Television

Television as we know it today has hardly changed much since the 1950's. Of course there have been improvements in stereo sound and closed captioning and better receivers for example but compared to advances in the telephone and the computer, television technology has hardly advanced.

The first televisions were in fact mechanical. And were based on a revolving disc invented in 1884 by Paul Nipkow. The disc had holes in it, spiralling into the centre through which an image was scanned and after transmission another disc was needed to reproduce the image.

John Logie Baird (1888 – 1946) gave the first public demonstration in January 27th 1926 of his "noctovision". This used infra red rays to communicate pictures from a darkened room by 1927 he was transmitting signals from London to Glasgow using telephone lines. A year later he used radio waves to transmit pictures between London and New York. His company, Baird Television Development Company, made the first programme for the BBC, broadcast on September 30th 1929.

Electronic television systems lagged behind mechanical systems for several years, mostly because mechanical television was cheaper to build and it didn't use delicate parts. Then Vladimir Zworykin and Philo Farnsworth made some critical breakthroughs and electronic television began to take off in the 1930's. Most televisions in use today use the Cathode Ray Tube (CRT) to display their images. (LCDs and plasma displays are available but are still rare when compared to CRTs). In a CRT the cathode is a heated filament (not unlike the filament in a light bulb). The heated filament is in a vacuum created inside a glass tube. The ray is a stream of electrons that naturally pour off a heated cathode into the vacuum. Electrons are negative. The anode is positive, so it attracts the electrons pouring off the cathode. In a TV's cathode ray tube the stream of electrons is focused by a focusing anode into a tight beam and then accelerated by an accelerating anode. This tight high-speed beam of electrons flies through the vacuum in the tube and hits the flat screen at the other end of the tube. This screen is coated with phosphor, which glows when struck by the beam. There is also a conductive coating inside the tube to soak up the electrons that pile up screen end of the tube.
But this beam has to be 'steered'. This is done by steering coils, which are coils of copper wire wrapped around the tube. These coils are able to create magnetic fields inside the tube, and the electronic beam responds to the fields. One set of coils creates a magnetic field that moves the electronic beam vertically, while another moves the beam horizontally. By controlling the voltages in the coils, you can position the electron beam at any point on the screen.

In a black and white TV, the screen is coated with white phosphor and the electron beam "paints" an image onto the screen by moving the electronic beam across the phosphor a line at a time. This is referred to as a "raster scan". The beam paints one line across the screen from left to right. It then quickly flies back to the left side (horizontal retrace), moves down slightly and

paints another horizontal line, and so on down the screen. When the beam reaches the bottom right of the screen it moves diagonally across the screen back to the top left of the screen (vertical retrace).
When the beam is painting it is on, and when it is flying back, it is off so that it does not leave a trail on the screen. The intensity of the beam changes as it moves from left to right to create different shades of black, grey and white across the screen. There are normally about 480 lines visible on a TV screen from top to bottom.

Standard TV's use "interlacing" to paint the screen. In this technique, the screen is painted 60 times per second but only half of the lines are painted per frame. The beam paints every other line as it moves down the screen, i.e. every odd numbered line. Then, the next time it moves down the screen it paints the even numbered lines, alternating back and forth between even numbered and odd numbered lines on each pass. The entire screen in two passes is painted 30 times every second. The alternative to interlacing is called "progressive scanning", which paints every line on the screen 60 times per second. Most computer monitors use this technique because it significantly reduces flicker.
Because the electron beam is painting all 625 (525 in the USA) 30 times per second, it paints a total of 18,750 lines per second.

The signal sent by a TV station is made up of 3 parts:
"Intensity information" for the beam as it paints each line.
"Horizontal retrace signals " to tell the TV when to move the beam back at the end of each line.
"Vertical retrace signals" 60 times per second to move the beam from bottom right to top left.
A signal containing all three parts is called a "composite video signal".

Colour TV works by using three electronic beams that move simultaneously across whereas black and white only uses one beam. The three electron beams are red, green and blue.
Instead of a single coat of phosphor as in black and white TV the screen is coated with red, green and blue phosphors arranged in dots or stripes.
On the inside of the tube, very close to the phosphor layer there is a thin metal screen called a shadow mask. This mask is perforated with very small holes that are aligned with the phosphor dots (or stripes) on the screen.
To create a red dot the red beam is fired at the red phosphor. The same for the green and blue dots. To create a white dot, red, green and blue beams are fired simultaneously. Turning off all three beams creates black as they scan past the dot. All other colours are combinations of red green and blue.
Black and white uses only a "luminance" signal. To achieve colour TV an extra chrominance signal is added by superimposing 3.579545 MHz sine wave onto the standard black and white signal. Right after the horizontal sync pulse, eight cycles of this sine wave are added as a colour burst. Then a phase shift in the chrominance signal indicates the colour display. The amplitude of the original signal determines the saturation. A black and white TV filters out and ignores the chrominance signal. A colour TV picks it out and

decodes it along with the normal intensity signal, to determine how to modulate the three colour beams.

In analogue TV the composite video signal and sound are separate. (At the back of a VCR the composite video is the yellow and the sound is white and/or red).
There are several ways to get these signals to a TV. They can be broadcast as radio waves to be received through antennae, cable or satellite. They can also be sent via VCR or DVD.

