SATELLITE COMMUNICATIONS STUDY

By

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FINAL REPORT

Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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CERTIFICATION OF ORIGINALITY

s is to certify that I am responsible for the work submitted in this project, that the original k is my own expect as specified in the references and acknowledgements, and the original k contained herein have not been undertaken or done by unspecified sources or persons.

n Hirman Firdaus Bin Wan Zabidi

ABSTRACT

Satellite communication systems have become an essential part of the world‘s telecommunication infrastructure, serving billions of people with telephone, data and video services. Despite the growth of fiber optic links, which have much greater capacity than satellite systems and a lower cost per bit, satellite systems continue to thrive and investment in new systems, continues. Satellite services have shifted away from telephony toward video and data delivery, with television broadcasting directly to the home emerging as one of the most powerful applications.

The objective of this project is to study satellite communications study through experiments and MATLAB simulation for QPSK as satellite modulation techniques. The experiments carried out were on TVRO board and weather satellites. Factors involved in determining actual signals from a broadcast television signal and tuning foreign television channels. Satellite footprints prediction is also has been carried on weather satellite experiments. It also shows the location of satellite within a certain time interval and indicates the area covered by a satellite. Besides that, the study on Global Positioning Systems (GPS) using Earth.Google also been conducted. It shows satellite images combined with maps and aerial photographs depends on medium or high resolution terrain data. In satellite modulation techniques which are QPSK, a MATLAB coding has been developed and the study on demodulator and modulator has also been considered.

Geostationary Earth Orbit (GEO) satellites carry the majority services, because the use of high gain fixed antennas at earth stations maximizes the capacity of the satellites. Over the years, there has been a trend away from trunk communications using very large earth station antennas toward delivery from more powerful satellites to individual users using much smaller antennas. Low Earth orbit (LEO) and Medium Earth Orbit (MEO) satellites are used for mobile communications and navigation system and, as the need for Geographic Information Systems grows with a variety of applications, LEO earth imaging satellites have the potential to provide strong revenue streams.

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INTRODUCTION

This chapter serves a background study of satellite communications systems which consists four main layers of satellite orbits which is the GEO, LEO, MEO and HEO. It also gives a brief idea what are the Global Positioning System (GPS) and its operation. Besides that, an overview of satellite communications system which emphasis on the study of television receiver is also been introduced. The basic idea of modulation techniques that been used in satellite communication which is Frequency Modulation (FM) and Binary Phase Shift Keying (BPSK) is also been included in this chapter.

The satellite system is composed of a space segment, a control segment and a ground segment:

- The space segment contains one or several active and spare satellites organized in a constellation.
- The control segment consists of all ground facilities for the control and monitoring of the satellites, also named TTC (tracking, telemetry and command) stations, and for the management of the traffic and the associated resources onboard the satellite.
- The ground segment consists of all the traffic earth stations. Depending on the type of service considered, these stations can be different size, from a few centimeters to tens of meters.

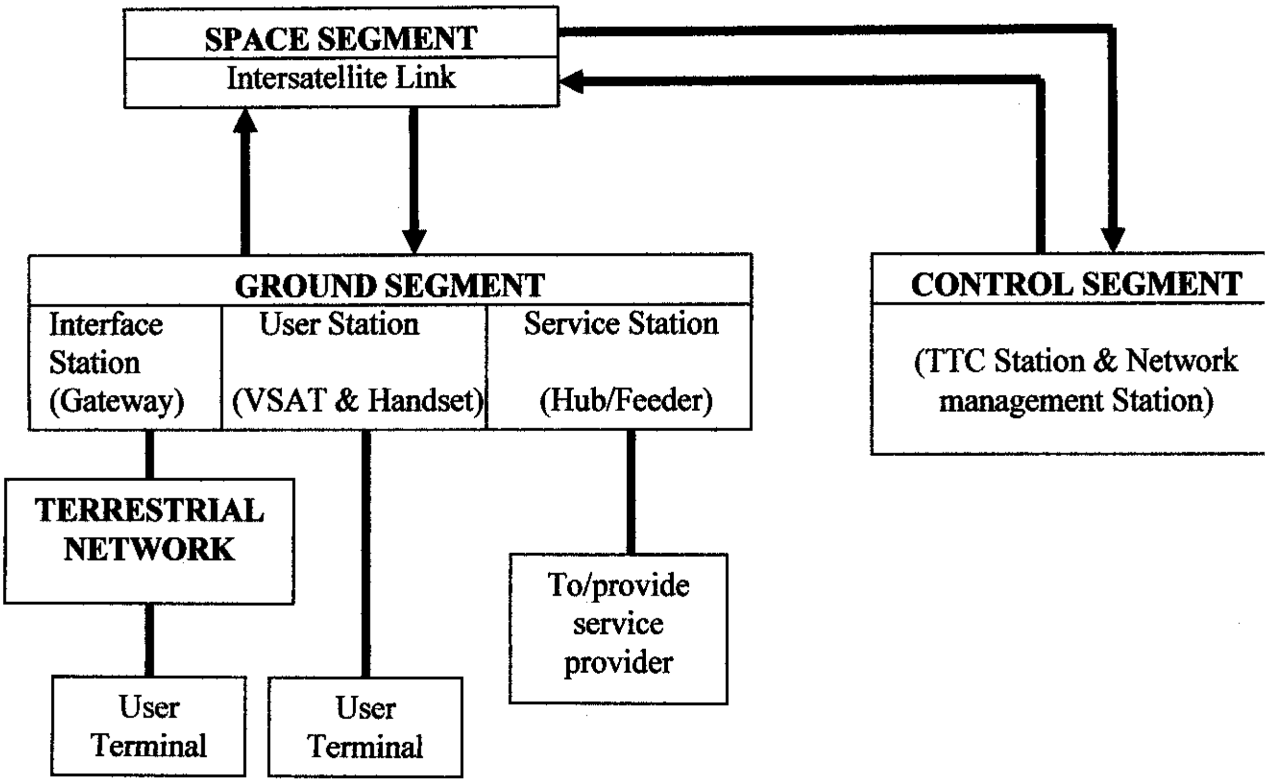


Figure 1: Satellite communications system and interfacing with terrestrial entities [1]

1.1 BACKGROUND OF STUDY

Satellite communication systems were originally developed to provide long-distance telephone service. In the late 1960s, launch vehicles had been developed that could place a 500 kg satellite in geostationary earth orbit (GEO), with a capacity of 5000 telephone circuits, marking the start of an area of expansion for telecommunication satellites. Geostationary satellites were soon carrying transoceanic and transcontinental telephone calls. For the first time, lives television links could be established across the Atlantic and Pacific oceans to carry news and sporting events.

1.1.1 Geostationary Earth Orbits (GEO)

At an altitude of 35,786km above the Equator, the angular velocity of a satellite in this orbit matches the angular rate of rotation of the Earth's surface. This makes the satellite appear stationary to an observer on the Earth. This useful feature has resulted in the orbit becoming extremely popular, and satellite spacing in the orbit is at the limits of terrestrial antenna discrimination (the angle between orbital slots has gradually narrowed from 3° to 2° and occasionally 1.5°)

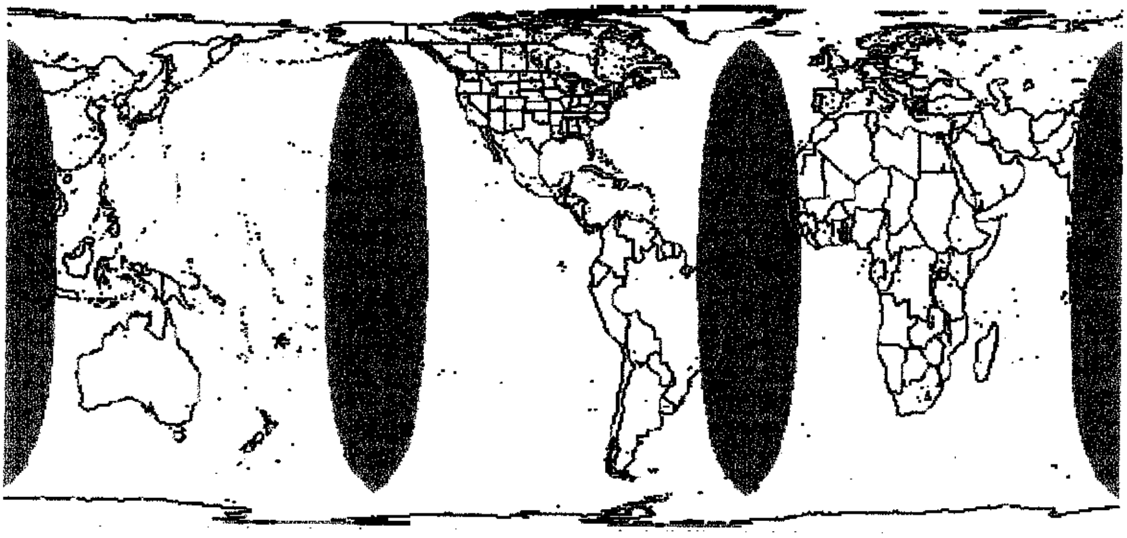


Figure 2: Near-global coverage from Clarke geostationary constellation (SaVi) [6]. Cylindrical projection, showing maximum range of visibility (minimum elevation angle<1°)

Coverage of high latitudes is impossible above 81° latitude and rarely possible above 75°, so full Earth coverage cannot be achieved by using any purely geostationary constellation. However, much of the Earth can be covered with a minimum of three geostationary satellites (figure 2).

Propagation delay between an earth station and a geostationary satellite varies with the difference in position in longitude and terminal latitude, but is around 125ms (milliseconds), or around 250ms between ground stations. This leads to the widely-quoted half-second round-trip latency for communications via geostationary satellite.

1.1.2 Low Earth Orbits (LEO)

At altitudes of typically between 500 and 2000km, lying beyond the upper atmosphere but below the peaks of the inner Van Allen radiation belt, a large number of satellites are required to provide simultaneous global coverage in low earth orbit. The actual number of satellites used depends upon the coverage required and upon the minimum elevation angle desired for communication. These determine the degree of atmosphere-induced slant loss permitted, and dimension the resulting link budget.

With a large number of satellites and their resulting small footprint areas (shown for the Boeing Teledesic design in Figure 3) and small spot beam coverage areas, large amounts of frequency reuse become possible across the Earth, providing large system capacity.

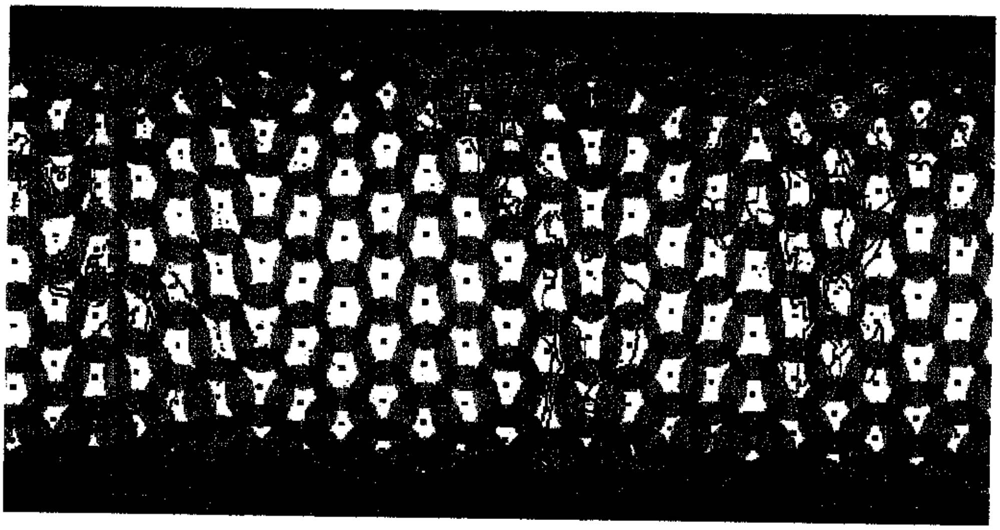


Figure 3: Global coverage from Boeing Teledesic LEO constellation (SaVi) [6].Cylindrical projection, using minimum elevation angle of 40°.

LEO satellites move rapidly relative to the surface of the Earth and to the ground terminals that they communicate with. Speeds at over 25,000 km/hour, with visibility of only a few minutes before handover to another satellite occurs, are the norm. Propagation delay between ground and LEO is often under 15ms, and varies rapidly as the satellite approaches and leaves local zenith while passing the ground terminal.

1.1.3 Medium Earth Orbits (MEO)

At altitudes of between 9,000 and 11,000km, between the inner and outer Van Allen belts, these orbits can permit full Earth coverage with fewer, larger satellites. The satellites have larger coverage footprints from the increased altitude, but also increased resulting delay. Movement is slower, with visibility times of tens of minutes before handover must take place. Propagation delay for the uplink or downlink between earth station and satellite is typically under 40ms. (Hughes' Spaceway NGSO MEO proposal is shown in Figures 4 and 5).

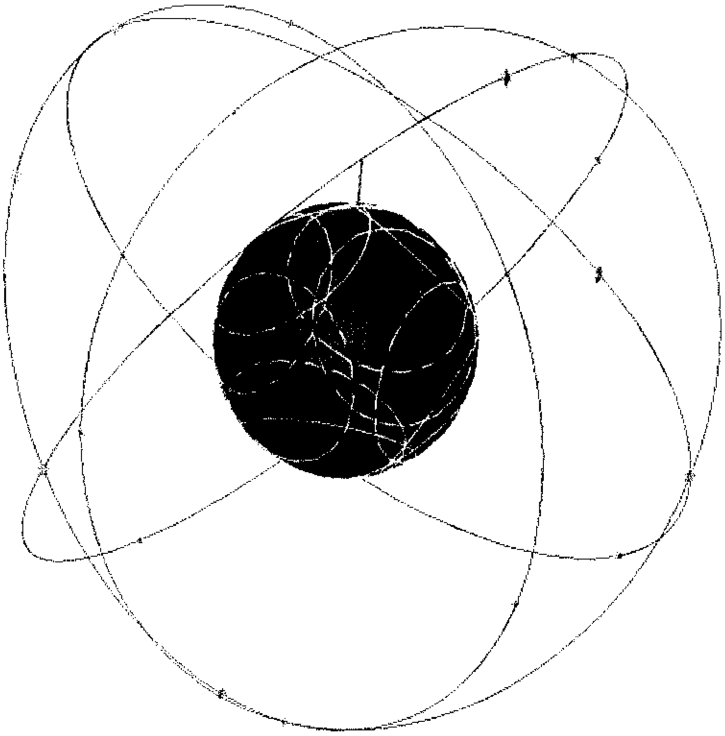


Figure 4: MEO Spaceway NGSO constellation at a moment in time (SaVi) [6]

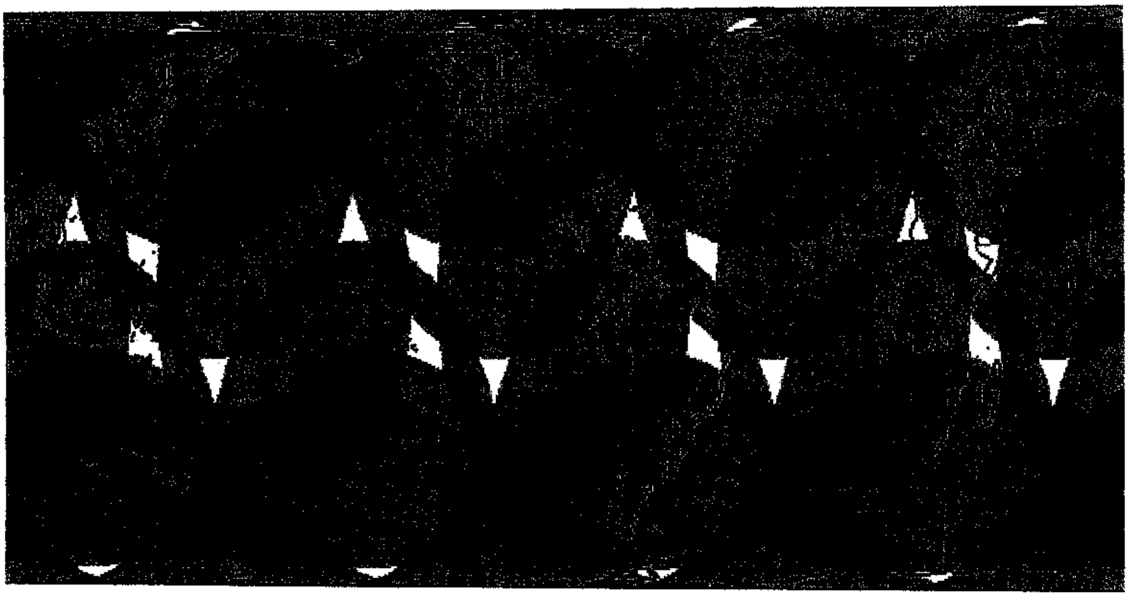


Figure 5: Global coverage from Spaceway NGSO MEO constellation (SaVi) [6]. Cylindrical projection, using minimum elevation angle of 30° [FCCSpacewayNGSO]

1.1.4 Highly Elliptical Orbits (HEO)

Use of elliptical orbits differs from the continuous-though-moving coverage of circular orbits. Coverage for communications services from elliptical orbits is generally only provided when the satellite is moving very slowly relative to the ground while at apogee, furthest from the Earth's surface, and power requirements in link budgets are dimensioned for this large distance.

When the satellite moves from near high apogee to low perigee and back at varying speed in accordance with Kepler's third law, its coverage area zooms in size, and service is generally disabled. (Other satellites in the constellation are nearing apogee in their own orbits and providing service coverage in its place as the Earth rotates). The satellite's electronics may even be shut down to protect them from damage while passing through the Van Allen radiation belts.

Useful elliptical orbits are inclined at 63.4 ° to the Equator, so that orbital motion near apogee appears to be stationary with respect to the Earth's surface. High inclination and high altitude enable coverage of high latitudes.

Use of Molnya (or Molniya) and Tundra elliptical orbits is now well established for providing satellite television services targeted to the high-latitude states of the former Soviet Republic (Figures 6 and 7)

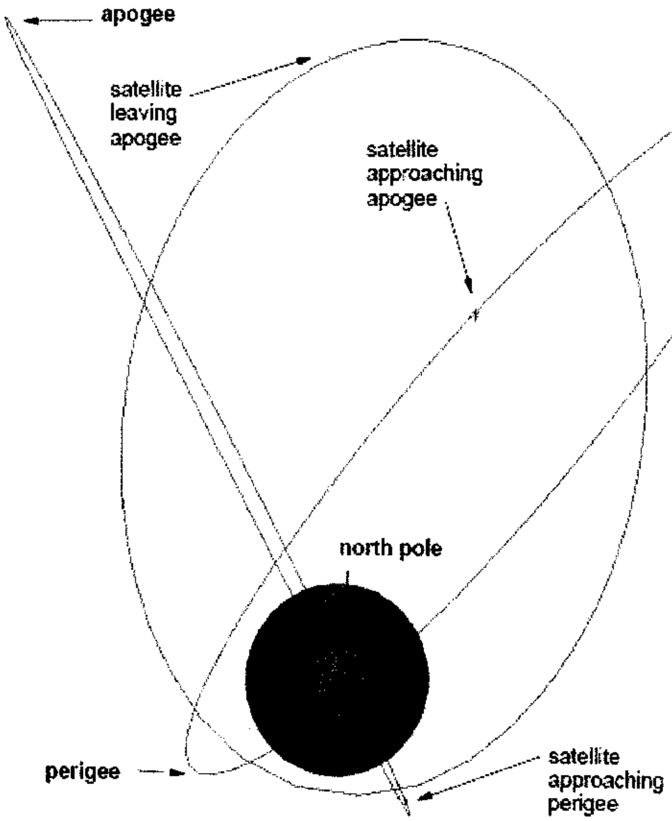


Figure 6: HEO LOOPUS constellation at a moment in time (SaVi) [6]

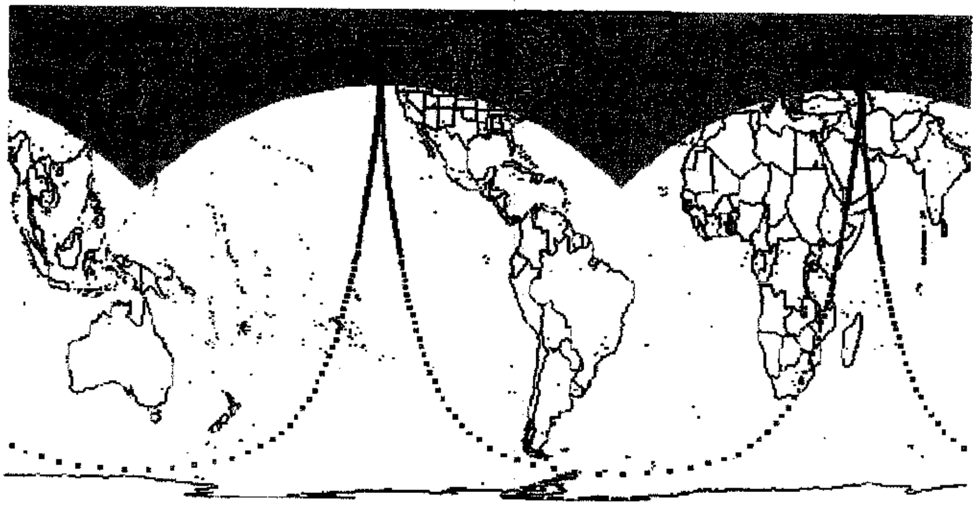


Figure 7: LOOPUS 3-satellite Molnya constellation [as in Dondl84] (SaVi) [6]. Repeating shared-ground track plot at 60s intervals shows apogee loops and higher speeds at perigee. One satellite is near perigee, moving to replace the satellite over Asia as it begins to leave apogee. Cylindrical projection, showing maximum range of visibility (minimum elevation angle<1°)

1.1.5 Global Positioning System (GPS)

GPS makes it possible to answer the simple question "Where am I?" almost instantaneously and with breathtaking precision. The new technology utilizes atomic clocks that keep time to within a billionth of a second. They were created by scientists who had no idea that the clocks would someday contribute to a global system of navigation. The system made its public debut to rave reviews in the 1991 Gulf War. U.S. troops used it for navigation on land, sea, and in the air, for targeting of bombs, and for on-board missile guidance. GPS allowed U.S. ground troops to move swiftly and accurately through the vast, featureless desert of the Arabian Peninsula. Since then, GPS technology has moved into the civilian sector.

