MPEG and DTV Transmission (Continuing from Tuesday)

At this point, we are at the eight levels, ready to go to the transmitter.

Comparing segments we have generated in the transmission stream to the NTSC equivalent (roughly).

ATSC data segment roughly analogous to an NTSC line. ATSC segment sync somewhat like NTSC horizontal sync. Duration and frequency are different. ATSC segment sync lasts 0.37 microseconds, NTSC sync lasts 4.7 microseconds. ATSC data segment lasts 77.3 microseconds, NTSC line lasts 63.6 microseconds.

ATSC segment sync narrower than NTSC horizontal sync. Done to maximize the active data payload and minimize time committed to sync overhead. 313 consecutive data segments combined to make a data field. Field sync segment goes along with the data field.

ATSC field sync is an entire data segment repeated once per field (24.2 milliseconds) and roughly analogous to NTSC vertical interval. ATSC field sync has known data symbol pattern of positive-negative pulses and used by receiver to eliminate signal ghosts; this is constant for every field sync, just like how NTSC has a constant format to its horizontal interval (even though this is more analogous to vertical sync, which isn't quite as constant as is horizontal sync). This is done by comparing received field sync with errors against the known field sync sequence before transmission. Resulting error vectors are used to adjust taps of the receiver ghost canceling equalizer.

Like segment syncs, the large signal level swing and repetitive nature of field syncs allow them to be successfully recovered at very high noise and interference levels (up to 0 dB SNR).

How Field Sync Used to Cancel Ghosting

Digital time base corrector converts analog signal to digital, watches clock synchronized by house sync to decide when to output the frame, then convert the digital back to analog and output the analog. Block diagram includes: A to D, clock, memory, clocked output, D to A.

We focused camera 3 onto the computer monitor and adjusted the shutter speed to get the computer screen without flickering due to phosphor decay from refresh rate differing from shutter speed.

Earliest time base correctors. Diagram 1. Coil with varactors creates a delay. Adjusting varactors adjusts the delay in the delay line (the coil of wire). Called an analog delay line. Error compensation for received field sync used to adjust how long the delay is; this removes the difference and the ghost goes away. Syncs with the echo, so that later inverting and adding cancels out the ghosting.

DTV Receiver

In home receiver, over the air signal demodulated by applying in reverse the same principals that have already been discussed. The incoming RF signal is received, downconverted, filtered, then detected. The segment and field syncs are recovered. Segment syncs aid in receiver clock recovery and field syncs are used to train the adaptive ghost-canceling equalizer.

Once proper data stream has been recovered, it is trellis decoded, de-interleaved, Reed-Solomon decoded, and derandomized. Result is recovery of original MPEG-2 data packets. MPEG-2 decoding circuits reconstruct video image for display on TV screen. Dolby AC-3 circuits decode sound information and drive receiver loudspeakers. Home view receives DTV and signal chain complete.

No doubt that 8-VSB has advantages over COFDM. 8-VSB using spectrum more efficiently; this gives greater area of coverage for a given transmitter power. Transmitter power costs lots of money. More power transmissions also lead to more interference with other services. In laboratory conditions and in field trials, 8-VSB's advantages and relative simplicity won out, and that is why 8-VSB is in use today.

The hospitals started complaining about equipment not working properly around time that DTV first started being broadcast.

Much difference between laboratory conditions linked to practical field trials, and real world use. In practice, 8-VSB has some serious shortcomings.

Can't switch to COFDM at this point, with all those receivers now out there.

First, 8-VSB despite adaptive equalizer, not sufficiently resilient to multipath. Lots of things cause multipath, even airplanes. If have outdoor antenna, expertly aligned, probably will enjoy very good pictures from chosen transmitter, at least as good as NTSC. Fringe areas might require professional installation of outside antennas. Indoor antennas fare considerably worse and have to be carefully oriented, and even placed near a window, to work at all.

One of key propositions in introducing DTV to US was that it should work in every situation where NTSC works, and plainly it doesn't.

An associated problem is that the antenna is likely to require re-orientation when the channel is changed. This can happen with NTSC also, but users are likely to accept a slight degree of degradation and not consider re-orienting the antenna.

