DIGITAL TELEVISION TRANSMISSION SYSTEMS

ENG (MRS) PN KARUNANAYAKE
COMMUNICATION SYSTEMS

ANALOG COLOR TV

NTSC SYTEM

- **NTSC** (NationalTelevision Standards Committee) was developed in the United States that was compatible with the black-and-white TV.

- Uses a luminance–chrominance encoding scheme with **red, green, and blue (RGB) primary signals encoded into one luminance signal (Y)** and **two quadrature-amplitude-modulated color (or chrominance) signals (U and V)**, and all are transmittedat the same time.

- Occupies **6MHz bandwidth** with the video signal transmitted between 0.5 and 5.45 MHz baseband. The **video carrier is 1.25MHz** and the video carrier generates two sidebands, each **4.2 (5.45– 1.25) MHz** wide.

- The **entire upper sideband will be transmitted** while only **1.25 MHz of the lower sideband (known as a vestigial sideband,VSB) is transmitted.**

- The **color subcarrier is 3.579545 MHz above the video carrier and quadrature amplitude modulated with the suppressed carrier while the audio signal is frequency modulated**.
- The NTSC system was deployed inmost of **North America, parts of South America, Myanmar, South Korea, Taiwan, Japan, the Philippines, and some Pacific island nationsand territories.**

ANALOG COLOR TV

SECAM

- In the SECAM (Sequential Color with Memory) system, **two color difference signals are transmitted alternately (line by line)** and **frequency modulated by the color subcarrie**r.

-This system was adopted by France, the Soviet Union, Eastern European, countries (except for Romania and Albania), and Middle East countries and was the first color TV standard in Europe.

PAL System

In Phase Alternate Line (PAL) system based on the NTSC performs line-by-line phase inversion of the quadrature component of the chrominance signal in the NTSC system. This new system was adopted by more than 120 countries successively, and in 1972 China decided to adopt it as well.

ISSUES OF ANALOG TV SYSTEMS

1. Interms of the **quality, long-term storage and dissemination of the video programs,** the analog TV program source suffers from **color–luminance interference, large-area flicker**, and **poor image definition**, and it is **difficult to replicate the content** for too many times.

2. S**ignal transmission efficiency**, the analog TV network is largely **restricted by the bandwidth** available. Due to **cochannel and adjacent-channel interference** in neighboring areas, different analog channels have to be used to carry the same programs to different areas to avoid mutual interference. The spectral efficiency is decreased, and it is very difficult to introduce new programs by assigning additional channels in the same region due to the limited available spectrum.

3. **Quality** of the signal transmission, the analog TV signal may suffer from “ghosts”. In addition, if the analog TV signal needs to be amplified for a longer transmission distance, the noise accumulation will make the signal quality very poor due to the deteriorating signal-to-noise ratio.

ADVANTAGES OF DIGITAL TV SYSTEM

1. Better Anti-Interference Ability, No Noise Accumulation, and High-Quality Signals.

2. Higher Transmission Efficiency and More Flexibility in Multiplexing.

- Depending on the video coding compression scheme used in a DTV system, one analog TV channel can atleast contain one HDTV (high - definition TV) program, or ∼10 SDTV (standard-definition TV) programs, or more than 20 DTV programs with VHS quality.

