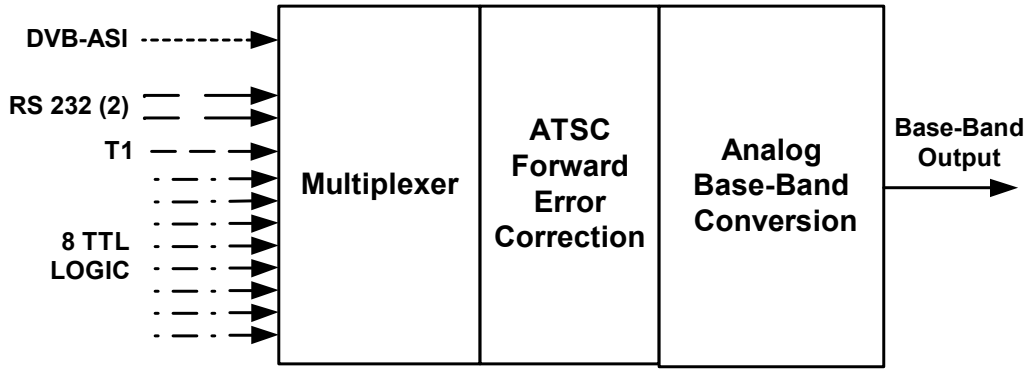

Figure 7
Analog Coder Modulator

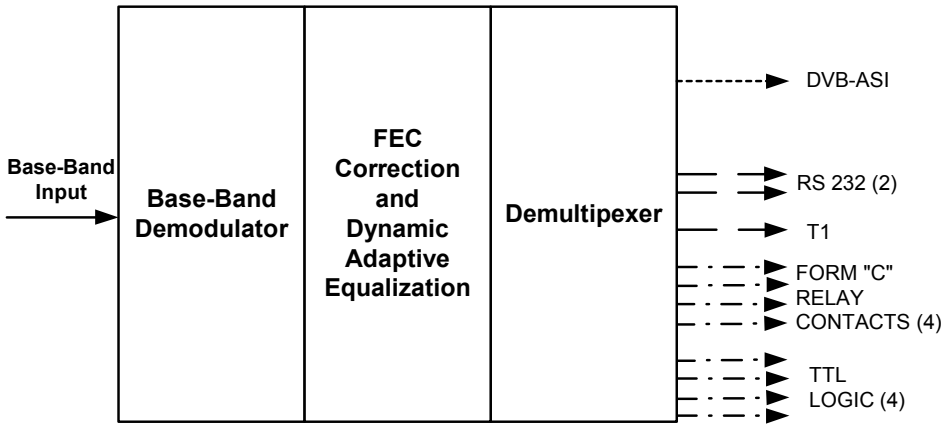

Figure 8
Analog Coder Demodulator

Figure 6 shows how the "Analog Coder" can be used to bring the COFDM digital signal back to the studio using the existing analog microwave link. In this configuration the Newscoder Demodulator/Decoder of Figure 1 has been replaced with the Newscoder COFDM Demodulator of Figure 4. The Central Receivers 70 MHz output feeds the Newscoder COFDM Demodulator of Figure 4. The demodulator error corrects the received signal and outputs the MPEG2 transport stream as an DVB-ASI signal. No decoding to Video/Audio occurs. The 70 MHz Newscoder COFDM Demodulator is, in effect, half of a Newscoder COFDM Demodulator/Decoder.

At this point in the system, the received COFDM signal has been demodulated and all errors corrected unlike that in System 1. The DVB-ASI signal from the Newscoder Demodulator is inputtted to the "Analog Coder" Modulator. The "Analog Coder" ™ Modulator, as shown in Figure 7, is housed in a 1 RU chassis. It accepts the DVB-ASI plus a T1 Data Pack and outputs a 1 V p-p Baseband Analog signal that can be inputted to the Baseband input of any Analog Microwave link. The only adjustment required to the analog transmitter is that the audio sub-carriers either be turned off or shifted to a frequency above 7.4 MHz. The emphasis on both ends of the link should be set to flat, however only slight degradation will occur if left on. The "Analog Coders" digital modulator adds powerful Trellis and Reed Solomon forward error correction (FEC). The "Analog Coder" modulator is an ideal addition to FM transmitters that use Direct FM modulation.

Figure 6 shown how the Studio site is modified to include the "Analog Coder" Demodulator and the existing Analog receiver. The "Analog Coder" Demodulator, as shown in figure 8, is housed in a 1 RU chassis that accepts the Baseband output from an Analog Microwave Receiver. The "Analog Coder" Demodulator outputs simultaneously the DVB ASI and the T1 Data Pack signals. Using the latest in digital 8VSB receiver chip technology, the received digital baseband signal is processed using a fast and powerful adaptive equalizer and forward error correction technology to extend the threshold level of the system. By using the adaptive equalizer, standard waveguide and antennas can be used with no degradation in performance.

One of the major advantages of the "Analog Coder" ™ over a Digital link is that the power amplifier in the transmitter can be operated at full, saturated output. An equivalent digital link would have to back the output power down by 4 to 6 dB. With this advantage an analog link using the "Analog Coder" ™ will have equivalent system gain and performance to that of a digital link. Additionally the "Analog Coder" ™ signal will pass through multiple-hope repeaters without demodulating and re-modulating at each repeater. Test conducted by KAKE-TV passed digital ATSC signals (19.39 Mbps) plus a T1 through 24 hops of an analog link using the Analog Coder with excellent results. These test included the insertion of several audio sub-carriers above 7.4 MHz. See Report on field tests using the Nucomm Analog Coder Modulator/Demodulator ATSC Transport System with Nurad 70-Series Analog Microwave equipment written by Larry Means of KAKE-TV. As well as a paper entitled The "Analog Coder" HDTV Digital Transmission Over an Analog Microwave Link describing the Analog Coder in more detail. Both papers can be found on the Nucomm web site, www.nucomm.com.