Antennas have reflector and director which create gain, which in effect amplifies the received signal.

COFDM however is the multipath slayer and is very tolerant of antenna orientation. In a New York Times article one commentator said that with 8-VSB it was difficult to get a signal indoors; with COFDM it was difficult *not* to get a signal.

Indoor antenna poor because not any useful ground wave at UHF, unlike lower frequencies like AM and HF shortwave.

There are electronically tuned receiving antennas that avoid the problems with rotating a large antenna.

Television has given up a lot of channels. Will probably give up the VHF channels (2-13). Gave up 70-83 a long time ago; stop at 69 (start at 14). Might be a low power version in metropolitan areas with people starting up COFDM services for mobile television.

Frequency bands. Diagram 2. Audio, VLF (submarines), AM, Channel 2, FM, police, Channel 6 to 13, gap, Channel 14 to 68, lost channels 69-83 to cell phones.

There is also the issue of mobile reception. When the receiver is moving, multipath signal constantly changing in both amplitude and time with respect to the wanted signal. Occupants other than the driver may watch TV. COFDM would handle this without a problem.

COFDM works a bit like how cell phone sites are set up. All the transmitters for a station broadcast on the same frequency (single-frequency networks), and COFDM prevents the multipath problems.

Mobile DTV via 8-VSB is not practical. Another aspect of mobility is the single frequency network. If network broadcaster's transmitters all tuned to same frequency, then mobile/portable users would not have to re-tune as they passed from one area of coverage to another. 8-VSB has difficulty with this concept as the weaker signal would appear to be so much more multipath interference. COFDM with its superior properties in this respect is not troubled.

One disadvantage of COFDM compared to 8-VSB is its greater susceptibility to impulse noise caused by domestic appliances switching on and off (appliances that do this automatically seem to be subjectively more annoying), lighting dimmers, microwave ovens, and power lines. Whether this is intrinsic to COFDM or could be combated by improvements in receiver technology remains to be ascertained.

While coverage area of 8-VSB is good, transmitter requirement is less, and the data carrying capacity is around 5% greater (not that much). The problem is that there are random holes in the coverage. Anyone buying a system would not know for sure that it was going to work until it was set up in its intended location. The US was an early player in the DTV game, but one by one world markets mostly opting for COFDM, largely as a result of US experience. Problem in the US is that 8-VSB is already established as the system for terrestrial digital television. Around 50% of households in US already have digital TVs.

Break

The ATSC 8-VSB system uses layered digital system architecture consisting of ...

RF Modulation

We have 8 levels. What do we do to these 8 levels to get it to the home? Transmit it. How modulating it? AM. What happens to the sidebands of the modulation envelope (modulating a square wave)? Get an infinite number of sidebands due to the infinite number of frequencies incorporated into square waves. We don't want this; we are hogging the entire RF spectrum, although not to a full amount of power since higher sidebands are at lower amplitude. Filter them out using a high pass filter and low pass filter (bandpass filter). Is that before exciter or after exciter? We have to have some filter on the exciter output. If we get rid of some of the higher frequencies, we rounded off the square waves.

Have carrier with sidebands. Vestigial sideband within 6 MHz. 8-VSB should look like noise (this will be on the test). Noise is equal amplitude across the spectrum being used. Efficiently uses entire bandwidth. Looks the same even if information drops to zero, because we then send placeholders to maintain the appearance of a block of noise.

Take output of the RF exciter to the amplifier. 15-20 kW output, but ERP (effective radiated power) of 1 MW or more. How does that much ERP happen with much less power in? Antenna gain; the radiation pattern makes the signal go where it would be most useful.

See Kennedy Park in Napa. A bunch of antennas at one end of the valley, pointed at the other end of the valley. These antennas probably constrain the pattern horizontally so that the primary lobe points to the other end of the valley. Sutro tower antennas constrain vertically.

Field Trip

To Kennedy Park.

Homework

List the steps from 601 to transmission. How many times the data gets changed into a new format. Through end of this lecture. Due Tuesday. Just do video, not audio or metadata (ancillary data).