Today, GPS is saving lives, helping society in many other ways, and generating jobs in a new multi-billion-dollar industry. Advances in integrated-circuit technology - the technology used to make computer chips - soon will lead to GPS receivers and transmitters the size of credit cards, so small and so inexpensive that virtually any vehicle can have one installed and any person can carry one.

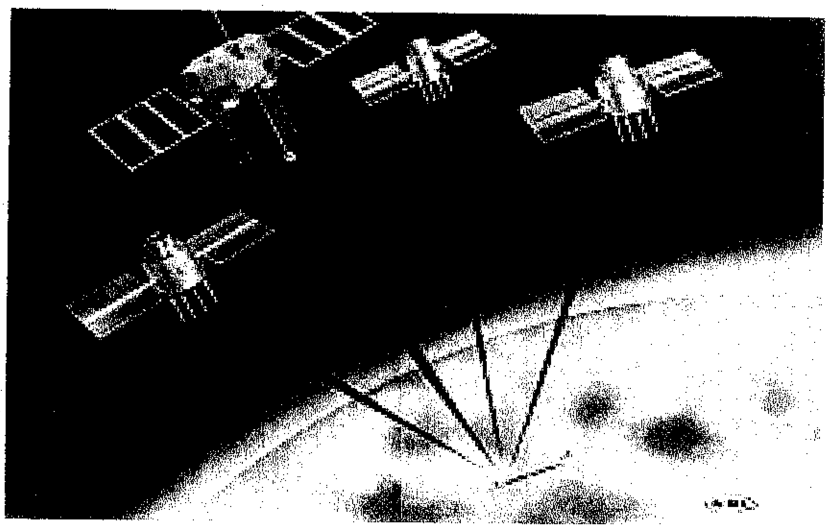


Figure 8: Satellite in Navstar Global Positioning System configuration [14]

1.1.5.1 Operation of the Global Positioning System

The goal of the Global Positioning System (GPS) is to determine your position on Earth in three dimensions: east-west, north-south, and vertical (longitude, latitude, and altitude). Signals from three overhead satellites provide this information.

Each satellite sends a signal that codes where the satellite is and the time of emission of the signal. The receiver clock times the reception of each signal, then subtracts the emission time to determine the time lapse and hence how far the signal has traveled (at the speed of light).

This is the distance the satellite was from you when it emitted the signal. In effect, three spheres are constructed from these distances, one sphere centered on each satellite. You are located at the single point at which the three spheres intersect.

Of course there is a wrinkle: The clock in your hand-held receiver is not nearly so accurate as the atomic clocks carried in the satellites. For this reason, the signal from a fourth overhead satellite is employed to check the accuracy of the clock in your hand-held receiver. This fourth signal enables the hand-held receiver to process GPS signals as though it contained an atomic clock.

1.1.5.2 GPS applications

In just a few short years, applications for GPS already have become almost limitless:

i. Emergency vehicles use GPS to pinpoint destinations and map their routes.
ii. GPS is used to locate vessels lost at sea.
iii. Trucking and transportation services use GPS to keep track of their fleets and to speed deliveries.
iv. Shipping companies equip their tankers and freighters with GPS for navigation and to record and control the movement of their vessels.
v. Pleasure boaters and owners of small commercial vehicles rely on GPS for navigation.
vi. Civilian pilots use GPS for navigation, crop-dusting, aerial photography, and surveying.

vii. Airlines have saved millions of dollars by using GPS to hone their flight plans; GPS can be used for instrument landing at small, as well as large, airports and is making new air-avoidance systems possible.

viii. GPS is used regularly for mapping, measuring the earth, and surveying. GPS has been used to map roads, to track forest fires, and to guide the blades of bulldozers in construction processes, making grading accurate to within a few inches.

ix. Earth scientists use GPS to monitor earthquakes and the shifting of the earth's tectonic plates.

x. Telecommunications companies increasingly rely on GPS to synchronize their land-based digital networks, comparing their reference clocks directly with GPS time.

xi. Satellite builders use GPS receivers to track the positions of their satellites.

xii. GPS is being installed in automobiles so that drivers not only can find out where they are but also can be given directions. In Japan, 500,000 automobiles have already been equipped with a GPS-based navigation system.

That's just the beginning. The current worldwide market for GPS receivers and technology is estimated at over $2 billion and is expected to grow to over $30 billion in the next 10 years.

1.2 SATELLITE COMMUNICATIONS

One of the most common methods of TV signal distribution is via communications satellite. A communications satellite orbits around the equator about 22,300 miles out in space. It rotates in synchronism with the earth and therefore appears to be stationary. The satellite is used as a radio relay station (Figure 9).The TV signal to be distributed is used to frequency-modulate a microwave carrier, and then it is transmitted to the satellite. The path from earth to the satellite is called the uplink. The satellite translates the signal to another frequency and the retransmits it back to earth. This is called downlink. A receive site on earth picks up the signal.

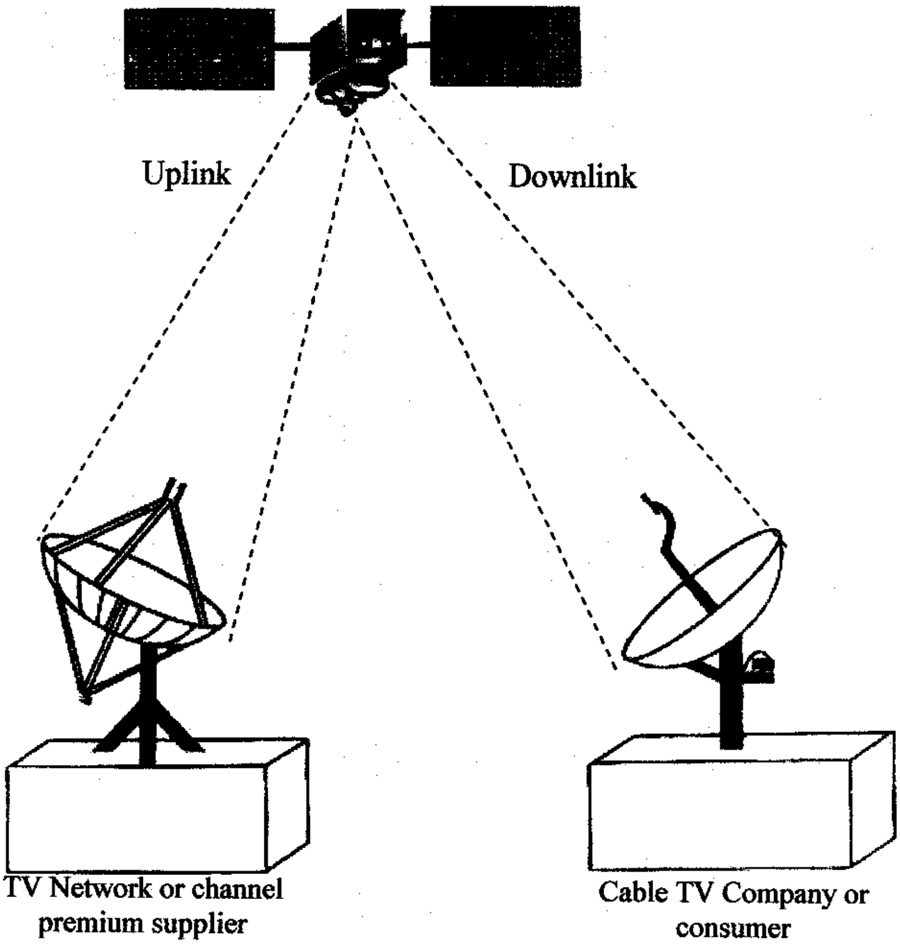


Figure 9: Satellite Television distributions [4].

1.2.1 Television signal

A considerable amount of intelligence is contained in a complete TV signal. As a result, the signal occupies a significant amount of spectrum. The TV signal consists of two main parts: the sound and the picture. The sound is usually stereo, and the picture carries color information as well as the synchronizing signals that keep the receiver in step with the transmitter.

1.2.2 Signal Bandwidth

The complete signal bandwidth of a TV signal (Figure 10). The entire TV signal occupies a channel in the spectrum with a bandwidth of 6 MHz. There are two carriers, one each for the picture and the sound.

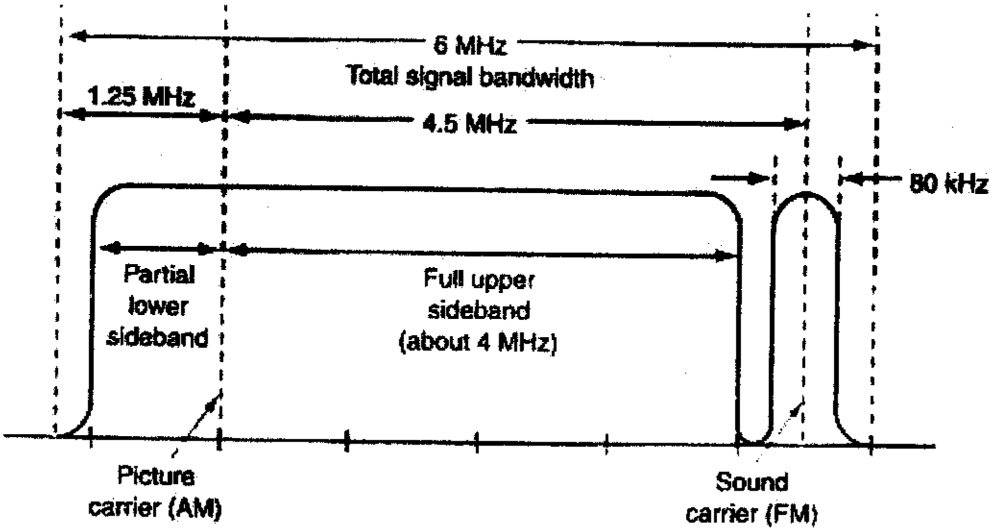


Figure 10: Spectrum of a broadcast TV signal. [4]

1.2.3 Audio Signal

The sound carrier is at the upper end of the spectrum. Frequency modulation is used to impress the sound signal on the carrier. The audio bandwidth of the signal is 50 Hz to 15 kHz. The maximum permitted frequency deviation is 25 kHz, considerably less than the deviation permitted by conventional Frequency Modulation (FM) broadcasting. As a result, a TV sound signal occupies somewhat than a standard FM broadcast station. Stereo sound is also available in TV, and the multiplexing method used to transmit two channels of sound information is virtually identical to that used in stereo transmission for FM broadcasting.

1.2.4 Video Signal

The picture information is transmitted on a separate carrier located 4.5 MHz lower in frequency than the sound carrier (Figure 10). The video signal derived from a camera is used to amplitude-modulate the picture carrier. Different methods of modulation are used for both sound and picture information so that there is less interference between the picture and sound signals. Further, amplitude modulation of the carrier takes up less bandwidth in the spectrum, and this is important when a high-frequency, content-modulation signal such as video is to be transmitted.

Figure 11 that vestigial sideband AM is used. The full upper sidebands of the picture information are transmitted, but a major portion of the lower sidebands is suppressed to conserve spectrum space. Only a vestige of the lower sideband is transmitted.

The color information in a picture is transmitted by way of FDM techniques. Two color signals derived from the camera are used to modulate 3.85 MHz subcarrier which, in turn, modulates the picture carrier along with the main video information. The color subcarriers use double-sideband suppressed carrier AM.

The video signal can contain frequency components up to about 4.3 MHz. Therefore, if both sidebands were transmitted simultaneously, the picture signal would occupy 8.4 MHz. The vestigial sideband transmission reduces this excessive bandwidth.

1.2.5 TV Spectrum Allocation

Because a TV signal occupies so much bandwidth, it must be transmitted in a very high frequency portion of the spectrum. TV signals are assigned to frequencies in the VHF and UHF range. U.S. TV stations use the frequency range between 54 and 806 MHz. This portion of the spectrum is divided into 68 6 MHz channels that are assigned frequencies. Table 1, 2 and 3 shows the frequency range of each TV channel, VHF and UHF TV channel frequency assignments.

To find exact frequencies of the transmitter and sound carriers, use figure 10.To compute the picture carrier, add 1.25 MHz to the lower frequency of range given in Fig. For example, for channel 6, the lower frequency is 82MHz. The picture carrier is 82 + 1.25, or 8.35MHz. The sound carrier is 4.5 MHz higher, or 83.25 + 4.5, that is, 87.75 MHz.

Table 1: Low band VHF [4]

Channel	Frequency MHz
2	54-60
3	60-66
4	66-72
5	76-82
6	82-88
FM Broadcast	88-108
Aircraft	118-135
Ham Radio	144-148
Mobile or marine	150-173

Table 2: High Band VHF [4]

Channel	Frequency MHz
7	174-180
8	180-186
9	186-192
10	192-198
11	198-204
12	204-210
13	210-216

Table 3: UHF channel [4]

Channel	Frequency MHz	Channel	Frequency MHz
14	470-476	42	638-644
15	476-482	43	644-650
16	482-488	44	650-656
17	488-494	45	656-662
18	494-500	46	662-668
19	500-506	47	668-674
20	506-512	48	674-680
21	512-518	49	680-686
22	518-524	50	686-692
23	524-530	51	692-698
24	530-536	52	698-704
25	536-542	53	704-710
26	542-548	54	710-716
27	548-554	55	716-722
28	554-560	56	722-728
29	560-566	57	728-734
30	566-572	58	734-740
31	572-578	59	740-746
32	578-584	60	746-752
33	584-590	61	752-758
34	590-596	62	758-764
35	596-602	63	764-770
36	602-608	64	770-776
37	608-614	65	776-782
38	614-620	66	782-788
39	620-626	67	788-794
40	626-632	68	794-800
41	632-638	69	800-806
		Cellular telephone	806 – 902

1.2.6 Generating the Video Signal

The video signal is most often generated by a TV camera, a very sophisticated electronic device that incorporates lenses and light-sensitive transducers to convert the scene or object to be viewed into an electrical signal that can be used to modulate a carrier. All visible scenes and objects are simply light that has been reflected and absorbed and then transmitted to our eyes. It is the purpose of the camera in a scene and converts them into an electrical signal.

To do this, the scene to be transmitted is collected and focused by a lens upon a light-sensitive imaging device. Both vacuum tube and semiconductor devices are used for converting the light information in the scene into an electrical signal. Some examples are the vidicon tube and the charged-coupled device (CCD) so widely used in camcorders and all modern TV cameras.

The scene is divided into smaller segments that can be transmitted serially over a period of time. Again, it is the job of the camera to subdivide the scene in an orderly manner so that an acceptable signal is developed. This process is known as scanning.

1.2.7 Principles of Scanning

Scanning is technique that divides a rectangular scene into individual lines. The standard TV scene dimensions have an aspect ratio 4:3; that is, the scene width is 4 units for every 3 units of height. To create a picture, the scene is subdivided into many fine horizontal lines called scan lines. Each line represents a very narrow portion of light variations in the scene. The greater the number of lines, the higher the resolution and the greater the detail that can be observed. U.S. TV standards call for the scene to be divided into a maximum of 525 horizontal lines.

Figure 12 is a simplified of the scanning process. In this example, the scene is a large black letter F on a white background. The task of the TV camera is to convert this scene into an electrical signal. The camera accomplishes this by transmitting a voltage of 1 V for black and 0 V for white. The scene is divided into 15 scan lines numbered 0 through 14. The scene is focused on the light-sensitive area of a vidicon tube or CCD imaging device which scans the scene 1 line at a time, transmitting the light variations along that line as voltage levels. Figure 13 shows the light variations along several of the lines. Where the white background is being scanned, a 0 V signal occurs. When a black picture element encountered, a 1 V level is transmitted. The electrical signals derived from each scan line are referred to as the video signal. They are transmitted serially one after the other until the entire scene has been sent (Figure 11).This is exactly how a standard TV picture is developed and transmitted.

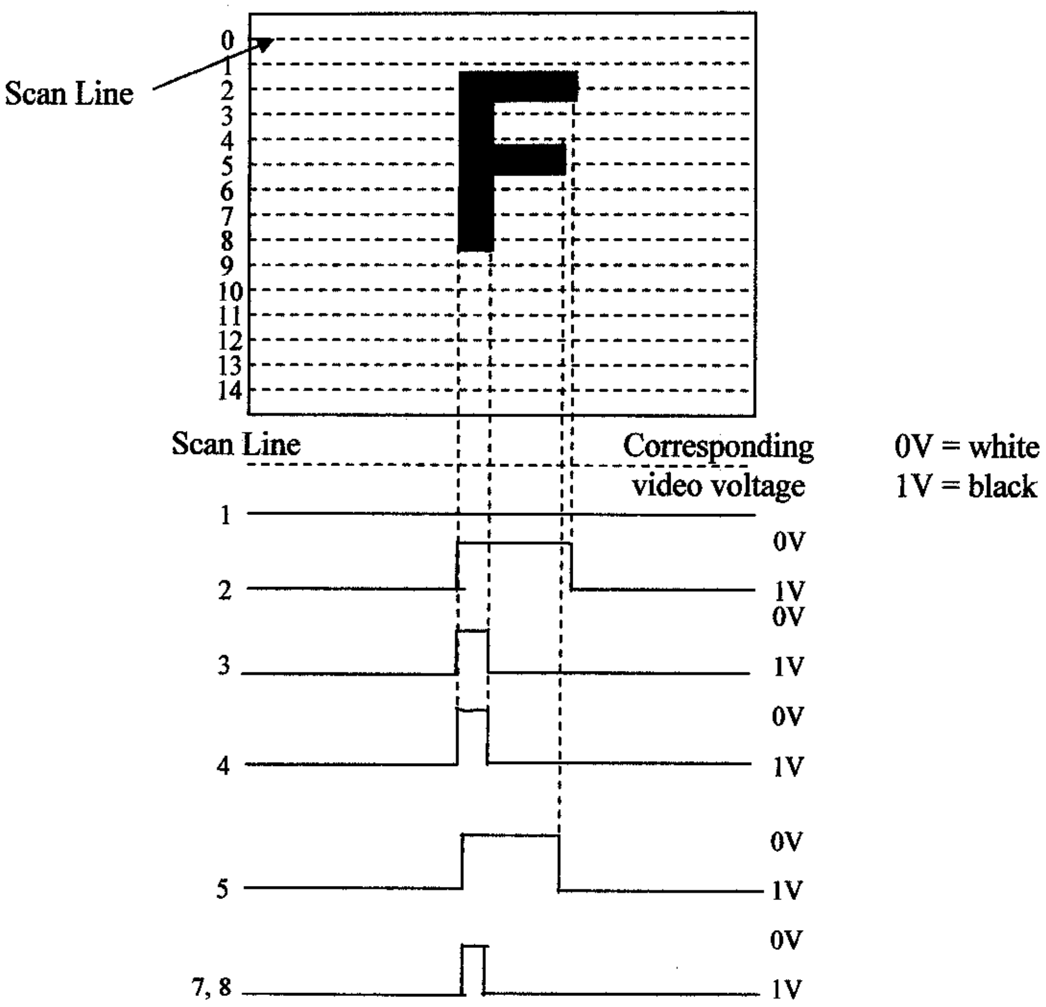


Figure 11: Simplified explanation of scanning [4]

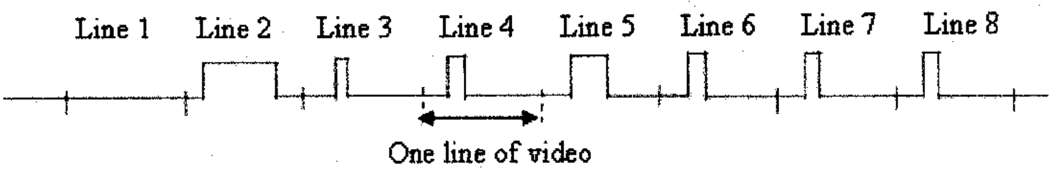


Figure 12: Scan voltages are transmitted serially [4]

Since the scene contains colors, there are different levels of light along each scan line. This information is transmitted as different shades of gray are represented by some voltage level between the 0- and 1-V extremes represented by white and black. The resulting signal is known as the brightness, or luminance, signal and is usually designated by the letter Y.