ADVANTAGES OF DIGITAL TV SYSTEM

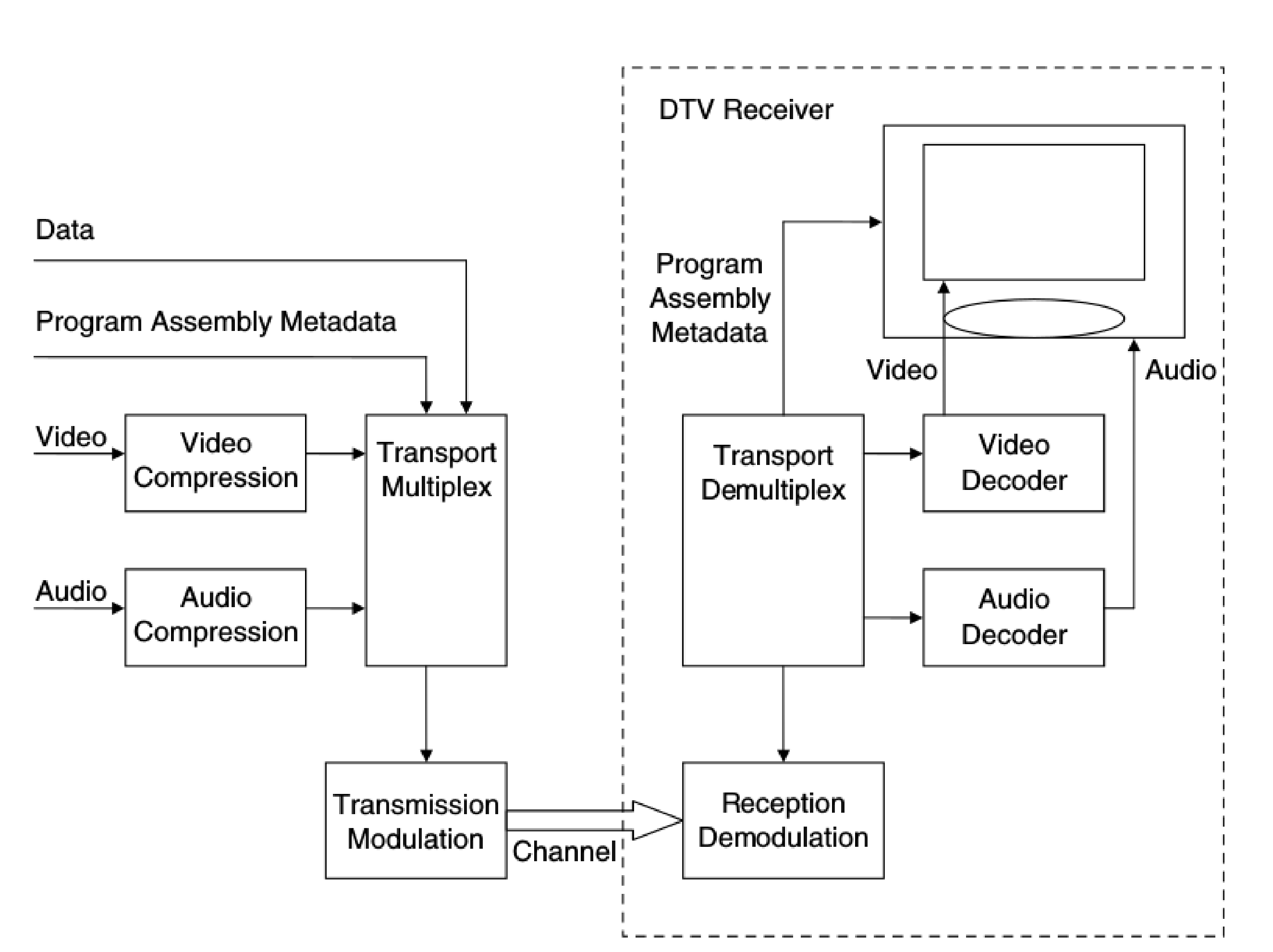
- 3. Easy to Encrypt and Support Interactive Services.
- 4. Easy to Store, Process, and Distribute under Network Environment

DTV FUNDEMENTALS

Four sub-systems are linked together to form a DTV broadcasting system: presentation, compression, transport and transmission.

- **Presentation**: describes image format and sound spatial imaging.
- **Compression**: reduces data quantity and rate to practical levels.
- **Transport Multiplex**: packetizes audio, video and data; includes assembly instructions for the DTV receiver.
- **Transmission:** adds error correction and then modulates symbols for channel distribution.

