



***Design and construction of a low cost solar TV
transmitter***

BY

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Abstract

In Zimbabwe television (ZTV) transmission coverage is approximately 55% nationwide and is mainly confined to urban areas. The dissertation overviews activities of the author's design of a solar tv transmitter prototype which will act as gap filler in remote areas where there is no television coverage. Due to recent progress in the field of Wireless Sensor Networks (WSN) in industry particularly for control and data processing, the same goal can be achieved in television broadcasting by harnessing this idea. Since WSN technology brings several advantages over traditional wired systems, including self-organization, rapid deployment, flexibility, and low power consumption this prompted the author to design the prototype. The prototype is going to be a completely self-contained outdoor unit with a battery backup which is recharged by a solar power unit. This will provide a complete solution to the Transmedia's dilemma of the coverage increase of ZTV1 signals in a cost effective manner to most people who are information starved. The prototype is going to broadcast two channels so as to increase viewer's choice. It can also be installed in colleges, rural community, or shopping malls where you can broadcast tutorial videos, entertainment and advertisements respectively. The design is going to implement digitilisation and analogue system so as to reduce cost and abide by International Telecommunication Union (ITU) digitalization deadline of June 15 2015.

DECLARATION

I, *Cosmas Chikwira* do hereby declare that I am the sole author of this research thesis. I authorize the University Of Midlands State University to lend this research thesis to other institutions or individuals for the purpose of scholarly research.

Signature..... Date.....

APPROVAL

This dissertation entitles “**Design and construction of a low cost solar TV transmitter**” by **Cosmas Chikwira** meets the regulations governing the award of a degree of BSC Telecommunications Honours Degree of the Midlands State University, and is approved for contribution to knowledge and literal presentation.

Supervisor:

Date:

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CHAPTER ONE

LITERATURE REVIEW

1.0 Introduction

Television transmission is a very important source of information in Zimbabwe. Television receivers update us on the latest happenings in and outside country. Consequently it has become the integral part of each and every Zimbabwean's life in urban areas. In rural areas television reception is very poor or there is no coverage prompting the viewers to rely on foreign broadcasters such as Botswana Television (BTV) and South African Broadcast Cooperation (SABC). Most people in areas without TV coverage are information starved. Important information and updates pertaining to critical weather conditions like droughts, hailstorms, heat waves, floods and cyclones is not available on time to the people residing in those areas. This prompted the author to design and construct a low cost solar TV transmitter prototype which will act as a gap filler.

1.1 Background and Justification

This dissertation is targeted at providing a combination of a low cost transmitter with two channels hence improving the television coverage from 55% to more than 75%. The transmitter is going to be a completely self-contained outdoor solar powered unit with a 12 volts (V.dc), 55 amp per hour (Ah) battery, with an alternative input of mains supply. The unit is designed for unattended, outdoor, function, so as to withstand elements of weather and vandalism. It can be easily installed in a variety of locations such as poles, roof tops or mountains hence minimising the cost of ownership and security. The transmitter unit is going to be simple and pre-configured hence requires no further adjustment during installation. This would effectively reduce cost without compromising quality of reception. The unit can also be placed in colleges where you can broadcast tutorial videos or in a farming community where you can broadcast farming tutorials. The design is going to be a combination of digital TV and analogue TV thereby assisting Transmedia to meet 15 June 2015, a deadline set by (International Telecommunication Union) ITU for all broadcasters digitalise. The dissertation seeks to use interviews and questionnaires as a way of gathering information. A series of interviews are going to be conducted with the regulatory bodies namely Postal and Telecommunications Regulatory Authority of Zimbabwe (POTRAZ), Broadcasting Authority Of Zimbabwe (BAZ) and Transmedia so as to come up with a gap filler map which will

enable the designer to know which areas need the service. This dissertation gives a clear outline of how the prototype is going to be designed, the results obtained, a discussion of the results, conclusion and recommendations for further research.

1.2 Purpose of study

To design a prototype of a small solar TV transmitter which will act as a gap filler and to enhance television coverage in remote areas.

1.3 Statement of the Problem

The dissertation aims at coming up with a low cost solar TV transmitter in a bid to eradicate network coverage deficiencies in marginalised areas.

1.4 Sub problems

- Adjust the gain of the transmitter amplifier to be in the range of 20-35 dB to achieve a broadcasting range of 30 meters (m) to 40 meters (m) a stipulation given to the author by Broadcasting Authority of Zimbabwe (BAZ) to avoid interference.
- Use of a perfect matching antenna which should be able to transmit electromagnetic waves (emw) from the transmission line without any reflection.
- Designing a circuit system which consume less power.

1.5 Hypothesis

An electromagnetic wave (emw) as evidenced by Maxwell's equation is self propagating. The emw requires conductive, natural and man-made properties for the signal to travel greater distances and achieve greater coverage. The dissertation seeks to address the problem of reduced ZTV coverage in Zimbabwe by designing a reliable and low cost prototype to provide ZTV coverage to marginalized areas.

1.6 Aim of Study

Most of the marginalised areas have benefitted from the rural electrification program, but something is yet to be done for TV receptions. Zimbabwe is one of the few countries that have the highest literacy rate, but most of the information meant for everyone is confined to urban areas. The prototype targets remote areas of Zimbabwe with the objective of enhancing television coverage. The prototype is going to provide a complete solution to the

Transmedia's dilemma of coverage increase of ZTV transmission in a cost effective manner in remote and marginalized areas. The prototype is geared to provide the expected signal quality to viewers.

1.7 Objectives of Study

Listed below are issues that need to be addressed so that the product acts as a remedy to those who are being deprived of their right to information.

- To gather relevant information or literature for the project.
- To enhance ZTV coverage to the information starved and marginalized areas of Zimbabwe
- To provide a low noise device so that it does not distort the received DVB signal from the DSTV decoder.
- The device should consume less power – powered by 12 V (dc) battery and recharged by solar.
- The device should provide a high quality video and audio signal to viewers.
- The device should be very affordable to the designer.
- The device should be portable and not bulky.

1.8 Limitations

- The battery bank should be able to power the system for more than 3 days continuously especially in winter when there is no direct sunlight.
- There is also need to pay particular attention to the frequency of operation to avoid interfering with other broadcasted signals.
- The author is supposed to seek the authority of POTRAZ and BAZ, which are the broadcasting regulatory authorities in Zimbabwe. Failure to acquire the permission may hinder the author's progress.
- Parastatals such as Transmedia and POTRAZ may be reluctant to provide the author with crucial information during questionnaire due to security concerns.
- Most of the electronic components are not available on the local market.

1.9 Assumptions

- The viewers are located in a homogenous terrain to avoid signal blockage hence providing maximum coverage.
- Most of the viewers can at least afford or own a TV receiver in their household such that during the testing process the author can easily acquire feedback from the starved viewers.
- Viewer's tv sets are compatible with the transmitted very high frequency (vhf) and ultra high frequency (uhf) video signal.
- The author assumes the device is going to consume less power so as not to over drain the battery bank.
- The author assumes the design cost of the device is going to be lower so that device will be very affordable to the designer.

CHAPTER TWO

THEORETICAL ASPECTS

2.0 Introduction

In chapter two the author delimits the research problem by taking a step by step analysis of all the electronic components used in the design of the solar TV transmitter prototype. This stage is crucial to the author for there is need fully understand the basics and characteristics of the components used. This gives a better understanding of the circuit design and enables troubleshooting in the event of malfunctioning of the circuit.

2.1 Basics of a Transmitter technology

A transmitter is an electronic device that emits radio frequency signals in free space. A receiver is an electronic device that receives radio frequency signals from the transmitter. The radio frequency may contain intelligence in the form of data. There are several transmitter/receiver types which operate at different frequencies.

2.2 Transmitter Location

There are several factors to be considered when choosing a site for locating a transmitter.

- It should be located in interference free areas e.g. away from power transformers.
- It should be located at a higher ground to enhance coverage.

2.3 Antenna

An antenna is form of transducer which converts electric currents into radio waves, and vice versa. It is usually used with a radio transmitter or radio receiver. Wireless antennas are separated into two main types, uni-directional and Omni-directional antennas. A directional antenna is one that radiates its energy more effectively in one direction than others. Typically, these antennas have one main lobe and several minor lobes e.g. are patch and dish antennas. An omni-directional antenna is an antenna that has a non-directional or circular pattern in a given plane with a directional pattern in any orthogonal plane e.g. dipoles and collinear antennas. The performance of an antenna is measured in dB, for every 3 dB of gain the power is doubled. Most manufactures specify gain as dBi (gain measured with reference to an isotropic radiator).

2.4 Dipole Antennas

Dipole is an omni-directional antenna. A dipole antenna most commonly refers to a half-wavelength ($\lambda/2$) dipole. The antenna is constructed of conductive elements whose combined length is about half of a wavelength at its intended frequency of operation. This is a simple antenna that radiates its energy out toward the horizon (perpendicular to the antenna) as illustrated in Fig 1.

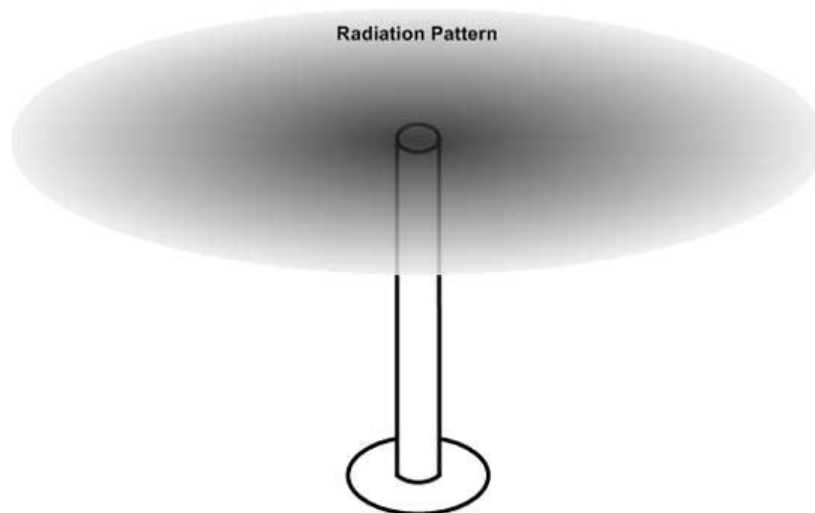


Figure 1 Radiation Pattern [1]

The radiation patterns in Fig 1 results from a perfect dipole formed with two thin wires oriented vertically along the z-axis. The strongest energy is radiated outward, perpendicular to the antenna in the x-y plane. The radiation pattern is an azimuth plane pattern, which is non directional as the antenna radiates its energy equally in all directions in the azimuth plane. Dipole antenna should be mounted so that it is vertically oriented with respect to the ground and this result in the maximum amount of energy radiating into the intended coverage area.