A TV signal alone requires 4MHz of bandwidth. But when the sound is added, a vestigial sideband and a little buffer space then a typical TV signal requires 6MHz.

At the moment we hear a lot about “digital satellite and cable systems” but often this is not really digital TV. This is a normal composite video signal converted to a digital signal, which is received by a set-up box on top of the TV set; it is converted back to an analogue signal for display.
True digital television is completely digital and involves digital cameras, digital transmission and digital display.

One of the main advantages of digital TV over analogue is resolution.
The computer monitor has been the driving force in this regard. If you spend all day at work in front of a computer, and then go home and watch TV the picture can seem very fuzzy compared to the sharpness of a computer monitor. This is because there are about 10 times more pixels on a computer monitor than a television screen. The lowest resolution computer monitor displays 640x480 pixels whereas, because of interlacing the effective resolution on of a TV screen is perhaps 512x400 pixels.
In high-density televisions (HDTV) there are also 720 or 1080 lines of resolution compared to the 625, which as explained, above are in an analogue television.

At the moment broadcasters are mostly transmitting both an analogue and a digital signal before eventually fully changing over to a digital signal. The digital channel carries 19.39 megabit per second (Mbps) stream of digital data that the TV receives and decodes.
The broadcasters have the ability to use this stream in several ways.
The signal could be sent in its full 19.39 Mbps. Alternatively it is possible to split the signal for “multi-casting”. That is four standard definition pictures can be broadcast (i.e. at four streams of 4.85 Mbps each) instead of one high definition picture. This could be done for example during the daytime then at prime time return to one high definition.

The reason that sub channels can be created is because digital TV allows several different formats. Firstly there is standard definition (SD), which is roughly equivalent to analogue TV:
480i – the picture is 704x480 pixels, sent at 60 interlaced frames per second (30 complete frames per second).
480p – the picture is 704x480 pixels, sent at 60 complete frames per second.

Then there are the high definition (HD) signals.
720p – the picture is 1280x720 pixels, sent at complete frames per second.
1080i – the picture is 1920x1080 pixels sent at interlaced frames per second (30 complete frames per second).
1080p – the picture is 1920x1080 pixels, sent at 60 complete frames per second.

(The “p” and the “i” refer to progressive and interlaced. Progressive format means that the picture updates every sixtieth of a second and interlaced means half of the picture updates every sixtieth of a second).
Another example is where newscast showing just a newscaster’s head and shoulders can be transmitted for example at 480p resolution and a 3Mbps bit rate, leaving 16.39Mbps for other sub channels. On the other hand in a sports broadcast for example where there is a lot of movement the broadcast could be made at 1080i using the entire 19.39 Mbps.

Not only video and audio can be transmitted but some of the signal can be used for other forms of data. Television will become interactive, with access to information related to the program being viewed, multimedia games and additional sounds and images being transmitted. Also closed captioning, and descriptive audio for people who are visually or aurally impaired. Although the idea of interactive TV is not new with digital television the signal for interactivity is embedded inside the broadcast signal.

A notable effect of a digital signal is that the quality of the signal does not deteriorate over distance. With analogue TV the signal weakens the further the receiver is from the transmitter and the picture gets subsequently worse. But with digital, although the signal weakens with distance as well, the picture quality remains perfect until the signal becomes too weak for the receiver to pick up. (In a digital signal, a one is always a one and a zero is always a zero).

The increased picture detail and higher quality sound needs to be squeezed into the same 6 MHz bandwidth as used for analogue TV. To do this Digital TV use MPEG-2 compression. This is already industry standard for DVD video for example. It takes advantage of how the eye perceives colour and motion variations. Inside each frame, an MPEG-2 encoder records just enough detail to make it look like nothing is missing. The encoder also compares adjacent frames and only records the sections of the picture that have moved or changed. If only a small section of the picture changes the MPEG-2 encoder only changes that area and leaves the rest of the picture unchanged. On the next frame in the video, only that section of the picture is changed. MPEG-2 is a “lossy” compression method and reduces the amount of data by about 55 to1.

What is also going to change with digital TV is the aspect ratio of the screen. The aspect ratio of analogue television is 4:3. (A standard that dates back to 1889). Digital TV has an aspect ratio of 16:9 (1.78:1) which is closer to that used in cinema theatres, typically 1.85:1. [Also standard 35mm film used by a typical TV show has an aspect ratio of 1.37:1 and a standard TV screen has 1.33:1 (4:3) so the conversion is not so difficult]

The sound quality improves greatly with digital TV. Especially in America, where HDTV uses Dolby Digital/AC-3 audio encoding system. This is the same digital sound used in most cinema theatres, DVDs, and many home theatre systems since the early 1990's. It can include up to 5.1 channels of sound: three in front, two to the rear and a subwoofer base, (that's the .1 channel). (In the UK only 2 channels will be available for sound).

To sum up, although the advancements in television have been relatively slow over the last 60 years when compared to other technologies there have been considerable developments in the recent past. The arrival of digital also TV raises the potential of 'the box' to becoming more than just a source of entertainment and information. The Television could possibly become a more integrated part of the computer world giving the viewer a more interactive experience.

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