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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

November 28, 1994

Mr. H. Franklin Wright
Chief, Frequency Liaison Branch
Office of Engineering and Technology
Federal Communications Commission
2025 M Street, N.W.
Room 7326, Stop Code 1300A4
Washington, D.C. 20554

Re: Experimental Station KI2XIE
Corbin City (Atlantic City), New Jersey
File Nos. 4264-EX-PL-94 and 4426-EX-ML-94

Dear Mr. Wright:

Transmitted herewith, on behalf of Orion Broadcasting Systems, Inc., is the second status report required pursuant to a condition placed on the license of the above-referenced Experimental Station.

Should further questions arise in connection with this matter, please communicate directly with the undersigned.

Very truly yours,

James S. Blitz
Counsel to Orion Broadcasting
Systems, Inc.

Enclosure

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STATUS REPORT

On May 31, 1994, the Commission granted Orion Broadcasting Systems, Inc. ("Orion") a license for Experimental Station KI2XIE (File No. 4262-EX-PL-94, the "License") to permit Orion to develop and test an interactive MMDS and ITFS system in Corbin City, New Jersey. A condition of the License requires Orion to provide the Commission with a report of its progress every 90 days from the date on which the License was granted. This is Orion's second such status report.

As Orion indicated in its August 25, 1994 status report, the Commission's grant of a modification of the License on August 12, 1994, permitting a minor change in equipment and other minor engineering adjustments (File No. 4426-EX-ML-94), resulted in some delay in commencing experimentation. However, Orion has now completed construction of the facilities and is prepared to commence its experimental program in approximately three weeks.

In conjunction with Decathlon Communications, Inc. of Denver, Colorado ("Decathlon"), the first step of the program will be the installation and testing of a Howlitt Packard vector signal generator, which will be used as the digital modulator for the system. This equipment will bc help to demonstrate the feasibility of a digital wireless cable system. Attached to this report is a document produced by Decathlon providing further details of this equipment and this first stage of Orion's testing program. Assuming these initial tests prove to be successful, Orion intends then to proceed with the other aspects of its testing program for interactive services as outlined in Orion's initial application for the License.

Orion's future progress reports will provide further information concerning the results of this experimentation.

ORION BROADCASTING SYSTEMS, INC.