2.5 Horizontally polarized and vertically polarized waves

The radio waves radiated from antennas standing vertically propagate vertically in relation to the ground, and are called vertical waves. In the same way, with horizontally placed antennas the electric field is horizontal in relation to the ground, so the waves are called horizontal waves as shown in Fig 2

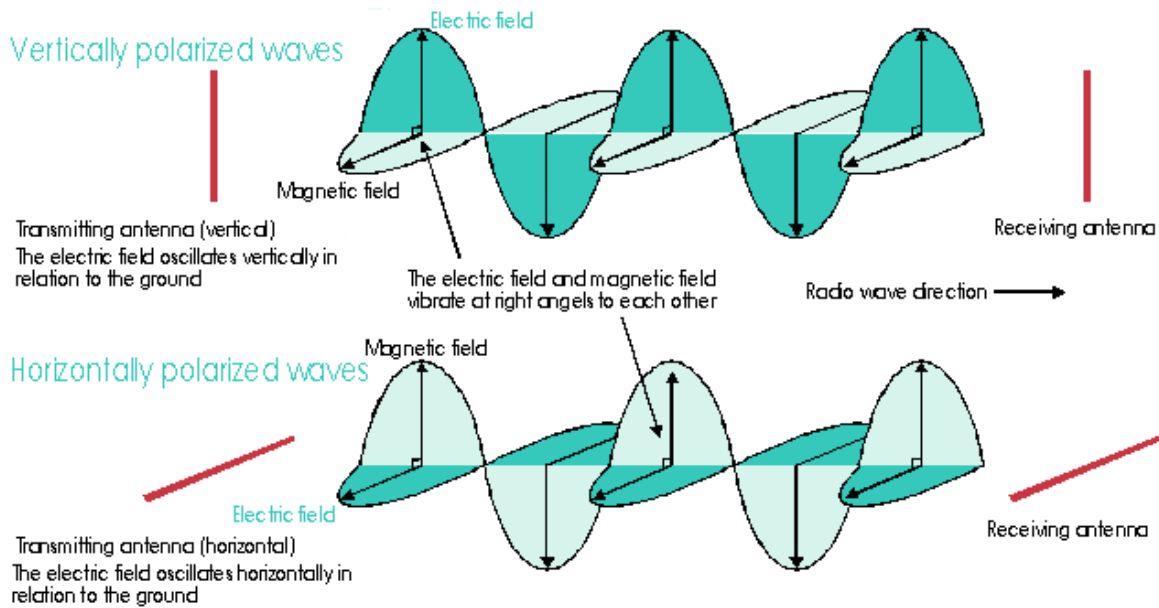


Figure 2 Antenna Polarizations [2]

2.6 Impedance matching, mismatch and SWR

The feedpoint impedance of an antenna may not be exactly the same as the characteristic impedance of its associated feeder. The antenna is then said to be mismatched to the feeder. When a wave travelling along a transmission line from the transmitter to the antenna (incident wave) encounters impedance that is not the same as Z_0 (discontinuity) then some of the wave energy is reflected (reflected wave) back towards the transmitter. The ratio of the reflected to incident wave amplitudes is called the reflection coefficient, designated by letter ρ (Rho).

$$|\rho| = \frac{Z_L - Z_0}{Z_L + Z_0}$$

Z_L is the load impedance

Z_0 is the characteristic impedance of the transmission line.

It follows that the magnitude of ρ lies between 0 and 1, being 0 for a perfectly matched line. Whenever two sinusoidal waves of the same frequency propagate in opposite directions along the same transmission line, as in any system exhibiting reflections, a static interference pattern (standing wave) is formed along the line, as illustrated in Fig 3

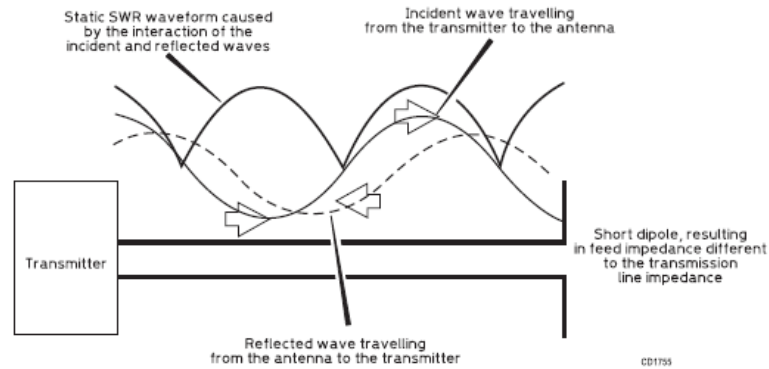


Figure 3 Standing wave [3]

The transmission line must be designed so that radio frequency (RF) power being carried to the antenna does not radiate. Radiation loss from transmission lines can be prevented by using two conductors arranged such that the electromagnetic field from one wire is balanced by an equal and opposite field from the other. In such a case the resultant field is zero; ie there is no radiation. This is illustrated in the Fig 4

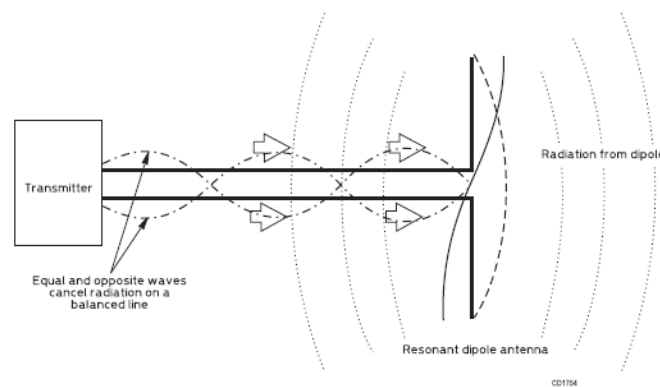


Figure 4 Radiation Pattern in a matched Line [4]

2.7 Directional Antennas

A directional antenna is an antenna that radiates their energy in a particular direction. They are used for point-to-point links. They are classified by the type of feed, e.g. axial (front feed), Cassegrain, Gregorian, and offset feed. In offset feed, the reflector is an asymmetrical segment of a paraboloid, so the focus, and the feed antenna, is located to one side of the dish. The purpose of this design is to move the feed structure out of the beam path, so it does not block the beam. The author is going to use this in his design because it is suitable for home satellite television dishes. An example of a parabolic dish antenna with an offset feed is the DSTV dish as shown in Fig 5. The antenna feed contains a low-noise amplifier and a broadband down-converter referred to as a low-noise block (LNB), which shifts all of the signals to L-band. The block of L-band signals then travels through the coaxial cable to the

receiver, which selects the desired frequency for demodulation. It is interesting that Direct TV broadcasts different programming simultaneously on right and left circular polarizations.

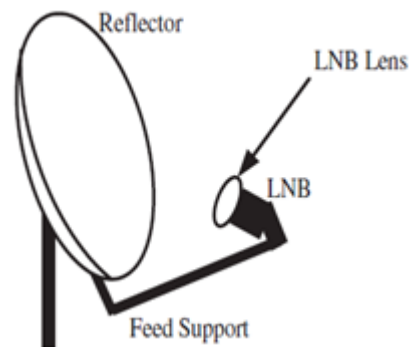


Figure 5 Offset feed Antenna [5]

2.8 Transmission Lines

A transmission line is a pair of conductors used to connect a source circuit to a load circuit. The function of a transmission line is to relay information between distant circuits. A coaxial cable is an example of a transmission line. Coaxial cables are the guided media that carries the signal of higher frequency range. Two types of coaxial cables are widely used: 50 ohm cable used for digital transmission and 75 ohm cable used for analogue transmission. It consists of one physical channel (the copper core) that carries the signal surrounded (after a layer of insulation) by another concentric physical channel (a metallic foil or braid), and an outer cover or sheath, all running along the same axis. The outer channel serves as a shield (or ground) as shown in Fig 6

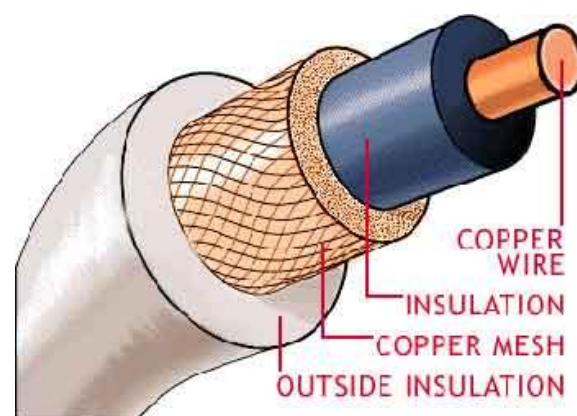


Figure 6 Coaxial Cable Structure [6]

Due to the shield provided, this cable has excellent noise immunity. It has a large bandwidth and low losses. It can be used for high bandwidth and video service hence it's going to be used by the author during the design of his prototype. The coaxial cable parameters are:

The copper wire has radius = 0.0025 m. The copper mesh is a cylindrical shell with inner radius = 0.0075 m, and outer radius = 0.008 m from the centre. For every length $L = 8$ m of cable, there

is a total charge $q = 2.8 e^{-008 c}$ on the inner conductor and a total charge of $Q = -5.6 e^{-006 c}$ on the outer conductor.

i. Advantages of Coaxial Cables

- It offers higher bandwidth as compared to twisted pair cable
- Because of better shielding in coaxial cable, loss of signal or attenuation is less.

ii. Disadvantages of Coaxial Cables

- It is usually more expensive than twisted pair.
- Coaxial cable is quite thick, heavy and bulky

2.9 Direct Current (DC) to Alternating Current (AC) Inverter

A power inverter is a device which converts battery power into the mains power. The power supply unit consist of an inverter which is going to transforms 12 Volts direct current (V.d.c) from solar panel into modified 250 V (a.c) and 50Hz. The three major waveform types are square-wave, modified sine-wave and true sine-wave as illustrated in Fig 7.

i. Modified Sine Wave Inverters

The least expensive type of modern inverter produces modified sine wave power. The waveform looks like a stair-step, where the power rises straight from zero to upper peak voltage, straight back to zero, and straight to lower peak voltage, resting at each point for a moment. Modified sine wave inverters will run many household appliances such as televisions, radios and microwaves.

ii. *Pure Sine Wave Inverters*

Pure sine wave inverters provide an output voltage which harmonically follows a sine wave. This is similar to the utility-supplied grid power. This type of inverter switch polarity ("+" and "-") between power cables smoothly, gradually reducing or increasing the voltage as required. As you can see from this example, though the modified and pure sine wave produce the same levels of output, the pure sine wave inverter produces a much smoother and less erratic output as shown in Fig 7

Comparison diagram of square, pure and modified sine wave.

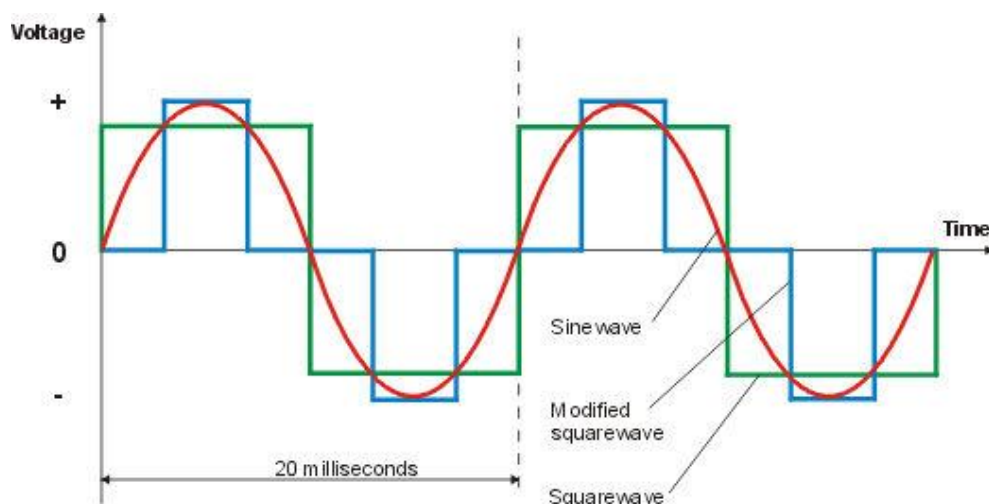


Figure 7 Comparison Diagram: square, pure and modified [7]

1. Pure sine wave inverters provide smoother sine wave signal which is suitable for all appliances, but this type of inverter is expensive.
2. Modified Sine Wave inverters are not suitable for certain appliances with capacitive and electromagnetic devices such as: a fridge, microwave oven and most kinds of motors.
3. Typically modified sine wave inverters work at lower efficiency than pure sine wave inverters
4. Modified sine wave inverters are normally significantly cheaper than pure sine wave inverters hence going to be used in the design of the prototype.