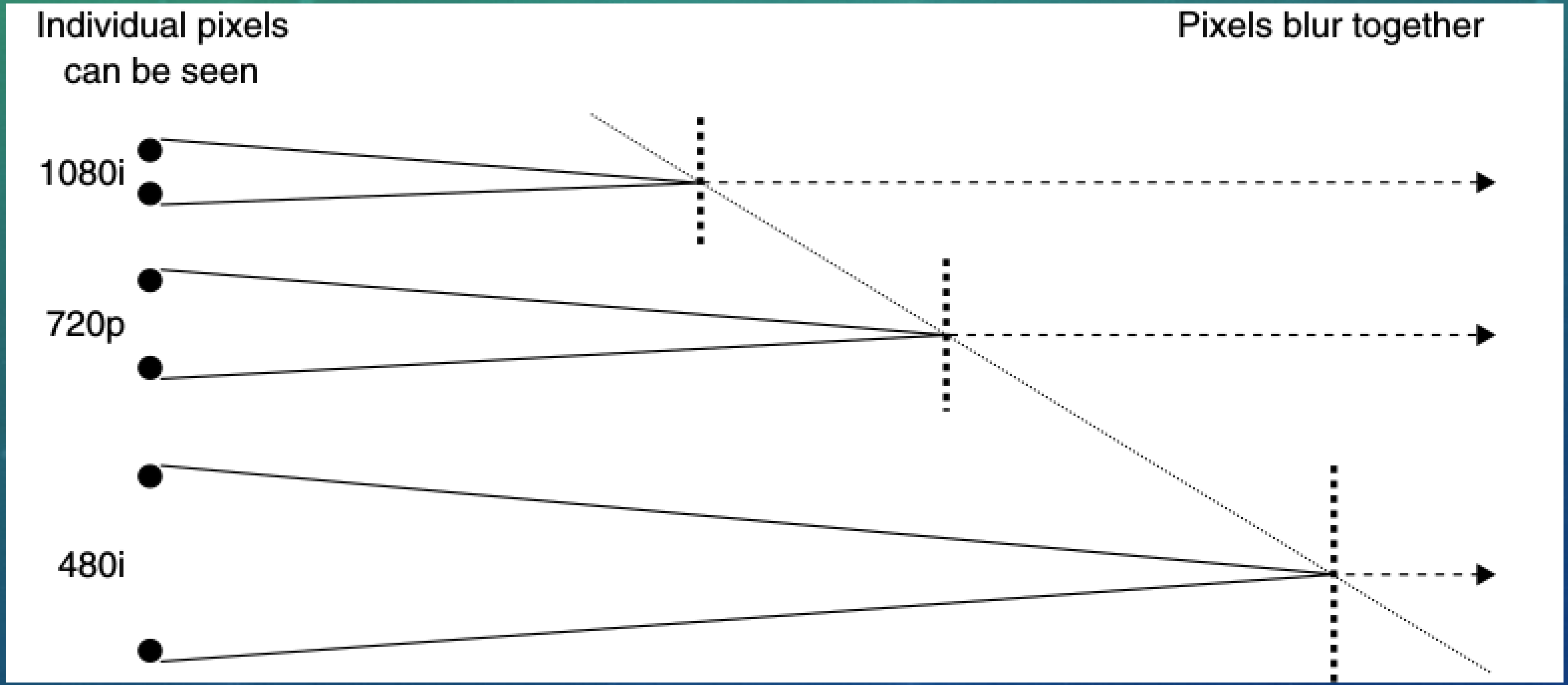
DTV FUNDEMENTALS



In the DTV receiver, the broadcast processing sequence is reversed.

● Reception: Signal capture, demodulation and recovery of data packets from the transmission channel.
● Transport Demultiplex: extraction of audio, video and data packets and assembly instructions.
● Decoding: Expansion of compressed audio and video data.
● Presentation: audio and video are synchronized and the complete program is ready for viewing.

OPTIMAL VIEWING DISTANCE FOR VARIOUS SCREEN SIZES (NOT TO SCALE)