J. Oliver Lovato
President

Nov. 28, 1994

10/8/94

Transmission Testing Setup

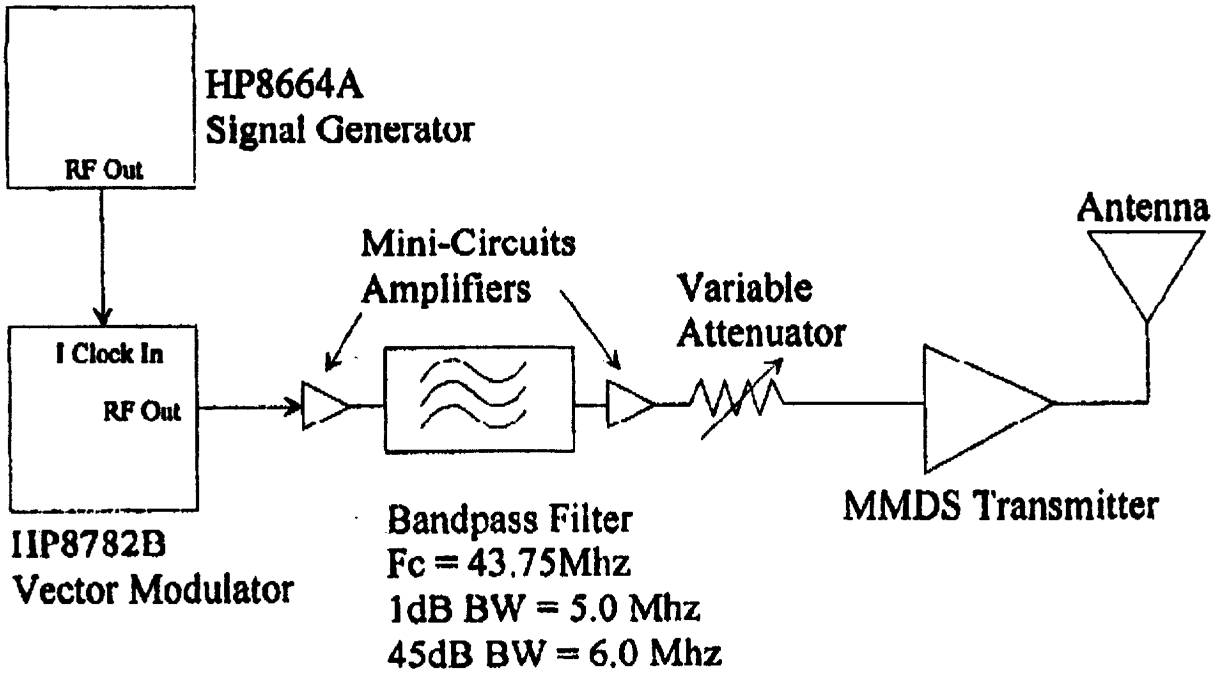

Figure 1

Receive Test Configuration

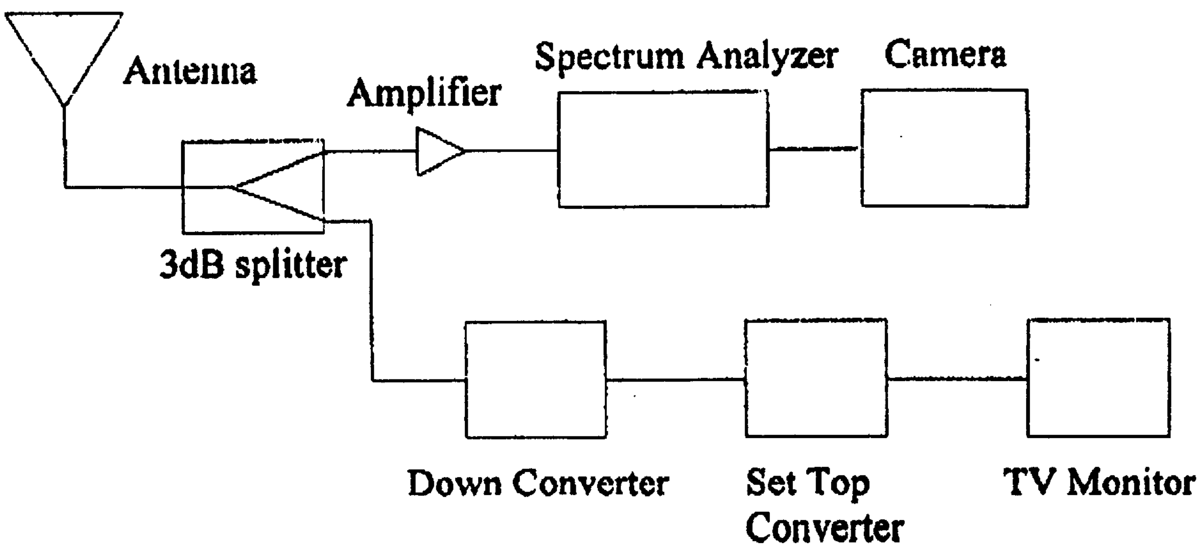

Figure 2

10/8/94

Power Output Test Setup

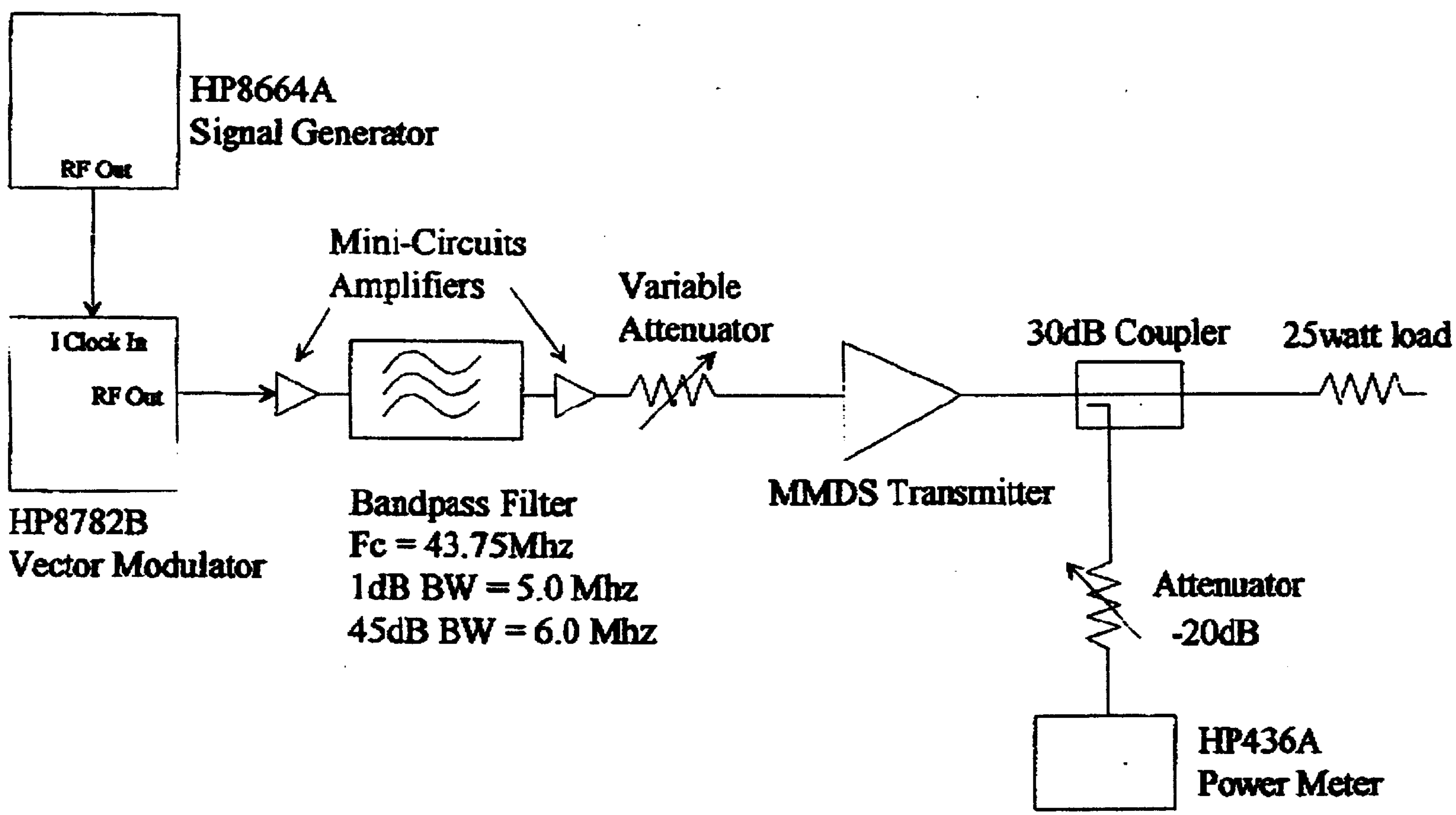

Figure 3

DECATHLON COMMUNICATIONS, INC.
7600 E. Eastman Avenue
Suite 406
Denver, Colorado 80231

Office (303) 755-7292
Fax (303) 755-2234

Decathlon Communications, Inc. (DCI) Wireless Cable Compressed Digital Video (CDV) System

Decathlon Communications has developed a proprietary system for wireless cable transmission and modulation. This digital system overcomes many of the major limitations that can degrade the transmission of wireless, compressed, digital TV signals to the home. As a consequence, it offers wireless cable operators an efficient and reliable modulation technology to use with digital compression that is needed to offer a much larger number of TV channels to subscribers. By using the Decathlon technology, wireless cable operators will have a better chance to challenge the dominant position of traditional "wired" cable systems. Decathlon's transmission modulation technology can also be applied to other areas because it addresses the important problem of controlling interference with "over-the-air" signals.