Schematic of the 12 V (d.c) to 220 V (a.c) Inverter

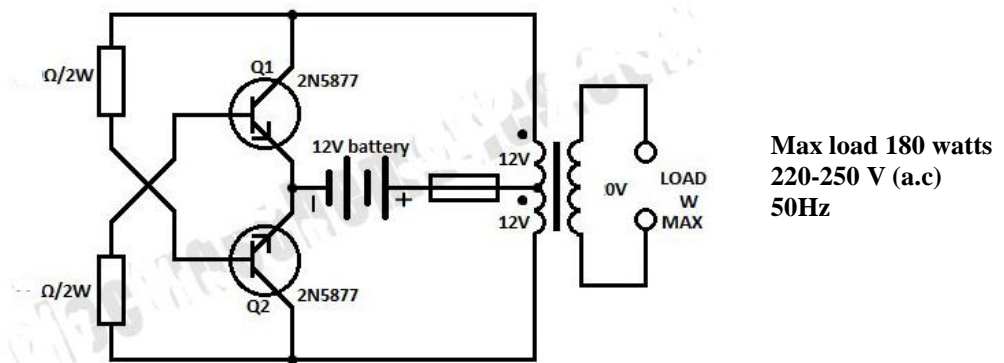


Figure 8 Schematic diagram of an inverter [8]

Simplified diagram in Fig 8 illustrates a 12 V(d.c) to 250 V (a.c) inverter circuit. The 250 V (a.c) power source is constructed with a simple 250 V (a.c):12 V (d.c) centre-tapped control transformer. This circuit outputs a 250 V (a.c) V peak to peak modified wave and can supply a load of up to 180 Watts (W). The circuit is self-starting and free-running. If Q1 is faster and has a higher gain than Q2, Q1 will turn on first when you apply the input power and will hold Q2 off. Load current and transformer magnetizing current then flows in the upper half of the primary winding, and auto transformer action supplies the base drive until the transformer saturates. When that action occurs, Q1 loses its base drive. As it turns off, the transformer voltage reverses, turning Q2 on and repeating the cycle. The output frequency depends on the transformer iron and input voltage but not on the load.

2.10 Amplifier

An amplifier is an electronic circuit which has the capability to amplify power, voltage, or current. Class “A” amplifier: Both small and large signal amplifiers are considered to be class A if they operate in linear region at all the times as illustrated in Fig 9

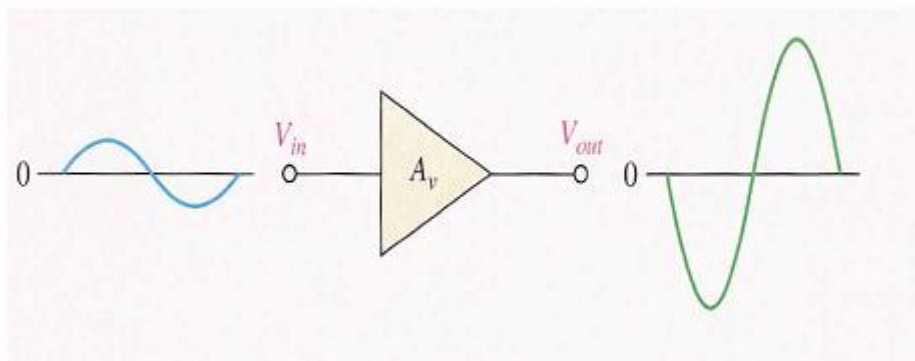


Figure 9 Amplifier [9]

When an amplifier is biased so that it operates in the linear region and its output will for 180 degree of the input cycle, it is a class A amplifier. The prototype is going to use a 10 dB Gain amplifier with wideband capabilities from 30 to 2400 MHz It's going to amplify two video signals from the transmitter to the dipole antenna.

2.11 Multiplexer

A multiplexer puts two or more simultaneous transmissions on a single communications circuit. Generally speaking, the multiplexed circuit must have the same capacity as the sum of the circuits it combines. The primary benefit of multiplexing is to save money.

There are three major types of multiplexers

- Frequency division multiplexers (FDM)E.g. AM/FM Radio, Telephone
- Time division multiplexers (TDM)
- Wavelength division multiplexing (WDM)-Used in optical carriers

Frequency Division Multiplexing (FDM)

- Frequency division multiplexers can be described as dividing the circuit in frequency domain so that many signals can travel on a single communication circuit simultaneously as illustrated in Fig 10

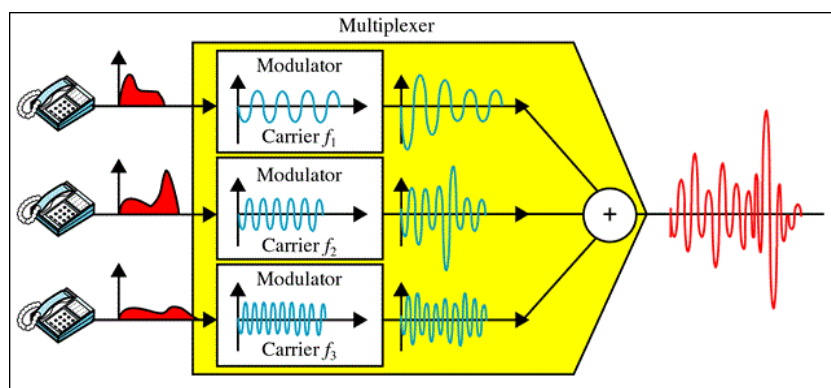


Figure 10 Multiplexer [10]

The circuit is divided into a series of two separate channels (206 MHz and 551.75 MHz), each transmitting on a different frequency. A guard band of 345.75 MHz keeps one channel from leaking over into another channel.

2.12 Modulation

Modulation is the process of superimposing the information contents of a modulating signal on a carrier signal (which is of high frequency) by varying the characteristic of carrier signal according to the modulating signal. Common modulation methods include:

Amplitude modulation (AM)

Frequency modulation (FM)

Phase modulation (PM)

2.13 Frequency Modulation

The carrier frequency is modified according to the modulation signal frequency, keeping the amplitude constant as shown in Fig 11

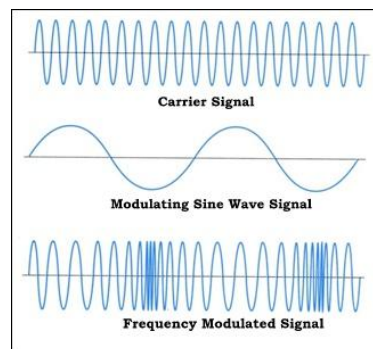


Figure 11 Frequency modulation [11]

i. Advantages of Frequency Modulation

- More noise resistivity when compared to other modulation techniques hence the author is going to use this technique in the prototype.
- Does not require special equipments like linear amplifiers and transmission levels are higher when compared to other modulation techniques.

ii. Disadvantages of Frequency Modulation

- It requires more complicated demodulators in the reception
- To limit the bandwidth in the frequency modulation, we use some filter which will again introduce some distortions in the signal.

Applications of Frequency Modulation (FM)

- Frequency modulation is used in most radio receivers.
- Frequency modulation is used in audio frequencies to synthesize sound.

2.14 ITU Regions and Areas

For the allocation of frequencies, the world has been divided into three Regions as shown in Fig 12.

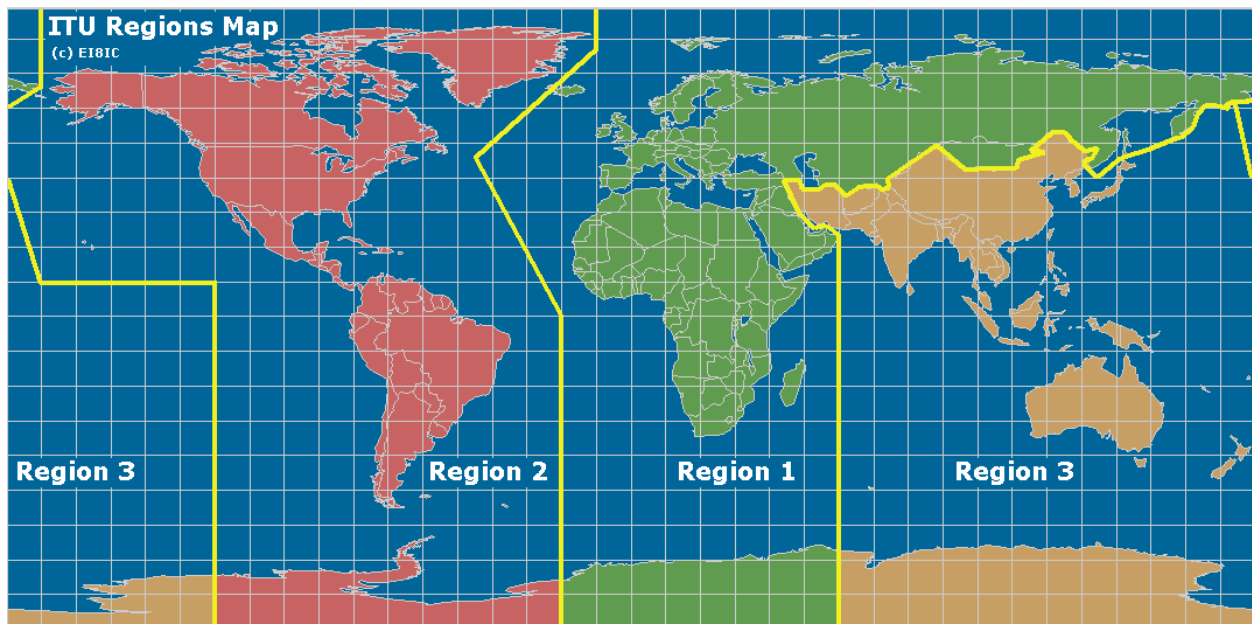


FIGURE 12 ITU Frequency Distribution [12]

Region 1:

It includes Africa, Europe, Armenia, the Russian Federation, Kazakhstan, Georgia, Mongolia, Uzbekistan, Turkmenistan, Turkey and Ukraine.

Region 2:

Consist of North and South America

Region 3:

It includes Australia and Southern parts of Asia

2.15 Frequency Regulatory authorities

i. Potraz and BAZ

POTRAZ divides the spectrum in Zimbabwe into a number of frequency bands using the Zimbabwe National Frequency Allocation Plan (ZNFAP) and specifies the general purposes for which the bands may be used. The ZNFAP plan divides the spectrum range of 8.3 KHz - 3000 GHz into a number of frequency bands and specifies the general purpose for which the bands may be used in Zimbabwe. Zimbabwe is a member of International Telecommunication Union (ITU), and Southern Africa Development Coordination (SADC),

therefore as much as possible, allocations in the ZNFAP are aligned to the allocations in the ITU Radio Regulations and SADC Frequency Allocation Plan. The author was advised that in Zimbabwe, the assignment or allotment of frequencies shall be done in accordance with the ZNFAP. In the case of Broadcasting Services, such applications shall be made to the Broadcasting Authority of Zimbabwe. To apply for a frequency assignment, a user will prepare and submit a relevant application form.

ii. Transmedia

Transmedia Corporation is the only licenced signal Carrier Company in Zimbabwe. It is responsible for connecting the world to Zimbabwe and connecting Zimbabwe to the world. The state-owned enterprise supports broadcasting and broadband infrastructure by offering communication services to the remote and furthest places in Zimbabwe. Transmedia provides signal distribution services for broadcasters such as Zimbabwe Broadcast Corporation (ZBC), Medical Service Providers and Star FM. The Corporation maintains and owns all television and radio transmitters throughout Zimbabwe. It currently carries 6 radios and 2 TV channels on FM. Harare and Bulawayo are the only sites with six services. There are 26 radio sites and 16 TV sites which are functional hence a factor which prompted the author to design the prototype to enhance TV coverage. Transmedia provides terrestrial television services to the Public Broadcasters and Community Broadcasters. The Corporation is facing challenges such as competition from players like Multichoice, and their equipment is obsolete analogue equipment. The author designed a map with all the ZTV's transmitter's locations for clarity as shown in Fig 13 below