LUMINANCE SENSITIVITY

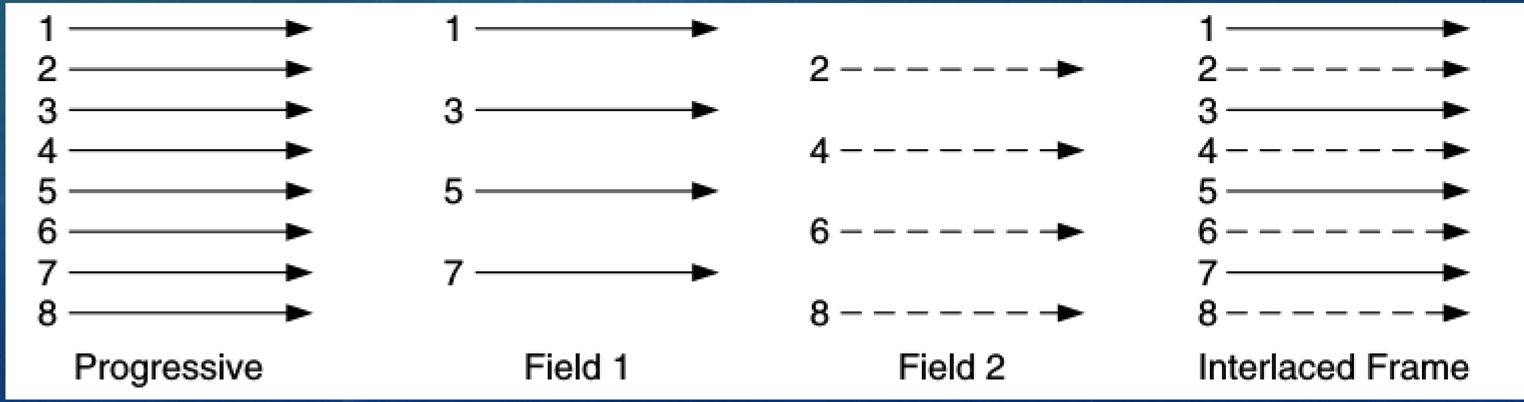
- Black-and-white TV represented images as luminance levels.
- Luminance is the sum of red, green and blue combined with defined weighting factors.
- Whenever this particular ratio of red, green and blue is present, black, white and gray are perceived.

For Analog TV

$$Y = (0.30 \bullet R) + (0.59 \bullet G) + (0.11 \bullet B)$$

SCANNING METHODS

- There are two types of scanning, interlaced and progressive. The progressive method scans an image sequentially from line 1 to the final line of the raster to create a video frame.
- The interlaced method scans odd lines in field1 and even lines in field 2. Together, field 1 and field two make an interlaced frame. In interlaced scanning, odd and even fields constitute one frame. DTV uses both interlaced and progressive scanning methods



REFRESH RATE

- Television creates the illusion of motion by capturing and presenting still images at a rapid enough rate that the human visual system perceives the successive images as continuous.
- This rate, the frequency between the display of two still images, is known as the refresh rate and is expressed in Hz or frames per second (fps).

- DTV frame rates that can be 30 or 29.97, 60 or 59.94. Film frame rates are 24 or 23.98 fps.

•

RESOLUTION AND THE PIXEL GRID

-Display formats will always be expressed in pixels per line by lines per frame. So,

COMPRESSION

-- A full bandwidth HDTV picture occupies 1.5 Gbps, well beyond the capability of a 6 MHz transmission channel. Data reductions of 50:1 for video and 12:1 for audio are common.

-Compression engines, circuits and algorithms that process raw audio and video are divided into two broad categories:

● **Lossless compression** reduces the volume of data and, when reconstructed, restores it to its original state, perfectly, without the loss of any information.

● **Lossy compression** discards data based on auditory and visual sensory characteristics and limits. Because of the sensory dependency, lossy encoders are called perceptual coders. When reconstructed, the sensory information is virtually indistinguishable from the source.

•

COMPRESSION

There are many methods of compressing digitized sounds and images. JPEG (Joint Picture Experts Group) concentrated on still images. The Motion Picture Experts Group began development of MPEG-1 in 1988 and froze the standard in 1991. MPEG-2 was standardized in 1994. MPEG-4 video was next and had two versions. The latest from MPEG is documented as MPEG-4, Part 10.

-

TRANSMISSION

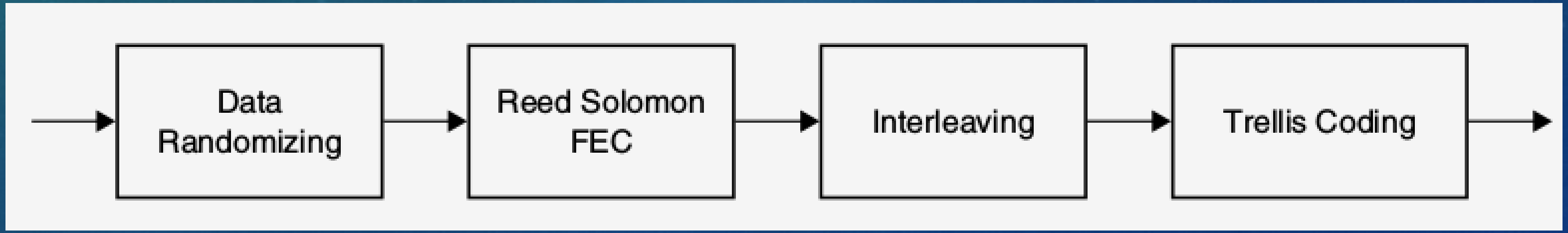
Transmission is a two step process. The first is **data protection** (organizing and adding bits), and the second is **modulation** (creating the symbols