A more detailed illustration of the scanning process is given in figure 13. The scene is scanned twice. One complete scanning of the scene is called a field and contains $262\frac{1}{2}$ lines. The entire field is scanned in 1/60 of a second for a 60-Hz field rate. In color TV the field rate is 59.94 Hz. Then the scene is scanned a second time, again using $262\frac{1}{2}$ lines. This second field is scanned in such a way that its scan lines fall between those of the first field. This produces what is known as interlaced scanning, with a total of $2 \times 262\frac{1}{2} = 525$ lines. In practice, only about 480 lines show on the picture tube screen. Two interlaced fields produce a complete frame of video. With the field rate being 1/60 of a second, two fields produce a frame rate of 1/30 of a second, or 30 Hz. The frame rate in color TV is one-half the field rate, or 29.97 Hz. Interlaced scanning is used to reduce flicker, which is annoying to the eye.

This rate is also fast enough that the human eye cannot detect individual scan lines, which results in a stable picture.

The rate of occurrence of the horizontal scan lines is 15,750 Hz for monochrome, or black and white, TV and 15,734 Hz for color TV. This means that it takes about 1/ 15,734 s, or 63.6 μs, to trace out 1 horizontal scan line.

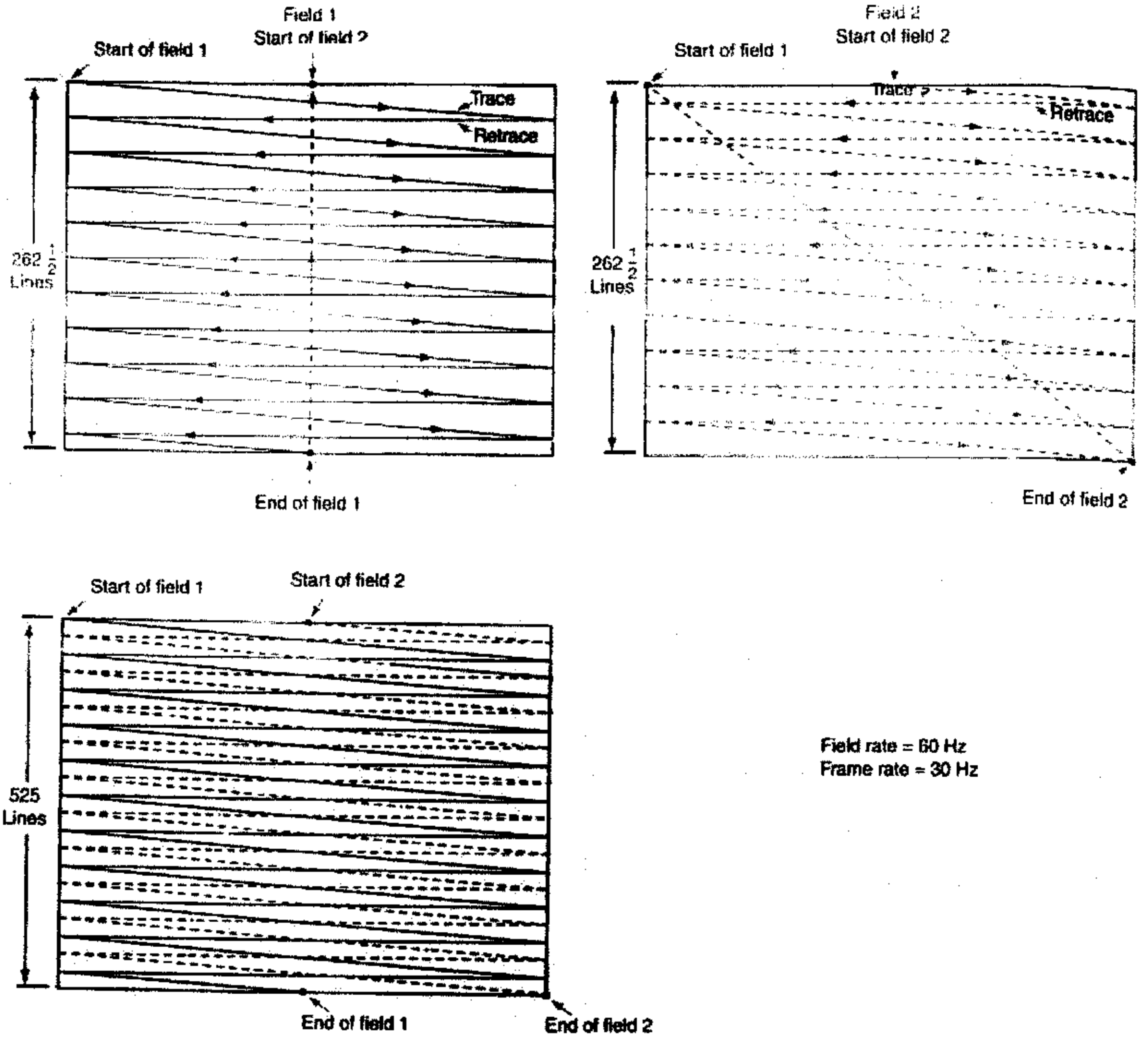


Figure 13: Interlaced scanning is used to minimize flicker [4]

At the TV receiver, the picture tube is scanned in step with the transmitter to accurately reproduce the picture. To ensure that the receiver stays exactly in synchronization with the transmitter, special horizontal and vertical sync pulses are added to and transmitted with the video signal (Figure 14). After 1 line has been scanned, a horizontal blanking pulse comes along. At the receiver, the blanking pulse is used to cut off the electron beam in the picture tube during the time the beam must retrace from right to left to get ready for the next left to right scan line. The horizontal sync pulse is used at the receiver to keep the sweep circuits that drive the picture tube in step with the transmitted signal. The width of the horizontal blanking pulse is about 10 μs. Since the total horizontal period is 63.6 μs only about 53.5 μs is devoted to the video signal.

At the end of each field, the scanning must retrace from the bottom to the top of the scene so that the next field can be scanned. This is initiated by the vertical blanking and sync pulses. The entire vertical pulse blanks the picture tube during the vertical retrace. The pulses on top of the vertical blanking pulse are the horizontal sync pulses that must continue to keep the horizontal sweep in sync during the vertical retrace. The equalizing pulses help synchronize the half scan lines in each field. Approximately 30 to 40 scan lines are used up during the vertical blanking interval. Therefore, only 480 to 495 lines of actual are shown on the screen.

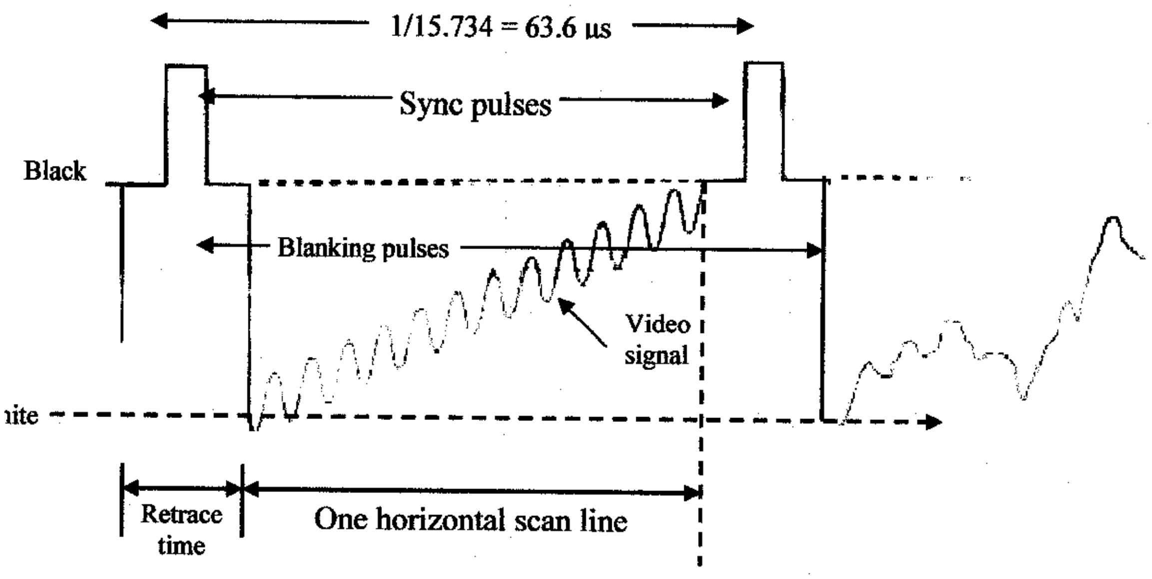


Figure 14: Sync pulses are used to keep the receiver in step with the transmitter [4]

1.2.8 Color Signal Generation

The video signal as described so far contains the video or luminance information, which is a black-and-white version of the scene. This is combined with the sync pulses. Now the color detail in the scene must somehow be represented by an electrical signal. This is done by dividing the light in each scan line into three separate signals, each representing on of the three basic colors, red, green, or blue. It is principle of physics that any color can be made by mixing some combination of the three primaries light colors (Figure 15).

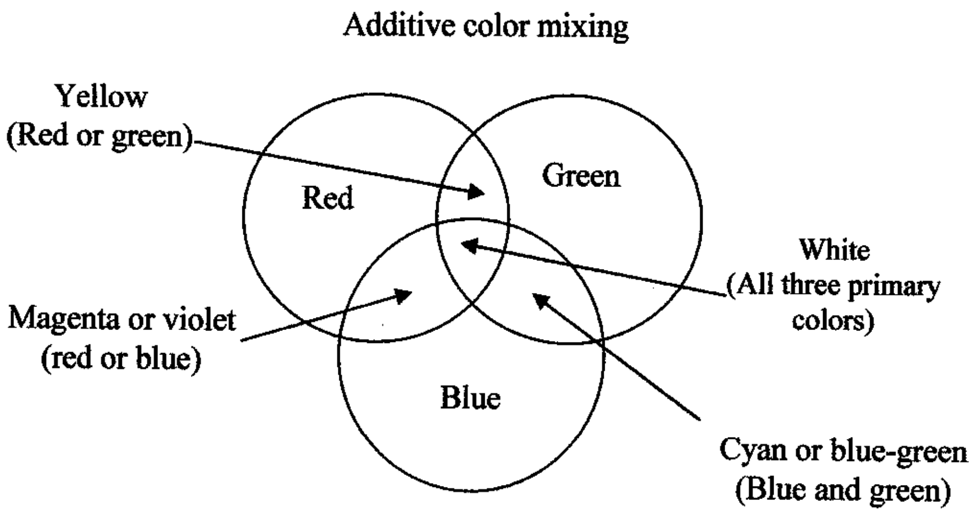


Figure 15: Creating other colors with red, green, and blue light [4]

In the same way, the light in any scene can be divided into its three basic color components by passing the light through red, green, and blue filters. This is done in a color TV camera, which is really three cameras in one (Figure 16). The lens focuses the scene on three separate light-sensitive devices such as a vidicon tube or a CCD imaging device by way of a series of mirrors and beam splitters. The red light in the scene passes through the red filter, the green through the green filters and blue through the blue filter. The result is the generation of three simultaneous signals (R, G, and B) during the scanning process by the light-sensitive imaging devices.

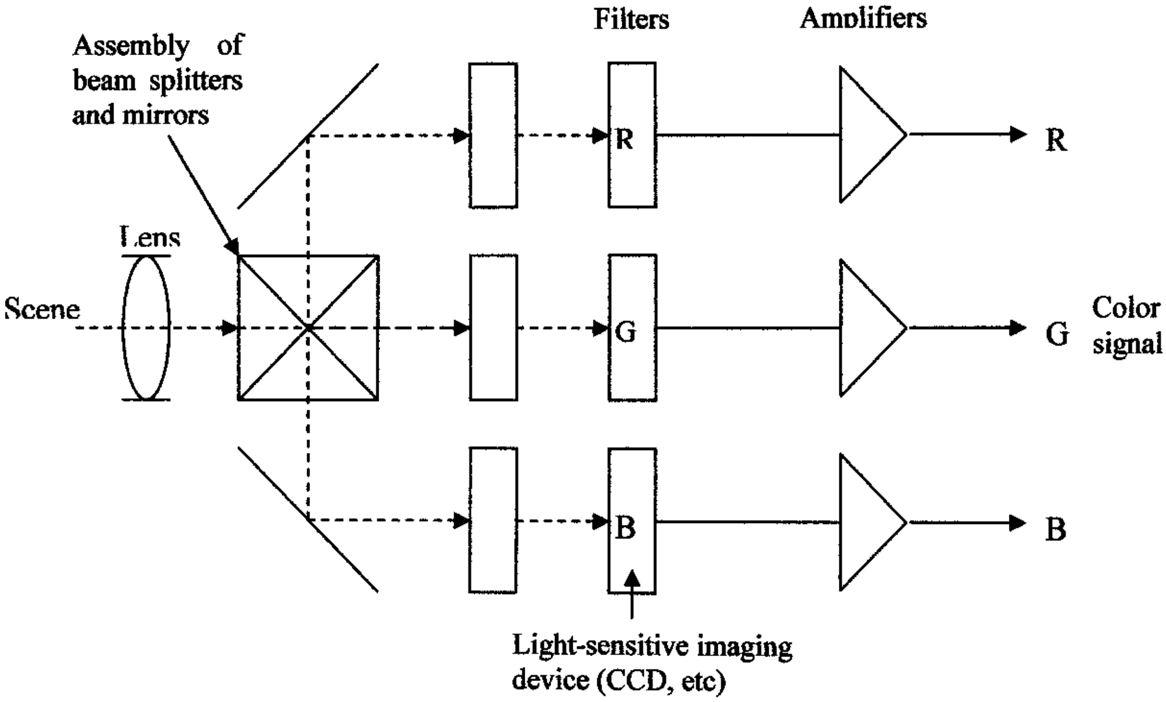


Figure 16: How the camera generates the color signals

The R, G, and B signals also contain the basic brightness or luminance information. If the color signals are mixed in the correct proportion, the result is the standard black and white video or luminance Y signal. The Y signal is generated by scaling each color signal with a tapped voltage divider and adding the signals together as shown in figure 16. The Y signal is made up of 30 percent red, 59 percent green, and 11 percent blue. The resulting Y signal is what a black and white TV set will see.

The color signal must be also be transmitted along with the luminance information in the same bandwidth allotted to the TV signal. This is done by a frequency-division multiplexing technique shown in Figure 18. Instead of all three color signals being transmitted, they are combined into color signals referred to as the I and Q signals. These signals are made of different proportions of the R, G, and B signals according to the following specifications:

Table 4: Red, Green and Blue Specifications for I and Q signals [4]

Signals	Red	Green	Blue
I	60 %	-28 %	-32 %
Q	21 %	-52 %	31 %

The minus signs in the given expressions mean that the color signal has been phase-inverted before the mixing process.

The I and Q signals are referred to as the chrominance signals. To transmit them, they are phase encoded; that is, they are used to modulate a subcarrier which is in turn mixed with the luminance signal to form a complete, or composite, video signal. These I and Q signals are fed to balanced modulators along with 3.58 MHz subcarrier signals that are 90° out of phase (Figure 17). This type of modulation is referred to as quadrature modulation, where quadrature means a 90° phase shift. The output of each balanced modulator is a sideband suppressed carrier AM signal. The resulting two signals are added to the Y signal to create the composite video signal. The combined signal modulates the picture carrier. The resulting signal is called the National Television Standards Committee (NTSC) composite video signal. This signal and its sidebands are within 6 MHz TV signal bandwidth.

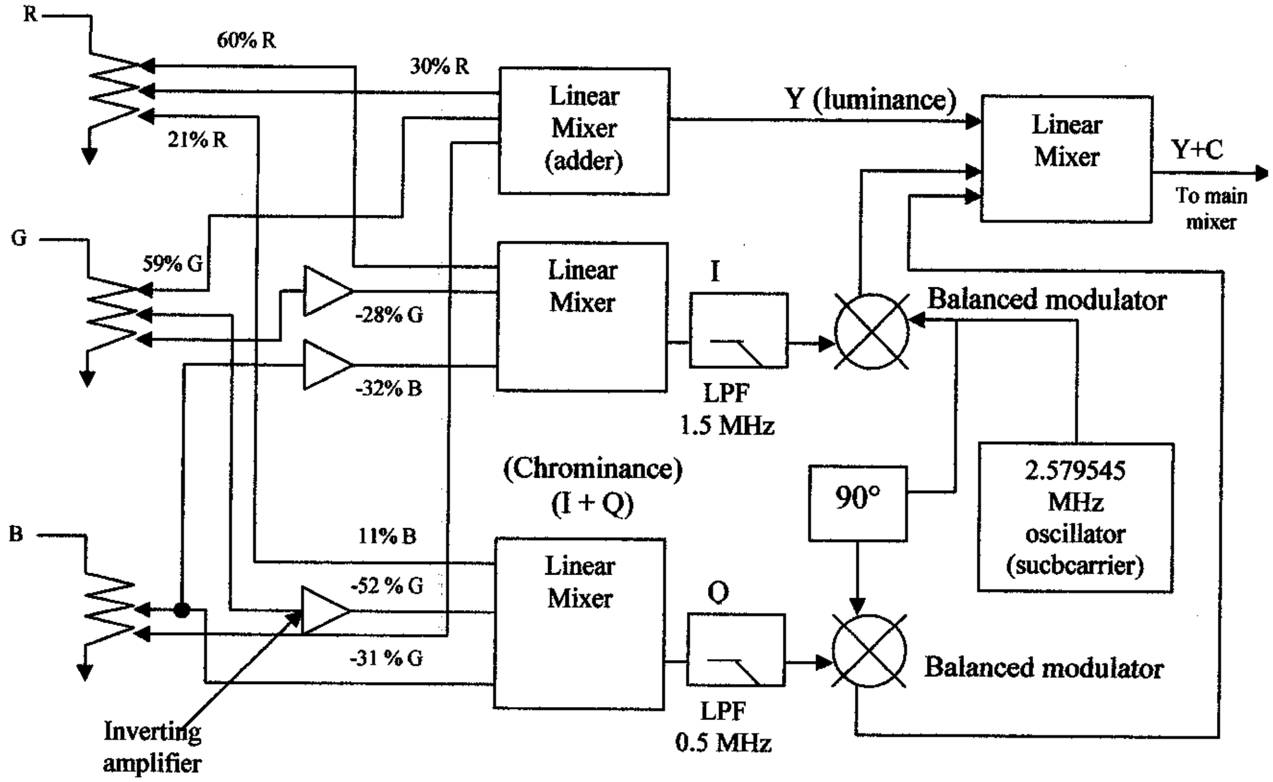


Figure 17: How the NTSC composite video signal is generated [4]

The I and Q color signals are also called the R-Y and the B-Y signals because the combination of the three color signals produces the effect of subtracting Y from the R or B signals. The phase of these signals with respect to the original 3.58 MHz subcarrier signals determines the color to be seen. The color tone can be varied at the receiver is that the viewer sees the correct colors. In many TV sets an extra phase shift of 57° is inserted to ensure that maximum color detail is seen. The resulting I and Q signals are shown as phasor in Figure 18. There is still 90° between the I and Q signals, but their position is moved 57°. The reason for this extra phase shift is that the eye is more sensitive to the color orange. Of the I signal is adjusted to the orange phase position, better detail will be seen. The I signal is transmitted with more bandwidth than the Q signal, as can be seen by the response of the low-pass filters at the outputs of the I and Q mixers in Figure 18.