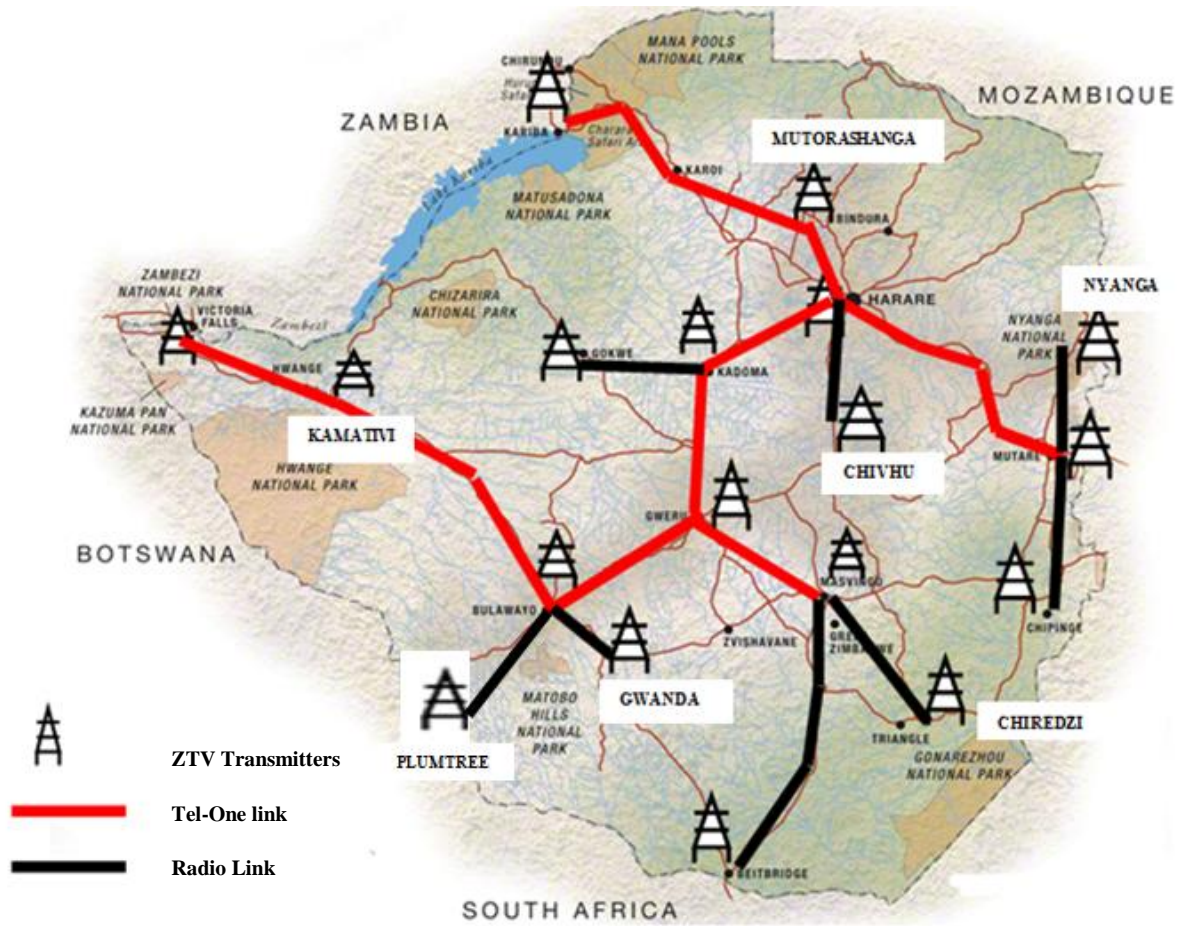


Figure 13 Transmitter location

Fig 13 shows all the transmitter location in Zimbabwe, from which the national transmitter coverage can be plotted as in Fig 14, showing areas with ZTV coverage in Zimbabwe.

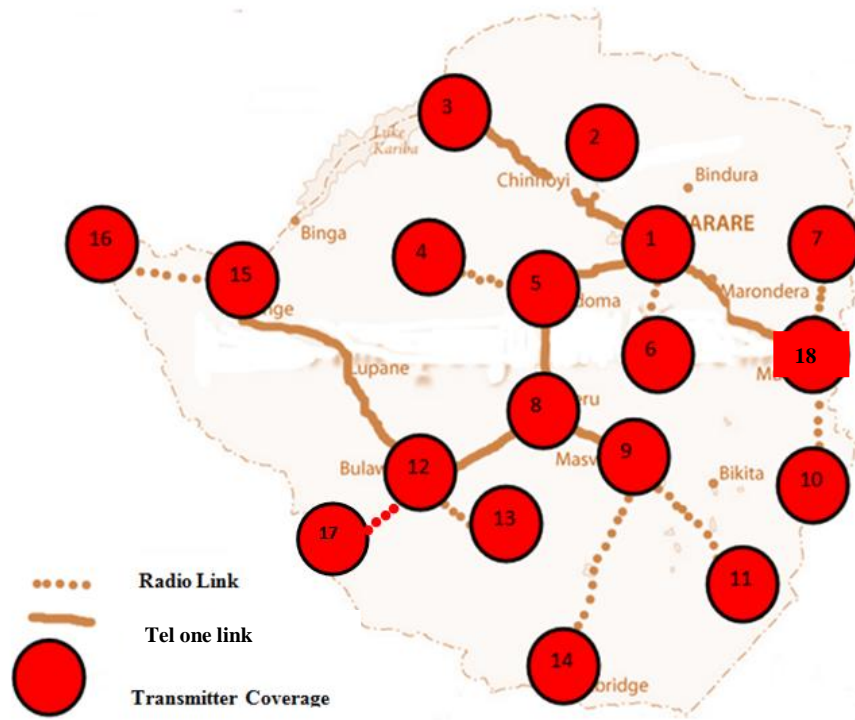


Figure 14 ZTV Transmitter coverage in Zimbabwe

1-Pockets Hill-Harare, 2-Mutorashanga, 3- Kariba, 4-Gokwe, 5-Kadoma, 6-Chivhu, 7- Nyanga, 8-Guinea Fowl-Gweru, 9-Glenlivet-Masvingo, 10-Chipinge, 11-Chiredzi, 12- Bulawayo, 13-Gwanda, 14-Beitbridge, 15-Kamativi, 16-Kariba, 17-Plumtree, 18-Mutare

2.16 Digitilisation

The (ITU) has set year 2015 as the deadline for the migration of all analogue TV transmissions to digital platforms. Transmedia has already started the process of sourcing digital equipment with the limited available resources. The initial phase of the project required about US 30 Million dollars, but the Government only allocated only US 5 Million dollars in the 2012 budget, only to reduce the figure by more than 50%. SADC nations have adopted the Digital Video Broadcasting – Second Generation Terrestrial (DVB-T2) standard with MPEG 4 compression technique for the migration process in favour of the Integrated Services Digital Broadcasting – Terrestrial (ISDB-T). ISDB-T is a type of digital broadcasting system for providing video, audio and multimedia services. DVB-T2 is the world’s most advanced digital terrestrial transmission system. It offers a higher flexibility, robustness and efficiency. It involves the latest coding and modulation techniques to achieve highly efficient utilisation of valuable terrestrial spectrum for the delivery of video data services, and audio to fixed, mobile and portable devices. In Zimbabwe ZTV is on the VHF band, but the digitalisation process will move it to the UHF band, but UHF covers a smaller

area hence it needs the construction of more transmission sites. Zimbabwe has the capacity to open up 93 radio stations but the only hitch is funding for the necessary equipment.

Advantages of Digitalization

- The spectrum is used efficiently i.e. a single frequency can be accommodate up to 20 channels, whereas the analogue platform only accommodates one channel per frequency.
- It can also offer mobile TV services using the same transmitter.

Digitalization Challenges

- Viewers will have to change their receivers and acquire set-top boxes (decoders), to enable them to receive transmission from the digitalized broadcast systems.
- Cost of distributing the signal via satellite to the remote transmission sites is also high

2.17 Coverage Layout and Structures

Fig 15 shows a pictorial Diagram of the network layout of the prototype's distribution to the users. The received digital video signal from the satellite is descrambled in the setbox. It is then converted to an analogue PAL video signal and then retransmitted to the viewers through the prototype.

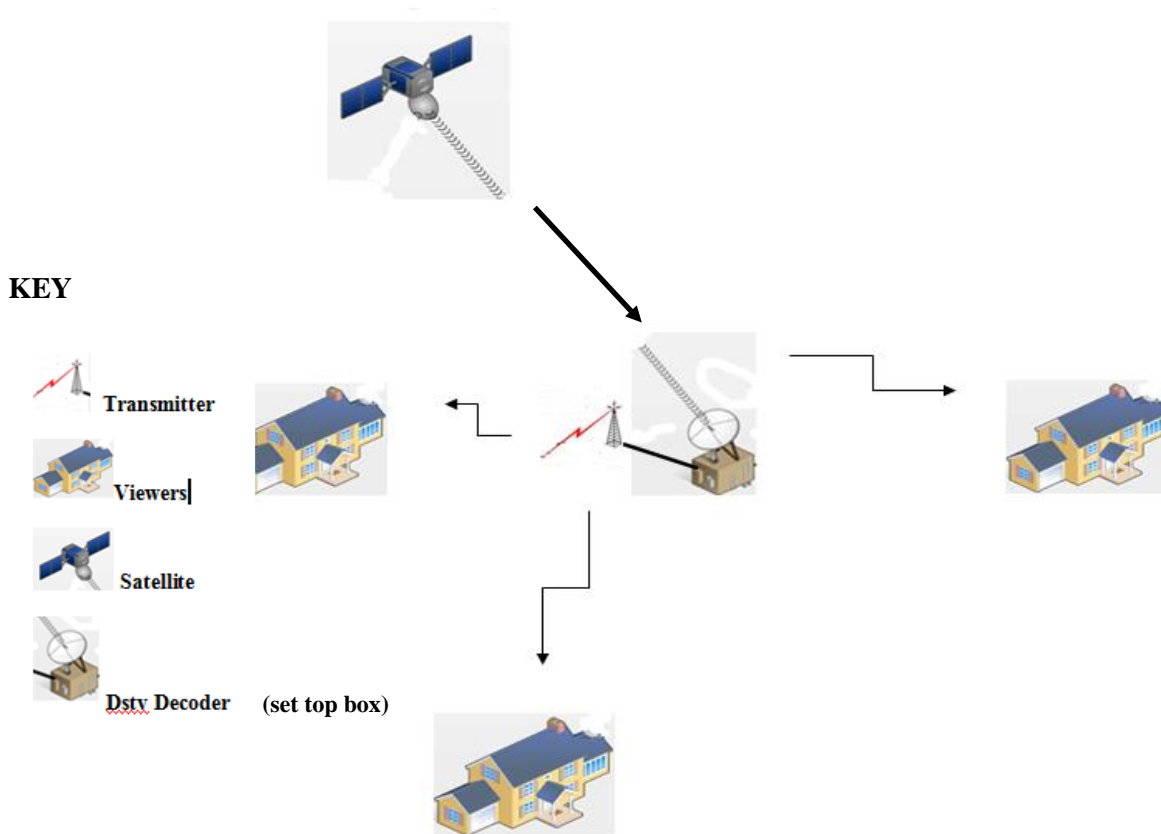


Figure 15 Coverage layout diagram

The output signal from the set top box (dstv decoder) is received from IntelSat Pas 7 satellite located at 65 degrees east, 36000 km above the earth. The satellite provides coverage to the whole SADC region hence the author's prototype can be located anywhere in Zimbabwe as shown in Fig 16.

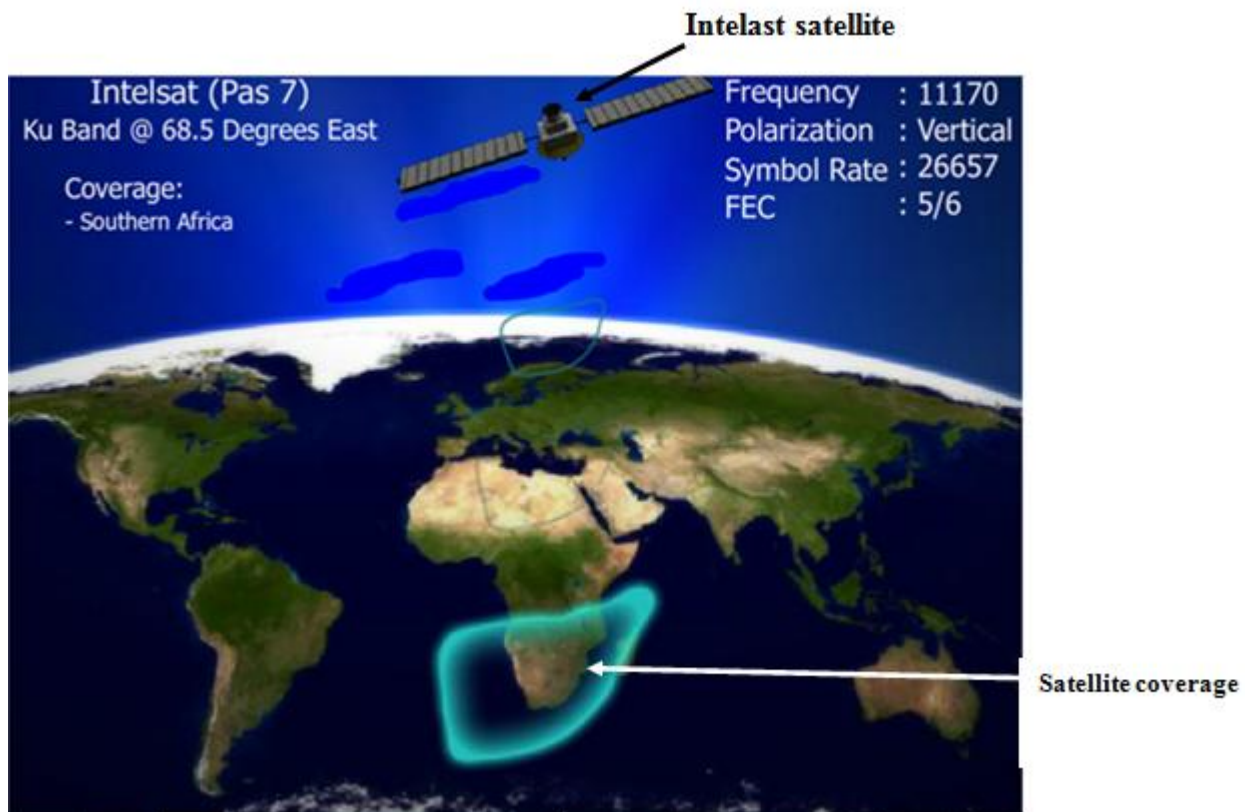


Figure 16 Satellite Coverage [13]

CHAPTER 3

METHODOLOGY

3.0 Introduction

In this chapter the author used a general research strategy which outlines a way in which the project is to be undertaken and identifies the methods to be used in it. The author explores a systematic, theoretical analysis of the applied methods to a field of study. The success of the project hinges on good planning, effective discovery during the data gathering and realistic expectations. This chapter will discuss in detail each subsystem that will lead to the well being of the prototype. It shows how the elements such as DVD player, power supply and modulators are interconnected for the prototype to function as illustrated in Fig 17.