-

DATA PROTECTION

Data protection includes four key steps:

- **Data randomizing**: spreads data over the full transmission channel
- **Reed-Solomon encoding**: adds extra information for error correction
- **Data interleaving**: spreads data over time so impulse noise errors can be corrected
- **Trellis encoding**: deterministically maps symbols to voltage levels



RANDOMIZATION

In technical terms, randomization uses a bit pseudo random number generator, feedback loop and XORs incoming data to scramble the stream. Its purpose is to avoid repetitive patterns and to spread energy equally across the spectrum. The resultant signal is noise-like when observed on a spectrum analyzer

-

REED-SOLOMON ENCODING

Retransmission of corrupted data packets is impossible, so a Forward Error Correction (FEC) technique is used. Extra parity bits are sent with the transport stream packets that allow recovery of corrupted bits. The algorithm is capable of correcting multiple invalid bytes caused by noise burst errors.

-

DATA INTERLEAVING

A complex convolutional byte interleaver disperses data. In other words, whole bytes are divided and time-dispersed sequenced to occur over a defined period. By spreading the data words over time, the number of bits in a word that are corrupted by impulse noise can be limited and remain within the limits of reconstruction techniques. If too many bits in a word are lost, the word cannot be reconstructed. Simply put, data interleaving breaks up words over time. This limits the damage done to any one word.

•

TRELLIS ENCODING

Trellis encoding divides 8-bit bytes into groups of 2 bits which produce 3 bit “symbols.” These symbols represent eight distinct voltage levels that are used to modulate the RF carrier wave.

-

DIGITAL MODULATION

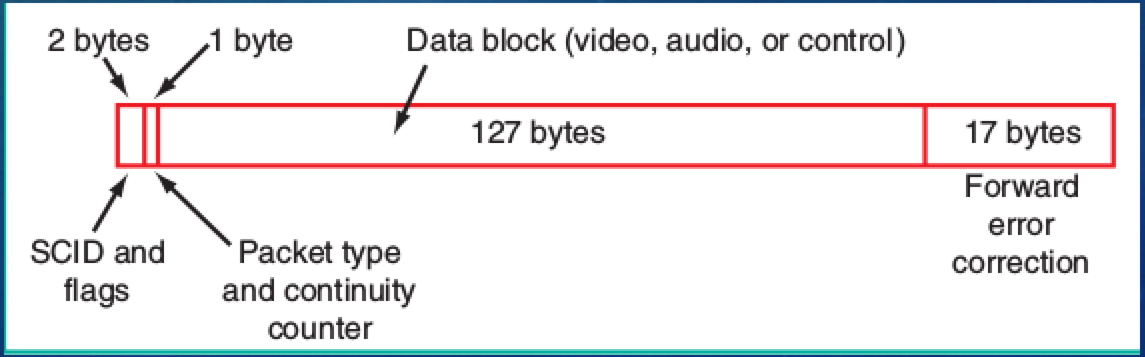
A benefit of digital modulation is noise immunity. Additionally, some enable compensation for propagation distortions.

Analog signals carried on RF waves are subject to noise impairments.
If the carrier wave is distorted, it will impact the analog signal. When the signal is demodulated, noise will be present and the presentation degraded. However modulation of digital symbols is more robust than analog signals. QAM & QPSK are popular methods of digital modulation.

•

DIGITAL DATA PACKET FORMAT

- The data block consists of 127 bytes, either video signals or audio signals. It may also contain digital data used for control purposes in the receiver.
- The last 17 bytes are the error detection check codes. These 17 bytes are developed by an error-checking circuit at the transmitter.
- The appended bytes are checked at the receiver to detect any errors and correct them.