The advantages of wireless cable are that there is no "cable plant" (the collection of cable, line amplifiers, etc.) to maintain, no rights-of-way to negotiate, and no city franchise fees to pay. When compared with DBS services, wireless also has the advantage that local or regional programming can be added very easily to the system. One of the disadvantages of wireless cable has been the difficulty in obtaining a sufficient number of channels to create adequate consumer demand for the service. In the U.S. the maximum number of channels obtainable is 33, but most systems have far fewer. It is generally recognized that the lack of available channels is a major obstacle to wireless becoming a major competitor to traditional wired cable systems. In those few systems where close to the maximum number of channels has been obtained, the new systems have competed well with the wired cable systems.

Compressed digital video can multiply the effective number of channels in a wireless system and make it competitive with other forms of transmission. In face, since most wireless systems have fewer channels than necessary to cause consumer demand to "take off," an increase in available channels is expected to have a much greater impact on demand than a similar increase in the number of wired cable channels. If so, then applying CDV to wireless is an opportunity with a high return on investment.

DCI has been developing an MPEG-based CDV system for wireless cable. This system is illustrated in Figure 1 below. This system will transmit from 4 to 10 programs within the 6 MHz band that presently carries only one channel of programming. The number of programs per 6 MHz bandwidth is determined by the desired image resolution, both within a frame and from frame-to-frame, that the system operator deems necessary, and by the mix of channel types. For example, more talk shows can be placed in a 6 MHz bandwidth than can high-motion, less-compressible sports programs.