3.1 System Structure

The prototype consists of 5 main subsystems which are:

- Set top box (DSTV decoder)
- DVD player
- Modulators
- Amplifier
- Antenna

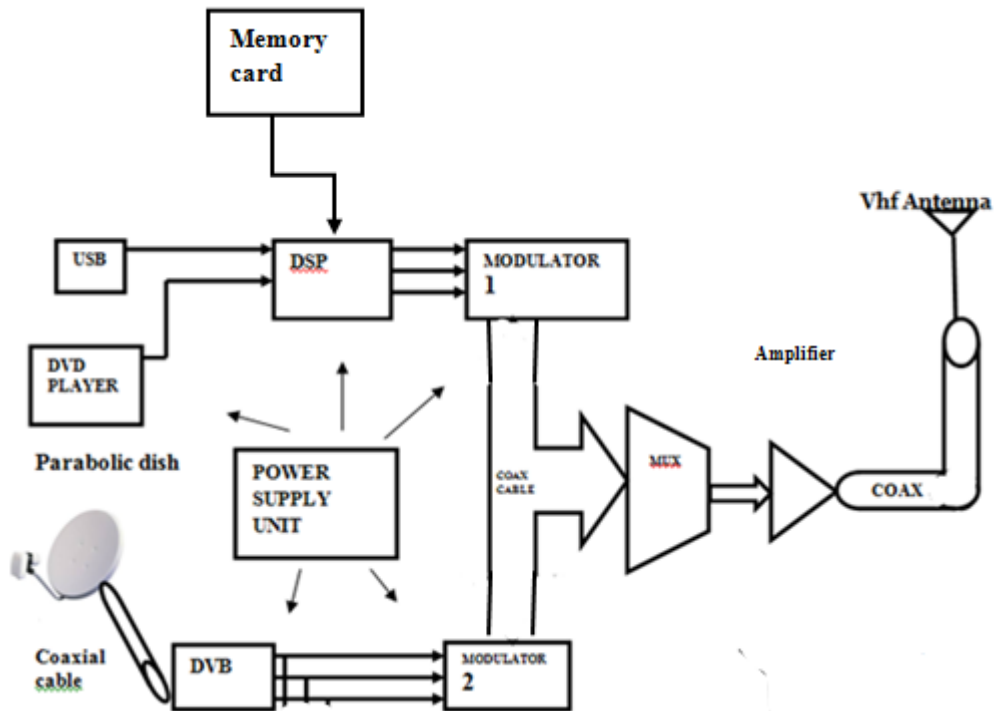


Figure 17 Transmitter System

The input signal can be from a Universal Serial Bus (USB) port, digital video disc (DVD/CD) player or Digital Video Broadcasting (DVB) signal from a Digital Satellite Television (DSTV) decoder.

3.2 Design of the Power Supply Unit

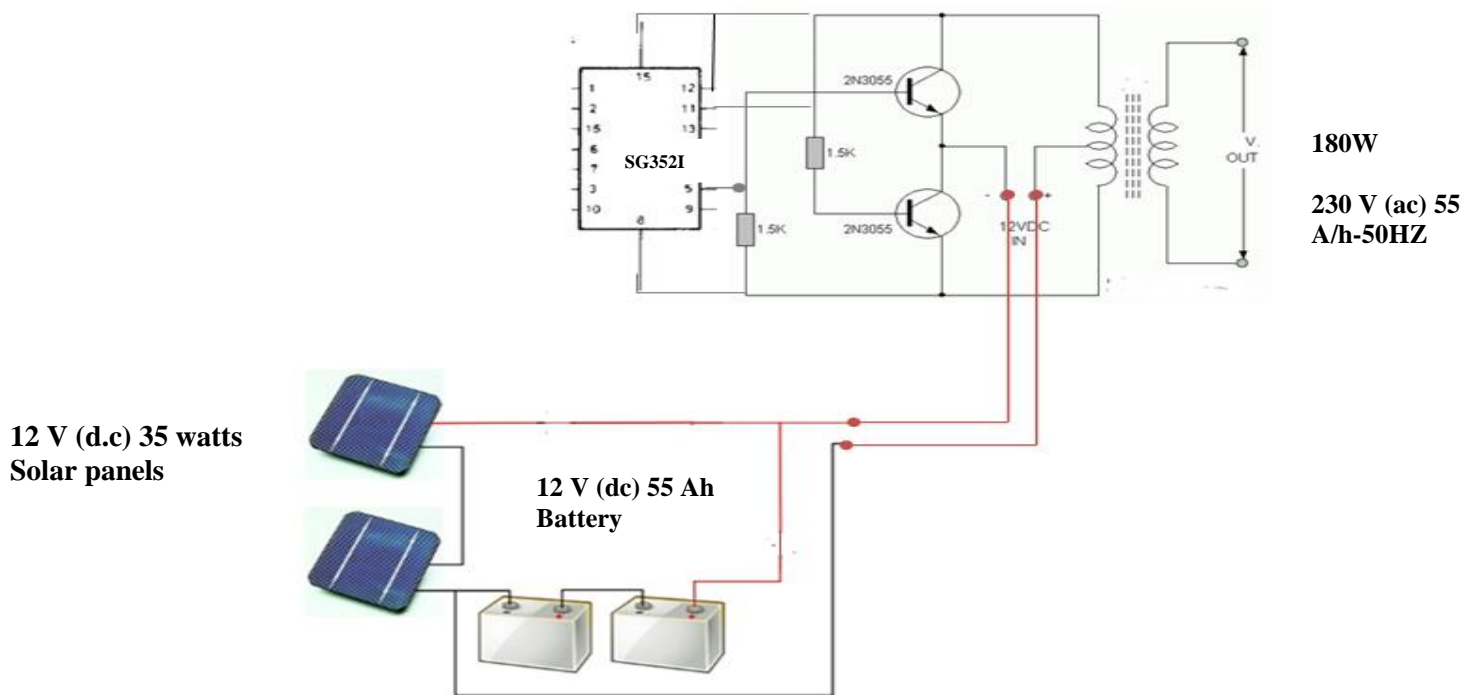


Figure 18 Power Supply Unit

Fig 18 shows a power supply unit constructed with a simple 250 V (a.c): 12 V (d.c) centre-tapped control transformer. It consists of 12 volts 35 Watts solar panels which recharge the 12 V (d.c) 55 Amps per hour (A/h) battery. The positive terminal of the 12 V (dc) input goes to the transformer's centre tap and the negative goes to the two transistor emitters. The output from the power unit from the power supply unit should be AC which is required to power the transmitter. The whole system (load) dissipates 73 watts and draws a current of 103 mA. Calculating the number of days the battery last for:

$$\begin{aligned} \text{55 Ah} &: 1 \text{ amp} \\ 7 &: 0.03 \text{ amp} \end{aligned}$$

$$\frac{55 \text{ hours} * 1 \text{ amp}}{0.103 \text{ amp}} = 533.981 \text{ hours}$$

$$\frac{533.981 \text{ hours}}{24 \text{ hours}} = 22.249 \text{ days}$$

The battery can last for 23 days without recharging. An actual test was carried out to verify the figure and the battery is able to power the system for more than a week.

Power supply parameters are below:

Specifications

Input Voltage	10-14 V (d.c)
Output power	180 watts
Output voltage	250 V (a.c)
Output wave	Modified sine wave
Output frequency	50-60 Hz

3.3Solar panel system



Figure 19 Solar Panel layout [14]

The prototype system is going to be an outdoor, remote system designed for off-grid power source and is going to be mounted to a steel pole. It is going to be weatherproof and sealed enclosure to guard against corrosion. The high quality solar panels in Fig 19 have an output voltage of 12 volts and 35 Watts. The solar panels are directly mounted to the DC enclosure so as to save space and make a more convenient assembly. The battery in the enclosure is an advance sealed lead battery. They have a well temperature performance hence gives the best available deep discharge with 55 Ah capacity beneath the panels in the metal box.

3.4 Design of DVD Player and laser system

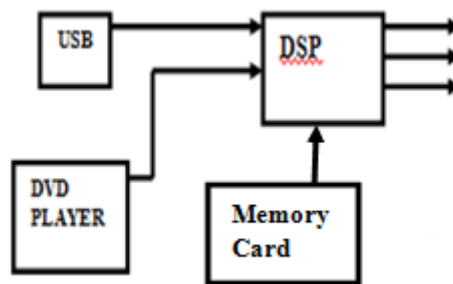


Figure 20 USB, Memory card, digital versatile disc (DVD) player diagram

Fig 20 shows a block diagram which consists of a digital versatile disc (DVD) player, memory card and Universal Bus Port (USB) port. This section is going to be an alternative input source to the transmitter where you can broadcast tutorial videos, adverts and entertainment.

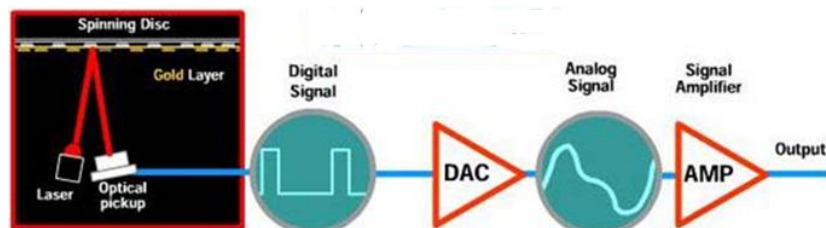


Figure 21 Laser System [15]

A digital versatile disc (DVD) player consists of a laser assembly that shines the laser beam from the optical mechanism onto the surface of the disc to read the pattern of the pits and bumps as shown in Fig 21. This laser will be reflected differently according to the change of pits and bumps. The pits and the separations between pits, called lands, vary in length to represent the digital information stored in the disc. A bump represents the number zero, so every time the laser burns a bump into the disc, a zero is stored there. The pits are arranged in a track that forms a spiral pattern on the recording layer of the disc. Though the laser hits a single spot, the DVD moves in a circular motion so that the entire area is covered. Mirrors are also used to change the spot. These reflected laser beams are then collected by a photo-detector (light sensor) which converts the different signals into a binary code (1's and 0's). The binary signal is then sent to DSP module (motherboard) which performs Digital to Analogue conversion of an MPEG-4 encoded video signal into a standard composite PAL

format or a National Television System Committee (NTSC) format video signal. Thus the corresponding analogue signal of the DVD is obtained.