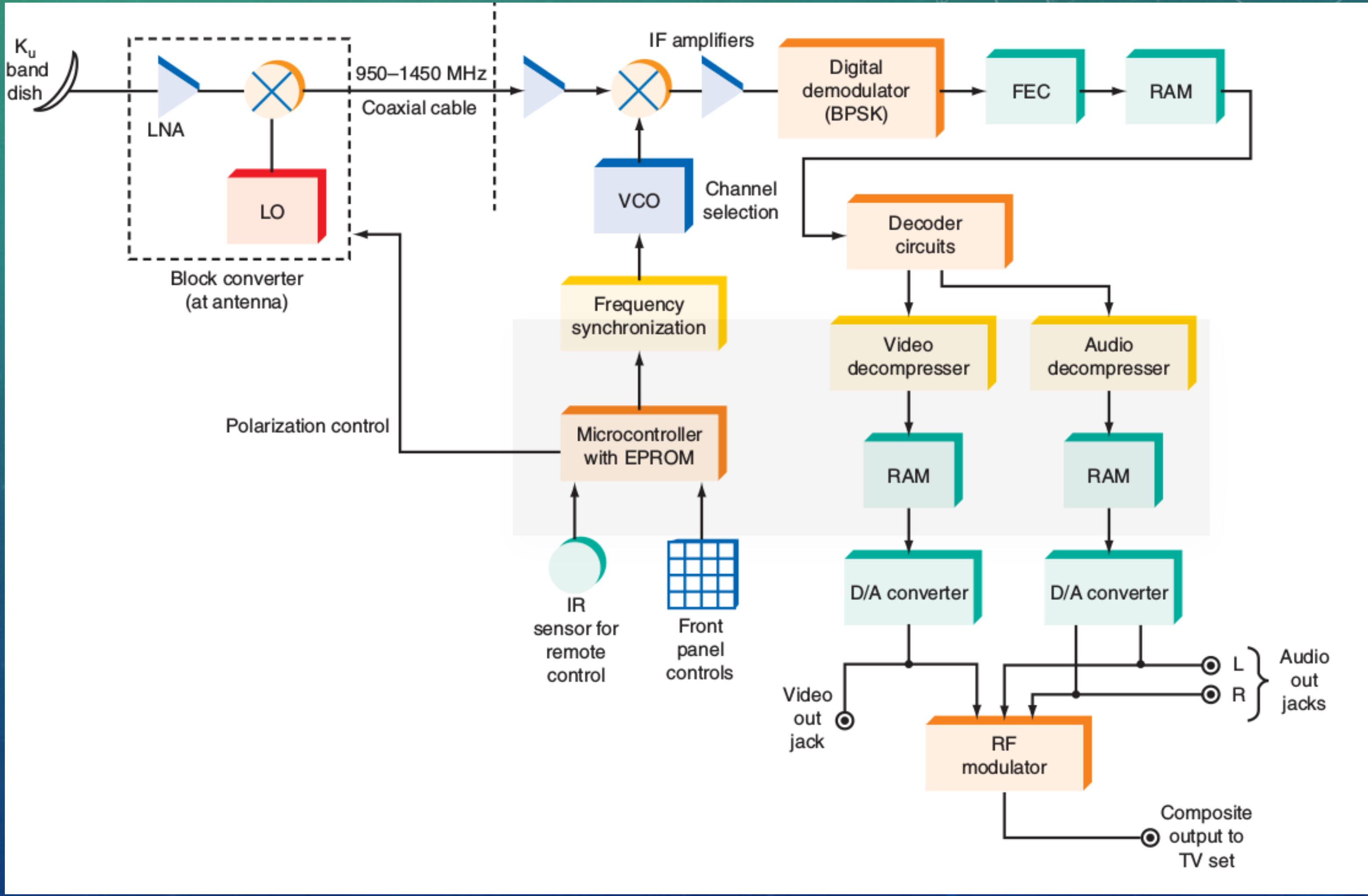
DIGITAL TV RECEIVER

The received signal is passed through a mixer with a variable-frequency local oscillator to provide channel selection.

- The digital signal at the second IF is then demodulated to recover the originally transmitted digital signal, which is passed through a forward error correction (FEC) circuit.