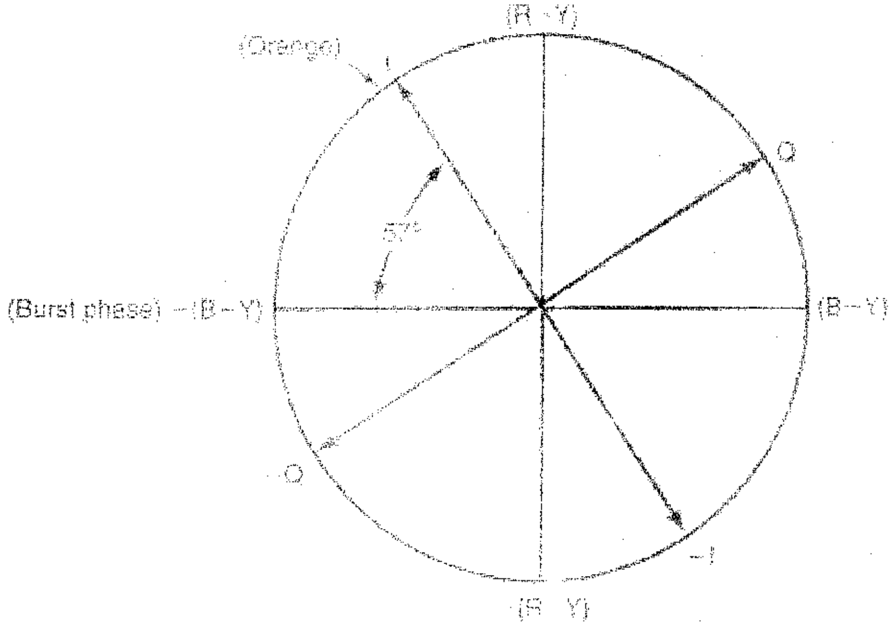


Figure 18: The chrominance signals are phase-encoded [4]

1.3 TV RECIEVER

The process involved in receiving a TV signal and recovering it to present the picture and sound outputs in a high-quality manner is complex.

A block diagram of a TV receiver is shown in Appendix I.

1.3.1 The Tuner

The signal from the antenna or the cable is connected to the tuner, which consists of an RF amplifier, a mixer, and a local oscillator. The tuner is used to select which TV channel is to be viewed and to convert the picture and sound carriers plus modulation to an intermediate frequency (IF).

Most TV set tuners are prepackaged in sealed and shielded enclosures. They are two tuners in one, one for the VHF signals and another for the UHF signals.

VHF – uses low-noise FETs for the RF amplifier and the mixer.

UHF – uses a diode mixer with no RF amplifier or a GaAs FET RF amplifier and mixer.

1.3.2 Tuning Synthesizer.

The local oscillators are phase-locked loop (PLL) frequency synthesizer set to frequencies that will convert the TV signals to the IF. The PLL synthesizer is tuned by setting the feedback frequency division ratio. In a TV set this is changed by microprocessors which part of the master control system.

1.3.3 Video IF and Demodulation

The standard TV receivers Ifs are 41.25 MHz for the sound and 45.75 MHz for the picture (the difference is 4.5 MHz). The IF signals are then sent to the video IF amplifiers. Selectivity is usually obtained with a surface acoustic wave (SAW) filter. This fixed tuned filter is designed to provide the exact selectivity required to pass both of the IF signals with the correct response to match the vestigial sideband signal transmitted. Figure 19 is a block diagram of the filter. It is made on a piezoelectric ceramic substrate such as lithium niobate. A pattern of interdigital fingers on the surface convert the IF signals into acoustic waves that travel across the filter surface. By controlling the shapes, sizes, and spacing of the interdigital filters, the response can be tailored to any application. Interdigital fingers at the output convert the acoustic waves into electrical signals at the IF.

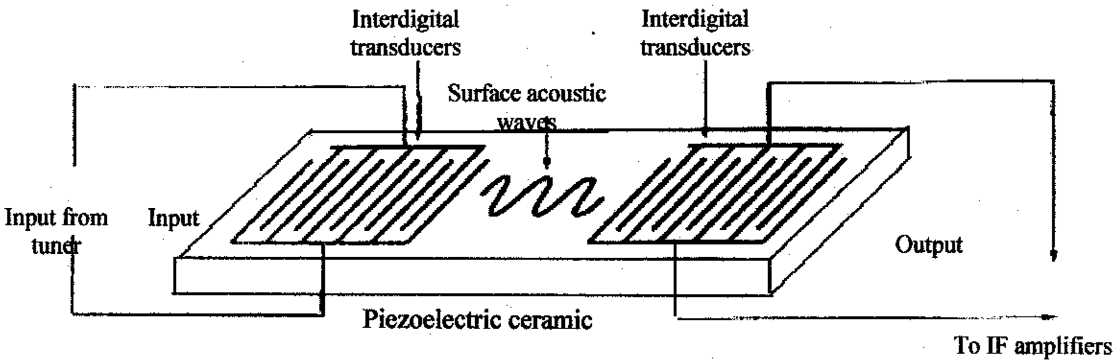


Figure 19: Surface acoustic wave (SAW) filter [4]

The response of the SAW IF filter is shown in Figure 20. The filter greatly attenuates the sound IF to prevent it from getting into the video circuits. The maximum response occurs in the 43 to 44 MHz range. The picture carrier IF is down to 50 percent on the curve.

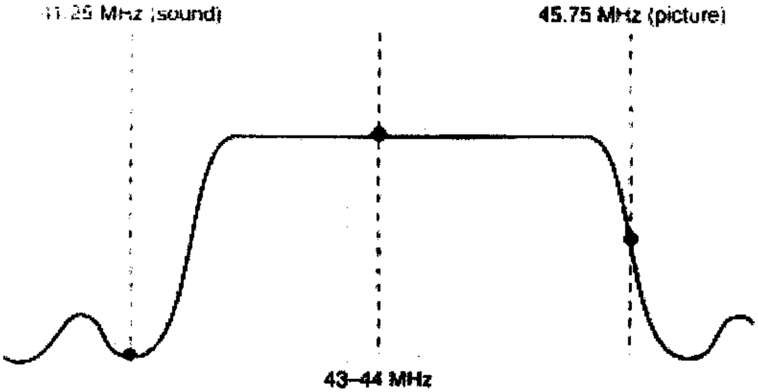


Figure 20: Typical IF responses curve [4]

Then, the signals are next amplified by IC amplifiers. The video (luminance, or Y) signal is then recovered by an AM demodulator. In most modern sets a synchronous balanced modulator type of synchronous demodulator is used. It is part of the IF amplifier IC.

The output of the video detector is the Y signal and the composite color signals, which are amplified by the video amplifiers. The Y signal is used to create an AGC voltage for controlling the gain of the IF amplifiers and the tuner amplifiers and mixers.

The composite color signal is taken from the video amplifier output by a filter and fed to color-balanced demodulator circuits. The color-burst signal is also picked up by a gating circuit and sent to a phase detector whose output is used to synchronize an oscillator is fed to two balanced demodulators that recover the I and Q signals. The carriers fed to the two balanced modulators are 90° out of phase. The 57° phase shifter used to correctly position the color phase for maximum recovery of color detail. The Q and I signals are combined in matrix with the Y signal, and out comes the three R, G, and B color signals. These are amplified and sent to the picture tube, which reproduces the picture.

1.4 MATLAB CODINGS

1.4.1 Frequency Modulation

The first attempt of using MATLAB was to get the understanding on the MATLAB function and programming method. Trial and error method was done to get the desired output of the simpler modulation method such as Frequency Modulation (FM). This method can be done since we know how the output waveform should look like. The important part in programming was to understand the syntax and how to realize the equation in syntax form. The coding for FM is shown below:

```
Vc=1;
fc=10;
Wc=2*pi*fc;
Vi=1;
fi=1;
Wi=2*pi*fi;
t=0:0.01:5;
K=40;
carrier=Vc*cos (Wc*t);
int=Vi*cos (Wi*t);
mod=Vc*cos(Wc*t + (K*Vi/Wi)*sin (Wi*t));
subplot (3,1,1);
plot (t,carrier);
subplot (3,1,2);
plot (t,int);
subplot (3,1,3);
plot (t,mod);
```

Figure 21: MATLAB coding to get FM output [7]

The Vc is the voltage for the carrier waveform, which has the fundamental frequency of 10 Hz. (fc). The line t=0:0.01:5 is to generate the timing sequence between 1 and 5 with interval of 0.01 (0.00, 0.01, 0.02, 0.03 .... 5.00). The K value determines how large the sine wave carrier departs from the centre frequency. It will depart further as K- value goes larger. K is to determine the deviation sensitivity of the signal phase. The deviation sensitivities are the output-versus-input transfer functions for the modulators, which give the relationship between what output parameter changes in respect to the input signal. The output of the coding is plotted as below:

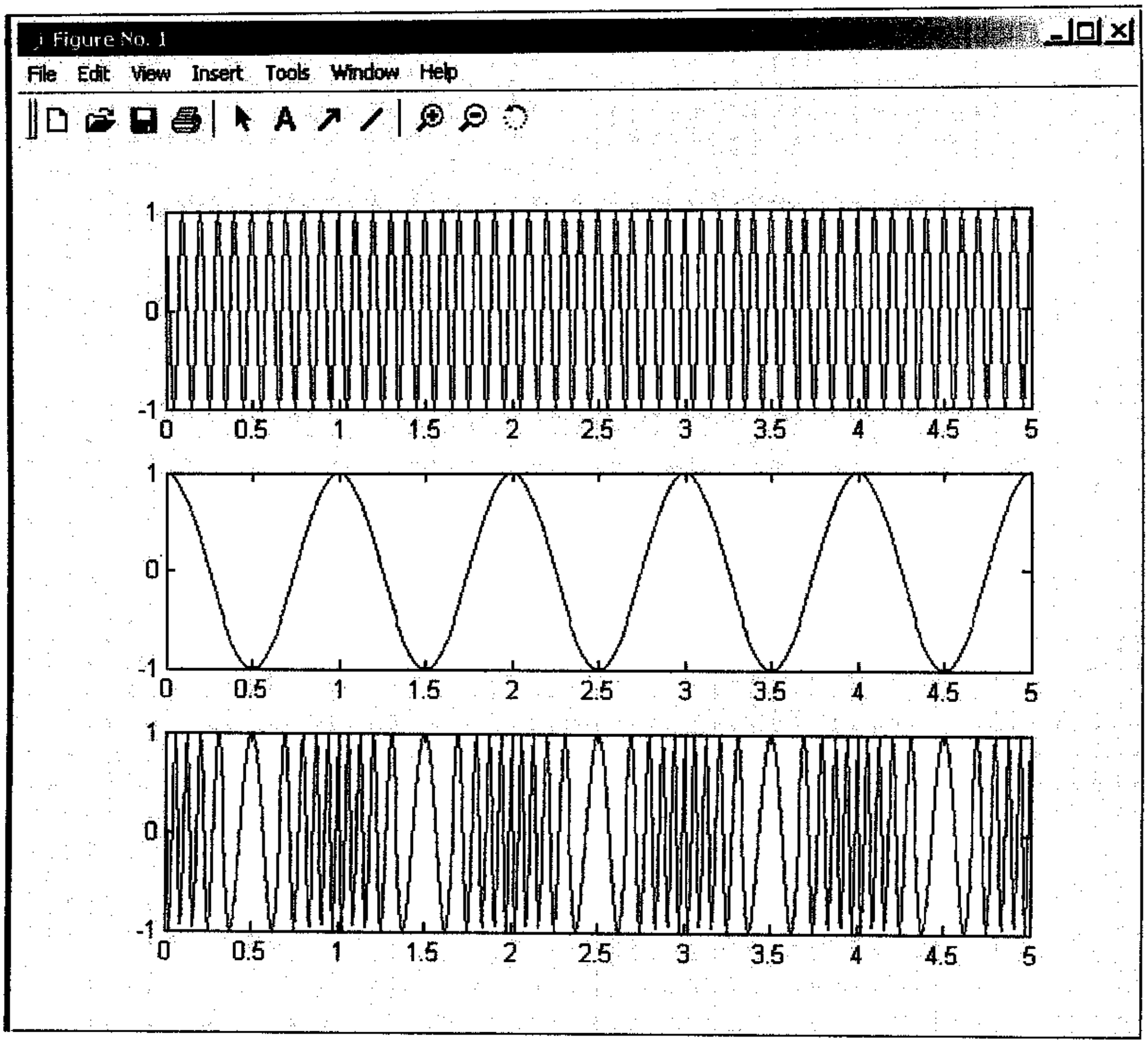


Figure 22: The output of the MATLAB coding [7]

1.4.2 Binary Phase Shift Keying (BPSK)

The MATLAB coding for BPSK is then simulated to acquire the modulated signal. The concept of BPSK is almost the same with QPSK. The only difference is that it using only two input signal, and the modulated signal is phase shifted between those two signals. The MATLAB coding for the signal as below:

```
clear all
N=20000;                                               % Number of bits
T=1;                                                   % Bit period
os=10;                                                 % sampling rate
s=sign(randn(1,N));                                    % bit sequence to be transmitted
s1=s(1:2:length(s));                                   % odd bits are I
s2=s(2:2:length(s));                                   % even bits are Q
phi1=cos(2*pi*[0:T/os:T-T/os]);                        % first basis function
phi2=sin(2*pi*[0:T/os:T-T/os]);                        % second basis function

for k=1:N/2,
    I(1+(k-1)*os:k*os)=s1(k)*phi1;
    Q(1+(k-1)*os:k*os)=s2(k)*phi2;
end
Qoff=[zeros(1,os/2) Q(1:length(Q)-os/2)];              % offset Q channel by T/2;
% Modulated QPSK signal
x=I+Qoff;
% Plots show the I, Q, and x for three symbols period
figure(1)
subplot(3,1,1);plot([0:T/os:3*T-T/os],I(1:os*3));title('I(t)');grid
subplot(3,1,2);plot([0:T/os:3*T-T/os],Q(1:os*3));title('Q(t)');grid
subplot(3,1,3);plot([0:T/os:3*T-T/os],x(1:os*3));title('x(t)');grid
```

Figure 23: The MATLAB coding for BPSK [7]

The variable N represents the number of bits of input signal, with T period between them. Each bit will be sampled at 10 samples per bits. Input 1 and input 2 are the odd and even of the input bits (stored in two variables). phi1 and phi2 are the first and second basis function, which is used in the loop (for) function to calculate each bit. The length must be set from 1 to N/2 for the matrix to match (since the odd and even bits are stored at different location). The outputs of the system are changing with time because of the randomly generated input signal used (input=sign (randn(1,N))).

The I and Q variable are for input signal of odd and even bits respectively. Qoff is to offset the Q by half of bit period. The modulation signal is defined by I + Qoff variable. The phi1 is the function of the input signal and phi2 as the QPSK function. The modulated signal is shown by x variable which add up I and Qoff. The input signal is randomly generated with randn command. It changes each time the M-file is run.

The modulated signal will be better if we use higher sampling rate, but takes more processing time. This simulation is for the transmitter part of the communication system. The output shown below:

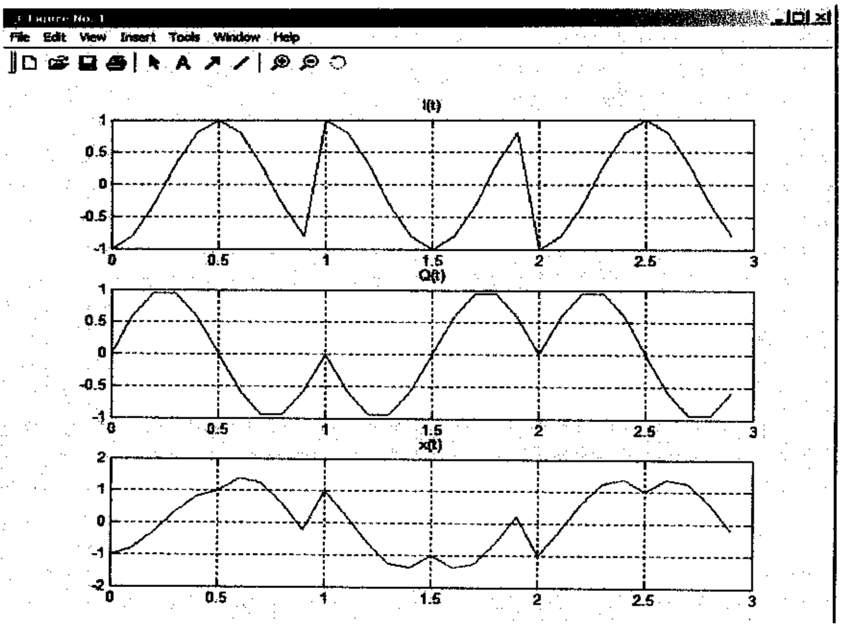


Figure 24: The output of MATLAB coding for BPSK [7]

As the above output, for the voltage high (at time=0.5 and time=2.5) the modulated signal is shown at the second waveform. For input voltage low (at time=1.5), the modulated signal is 180° out of phase. The third output waveform is the output of the demodulated signal. It is smoother if we use a higher sampling rate (os).

CHAPTER 2

LITERATURE REVIEW

This chapter will cover all the literature reviews which author have studied. It includes summary and the information of each report such as the title, authors and designation of the authors.

2.1 New Approaches in GPS based location system

Title:	New Approaches in GPS based location system
Author:	Anand Ramamoorthy
Designation:	Senior Manager, Car Infotainment and Telematics Group Renesas Technology America

This report is on the subject of the use of GPS as well as wireless carrier networks to provide high accuracy and reliable position information also referred to as A-GPS (Assisted GPS). A-GPS provides a user with the ability to obtain a location in places where standalone GPS may not work. In these circumstances, the user's position is calculated using information provided by the network.

Both network and standalone GPS location technologies have inherent weaknesses, resulting in reduced accuracy, decreased availability and higher implementation costs.

Assisted GPS utilizes the complimentary nature of both approaches to overcome situational weaknesses experienced by either network or GPS approaches working alone. The benefits of Assisted GPS approach include maximum availability, increased sensitivity, higher accuracy, lower complexity and a rapid time-to-first-fix. Apart from United States, large-scale adoption of this approach is beginning to happen in Japan where conventional GPS fails to perform in urban canyons like Tokyo. Attempts are being made to ensure that this technology is supported on a multitude of wireless networks deployed worldwide such as GSM, CDMA, TDMA, 3G etc. User experience and economics of incorporating this approach in a client/server environment will eventually drive this technology.