Parts of a DVD player modules

- Optical system: Consists of the laser beam, photo-detectors and mirrors. During the read process, an electric motor rotates the disc at a speed of up to 500 rpm. The laser beam switches on and scans along a track, with the photocell, from the center of the DVD to the outside reading data.
- The laser beam is a red laser diode which works at a wavelength of 600 nanometers. The laser flashes onto the shiny side of the CD, bouncing off the pattern of pits (bumps) and lands (flat areas) on the disc. The lands reflect the laser light straight back, while the pits scatter the light.
- The disc drive mechanism consists of a motor that will drive the disc in a circular motion. Thus the entire disc drive is basically a spindle that holds the disc and a motor that is used to circle the disc. The spindle is held in its position with the help of small gears and belts that are attached internally.
- An electronic circuit which performs Digital signal processing (DSP) algorithms of digital to analog conversion (DAC) changing pattern of digital electric currents to analogue electric currents.

3.5 Design of modulator circuit system

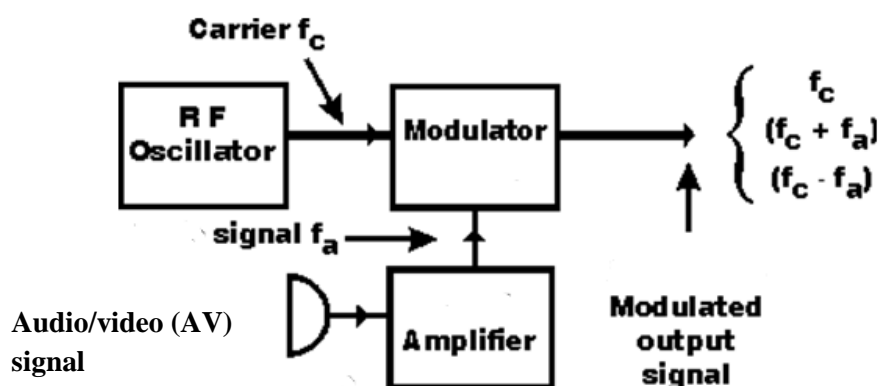


Figure 22 Modulator block diagram

The modulator is an electronic device whose input signal is a baseband signal which is used to modulate the audio/video (AV) signal as shown in Fig 22. RF modulators receive the audio

and video PAL, NTSC composite video, RGB and YUV signal from the decoder and dvd input, and generate an RF signal that can be fed into a coaxial cable. The format can be handled by television receivers. When the TV is tuned to the programmed channel, the video and audio signal of the transmitter is accessed. The carrier signal (f_c) forms one input, and a band of AV signal (f_a), is the modulating signal. The AV signal f_a does not appear in the output because of the filter action of the modulator output circuits. The modulated output signal from modulator 1 is 206 MHz and modulator 2 is 551.75 MHz. The frequency spacing (guard band) between the two channels is 345 MHz to avoid interference.

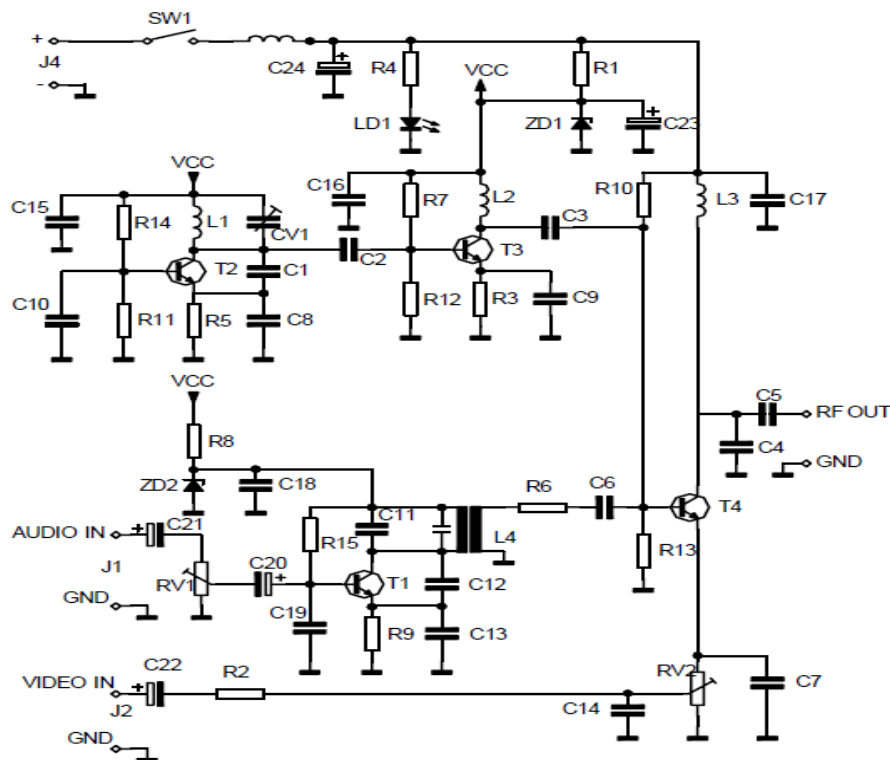


Figure 23 Modulator circuit diagram [16]

PAL or NTSC video and audio signal is fed from the source through electrolytic capacitors C22 and C21 in Fig 23 which are coupling capacitors (act as a DC blocking capacitor to prevent any DC bias voltage), allowing AC to pass through. The Radio Frequency signal is applied to the primary side of T2, and coupled through the secondary to the Base of the transistor T3. The Tank Circuit comprised of the capacitor and inductor L1 and CV1 to produce the output modulating signal. The input AV signal can be adjusted through potentiometer RV2 and RV1 to avoid distortion. A carrier signal is generated by an oscillator circuit which consists of L1, L2, CV1 and R7 which generate 551.71 MHz. The trimmer

capacitor CV1 is adjustable to enable fine tuning. The carrier signal is modulated with the AV signal to form an RF output signal. The coupling capacitor C5 blocks any DC components and allow AC signal to pass through as an output signal. The output signal is a 551.75 MHz PAL video signal ready for transmission. This FM transmitter circuit project is very simple and powerful transmitter circuit with a range of up to 30 to 40 m in the open. Distance of transmission is critically dependent on the operating conditions, in a building or out on the open, type of aerial used (dipole wire or single), operating voltage. Output from the collector is fed into the base of the second transistor where it modulates the resonant frequency of the tank circuit (L1 coil and the red trim cap).

3.6 Multiplexer circuit system



Figure 24 Multiplexer [17]

The multiplexer shown in Fig 24 makes it possible for the two video channels (206 MHz and 551.75) from modulator 1 and 2 to use one coaxial feeder and antenna. There is no interference since the two channels are at different frequencies hence frequency division multiplexing is achieved. It has two inputs from two separate signal sources which are in this case two modulators. Each modulator is a generator producing a sinewave output, one at frequency f_1 (206 MHz) and the other at frequency f_2 (551.75). The mixer multiplies the signals together. The output comprises a complex mixture of separate sinewaves at many different frequencies. The major output frequencies are shown in Fig 25.

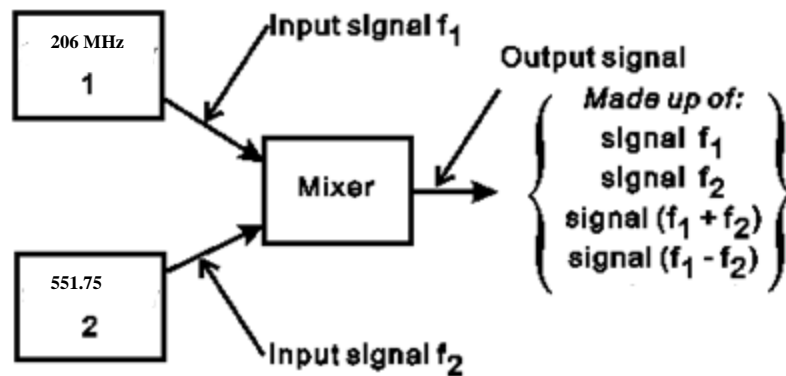


Figure 25 Multiplexer block diagram

The output in Fig 25 comprises the two separate input frequencies f_1 and f_2 and their sum, ($f_1 + f_2$), and their difference, ($f_1 - f_2$) and other component signals too. The output will normally be tuned to the sum, ($f_1 + f_2$), or tuned to the difference, ($f_1 - f_2$), signal as required.

3.7 Amplifier circuit system

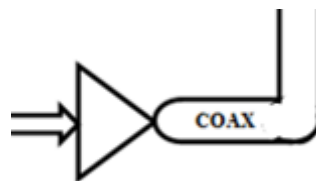


Figure 26 Amplifier block diagram

Fig 26 shows a wideband amplifier that increases the power of the modulated AV signal. It provides a constant amplification with a ratio of its low corner frequency to its high corner frequency. The wideband amplifier is complementary in concept to audio amplifier and video amplifier. This is a simple linear amplifier with low noise level with a broad band transfer. It amplifies the compounds of “AV” where video and audio signals are sent separately. It has a total gain of 10 to 15 dB with the 40 – 850 MHz domain frequency. The amplification can be adjusted at the middle and then adjust it until you obtain the best gain. Both input and output impedances are compatible with 75 Ω cables. The amplified gain of the circuit is determined by adjusting VR2. Transistors Q1, Q2 act as a signal amplifier, and Q3 serves as the output circuit of common emitter follower. The value of R1 determines the input impedance of circuit. The AV signal enters through C2 to the base of Q1. VR1 sets the level of the signal swing. The output of Q1 is connected to the base of Q2. The amplified gain of the circuit is determined by adjusting VR2, which is in the feedback circuit, between collector pin of Q2

and emitter pin of Q1. However the rate of increase is depended on the ratio between the resistance of: R5 and R6, R8, VR2, C3.

3.8 Amplifier Circuit diagram

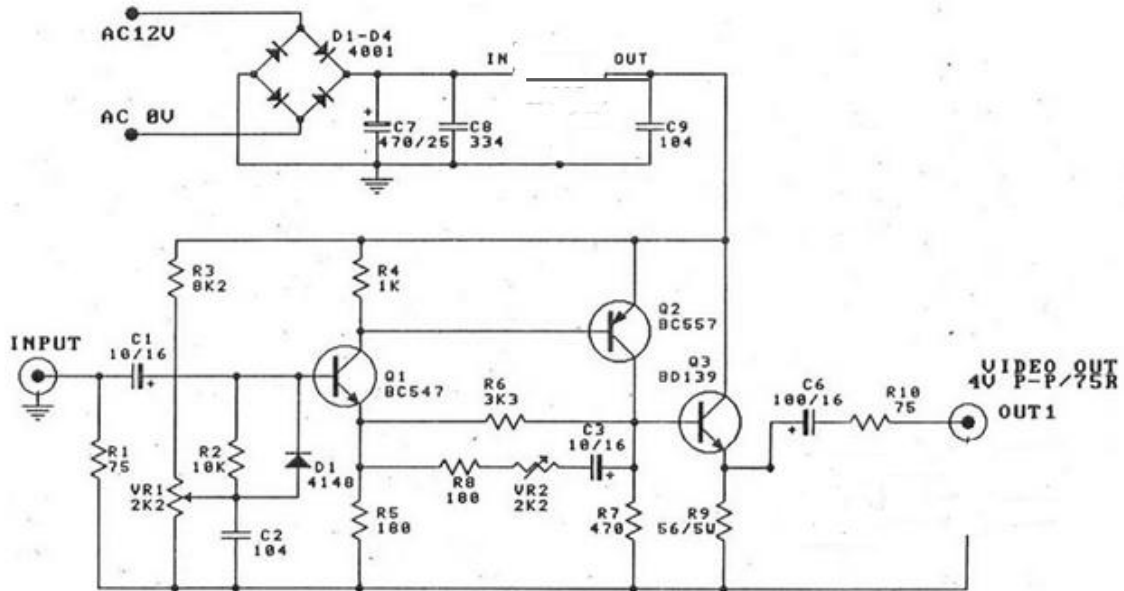


Figure 27 Amplifier circuit diagram [18]

Circuit components

- R1, R10, R11, R12 _____ 75 ohm _____ 1/4W Resistor
- R2 _____ 10K _____ 1/4W Resistor
- R3 _____ 8.2K _____ 1/4W Resistor
- R4 _____ 1K _____ 1/4W Resistor
- R7 _____ 470 ohm _____ 1/4W Resistor
- R9 _____ 56 ohm _____ 5W Resistor
- VR1, VR2 _____ 2.2K _____ Potentiometer
- C1, C3 _____ 10µF 16V _____ Electrolytic Capacitors
- C2, C8, C9 _____ 0.1µF 50V _____ Polyester Capacitor
- D2, D3, D4, D5 _____ 1N4001 _____ 100V 1A Diodes
- Q1 _____ BC547b, BC546 45V 100mA NPN Transistor
- Q2 _____ BC557b, BC556 45V 100mA PNP Transistor
- IC1 _____ LM7812 _____ 12VDC voltage regulator IC

3.9 Design of antenna system

The antenna is a tilt-and-swivel connector, which allows it to be used vertically, at a right angle, or any angle in-between. It's a perfect match with any of our transmitters and receivers. The Stainless Steel swivel antenna as in Fig 28 can be easily adjusted to match VHF and UHF frequency range and not susceptible to voltage standing wave ratio (VSWR). This stainless steel whip is of good quality and is the best mobile antenna suitable for outdoor usage as it can withstand weather elements.