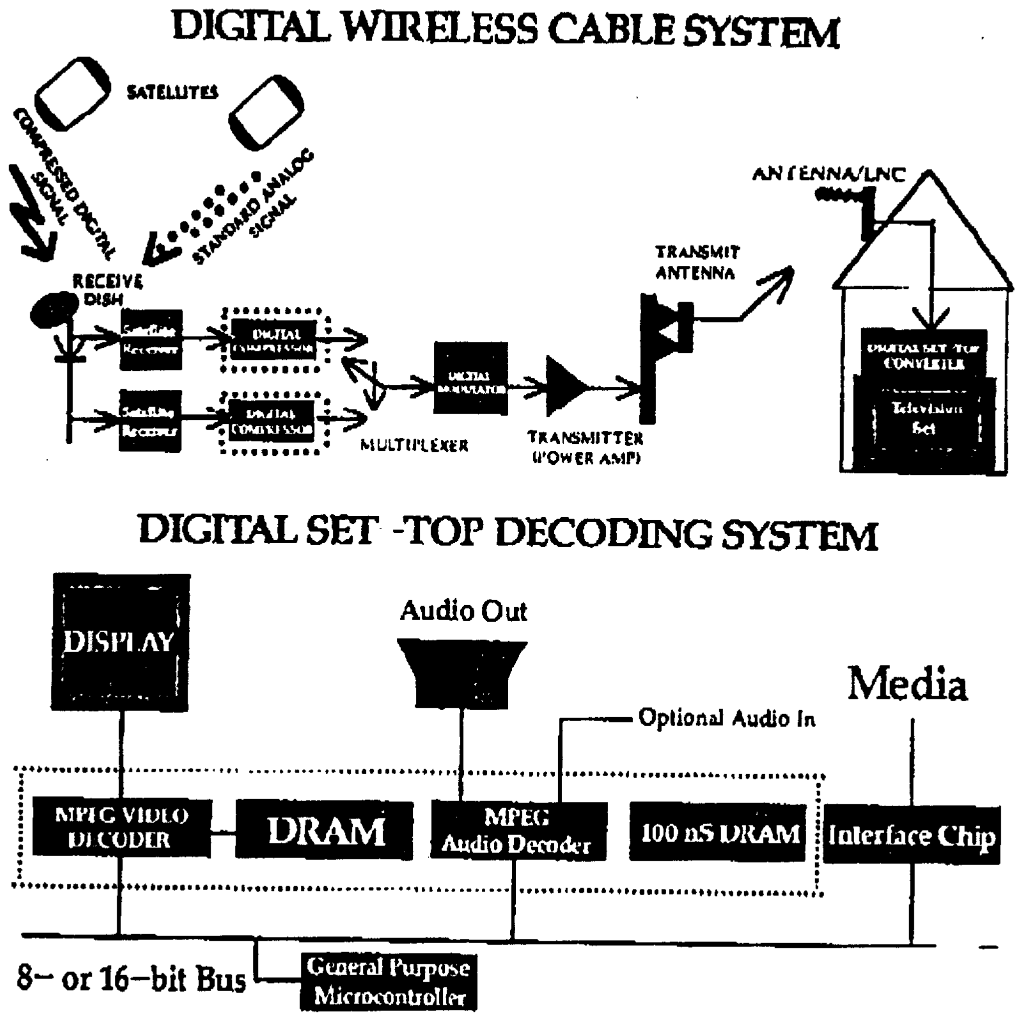

Figure 1.

In the DCI system pre-compressed as well as terrestrial local and satellite-delivered analog channels are received at the head-end. The analog signals are compressed, then multiplexed into a single digital data stream. This multiplexed data stream can also include other information, such as text, banking transactions and E-Mail.

The combined data stream is then modulated onto the carrier and transmitted to the home, where it is received by a small microwave antenna, low-noise amplified and block-down converted by an LNB/LNC. The down converted signal is then sent to a set-top decoder which demodulates and error-corrects the signal into the original data stream. The set-top then demultiplexes (separates) the desired data or CDV signal from the data stream. If a video rather than a data-only signal has been selected by the customer, the CDV data is sent to MPEG decompression circuitry for both video and audio decompression. The decompressed audio and video are both output on "video" and "audio" jacks for use with television monitors and modulated onto TV channels 2 or 4 for viewing on conventional television sets.

The Decathlon Modulation System

Decathlon Communications, Inc. is developing a 49-QPRS system for its terrestrial wireless cable delivery of CDV signals received from satellite. This system uses 49 QPRS which is intentionally-overfiltered 16-QAM. The overfiltering is done in such a way that each symbol effects the very next symbol, but no others. (A "symbol" is one combination point from the sine/cosine Constellation) This causes nulls to appear in the spectrum at the minimum bandwidth frequencies. Since there are nulls in the spectrum at the desired band edges, 49-QPRS achieves what practical 16-QAM can not: 4bps/HZ spectral efficiency. The 49 QPRS constellation and spectrum are shown in Figure 2.

QPRS has the advantage that imperfect filtering in the receiver will not have as great of an effect as in QAM, since filter band-edge imperfections will affect the signal close to its nulls, where there is little signal power. QPRS does require additional signal power at the transmitter for the same bit error rate as 16-QAM. However, Viterbi-decoding the intentional overfiltering can overcome this penalty. For the bandwidth-limited, but not power limited, wireless cable market, this power penalty is quite acceptable in order to achieve better performance than 16-QAM, and roughly equal performance to 32-QAM.