2.2 Global Positioning System (GPS) and its Applications in Forestry

Title: Global Positioning System (GPS) and its Applications in Forestry
Author: Maitreyi Mandal
Designation: Junior Research Fellow Centre for Development and Environment Policy
Indian Institute of Management, Calcutta

This report is about GPS applications in forestry. GPS surveying applications:

1. Pre-Harvest & post-harvest cut block traversing
2. Road systems & landings
3. Mechanical site preparation
4. Juvenile spacing, mechanical brushing & planting
5. Forest health (i.e.) insect & disease tracking
6. Forest fire monitoring
7. Research plots

This report is on the subject of usage of GPS to create and maintain digital map databases for the forests we manage. Field digitizing silviculture features, wildlife habitats, cultural and infrastructure features are partly collected on foot. Fire spotting and areas spraying use GPS in aircraft. Field biologists and sport fishers use "fish finders" with integrated GPS units. Forestry applications that use GPS are continually changing. Simple field digitization and differential processing is a good start, but individuals with knowledge and experience across the wider spectrum of GPS activities increase their appeal to forest companies and organizations.

2.3 Internetworking with Satellite Constellation

Title: Internetworking with Satellite Constellation.
Author: Lloyd Wood
Designation: Degree of Doctor of Philosophy, Centre for Communication Systems Research, School of Electronics, Computing and Mathematics, University of Surrey, Guildford, United Kingdom.

This report is on the subject of examining satellite constellation networks with intersatellite links; this thesis has focused on measuring path propagation delays across simulated constellation networks, between ground terminals as end points, as a way of characterizing the perceived performance of the constellation. These path delays reflect the properties of the constellation well, as they show continuous satellite motion as well as more abrupt handover and routing changes. Analysis of the resulting path delay statistics has shown that the impact of the orbital seam on path propagation delays experienced when traversing star constellation networks is decreased dramatically with the use of cross seam links. Total delay and variation in delay are both reduced by the use of cross seam links, making cross-seam links worthwhile to implement despite any technical or practical difficulties in doing so.

Handover events form a significant feature of LEO and MEO satellite constellation networks, although the degree of their impact on traffic and on movement of network state between satellites depends a great deal upon the design and implementation of the satellite constellation network. Use of terminal handover together with exploitation of diversity in rosette constellations can permit use of multiple paths of different delays between ground terminals. Terminal handover can be used to provide ingress control of traffic for the constellation network.

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1 DEVELOPMENT STAGES

A. Preliminary Research

Preliminary research is the initial and main stage of the project development process. At this stage, firm understanding and planning on the project is considered. Thus, this stage aids the author to predetermine the problem, objectives, scope of study, tools, and development flow as well as problem analysis throughout the project execution.

B. Problem Analysis/Data Gathering

Problem analysis and data gathering is a continuation stage of preliminary research. The identified problem is analyzed at this stage. Data gathering offers better understanding and help in problem solving as well as decision making process. At this stage, the author able to determine the tools required for the development process.

C. Experiments

Several experiments have been conducted at the Satellite Communications Laboratory involving satellite communications equipments in order to get better understanding on the satellite communications systems. It includes familiarization with Television Receive Only (TVRO) board, troubleshooting on the TVRO board and prediction of weather satellite footprint using Track II software. An experiment on Global Positioning Systems (GPS) using earth.google software also has been carried out.

D. Tools Identification

The required tools for this project are identified at this stage. The software that is important for this project is MATLAB and Google.earth. It provides a lot of simulations on satellite communications such as GPSTOOL, Communications Toolbox etc.

CHAPTER 4

RESULTS AND DISCUSSIONS

This chapter serves the result and discussion of the project. The results involved basic modulation techniques in the satellite communications system which is Quaternary Phase Shift Keying (QPSK) using MATLAB coding. The definition of QPSK and its modulator/demodulator also included. It also discussed several experiment that have been conducted by the author such as familiarization with TVRO board, TVRO troubleshooting and prediction of weather satellite footprints. The author also gets use with Global Positioning System using earth.google.

4.1 QUATERNARY PHASE SHIFT KEYING (QPSK)

Quadrature Phase Shift Keying (QPSK) is the most popular kind of M-PSK modulation techniques. It has the same bandwidth as Binary PSK (BPSK) but it allows two times faster transmission without increasing error probability. Other M-PSK modulations (with $M > 4$) allow faster transmission but at the cost of error probability. QPSK, as all M-PSK signals, have constant envelope. Because of that fact it is very resistant to the nonlinear distortion frequently met in wireless communication channels. The most important rivals for QPSK modulation are M-QAM modulations which have better bandwidth efficiency at the similar error probability and bandwidth cost. Unfortunately M-QAM lose their superiority while in the communication channel a nonlinear distortion occurs.

4.1.1 Definitions

QPSK signal is defined in similar way as BPSK signal:

$$s_i(t)=\begin{cases}\sqrt{\frac{2E}{T}}\cos[2\pi f_c t+\theta_i] & ,0\le t\le T\\ 0 & ,other \quad t\end{cases}$$

(4.1.1.1)

The difference is in the quantity of used phases because there are four possible phases in QPSK signal:

$$\theta_i=\frac{\pi}{4},\frac{3\pi}{4},\frac{5\pi}{4},\frac{7\pi}{4}$$

(4.1.1.2)

unlike in BPSK signal where only two phases are used: $\theta_1 = 0$ and $\theta_2 = \pi$.

In equation (4.1.1.1) E is a single symbol energy (which can be also calculated using the amplitude of signal

$$E=\frac{A^2T}{2}).$$

(4.1.1.3)

T is time duration of single symbol and

$$f_c=\frac{n_c}{T}$$

(4.1.1.4)

is the frequency for fixed integer n_c. Thus there are an integer number of carrier cycles in each transmitted bit.

Equation (4.1.1.1) can be written in other form:

$$s_i(t)=\sqrt{\frac{2E}{T}}\cos\theta_i\cos(2\pi f_c t)-\sqrt{\frac{2E}{T}}\sin\theta_i\sin(2\pi f_c t)$$

(4.1.1.5)

$$\phi_1(t)=\sqrt{\frac{2}{T}}\cos(2\pi f_c t)$$

(4.1.1.6)

$$\phi_2(t) = \sqrt{\frac{2}{T}} \sin(2\pi f_c t) \tag{4.1.1.7}$$

In (4.1.1.5) we can see that (4.1.1.6) and (4.1.1.6) are orthonormal basis functions. Now rewriting (4.1.1.5) using the basis functions we get the expression:

$$s_i(t) = \sqrt{E}\cos\theta_i \cdot \phi_1(t) - \sqrt{E}\sin\theta_i \cdot \phi_2(t) \tag{4.1.1.8}$$

In BPSK signal only one basis function can be considered because second base function is always multiplied by zero

$$(\ \sin(\theta_i) = \sin(0) = \sin(\pi) = 0\ ). \tag{4.1.1.9}$$

BSPK having only two signal symbols (represented by different phases) can transmit only one data bit corresponding to each symbol and the QPSK having four signal symbols can unambiguously transmit two data bits with one symbol. These two bits of data are called dibits and they are assigned to signal points in the Gray coding order.

These two facts show that the bandwidth efficiency in QPSK is twice as big as in BPSK. In Table 5 QPSK signal coordinates with corresponding dibits are included.

Table 5 [5]

dibits	i	θ_i	$\sqrt{E}\cos\theta_i$	$-\sqrt{E}\sin\theta_i$	signal
10	1	$\frac{\pi}{4}$	$+\sqrt{\frac{E}{2}}$	$-\sqrt{\frac{E}{2}}$	$s_i(t) = \sqrt{\frac{E}{2}} \cdot \phi_1(t) - \sqrt{\frac{E}{2}}\phi_2(t)$
00	2	$\frac{3\pi}{4}$	$-\sqrt{\frac{E}{2}}$	$-\sqrt{\frac{E}{2}}$	$s_i(t) = -\sqrt{\frac{E}{2}} \cdot \phi_1(t) - \sqrt{\frac{E}{2}}\phi_2(t)$
01	3	$\frac{5\pi}{4}$	$-\sqrt{\frac{E}{2}}$	$+\sqrt{\frac{E}{2}}$	$s_i(t) = -\sqrt{\frac{E}{2}} \cdot \phi_1(t) + \sqrt{\frac{E}{2}}\phi_2(t)$
11	4	$\frac{7\pi}{4}$	$+\sqrt{\frac{E}{2}}$	$+\sqrt{\frac{E}{2}}$	$s_i(t) = \sqrt{\frac{E}{2}} \cdot \phi_1(t) + \sqrt{\frac{E}{2}}\phi_2(t)$

Using the signal coordinates from Table 5 can now easily draw the signal constellation as it is shown in Figure 25.

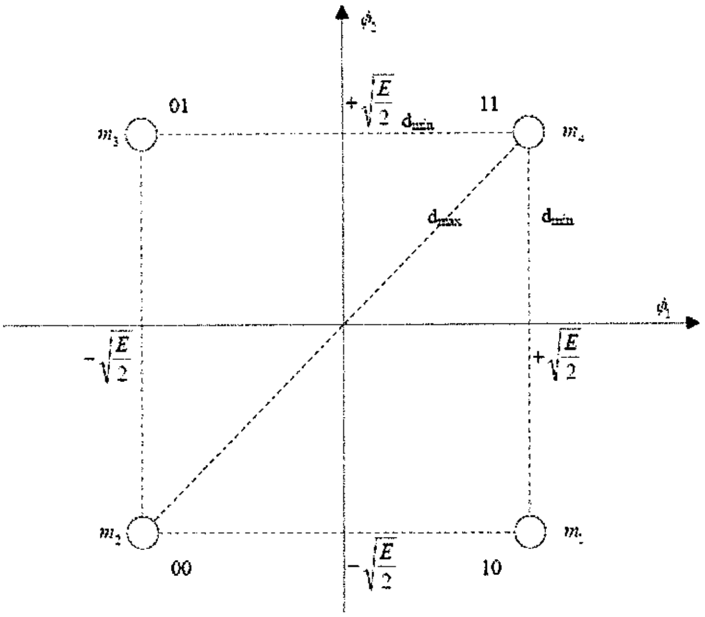


Figure 25: Constellation Diagram for QPSK [5]

Distance between two signal points on constellation diagram can have one of the following values: $d_{min} = 2E$ or $d_{max} = 2\ E$. Because the probability of confusing between two signal

points depends on this distance and is higher when signal points are closer so it is better to set dibits with two different bits as far as it is possible. In such a situation the probability of committing mistake on two bits will be lower than committing a mistake on single bit. This most efficient placement of dibits can be achieved using the Gray coding which is typically used in QPSK modulation.

Using only the phase values mentioned above makes the signal point's co-ordinates only

$$\pm\sqrt{\frac{E}{2}} \qquad (4.1.1.10)$$

, which makes modulator's and demodulator's structure simpler than for the other phases.

4.1.2 Modulator and demodulator

The modulator of QPSK signal and its waveforms are shown in figure 22 and 23. While the QPSK signal is a sum of two BPSK signals (I- and Q- channels) the modulator also consists of two BPSK modulators. At first the input data sequence a_k is converted to NRZ signals in that way that a logic 1 is converted to the + E_b value and a logic 0 to the − E_b value.

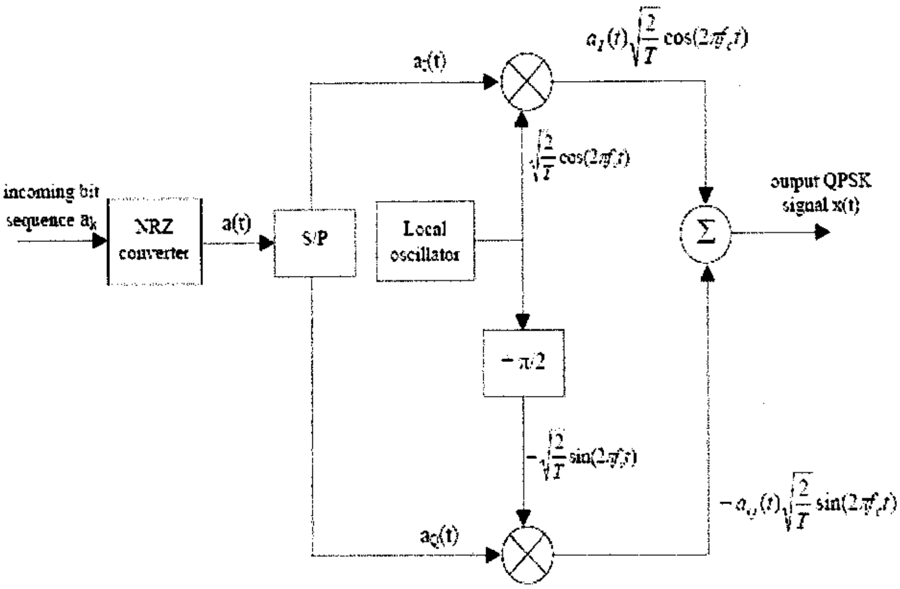


Figure 26: QPSK Modulator [5]

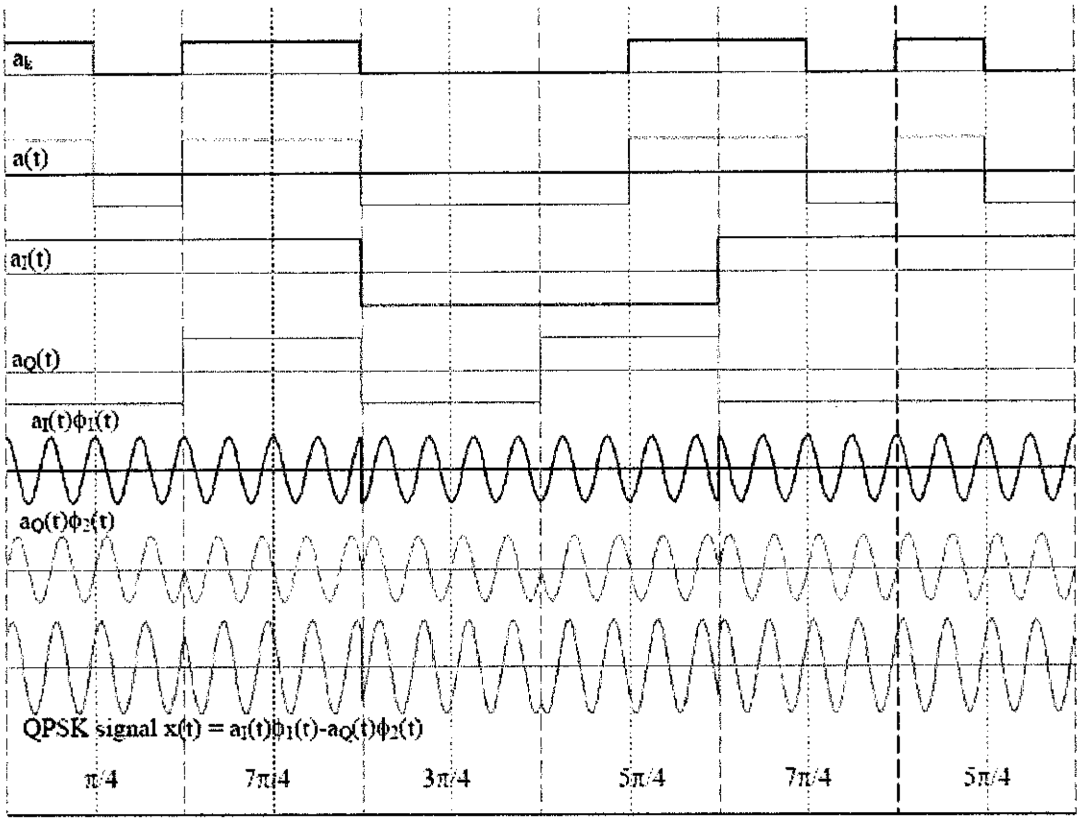


Figure 27: QPSK Waveforms [5]

The E_b is a single bit energy and it is equal to $E_b=E/2$. Every pulse has duration of T_b. Next the NRZ signal *a (t)* is split by the serial-to-parallel converter. The odd-numbered pulses $a_I(t)$ go to the inphase (I) channel and the even-numbered pulses $a_Q(t)$ go to the quadrature (Q) channel. Later on both pulse trains are multiplied by the basis signals, in the in phase channel it is

$$\phi_1(t) = \sqrt{\frac{2}{T}}\cos(2\pi f_c t) \qquad (4.1.1.11)$$

and in the quadrature channel

$$\phi_2(t) = \sqrt{\frac{2}{T}}\sin(2\pi f_c t) \qquad (4.1.1.12)$$

At the end both I- and Q-channel signals are added in a summer to obtain the QPSK output signal $x\ (t)$. In Figure 28 shows that QPSK demodulator's block diagram. Alike in the QPSK modulator, the demodulator consists of two BPSK demodulators. The incoming QPSK signal x (t) is sent to corelator's in each channel and to the carrier recovery unit. In each corelator the incoming signal is first multiplied by the basis function $\Phi_1(t)$ in the I-channel and $\Phi_2(t)$ in the Q-channel) and then integrated. Later on the decision unit compares the corelator's output signal and makes logical 1 if it is greater than zero and logical 0 if it is less than zero. This way it can obtain the odd-numbered bits sequence a_{Ik} in the I-channel and even-numbered bits sequence a_{Qk} in the Q-channel. At the end the parallel-to-serial converter combines these two sequences into one output sequence a_k. (for QPSK MATLAB coding refer Appendix II).

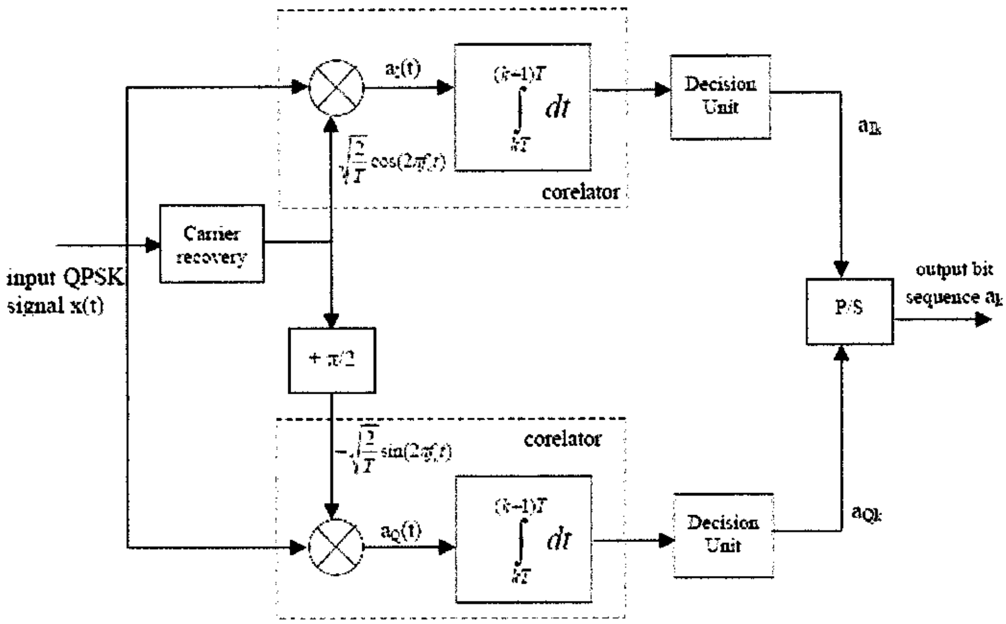


Figure 28: QPSK Demodulator [5]

4.2 SATELLITE COMMUNICATION EXPERIMENTS

4.2.1 Experiment on TVRO Familiarization

The author had visited Satellite Communication Lab. The author has been given an opportunity to run an experiment on TVRO circuit board. The circuit board contains several important devices, which are:

- Manual tuning: tune within the given bandwidth manually.
- Audio subcarrier tuner: audio tuner.
- Precision Pulse Generator/Motech: position of the disc/parabola.
- Astrotel: control position of collector.
- Satellite finder: shows how strong the signal receives.

TVRO stands for Television Receive Only. The author has discovered about six television channels with various settings on the circuit board. In order to get clearer channel, steps that has been taken are:

i. The Astrotel is set to position of 160.
ii. The Motech is slowly increased until the signal of satellite finder is strong enough.
iii. When all the steps above achieved, find the channel manually by Manual Tuning.
iv. Audio subcarrier is adjusted to get clearer channel audio.

Six television channels have been discovered during the experiment. The results as follows in Table 6:

Table 6 [11]: Channel Tuning

TV channel	Satellite Finder	Astrotel	Motech	Polarity
Indonesian MTV channel	5.5	160	782	Negative
China Azio TV	5.5	160	832	Negative
China TV 1	4.5	160	632	Negative
China YNTV 1	5.0	160	632	Negative
S - channel	4	160	632	Negative
Malaysian TV 1	1	160	898	Negative

Discussions

The purpose of this lab is to get familiarize with the satellite communication devices. During this lab session, author able to handle TVRO board and its important equipments. The author has been given opportunity to experience how to tune foreign TV channel using satellite and managed to search 6 television channels.