Figure 28 Stainless Steel swivel antenna [19]

3.10 Installation set up

Fig 29 shows the complete installation set up of all the equipment mounted on a pole. The diagram shows the parabolic antenna, omni-directional antenna and the transmitter prototype located in an off grid area powered by solar with battery backup.



Figure 29 Complete installation setup [20]

Fig 30 shows the system rack and all the units that make the system whole. The units are slotted in the metal casing as modules. They are all powered by the power supply unit at the bottom which consist of a rechargeable battery backup charged by solar. The metal door consist of a glass for monitoring the inside conditions without necessarily opening the door.

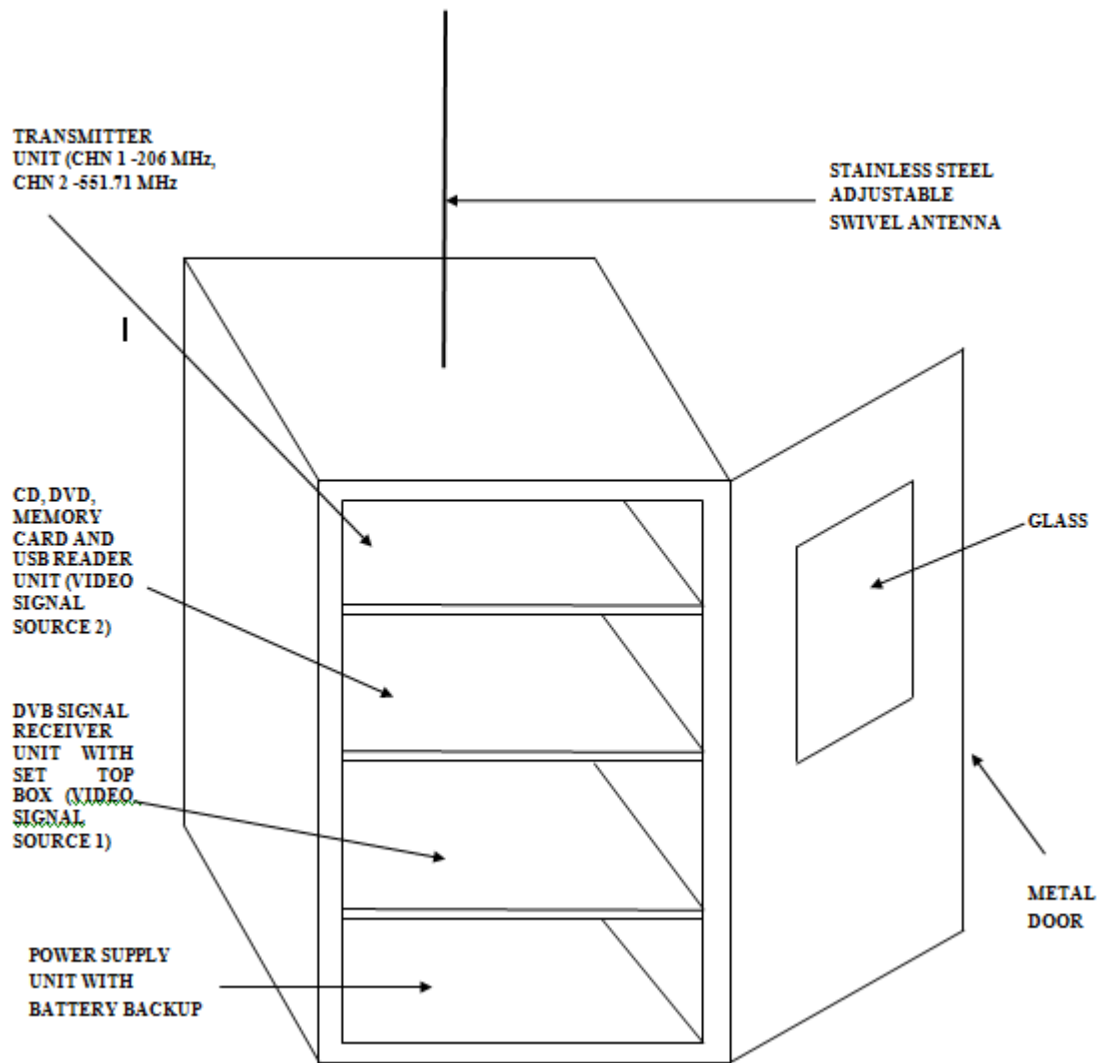


Figure 30 Diagram of the layout of the System rack and units

The construction of a research instrument or tool is the most important aspect of a research project. Due to the fact that anything that is gathered reflects the opinion results of findings or conclusions based upon the type of information collected and the data collected is entirely dependent upon the questions asked. Contacts were established with key personnel from POTRAZ, Transmedia and BAZ. These are regulatory authority boards responsible for administering the use of spectrum by all services, applications and systems in Zimbabwe.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter presents the results of the research, from the circuit design to the obtained results during the circuit test operation. The results are presented in tabular form and the graphical plots giving the analysis and interpretation. The author tested the prototype in an open space using a Motorola R2559A spectrum analyzer to measure the signal strength and frequency against distance. The spectrum analyzer is capable of monitoring signals from 400 kHz to 999.9999 MHz, centre frequency is set in 100 Hz increments. The spectrum analyzer is adjusted to the monitor Channel 1 (206 MHz) and channel 2 (551.75 MHz) and the following results were tabulated.

4.1 Presentation of results

Table 1 shows the results of the output power levels in decibels against the distance in meters on channel one.

Channel 1 (206 MHz)

Distance(m)	Attenuation (dB)
0	-29.4
5	-33.6
10	-42.7
15	-44.6
20	-48.2
25	-55.8
30	-61.9
35	-68.1
40	-79.4
45	-87.7
50	-106.4

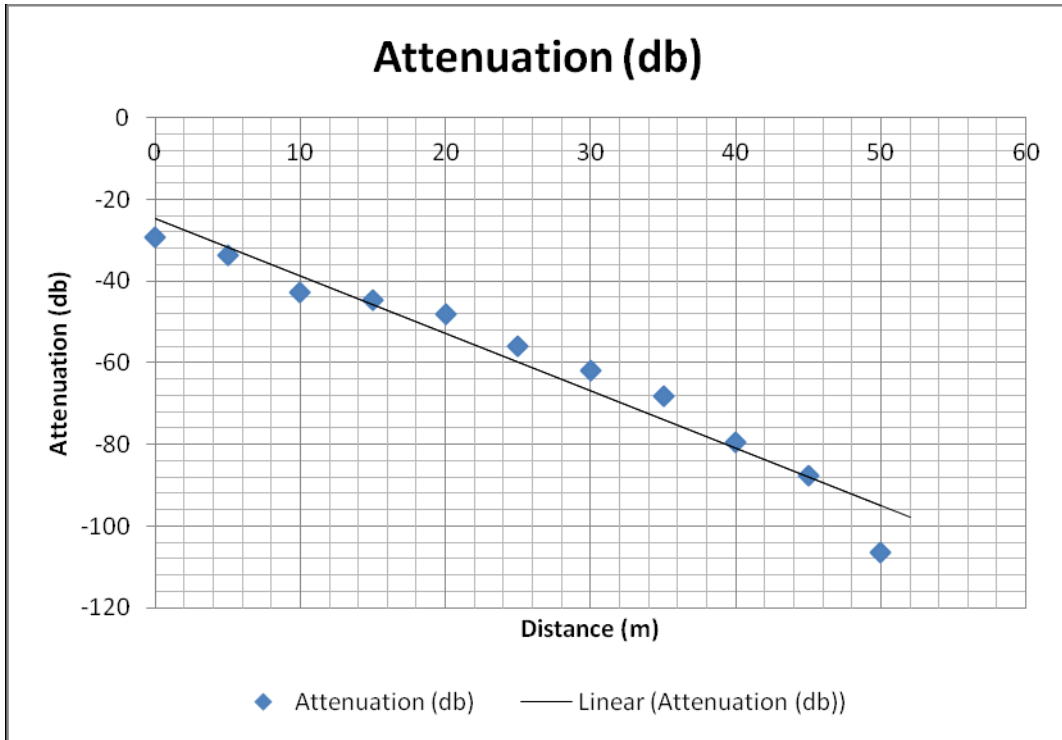


Figure 31 Diagram shows a graph of power level (dB) of channel one which decreases with an increase in distance (m)

Table 2 shows the results of the output power levels in decibels against the distance in meters on channel two.

Channel 2 (551.75 MHz)

Distance (m)	Attenuation (dB)
0	-30.3
5	-33.1
10	-44
15	-46.7
20	-50.4
25	-61.9
30	-64.9
35	-75.3
40	-105.3
45	-115
50	-126.2

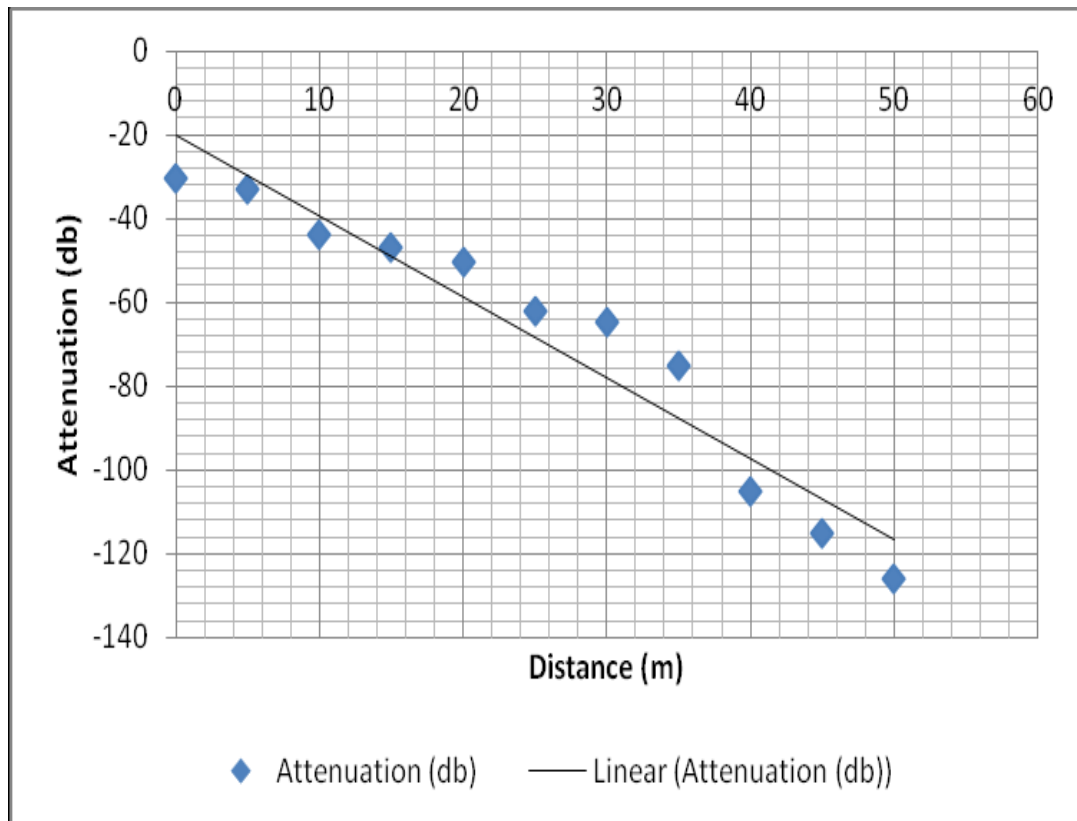


Figure 32 Diagram shows the variation of power level in decibels against distance (m)

Table 3 shows a sample the results of the output power levels in decibels against the distance in meters on channel one (206 MHz) in an area with thick vegetation.