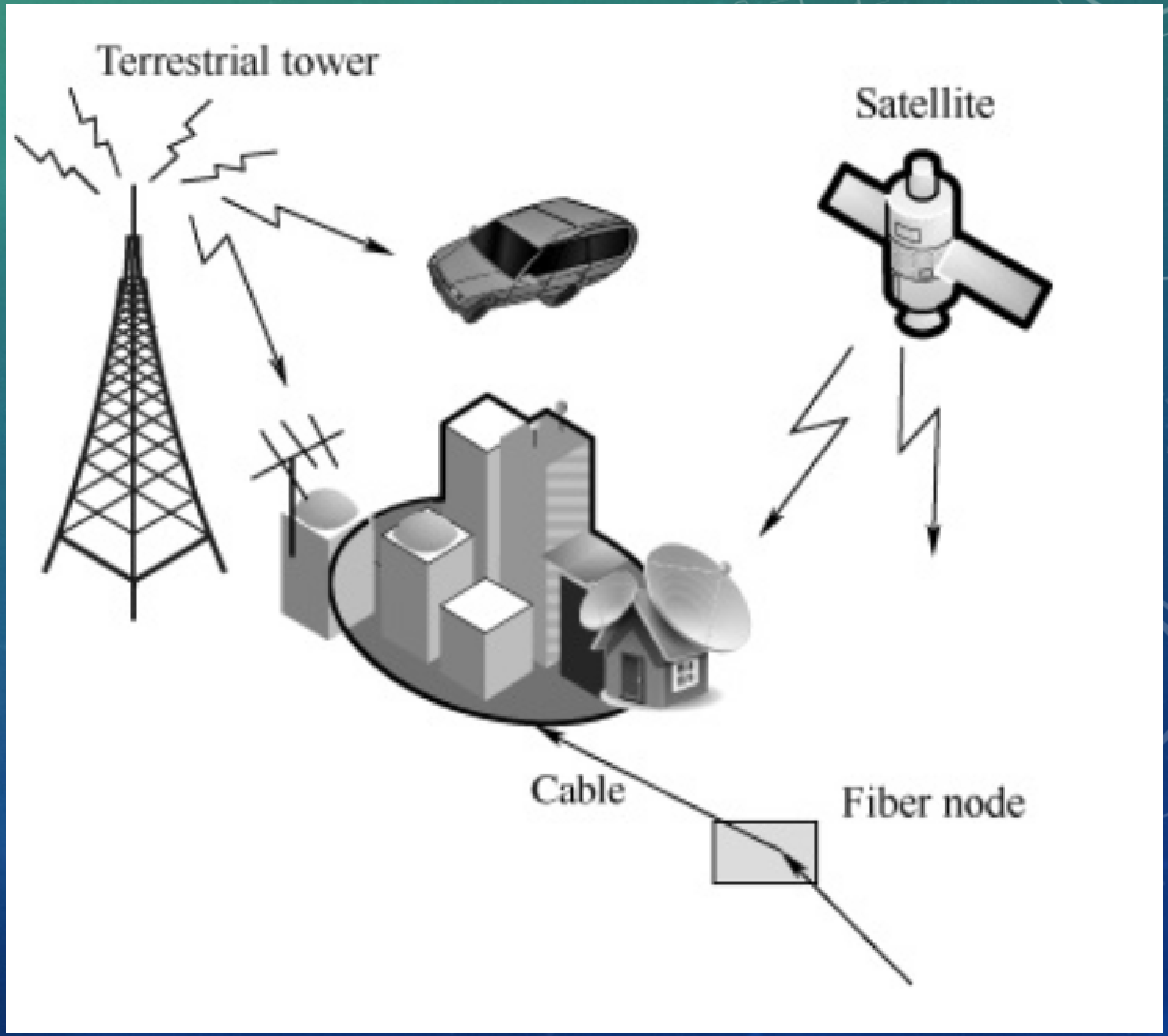
- Any bits lost or obscured by noise during the transmission process are usually caught and corrected to ensure a near-perfect digital signal.

- The resulting error-corrected signals are then sent to the audio and video decompression circuits.