4.2.2 Experiment on TVRO Receiver

Scope of Study

Actual video signals from a broadcast television satellite is shown and experimented using the satellite TVRO Receiver, SIP399.

Objectives

1. Experienced in using a training model of a TVRO receiver.
2. Experienced in using of a spectrum analyzer.
3. Tuning the audio and video for TV broadcasting.

Materials Required

Satellite TVRO System (SIP399) included:

Antenna, LNBF, Receiver Panel, Antenna Actuator and controller, assorted cables

Power Supply Base (S300PSB)

RF Spectrum Analyzer

Digital Multimeter (DMM)

Oscilloscope

Coaxial Cable, 7 feet, F to F connector

(Figures refer appendix)

Experimental Procedures

1. Power up the Base and set the +15VDC output to +15VDC before inserting the Satellite TVRO Receiver into the Power Supply Base.
2. The SIP399 in inserted into the base. RF cable is connected from the LBNF to the RF connector of the downconverter. The polarization control is also connected to the terminal strip on the rear of the panel.
3. The AUDIO OUT and VIDEO OUT jacks on the receiver are connected to the appropriate inputs on the TV monitor.
4. The Power Supply Base, the TV monitor, and the antenna controller are powered up.
5. The parabolic antenna is aligned to the approximate elevation and azimuth for a major TV broadcast satellite. The VIDEO POLARITY is set to "+"position.

6. TUNING MODE is switched to MANUAL and the BAND FILTER is set to NARROW. The FINE TUNE is set straight up. A quality TV picture is search with the combination of antenna controller and MANUAL TUNING. The audio is tuning using AUDIO SUBCARRIER.
7. The voltage at TP3 is measured with oscilloscope and recorded. The MEMORY READ/WRITE switch is set to WRITE. The UP/DOWN switch is moved until the voltage at TP3 equals that measured in the previous step.
8. A channel is selected to store the digital data that is tuned. The ODD/EVEN and SELECT CHANNEL switches to tune.
9. The LOAD button is pressed. The DC digitized DC voltage equal to the analog voltage measured earlier has been stored in the receiver's memory. The memory functionality is the switched to READ and the TUNING MODE to FIXED.
10. Tuning to the selected channel, the CHANNEL SELECT and ODD/EVEN switches is positioned to the preset position. The FINE TUNE control is operational for fine adjustment of picture quality.
11. The RF OUT F connector is connected from the downconverter to the spectrum analyzer. The analyzer is set to a center frequency of 1200 MHz. The LBNF output range of 950 to 1450 MHz. The controls are adjusted until a picture that represents the satellite's RF spectrum seemed.
12. The number of observed broadcast channel can be counted by changed the center frequency above and below it. Polarization on the receiver panel is switched and observed.
13. The observation of the satellite's RF spectrum completed (For connections and TVRO board refer Appendix III).

Observations

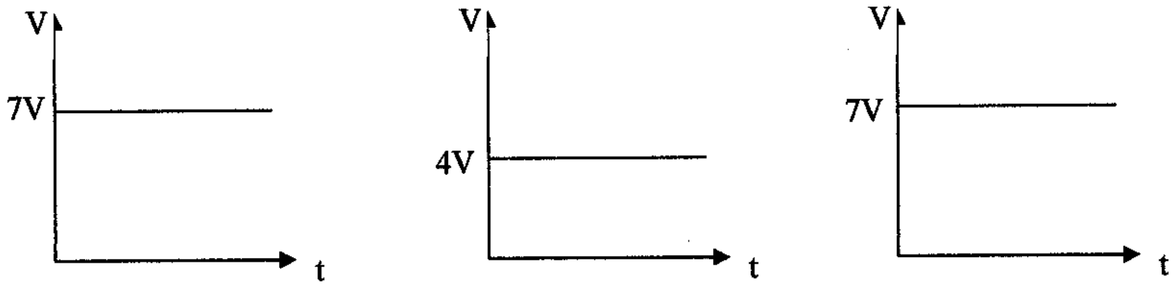


Figure 29: Voltage at TP3 (step 7) [11]

From Figure 29, initially the voltage measured at TP3 is 7 V. During this time, TV channel still receive a clear picture. Then when "Memory" is switch to "write" position, the oscillator shows a voltage drop (4V) and the TV channel does not receive clearer information. After several tuning using "Up/Down" switch, the TV channel started to receive clear picture and the voltage is observed. The voltage is equally to the initial value which is 7 V.

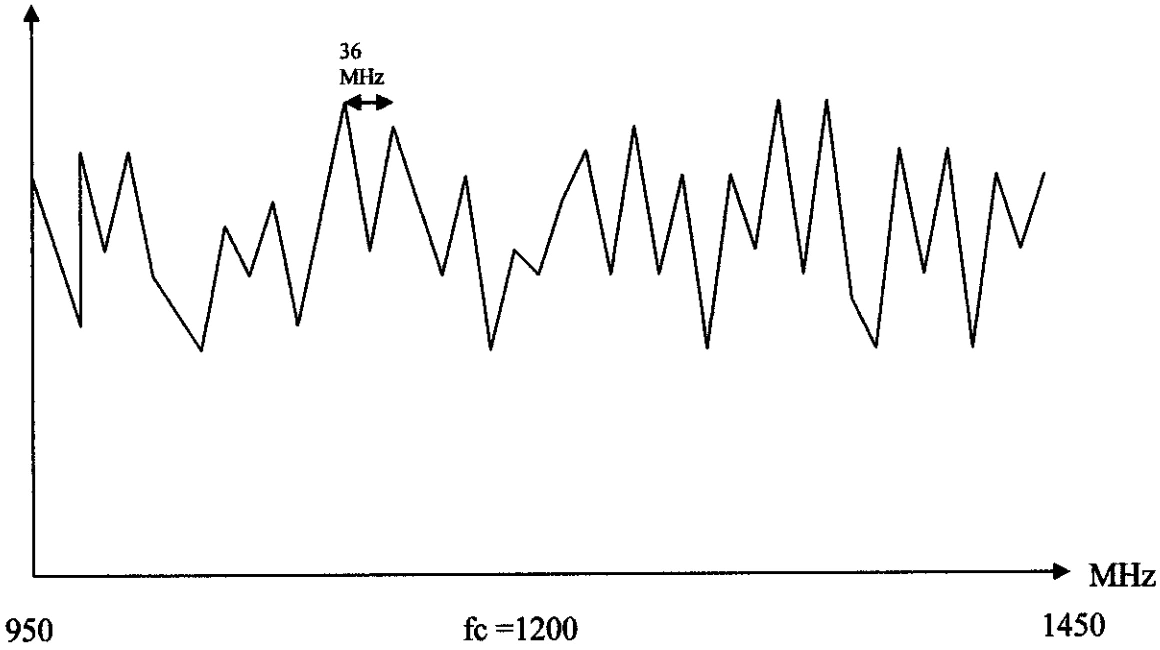


Figure 30: Satellite RF Spectrum [11]

As for the Figure 30, the author has observed the satellite RF spectrum using RF spectrum analyzer. The spectrum is initially set at 950 MHz and stop at 1450 MHz, and center frequency is 1200 MHz. From the spectrum, it can determine more than one channel within a bandwidth.

4.2.3 Experiment on TVRO troubleshooting

Objectives

Determine the problem based on both visual and audible clues from the video and audio outputs as well as checking various voltages.

Results

Table 7: Action of DIP Switches. [11]

DIP Switch	Symptom	Actual Action	Results
SW 11-1	No audio or video	No + DC to LBNF	On = 16 V Off = 0 V
SW 11-2	No audio. Video available	No +5 VDC to U 2	On = 4.94 V Off = 0.23 V
SW 11-3	No audio but noise	No +5 VDC to U 1	On = 5 V Off = 0.08 V
SW 11-4	No video. Audio is available	No +5VDC to U 10	On =12 V Off = 0.5 V
SW 11-5	No DC restore. Torn or wavy picture.	No +12 VDC to DC clamp	Not used
SW 11-6	Not used.	Not used	Not used
SW 11-7	Not used.	Not used	Not used
SW 11-8	Not used.	Not used	Not used

Discussions

The experiment was carried out at low band pass filter (SW 11) which is to troubleshoot the TVRO panel. This is the important steps has to be taken if there a problem occurred to the TVRO panel. It is to make sure TVRO panel always in good condition.

4.2.4 Experiment on Weather Satellite

The experiment of weather satellite is carried by using Track II software that has been installed in Satellite Communications Laboratory. This software enables the author to predict the footprint of a particular satellite by a given time. The footprint prediction is taken from a set of data that have been installed within the software. This data must be updated every 3 months. The update data can be taken from www.celestrak.com.

Materials Required

Antenna Dish with 1691MHz Feedhorn

Cables included:

    Low-loss Coax with connectors (100ft), 5 pin DIN to 5 pin DIN, 5 pin DIN to 9 pin DIN

12 V Power Adapters

1691 MHz GOES/METEOSAT Receiver

PROSat Decoder Interface

TrackII software

Computer

Experimental Procedures.

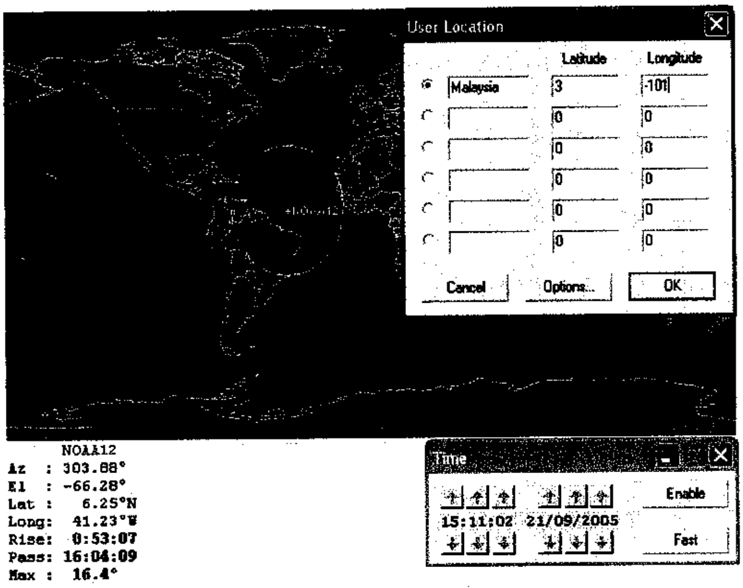
1. Run TrackII program.
2. Set the user current position :
   i) Select user positions on the Update menu
   ii) Key in Malaysia and latitude 3 and longitude -101 (Figure 31)
3. The clock is set
   i) Select Show Local Time on the Clock Menu
4. Select satellites to be detected
   i) Select New Satellite on the Satellite Menu (Figure 32)

   NOAA stands for National Oceanic and Atmospheric Administration.

   ii) Select the satellites NOAA 12, 15 and 17 (Figure 33)

NOTE:

1. SIP 369 Panel is used only for detection of polar and frequency of 137.50 MHz only. The NOAA satellites that are currently detected under this frequency are NOAA 12 and NOAA 15.
2.



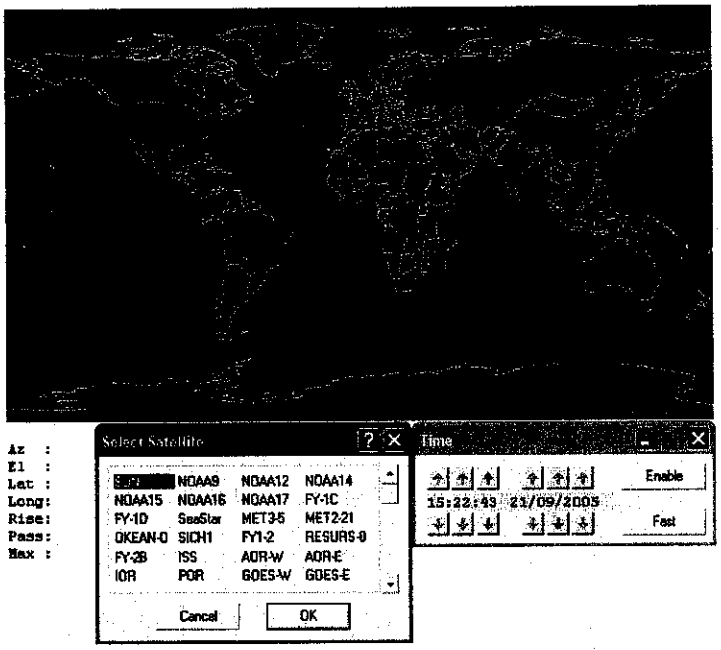
	Latitude	Longitude
● Malaysia	3	-101
○	0	0
○	0	0
○	0	0
○	0	0
○	0	0

```
      NOAA12
Az  : 303.88°
El  : -66.28°
Lat :   6.25°N
Long:  41.23°W
Rise:  0:53:07
Pass: 16:04:09
Max :  16.4°
```

15:11:02 21/09/2005

Figure 31: User Current Positions

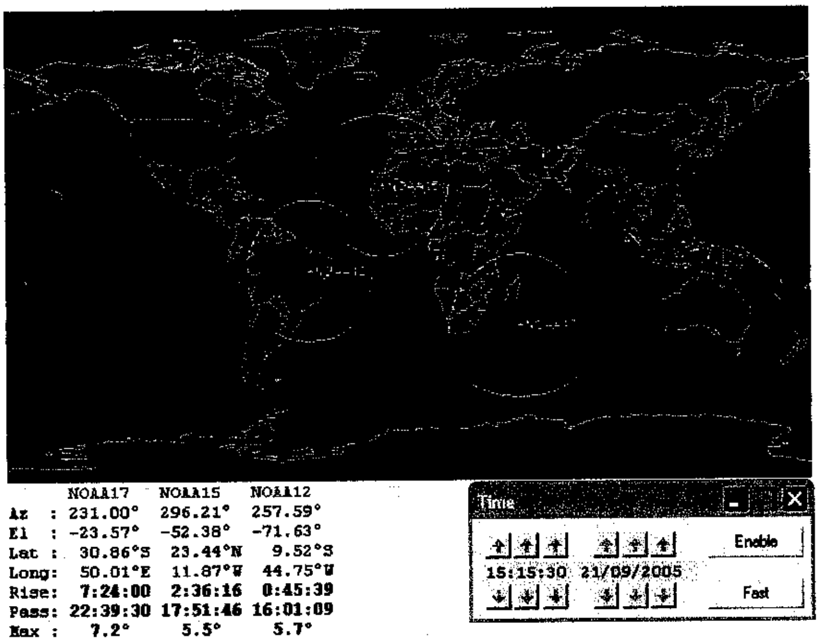
Figure 31 shows the initial position of satellite NOAA 12 before key in user current position which is Malaysia at the latitude of 3° and longitude -110°. It shows the azimuth angle and elevation angle is at 303.88° and at -66.28° respectively. The latitude is 6.25° N, longitude 41.25°W on September, 25th, 2005 at 15:11 (24 hours standard).



15:22:43 21/09/2005

Figure 32: Satellites Menu

Figure 32 shows the list of satellites available for footprints prediction in Track II. There are more than 30 satellite names where is only NOAA 12, NOAA 15 and NOAA 17 satellites used for this experiment.



```
      NOAA17     NOAA15     NOAA12
Az  : 231.00°    296.21°    257.59°
El  : -23.57°    -52.38°    -71.63°
Lat :  30.86°S    23.44°N     9.52°S
Long:  50.01°E    11.87°W    44.75°W
Rise:   7:24:00    2:36:16    0:45:39
Pass: 22:39:30  17:51:46  16:01:09
Max :    7.2°       5.5°       5.7°
```

15:15:30 21/09/2005

Figure 33: Satellites NOAA 12, 15, 17

Figure 33 shows simultaneously the location of three satellites which is NOAA 12, NOAA 15 and NOAA 17. It displays the azimuth and elevation angle of each satellite as well as its latitude and longitude.

	NOAA 12	NOAA 15	NOAA 17
Azimuth	257.59°	296.21°	231.00°
Elevation	-71.63°	-52.38°	-23.57°
Latitude	9.52°S	23.44°N	30.86°S
Longitude	44.75°W	11.87°W	50.01°E

Observations

The purpose of this lab is to get familiarize with the weather satellite equipments. During this lab session, author able to handle weather satellite apparatus and its important equipments. From author's observation, this experiment is able to schedule a time for a satellite pass. It can predict satellite footprints within a certain time interval. It also indicates the area of each satellite covered (Figures and explanation refer Appendix V)

4.3 GLOBAL POSITIONING SYSTEMS

The Global Positioning System (GPS) includes 24 satellites, in circular orbits around Earth with orbital period of 12 hours, distributed in six orbital planes equally spaced in angle. Each satellite carries an operating atomic clock (along with several backup clocks) and emits timed signals that include a code telling its location. By analyzing signals from at least four of these satellites, a receiver on the surface of Earth with a built-in microprocessor can display the location of the receiver (latitude, longitude, and altitude).. GPS satellites are gradually revolutionizing driving, flying, hiking, exploring, rescuing, and map making.

4.3.1 Google Earth

Real life takes another step closer to science fiction with the release of an exciting new computer application called Google Earth. The program's beta version was released for free download on the internet on October 2004 by the California-based company behind the famous Google search engine.

Simple to operate, Google Earth allows users to zoom into a 3D model of the real world, based on real, medium or high resolution satellite images combined with maps and aerial photographs. Users can zoom from earth's orbit to street level instantly and then navigate freely around the globe, panning or jumping from place to place.

The program combines bitmapped satellite images with vector overlays that represent borders, roads, railways, and more. Upgraded versions of the program are available at a cost, featuring such extras as GPS location and traffic counts. The photographs Google Earth uses were taken sometime over the last three years The program requires some serious muscle in terms of computer processing power, and it's also necessary to have a broadband connection and a meaty graphics card.

Procedures

Google Earth step by step

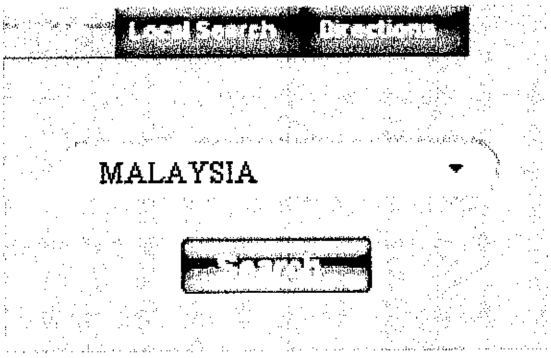
1. Go to http://earth.google.com
2. Download the Google Earth (Beta) software
3. Run Google Earth. Try any of these uses of the application:

- Type in an address and fly to it
- Grab the globe with the cursor and spin it
- Fast zoom in to a location
- Tilt and rotate the screen using the navigation panel

Google Earth features

<u>Fly-To box</u>

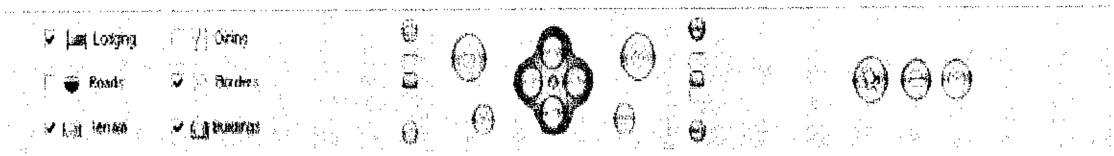
- Type in a specific address and fly there
- Or use an intersection, city, state, zip code, country, or latitude/longitude combination



MALAYSIA

Tilt, zoom and rotate

- See other views by manipulating the viewer controls



Source for images

The images seen in Google Earth have been taken from cameras mounted on planes and satellites. Through acquisition of Keyhole, Google has established relationships with a variety of commercial providers of aerial and satellite imagery. The image database ranges from several months old to a few years in age, and it is refreshed periodically. There are no real time images in the service.

Resolution of images

Different areas are covered at different resolutions. The resolution varies from 1 KM per pixel, where a single pixel in the image covers an area of 1 km to 6 inches per pixel. At the lowest resolution, large geographic features such as mountains and lakes are visible, and at the highest resolution, detailed features of the earth such as buildings and cars are visible.