Distance (m)	Power level (dB)
0	-37.4
5	-45.9
10	-54.3
15	-58.6
20	-63.7
25	-71.6
30	-74.3
35	-84.8
40	-97
45	-118
50	-137

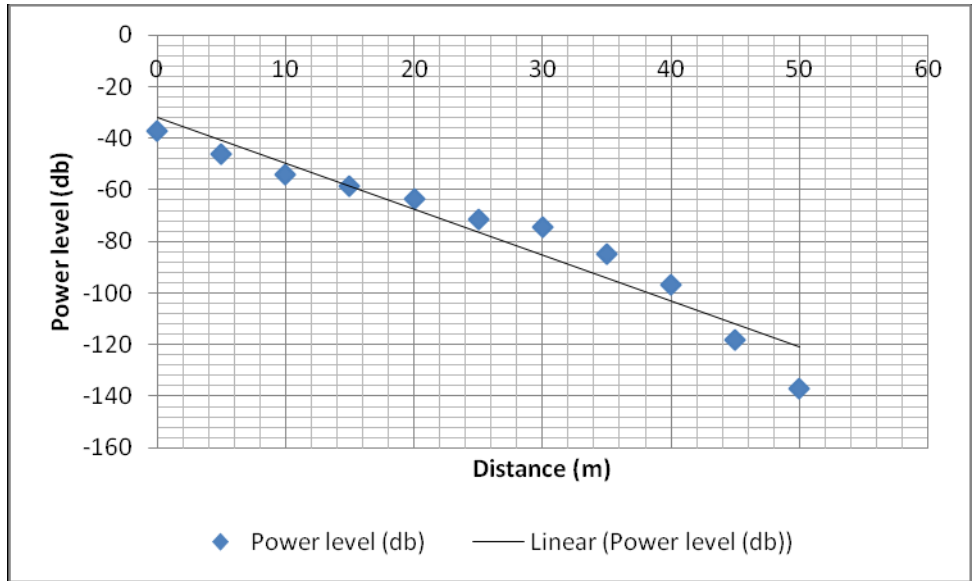


Figure 33 Graph shows a sample of results of power levels of an area with thick vegetation

Table 4 showing a comparison of results of Channel 1 (206 MHz) and Channel 2 (551.75 MHz) and results of signal strength in thick vegetation.

Distance(m)	Signal Strength 206 MHz (dB)	Signal Strength 551.75 MHz (dB)	Signal Strength Dense vegetation(dB)
0	-29.4	-30.3	-37.4
5	-33.6	-33.1	-45.9
10	-42.7	-44	-54.3
15	-44.6	-46.7	-58.6
20	-48.2	-50.4	-63.7
25	-55.8	-61.9	-71.6
30	-61.9	-64.9	-74.3
35	-68.1	-75.3	-84.8
40	-79.4	-105.3	-97
45	-87.7	-115	-118
50	-106.4	-126.2	-137

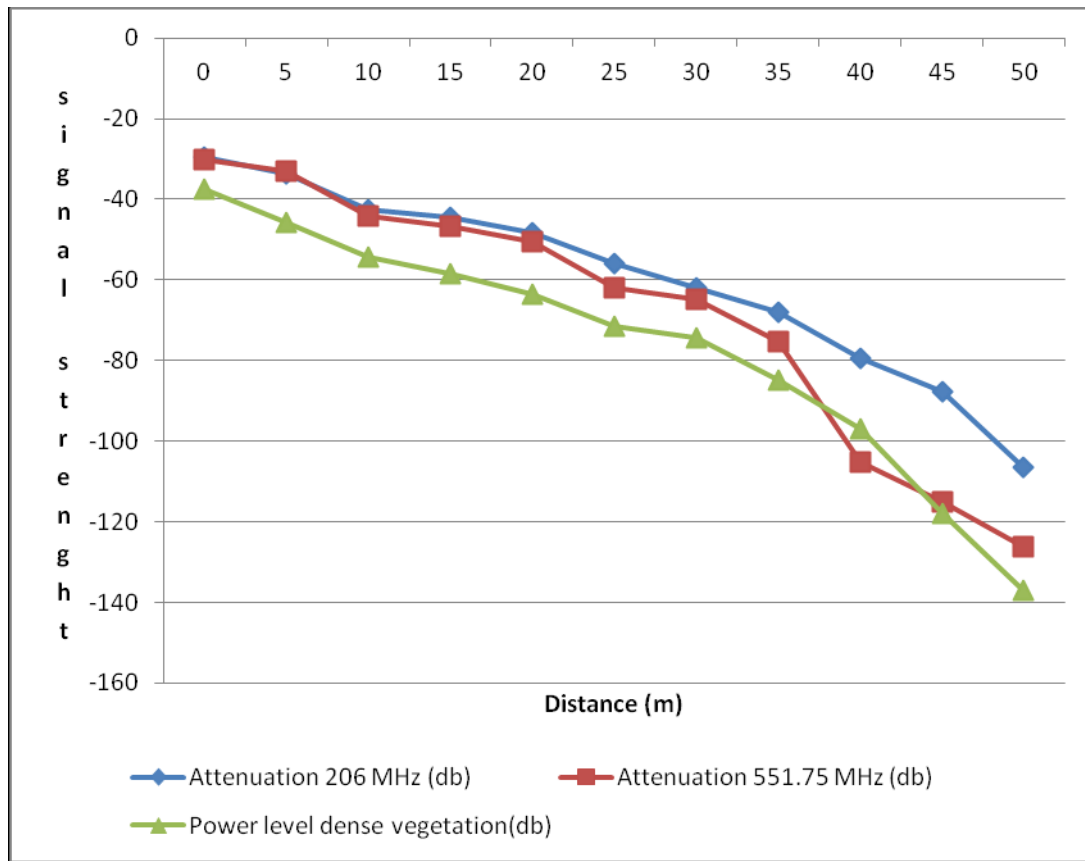


Figure 34 Comparison graph of Channel 1 (206 MHz) and Channel 2 (551.75 MHz) and results of signal strength in thick vegetation.

4.2 Results analysis and interpretation

Table 1 and Fig 31 shows a decrease in signal strength as distance from the transmitter increases on channel 1 which is broadcasting in the vhf range of 206 Mhz. At 0 meters the signal strength is -29.4 dB. As distance increases to about 20 meters from the transmitter, the signal strength reduces to -48.2 dB. At 30 meters the signal strength is -61.9 meters. As distance increases to about 50 meters the signal deteriorates rapidly to about -106.4 dB which mostly noise. The obtained results show the theoretical propagation of an electromagnetic wave in space as the medium in the vhf range. The signal strength reduces as distance increases due to attenuation. The obtained results were precise, accurate and conforms to the theoretical approach that attenuation varies linearly with increase in distance and thus the system can be used as a reliable transmitter.

Table 2 and Fig 32 show the characteristics of the signal strength of channel 2 which is broadcasting in the uhf range of 551.75 MHz. At 0 meters the signal strength is about -30.3 meters. As the distance increases to 20 meters the signal strength reduces to -50.4 dB. As distance increase to 30 meters the signal strength rapidly deteriorates to -64.9 dB. Again the linear relationship between signal strength and distance is maintained and the average range of the transmitter is about 30 meters (diameter is 60 meters). However the tabulated results and graph shows that the coverage range of the Uhf signal (channel 2) is slightly less as compared to Channel 1 the signal is greatly attenuated. This is due to the reason that attenuation increases with an increase in frequency.

In Fig 33 shows a sample of results of the signal strength of the received signal in an area which has got heavy foliage. It's a measure the system performance when there is no line of sight. The presence of vegetation increases attenuation as depicted on the graph.

Fig 34 finally illustrates the comparison of the channel 1, channel 2 and signal level in an area with dense vegetation. The graph clearly shows the signal strength being greatly attenuated when in an area with thick foliage.

CHAPTER FIVE

CONCLUSION

5.0 Introduction

The design of the prototype was a success leaving the design of the system at an advanced stage. From the obtained results, the design of the solar power Tv transmitter proved to be feasible hence can be achieved.

5.1 Discussion

The system contains 5 main subsystems which are: Set top box (DSTV decoder), DVD player, Modulators, Amplifier and Antenna

The system has got low power consumption as it draws a maximum of 103 mA hence the battery stays longer even in winter when sunlight to charge the battery is scarce.

The solar panel is a 35 watts monocrystalline solar type which is expensive but very efficient as compared to polycrystalline type as it does not require direct sunlight to charge the battery.

The system has got a dc voltmeter to measure the input d.c. voltage from the battery and solar panels into the power supply. There is also an a.c voltmeter which measures the a.c supply into the system. This enables a responsible personnel to monitor if the supply voltage is within the nominal range to avoid damaging the system.

5.2 Recommendations

There is need to improve the coverage range of the system since in the majority of the rural areas, people are sparsely populated hence it becomes difficult for viewers to receive the coverage. The researcher however recommends that:

There is need to use a high gain amplifier to boost the weaker signals from the system so as to enhance coverage. The viewers should use an out door antenna system since the weaker signal from the system fail to penetrate the brick walls for the viewers to receive a quality signal.

There is also need to implement repeaters to rebroadcast the signals to the areas beyond the coverage range. There is need to safeguard the system against vandalism since it is vulnerable due to its intended location.

Appendix A

Appendix B

List of Tables

Table 1 shows the results of the output power levels in decibels against the distance in meters on channel one.

Table 2 shows the results of the output power levels in decibels against the distance in meters on channel two.

Table 3 shows a sample the results of the output power levels in decibels against the distance in meters on channel one (206 MHz) in an area with thick vegetation.

Table 4 shows a comparison of results of Channel 1 (206 MHz) and Channel 2 (551.75 MHz) and results of signal strength in thick vegetation.

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Appendix D

List of components

Component	Value	Quantity
Solar panel	35 Watts	1
Sealed lead battery	12V (.d.c) 55A/h	1
Power Supply	220 V (a.c) 50-60 Hz	1
C2,C8,C9 50V_Polyester Capacitor	0.1uF	3
Resistors : R1, R10, R11, R12	75 ohm 1/4W	4
Potentiometer VR1, VR2	2.2K	1
voltage regulator IC	LM7812 12VDC	1
1A Diodes D2, D3, D4, D5	1N4001 100V	1
Switch		1
Electrolytic Capacitors C1, C3	10uF 16V	1

Appendix E

FORM BS1

APPLICATION FOR LICENCE

Instructions on how to complete this form

██████████ annexure wherever necessary;

□ upon completion the originals of this form and supporting annexure shall be

Submitted to:

The Chairman

Broadcasting Authority of Zimbabwe Media Centre

Rainbow Towers Grounds,

P.O Box 496, Causeway

Harare

State the name, address and telephone number of the person(s) who may be contacted regarding any question in respect of this application:

.....

SECTION 1: PARTICULARS OF APPLICANT

1. Name of applicant (attach certified copies of certificate of incorporation and memorandum and articles of association):

.....
.....

2. Type of licence applied for:

.....

3. Address of applicant's head office:

.....

4. Names, addresses and occupations of directors (attach certified copy of latest form C.R.14):

.....

5. Has the applicant or any of its associates ever been convicted of any offence within or outside Zimbabwe? YES/NO.

6. Has the applicant or any of his associates failed to satisfy within one year any judgment debt issued in Zimbabwe or elsewhere? YES/NO.

7. Has the applicant or any of his associates ever-

(a) been adjudged insolvent by a court in Zimbabwe or any other country?

YES/NO.

(b) been served with an insolvency petition for its compulsory winding within the last ten years in Zimbabwe or in any other country? YES/NO.

(c) made any compromise with its creditors? YES/NO.

(d) been liquidated? YES/NO.

(e) instituted proceedings for its voluntary windings up with in the last ten years in Zimbabwe or elsewhere? YES/NO.

*If the answer to any of the question is yes, please provide details.

16. Indicate the extent, if any of ownership or shareholding in an advertising agency:

.....
.....

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