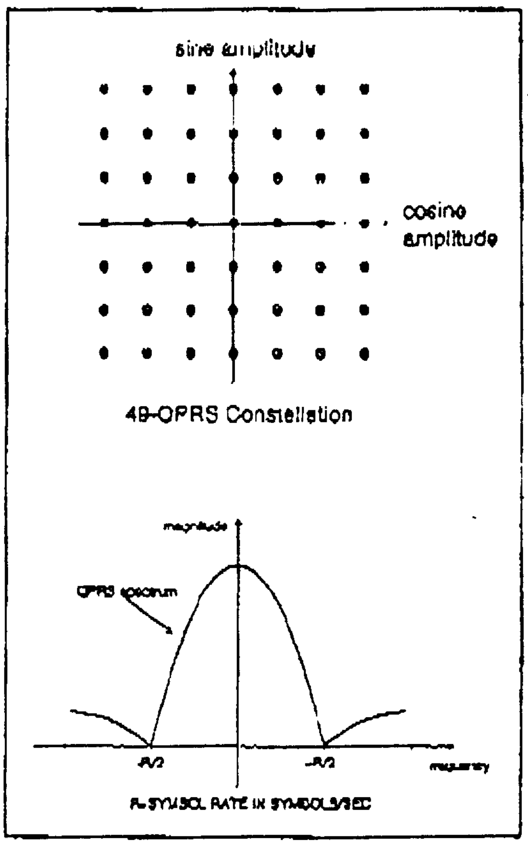

Figure 2. 49-QPRS Modulation

QPRS suffers from the two additional difficulties: 1) it is more sensitive to phase noise than 16-QAM, and 2) Its peak power to average power ratio is higher. Decathlons' system processes the received 49-QPRS signal in such a way (discussed below) that the phase-noise sensitivity is overcome. The peak-power/average power ratio is not a problem for this wireless cable system, since there is sufficient left-over power (link margin) to make the QPRS peak power meet the necessary values.

If the approximately 3.3 bps/Hz 16-QAM spectral efficiency is inadequate for a given application, and 32-QAM was used instead to get 4 bps/Hz, we would expect there to be a "penalty" in the form of increased required transmitter power. That QPRS also requires more transmitter power to achieve 4bps/Hz is part of the spectral efficiency/power efficiency trade-off.

Currently there is no inexpensive digital multi-media system suitable for home use. There is also a void in technical literature as to the characteristics of the multipath channel that will be encountered in such a system. A multipath channel is one in which the receive antenna sees reflections of the transmitted signal. These reflections can interfere with the direct signal causing errors. (In analog TV this is called "ghosting".) Whereas multipath gracefully degrades an analog signal, it can render a digital signal useless if provisions are not made for dealing with the multipath. The most difficult multipath occurs when the signal is reflected off of a moving object such as an airplane . Then, the receiver must adapt to a rapidly changing signal.

Also, transmission of digital television requires data compression and a high-order modulation to transmit the large amount of data for digital television to the home. The consumer receivers must be affordable, but they must recover a very low-noise carrier in order to properly demodulate the high-order modulation.

This accurate low-noise carrier recovery is typically a major part of the cost of the receiver. When the system is to be used in a multipath (multiple signal reflections) environment, the receiver must be able to "undo" as much of the multipath distortion as possible. This is done by an equalizer circuit which automatically builds the inverse to the channel distortions and restores the signal, as far as possible, to the undistorted state. To do this, the equalizer must measure, either directly or in directly, the channel's characteristics.

"Pilots" are signals which are added to the transmitted signal to make it easier for the receiver to recover the carrier, equalize the signal, etc. Present-technology pilots are usually frequency tones or bursted time signals. These signals are used for carrier recovery and equalization. For equalization, the frequency-tone pilots are used to correct channel distortions by adjusting the frequency characteristics of the received signal. Time-signal pilots are used to correct the channel distortions by adjusting the time response characteristics of the received signal to be the correct time response. Note that when the channel is properly equalized by either of these methods, since the signal will be nearly distortion free, both the time and frequency responses will be nearly correct.