System requirements

Minimum configuration:

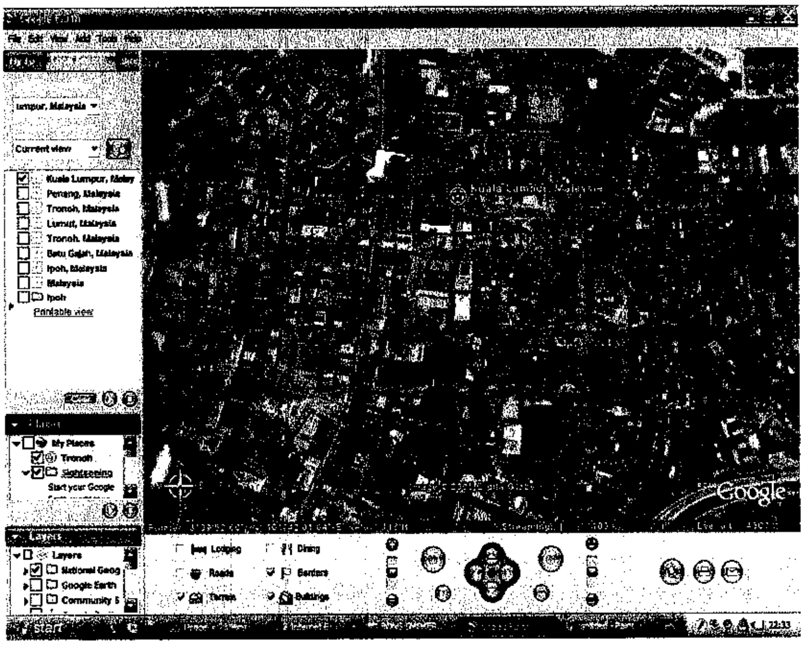
- Windows 98/ME, Windows 2000, Windows XP
- CPU Speed: Intel® Pentium® PIII 500 MHz
- RAM: 128MB
- 200 MB hard disk space
- 3D-capable video card with 16MB VRAM.
- 1024 x 768, 32-bit True Color Screen
- Network speed: 128 kbps

Discussions

This experiment of Global Positioning Systems shows different areas with different of resolutions. The whole world is covered with medium resolution imagery and terrain data but there is also additional high-resolution imagery, meanwhile additional high-resolution imagery only available for most of the major cities in the world. The author have captured image of local places where the author studied and international images of major cities in the world

i) Local images

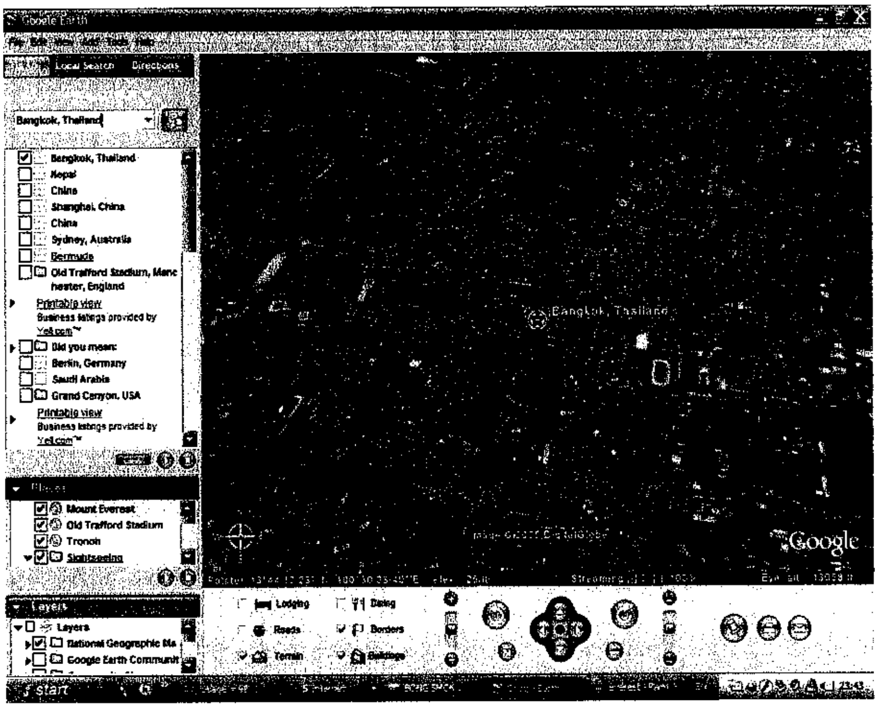
Throughout the experiments, the author has captured four images of local location which is in Malaysia that is Kuala Lumpur, Lumut, Batu Gajah and Tronoh. The images are covered with medium resolution imagery and terrain data so the images cannot be too detailed. This resolution only allows seeing major geographic features and man-made development such as towns, but not detailing of individual buildings. These locations are chosen because Kuala Lumpur is the capital city of Malaysia meanwhile for Lumut, Batu Gajah and Tronoh is the place where the author studied. As for Kuala Lumpur, the buildings and the roads are clearly visible because it is a major city in the world. (More figures refer Appendix V)



Kuala Lumpur,Malaysia

ii) International images

For international images, the author has captured three random places in the world which is Bangkok, Thailand; Old Trafford and Anfield, England. These images covered with high-resolution imagery which reveals detail for individual buildings. This resolution is available for most of the major cities in the US, Western Europe, Canada, and the England. Detailed road maps are also available for the US, Canada, the UK, and Western Europe. (More figures refer Appendix VI)



Bangkok, Thailand

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

The experiments that have been carried out throughout the semester are to study satellite communications systems. The experiments are involved television receiver and weather satellite footprint prediction. The research and analysis have been continuously conducted as to gain some extra knowledge on the programming part, which is MATLAB coding.

QPSK modulation technique is widely used in satellite communications system. This technique is a constant amplitude modulation with four output phases available for a single carrier frequency. The QPSK transmitter circuit modulates the signal and demodulated at the QPSK receiver circuit.

Google Earth™ is Google's new satellite imagery-based mapping product that combines global coverage of imagery with new navigational features including integrated Google search capabilities. Google Earth is a broadband mapping tool that enables users to fly from space to street level views to find geographic information, and to explore places around the world. With GPS, the world has been given a technology of unbounded promise. GPS technology offers several advantages: First and foremost, the service is free worldwide and anyone with a receiver can receive the signals and locate a position. Second, the system supports unlimited users simultaneously. Third, one of the great advantages of GPS is the fact that it provides navigation capability

Track II has become the preferred standard for weather satellites users' world wide. Track II for Windows has all the features of the best-selling MS-DOS version while making full use of the easy to use Windows interface. It shows several satellites simultaneously and can print out schedules if required. This program is intended to be used mainly for tracking weather satellites. It has several features which are particularly useful for weather satellite users.

5.2 RECOMMENDATIONS

There are several improvements that are recommended for this project. The satellite communications laboratory should have qualified technicians to handle satellite communications equipments such as parabolic dish, TVRO board, and weather satellite workbench etc. By having those experienced personnel, all the equipments can be utilized at its optimum. Besides that the laboratory manual that have been provided by the manufacturer are incomplete and difficult to understand. Thus laboratory manual that is user friendly which is can be understand easily by a student are preferable. Hence the experiment especially involving satellite communication can be carried out by anyone.

Another recommendation made is the satellite communications laboratory must be equipped with internet access. There are experiments required internets accesses such as weather satellite which its footprints prediction data of each satellite must be update every 3 months. Besides that with internet streaming, anyone that using communications laboratory can keep tracking on what happened in communications world nowadays without wasting times.

The final recommendation is to study the Global Positioning Systems receiver. The studies possibly can include its operation and designed the receiver circuit. There is an example and a lot yet to be discovered in this subject matter which seems to be new for the next final year project student. It surely challenging and demanding a lot of commitment doing this project as communication itself keeps developing year by year.

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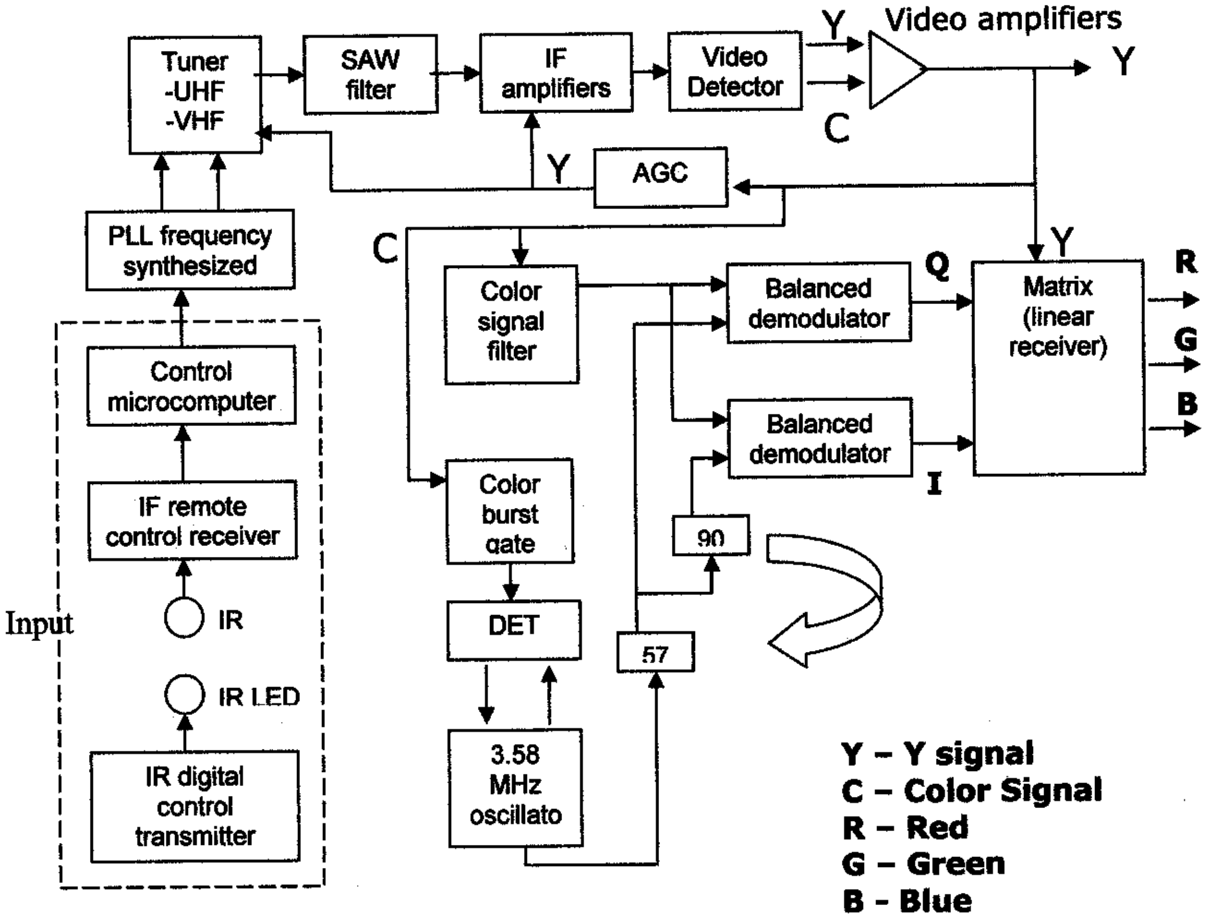
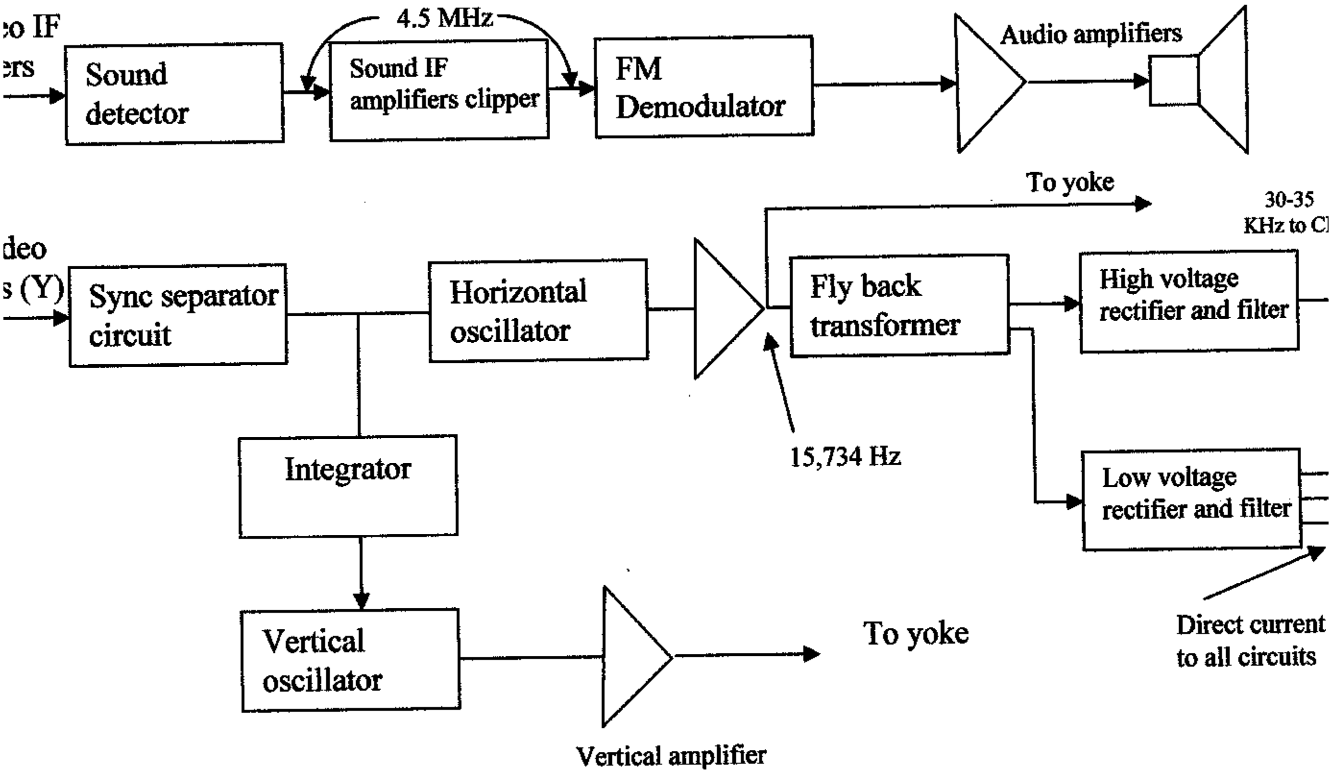
APPENDIX I
TELEVISION RECEIVER



Y – Y signal
C – Color Signal
R – Red
G – Green
B - Blue

o IF
rs
Sound detector
4.5 MHz
Sound IF amplifiers clipper
FM Demodulator
Audio amplifiers
deo
s (Y)
Sync separator circuit
Horizontal oscillator
To yoke
30-35 KHz to C
Fly back transformer
High voltage rectifier and filter
15,734 Hz
Integrator
Low voltage rectifier and filter
Vertical oscillator
To yoke
Direct current to all circuits
Vertical amplifier

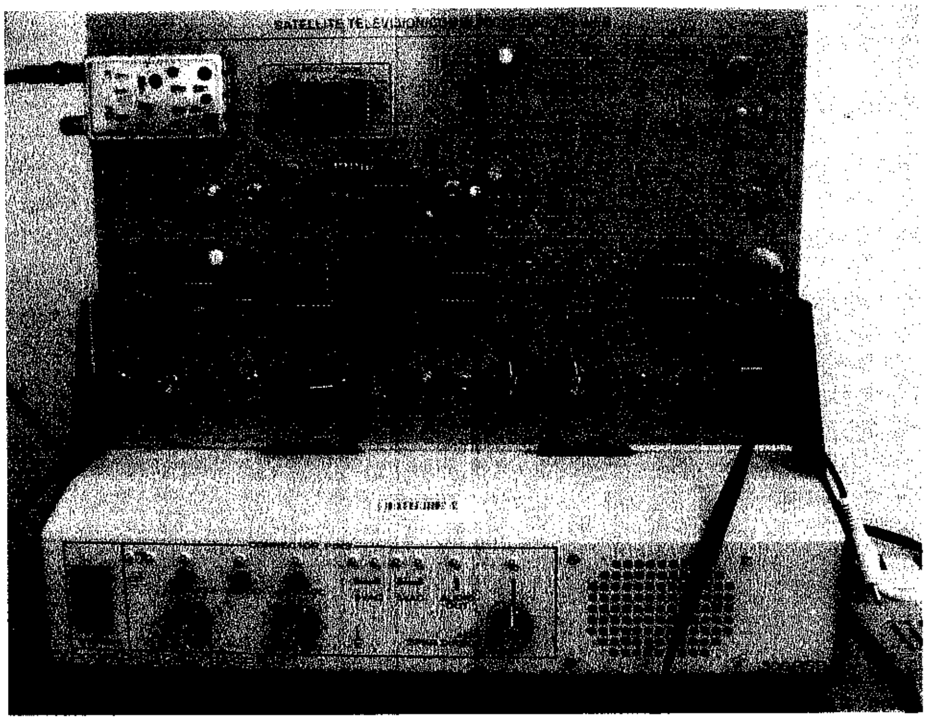
APPENDIX II
QPSK MATLAB CODING

```
sr=2560.0;  %rate
ml=2;           %no of modulation levels
br=sr .* ml;  %bit rate (array multiply)
nd=1000;         %no. of symbols
ebn0=3;         %Eb/N0
IPOINT=8;       %no. of oversamples
%*************************
irfn=21;      %No of taps
alfs=0.5      %rolloff factor
[xh]  = hrollfcoef(irfn,IPOINT,sr,alfs,1);   % transmitter filter coeff.
[xh2] = hrollfcoef(irfn,IPOINT,sr,alfs,0);   % receiver filter coeff.
%*************************
nloop=100;        % no of loops for simulation
noe=0;          % no of error data
nod=0;          %no of transmitted data

for iii=1:nloop
    %*****************************
    data1=rand(1,nd*ml) >0.5           %randomly generated data
    %*****************************
    [ich,qch]=qpskmod (data1,1,nd,ml);
    [ich1,qch1]=compoversamp (ich,qch,length(ich),...
        IPOINT);
    [ich2,qch2]=compconv(ich1,qch1,xh);
    %*****************************
    spow=sum(ich2.*ich2+qch2.*qch2)/nd;
    attn=0.5*spow*sr/br*10.^(-ebn0/10);
    attn=sqrt(attn);
    %*****************************
    [ich3,qch3]=comb (ich2,qch2,attn);

    [ich4,qch4]=compconv(ich3,qch3,xh2);

    syncpoint = irfn*IPOINT+1;

    ich5=ich4(syncpoint:IPOINT:length(ich4));
    qch5=qch4(syncpoint:IPOINT:length(ich4));
    %*****************************
    [demodata]=qpskdemod(ich5,qch5,1,nd,ml);
    %*****************************
    noe2=sum(abs(data1-demodata));
    nod2=length(data1);
    noe=noe+noe2;
    nod=nod+nod2;
    fprintf('%d\t%e\n',iii,noe2/nod2);
end

%************************

ber=noe/nod;
fprintf('%d\t%d\t%d\t%e\n',ebn0,noe,nod,noe/nod);
fid=fopen('BERqpsk.dat','a');
fprintf(fid,'%d\t%e\t%f\t%f\t\n',ebn0,noe/nod,noe,nod);
fclose(fid);

function [iout,qout] = comb (idata,qdata,attn)

iout = rand (1,length (idata)).*attn;
qout = rand (1,length (qdata)).*attn;

iout = iout + idata (1 : length (idata));
qout = qout + qdata (1 : length (qdata));

function [iout,qout]=compconv (idata,qdata, filter)

iout = conv (idata,filter);
```