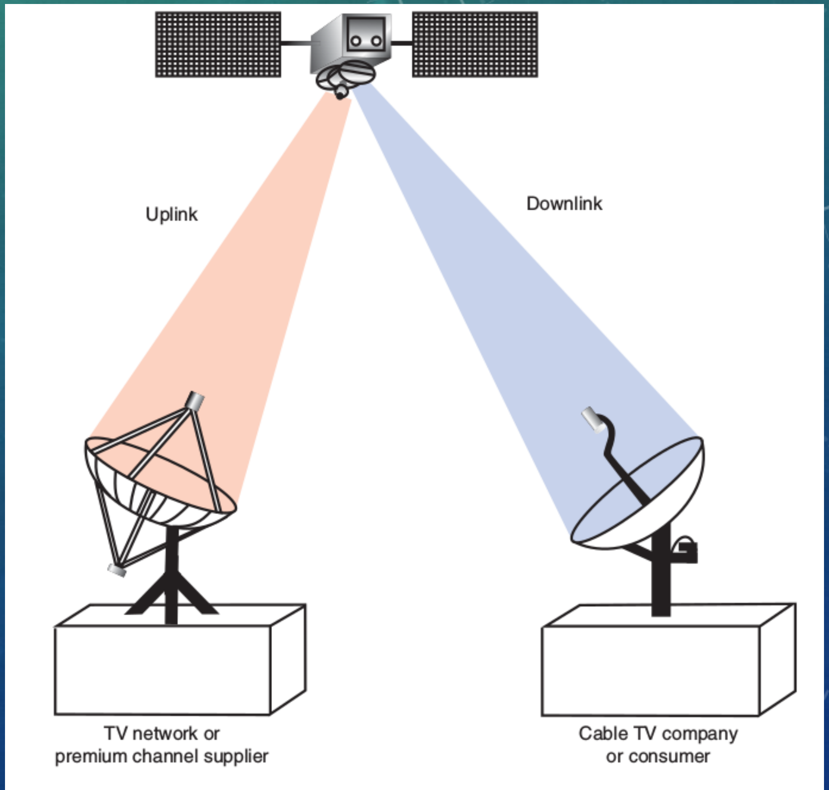
TV BROADCASTING SYSTEMS

- 1. Terrestrial (also known as over
- the air).
- 2. Cable
- 3. Satellite TV networks



SATELLITE TV

- A communication satellite rotates in synchronism with the earth and therefore appears to be stationary. The satellite is used as a radio relay station.
- The TV signal to be distributed is used to modulate a microwave carrier, and then it is transmitted to the satellite.
- A receiver on earth picks up the signal.
- The receive site may be a cable TV company or an individual consumer.
- Satellites are widely used by the TV networks, the premium channel companies, and the cable TV industry for distributing signals nationally.



•

DIRECT BROADCAST SATELLITE SYSTEMS

- The direct broadcast satellite (DBS) system was designed specifically to be an all-digital system.
Data compression techniques are used to reduce the data rate required to produce high-quality picture and sound.
-To receive the digital video from the satellite, a consumer must purchase a satellite TV receiver and antenna.
- These satellite receivers operate in the Ku band. By using higher frequencies as well as higher-power satellite transponders, the necessary dish antenna can be extremely small. The new satellite DBS system antennas have only an 18-in diameter.

SATELLITE TRANSMISSION

The direct broadcast satellite (DBS) system was designed specifically to be an all-digital system. Data compression techniques are used to reduce the data rate required to produce high-quality picture and sound.

The video to be transmitted must first be placed into digital form. This translates to a total data rate of 202, Mbps which is very high data rate that is hard to achieve reliably.

SATELLITE TRANSMISSION

- To lower the data rate and improve the reliability of transmission, the new DBS system uses compressed digital video. Once the video signals have been put into digital form, they are processed by digital signal processing (DSP) circuits to minimize the full amount of data to be transmitted.

- Digital compression greatly reduces the actual transmitting speed to somewhere in the 20- to 30-Mbps range. The compressed serial digital signal is then used to modulate the uplinked carrier using BPSK.

- The DBS satellite uses the Ku band with a frequency range of 11 to 14 GHz.

- Uplink signals are usually in the 14- to 14.5-GHz range, and the downlink usually covers the range of 10.95 to 12.75 GHz.

- The advantage of using the Ku band is that the receiving antennas are made much smaller for a given amount of gain.

- Disadvantage is these higher frequencies are more affected by atmospheric conditions than are the lower microwave frequencies.