Without pilots, equalization can be performed by "blindly" adapting the equalizer until the best performance is achieved. Such "blind adaptive equalization" can be very difficult to perform and can require complex hardware to achieve rapid equalization. However, advances in integrated circuit technology may allow such blind equalization for the required high data rates with small numbers of IC's.

The challenge for creating an affordable receiver for digital television is to create an affordable system which can perform the normal receiver functions; recover the much higher quality carrier required for high-order modulations; and perform the necessary equalization. The Decathlon Communications, Inc., Pilot System, for which a patent application is pending, uses a novel pilot signal method to accomplish this.

The Decathlon Pilot System

The Decathlon Pilot System distorts the transmitted signal in a special fashion. This distortion leaves "marks" which enable an affordable receiver to process the pilot, recover the carrier, recover symbol timing, and equalize the signal. This pilot simplifies the receiver signal processing which is required to give the necessary performance.

As mentioned, the "marks" on the signal are also used to equalize the signal. Since the intentional pilot distortion is continuous and affects all of the signal, it does not suffer from the limitations of frequency-tone pilots or time-bursted pilots. The Decathlon Pilot System simplifies receiver circuitry while giving better carrier recovery and equalizer performance. Since it distorts the symbol transmitted over the channel, symbol timing recovery is also achieved with simple circuitry.

The Decathlon Pilot System can be used with virtually any signal type, since virtually any signal can be distorted in this fashion. (The intentional pilot distortion is removed in the receiver.)

Decathlon's digital television system currently uses this pilot with QPRS (Quadrature Partial Response Signalling) modulation, although, as sated, it can be used with other modulations, such as "N"-QAM or "N"-VSB. QPRS has the advantage of being relatively simple to modulate, while giving true nulls at the band edges. These nulls mean that 49-QPRS achieves a spectral efficiency of 4 bps/Hz with roughly the complexity of 16-QAM(which usually achieves roughly 3.2 bps/Hz.)

49 QPRS does require more accurate symbol timing recovery and carrier recovery than 16-QAM. But, it should be noted that 49 QPRS should be compared , not with modulations of roughly the same implementation complexity, like 16-QAM, but with modulations which achieve the same spectral efficiency.

In other words, there will always be "costs" associated with improving spectral efficiency, whether it be with QAM, QPRS, or VSB. The Decathlon Pilot System achieves the necessary carrier recovery for QPRS while still achieving high spectral efficiency with spectral nulls at the band edge.

Summary

The Decathlon Pilot System achieves carrier recovery, symbol synchronization, and "unblind" equalization for high-performance, affordable digital television receivers. The system has been implemented with 49 QPRS which achieves a real 4 bps/Hz spectral efficiency. This will give 24 Mbps completely within a 6 MHz television channel allocation. The Pilot System can also be applied to other modulations, including QAM and VSB.

This system performs all of the following functions:

1. Affordable adaptive equalization to cancel the effects of multipath reflections at the receiver. The response of the equalizer will be determined by the measurement of channel responses.

2. Highly bandwidth-efficient modulation and demodulation that work best over the actual channels and in conjunction with the Adaptive Equalizer and Forward Error Correction (FEC) circuitry.

3. Affordable forward error correction using existing integrated circuits which implement Reed/Solomon encoding and decoding. Additional concatenated Viterbi decoding may be added.

4. Pilot Signal. High bandwidth-efficiency modulations such as Quadrature Amplitude Modulation (QAM) or Quadrature Partial Response Signaling (QPRS) often use a pilot signal to provide a carrier phase-and-frequency reference for the receiver to lock to. Demodulation can then be performed with simple, more affordable hardware. The system radically extends this concept to the creation of a Pilot Signal which can provide:

a. Carrier recovery (phase and frequency.)

b. Symbol synchronization.

c. Determination of channel impulse response.

d. An automatic gain control reference signal.

e. Minimization of pilot interference into co-channel and adjacent-channel analog NTSC signals.