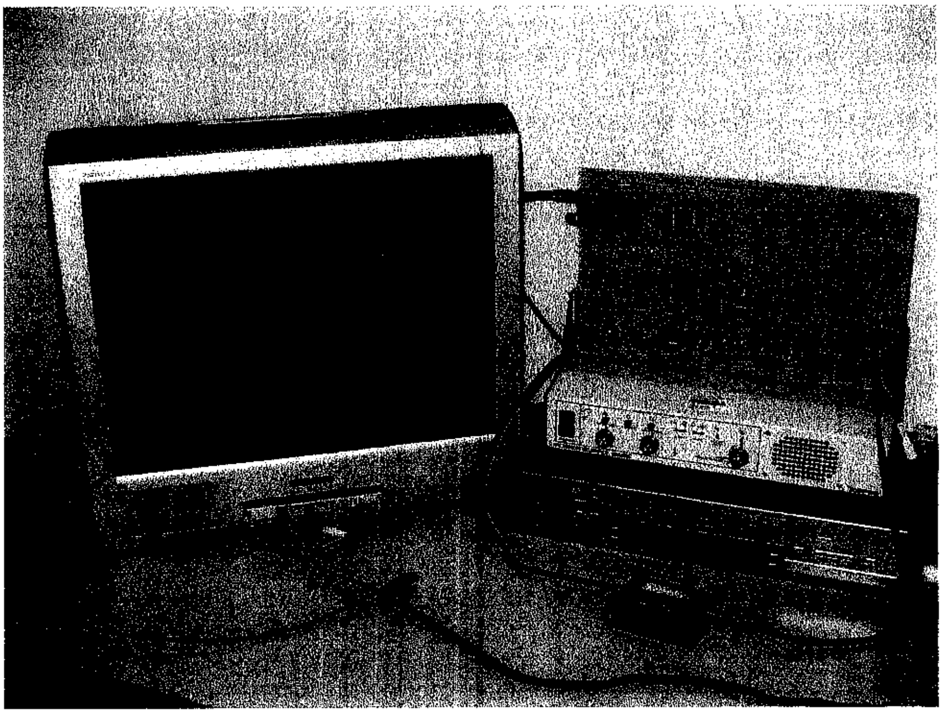
```
qout = conv (qdata,filter);

function [iout,qout]= compoversamp (idata,qdata,nsymb,sample)

iout = zeros (1,nsymb*sample);
qout = zeros (1,nsymb*sample);
iout (1:sample:1+sample*(nsymb-1))=idata;
qout (1:sample:1+sample*(nsymb-1))=qdata
function [out]=oversamp (indata, nsymb, sample)

out=zeros(1,nysmb*sample);
out(1:sample:1+sample*(nsymb-1))=indata;


function [demodata]=qpskdemod(idata,qdata,para,nd,ml)

demodata=zeros(para,ml*nd);
demodata((1:para),(1:ml:ml*nd-1))=idata((1:para), ...
    (1:nd))>=0;
demodata((1:para),(2:ml:ml*nd)) = qdata ((1:para), ...
    (1:nd))>=0;


function [iout,qout]=qpskmod(paradata,para,nd,ml)
m2=ml ./ 2;
paradata2 = paradata .* 2 - 1;
count2=0;
for jj=1:nd

    isi=zeros(para,1);
    isq=zeros(para,1);

    for ii = 1 : m2
        isi = isi + 2.^ (m2 - ii ) ...
            .* paradata2((1:para),ii+count2);
        isq = isq + 2.^ (m2 - ii ) ...
            .* paradata2((1:para),m2+ii+count2);
    end
    iout((1:para),jj)=isi;
    qout((1:para),jj)=isq;
    count2=count2+ml;
end
function [xh] = hrollfcoef(irfn,ipoint,sr,alfs,ncc)
xi=zeros(1,irfn*ipoint+1);
xq=zeros(1,irfn*ipoint+1);

point=ipoint;
tr=sr;
tstp=1.0 ./ tr ./ ipoint;
n=ipoint .* irfn;
mid= ( n ./ 2) + 1;
sub1 = 4.0 .* alfs .* tr;

for i = 1:n

    icon= i - mid;
    ym=icon;

    if icon == 0.0

        xt = (1.0 - alfs + 4.0 .*alfs ./ pi) .* tr;
    else
        sub2 = 16.0 .* alfs .* alfs .* ym .* ym ./ ipoint ./ ipoint;
        if sub2 ~=1.0
            x1=sin(pi*(1.0-alfs)/ipoint*ym) ./ pi ./ ...
                (1.0 - sub2) ./ym ./ tstp;
            x2=cos(pi*(1.0+alfs)/ipoint*ym)./ ...
                pi .* sub1 ./ (1.0 - sub2);
            xt = x1 +x2 ;
```

```
else
            xt = alfs .* tr .* ((1.0 - 2.0 / pi) .* cos (pi / 4.0 / alfs) + (1.0 + 2.0 ./
pi) .*sin(pi/4.0/alfs)) ./ sqrt (2.0);

        end
    end

    if ncc == 0
        xh (i) = xt ./ ipoint ./ tr;
    elseif ncc == 1
        xh (i) = xt ./ tr;
    else
        error ('ncc error');
    end
end
```

APPENDIX III
TVRO BOARD AND CONNECTIONS

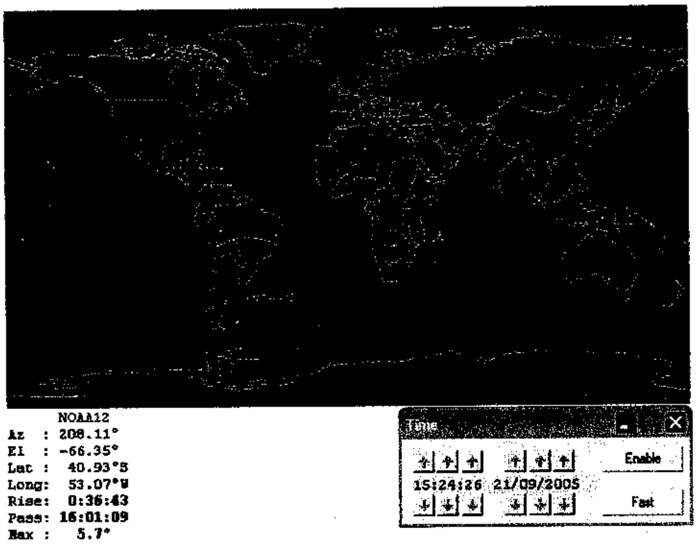


Television Receive-Only (TVRO) Board.



Television Receive-Only (TVRO) connections.

APPENDIX IV
FOOTPRINTS PREDICTION OF WEATHER SATELLITE

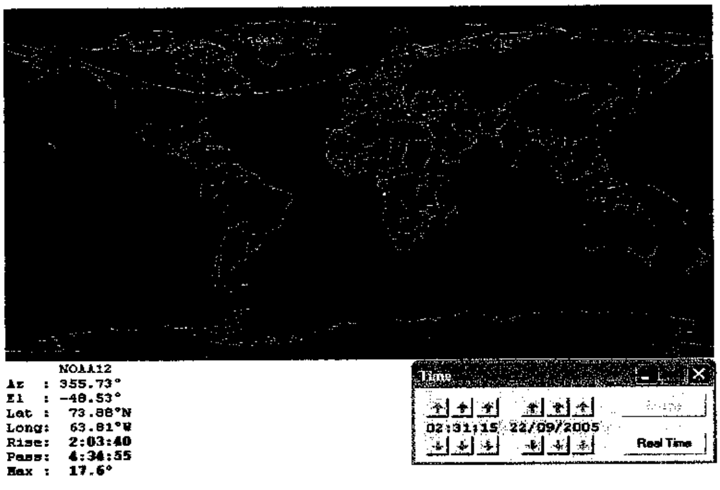


```
      NOAA12
Az  : 208.11°
El  : -66.35°
Lat :  40.93°S
Long:  53.07°W
Rise:  0:36:43
Pass: 16:01:09
Max :   5.7°
```

```
15:24:26 21/09/2005
```

Initial Position of NOAA 12

Figure shows the initial position of NOAA 12 before the footprints prediction for the azimuth and elevation angle at 208.11° and -66.35°. The latitude is 40.93°S and the longitude is 53.07°W on September, 21st, 2005 at 15:24 (24-hours standard)

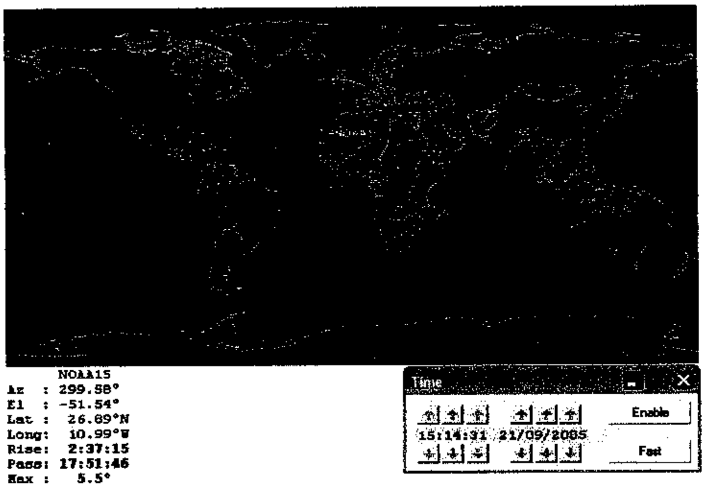


```
      NOAA12
Az  : 355.73°
El  : -48.53°
Lat :  73.88°N
Long:  63.81°W
Rise:  2:03:40
Pass:  4:34:55
Max :  17.6°
```

```
02:31:15 22/09/2005
```

Prediction Location of NOAA 12 after 10 hours

Figure shows the footprint prediction and current position of NOAA 12 after 10 hours. The azimuth and elevation angle is at 355.73° and -48.53°. The latitude is at 73.88°N and the longitude is at 63.81°W on September, 22nd, 2005 at 2:31 (24-hours standard)

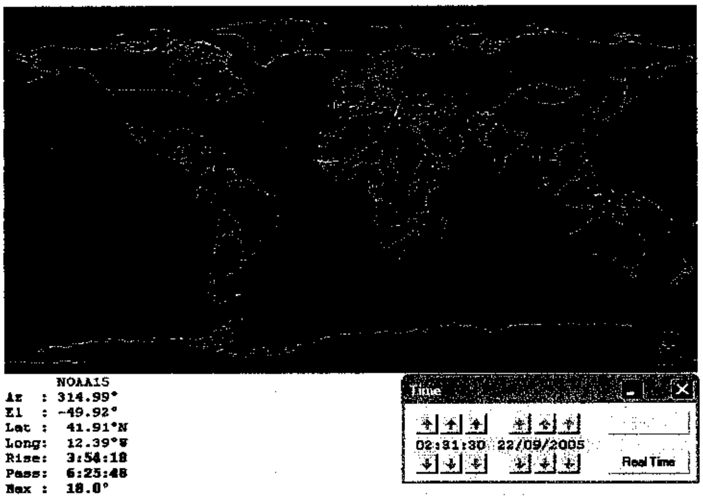


```
        NOAA15
Az   : 299.58°
El   : -51.54°
Lat  :  26.89°N
Long:   10.99°W
Rise:   2:37:15
Pass: 17:51:46
Max  :    5.5°
```

```
15:14:31 21/09/2005
```

Initial position of NOAA 15

Figure shows the initial position of NOAA 15 before the footprints prediction for the azimuth and elevation angle at 299.58° and -51.54°. The latitude is 26.89°N and the longitude is 10.99°W on September, 21st, 2005 at 15:14 (24-hours standard)



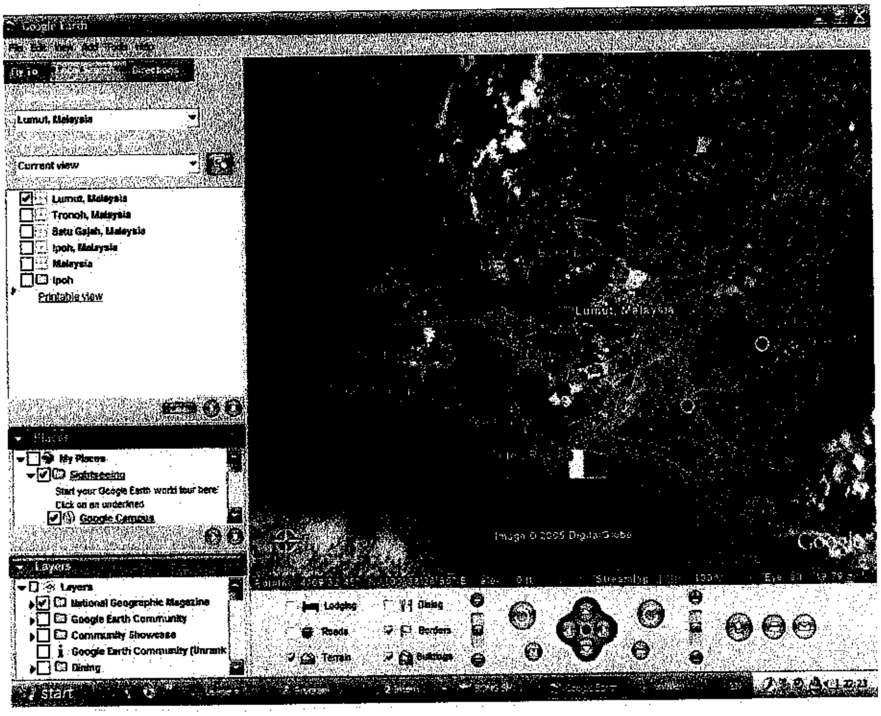
```
        NOAA15
Az   : 314.99°
El   : -49.92°
Lat  :  41.91°N
Long:   12.39°W
Rise:   3:54:18
Pass:   6:25:48
Max  :  18.0°
```

```
02:31:30 22/09/2005
```

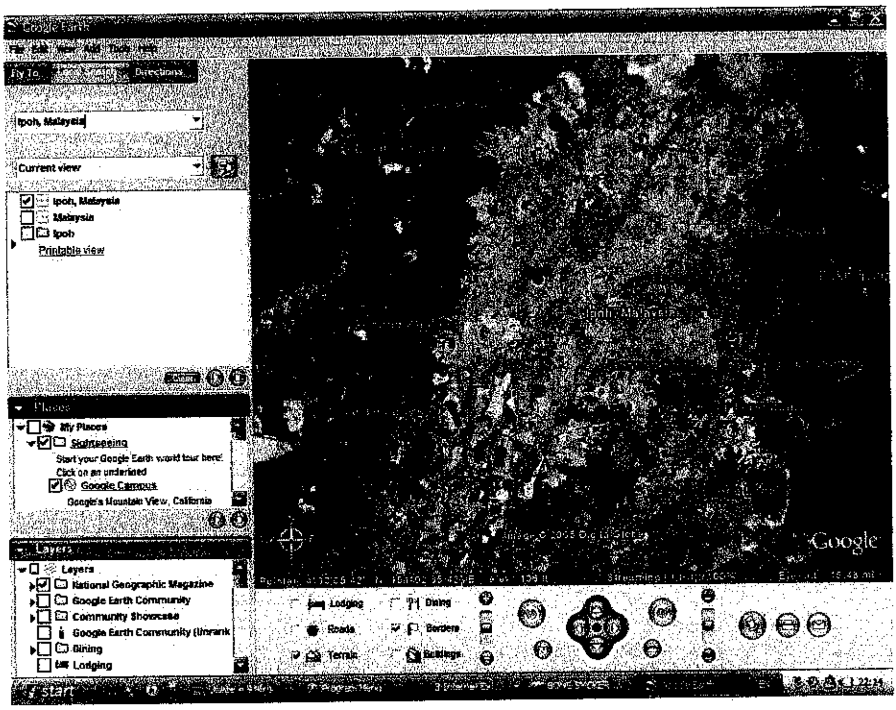
Prediction Location of NOAA 15 after 10 hours

Figure shows the footprint prediction and current position of NOAA 15 after 10 hours. The azimuth and elevation angle is at 314.99° and -49.92°. The latitude is at 41.91°N and the longitude is at 12.39°W on September, 22nd, 2005 at 2:31 (24-hours standard)

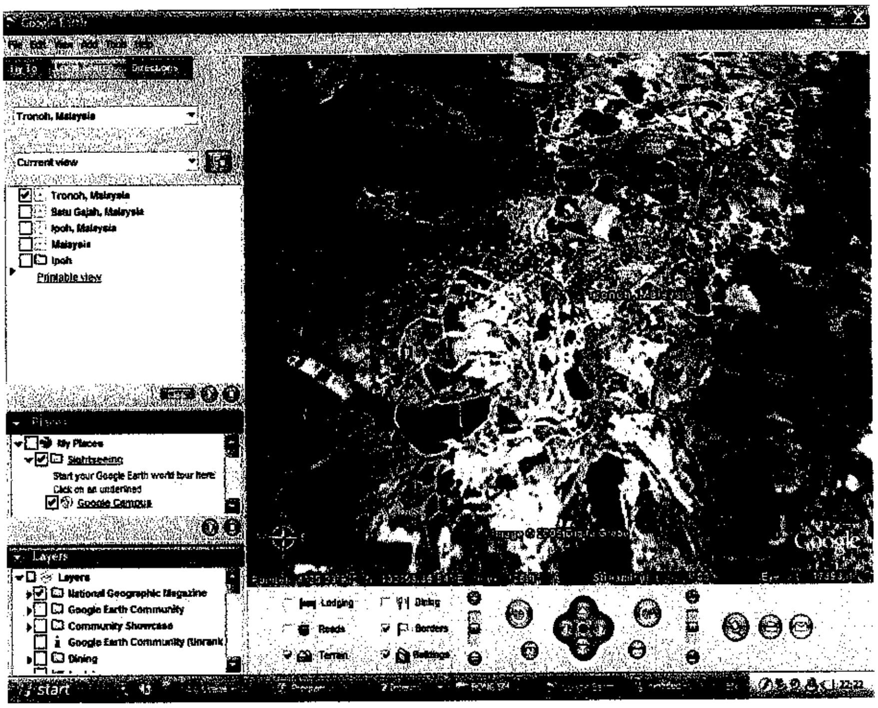
APPENDIX V
LOCAL IMAGES FROM GPS



Lumut, Perak, Malaysia



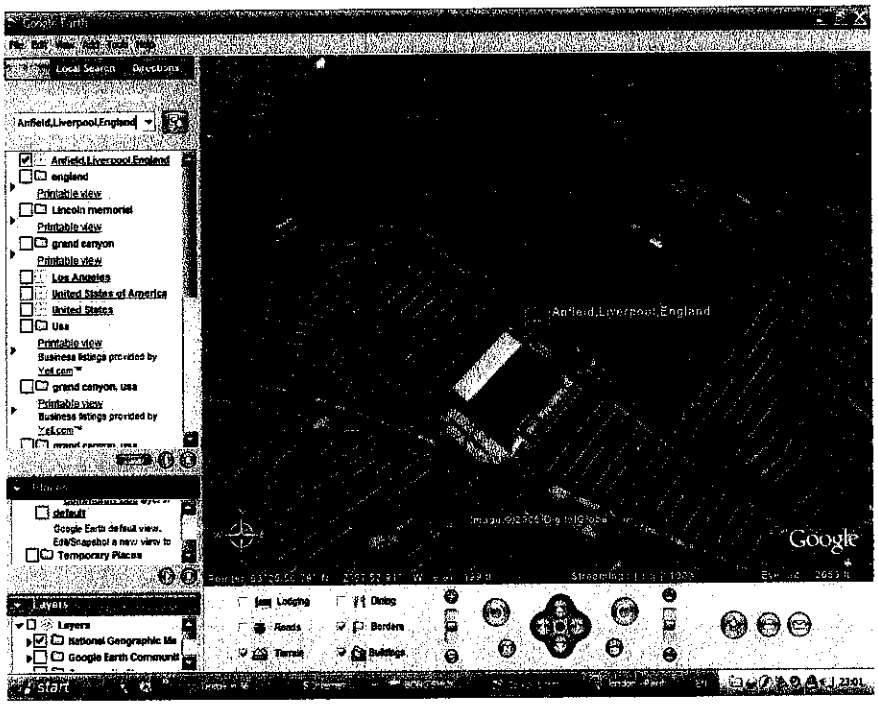
Batu Gajah, Perak, Malaysia



Tronoh, Perak, Malaysia

APPENDIX VI
INTERNATIONAL IMAGES FROM GPS

Old Trafford Stadium, London, England



Anfield Stadium, London, England.