Modelling, Simulation and Analysis of a Low-Noise Block Converter (LNBC) Used For Communication Satellite Reception Using Matlab

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Abstract— **Modelling, Simulation and analysis of Low Noise Block Converter(LNBC) used for Communication Satellite reception using MATLAB is a work that tends to use some aspect of Computer Engineering tools to realise LNBC fundamentals where Channels programming sources provided programming for Broadcasting , the method involves using MATLAB to illustrate how microwave frequencies receives from Satellite are documented to lower block and range of frequencies, analysis of various LNBC was carried out with a view to drawing comparison between various signals, a test of faulty LNBC was carried out with LNBC schematics, simulation result were provided to show various responses with regards Modelling input waveguide signal, corrupted signal, filtered signal, modulated signal and recovered signals.**

Index Terms— **LNBC, Signal, Channel, Satellite**

I. BACKGROUND

In a relatively short time, satellites have become an essential part of global communication. In 1960, the first communications satellite called “ECHO 1” was launched by the United States, transmitting telephone signals. It was basically not much more than a reflector that reflected the signals it received from the earth. In 1962, “TELSTAR” followed which was the first so called active TV satellite. Instead of reflecting the incoming signals, it also converted the signals in order to avoid interference between the incoming and outgoing signals. These signals are generated with the help of satellite dishes (a parabolic television antenna that receives signals from communication satellites in orbits around the earth). All current communication satellites are earth-synchronous or geo-stationary, ie they circle the earth in a specified orbit at the same speed as the earth itself as a result, and they appear to stand still. These satellite revolve around the earth at a height of 36,000km, precisely over the equator.

II. SIGNAL GENERATION AND TRANSMISSION

All along we have been mentioning signal. What really is a signal? A signal is defined as a quantity that varies as a function of time and space, and conveys information. Picture and audio signals are generated using satellite dishes. A satellite dish for a special purpose of a parabolic antenna designed for the purpose of transmitting signals to and or receiving signals from another satellite. Signals are sent up to satellite from the broadcast centre (earth’s surface). The transmission station is called an Uplink Station. The transmission takes place through frequency modulation (FM) for the reasons that;

It prevents interference and noise

It translates different signals to different spectral location, thus enabling a receiver to select the desired signal.

It enables several radio stations to broadcast simultaneously

There are no problems in the frequency and dynamic range that needs to be transmitted.

The outgoing transmission takes place at a very high frequency of 14,000MHZ (14GHZ). A device in the satellite called the transponder takes the received signals from the broadcast centre at uplink frequency (14GHZ) and heterodynes (mixes it) to the down link frequency, amplifies it, before transmitting it back earth through an antenna that looks quite similar to the receiving dish antenna. The signal is then received with the help of a C-band satellite dish antenna. A device called the feedhorn on the dish gathers the signal and conducts them to the low noise block converter (LNBC) which is my subject of discussion.

On the focal length of a dish is hung the low noise block converter that receives the very low level microwave signal from the satellite, amplifies it, changes the signals to a lower frequency band and sends them down the cable to the indoor receiver. In the course of this work, I would be writing a MATLAB program to illustrate how these conversion of a block of microwave frequencies are received from the satellite being down-converted to a lower (block) range of frequencies in the cable to the receiver.

III. THE LOW NOISE BLOCK CONVERTER (LNBC)

The low-noise block converter popularly called the LNBC is a device fastened firmly on the satellite dish that receives the very low level microwave signals from the satellite, amplifies it to filter out the noise (i.e. radio signals not carrying programmers) changes the signals to a lower frequency band and sends them down the cables to the indoor receiver. The LNBC uses the super heterodyne principle to take a wide block (or band) of relatively high frequencies, amplify and converts them to similar signals carried at a much lower frequency called the intermediate frequency (IF). These lower frequencies travels through cables with much less attenuation of the signal, so there is much more signal left on

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the satellite receiver end of the cable. It is also much easier and cheaper to design electronic circuits to operate at these lower frequencies, rather than the very high frequencies of satellite transmission. LNBC can be switched electronically between horizontal and vertical polarization reception. The corresponding component in the uplink transmit link is called a Block Up Converter (BUC).

The "low-noise" part of the LNBC relates to the quality of the first stage input amplifier transistor measured in Noise temperature units, noise figure units, or noise factor units. It also means that special electronic engineering techniques are used, that the amplification and mixing takes place before cable attenuation in a circuit that requires no power supply or receiver. This all leads to a signal which has less noise (unwanted signals) on the output than would be possible with less stringent engineering. If low-noise engineering techniques were not used, the sound and picture of satellite TV would be of very low quality, it could even be received at all without much larger dish reflector. The low-noise quality of an LNBC is expressed as the noise figure or noise temperature.

The "block" part refers to the conversion of a higher block of microwave frequencies (received from the satellite, typically in the range of 4GHZ to 21GHZ) being down-converted to a lower block range of frequencies for the receiver. The super heterodyne effect of LNBC helps to compensate for the signal loss associated with typical coaxial cable at relatively high frequencies. An LNBC sits on the end of the arm of a dish and faces the parabolic reflector that focuses the signals from a satellite 24,000 miles away into the "feed horn" of the LNBC. It is called low-noise block converter because it converts a whole band or "block" of frequencies to a lower band.

IV. PROBLEM FORMULATION

In the conversion of a wide block (or band) of relatively high frequencies, both noise figure and noise factor may be converted into noise temperature. Hence, the lower the noise temperature, the better. So an LNBC with noise temperature of 100K is twice as good as one with 200K.

The aspect of computer engineering is not left out. During the programming sources where we have the channels that provides programming for broadcast.

V. OBJECTIVES

The project primary objective is to illustrate using MATLAB how microwave frequencies received from satellite are down-converted to a lower (block) range of frequencies in the cable to the receiver. It also introduces the various kinds of the low-noise block converters and their specifications, principles of operation, etc.

VI. LITERATURE REVIEW OF RELATED WORK

The low noise block converter (LNBC) was invented by two Chinese microelectronics technologists KUO TIEN CHANG and JIA LUN CHEN. The first embodiment of their invention comprised of a local oscillator, a mixer, an IF-amplifier and a regulator. The low-noise amplifier amplifies a received high-band signal. The local oscillator generates a local-frequency signal. The mixer mixes the local-frequency signal and the high-band received signal into an intermediate frequency signal. The regulator is coupled to the IF amplifier to provide a regular voltage or current to the low-noise amplifier and the local oscillator.

The second embodiment of the present invention is a low-noise block comprising of a low-noise amplifier, a local oscillator, a mixer, an IF-amplifier and a regulator. The low-noise mixes the local-frequency signal and the high-band received signal into an intermediate frequency signal. The IF amplifier amplifies the intermediate frequency signal. The regulator is coupled to the low noise amplifier to provide a regular voltage or current to the IF amplifier and the local oscillator.

The third embodiment of the present invention is a low-noise block with multiple outputs comprising a switch circuit, a first low-noise block according to the first embodiment and a second low-noise block according to the first embodiment. The first low-noise block receives the vertical phase component of the input signal. The second low-noise block receives the horizontal phase component of the input signal. The switch circuit is coupled to the outputs of the first low-noise block and the second low-noise block to provide an output signal.

VII. RESEARCH METHODOLOGY PROCEDURE

The low noise block down converter illustrates how the conversion of a wide block (or band) of relatively high frequencies is been done. As earlier stated, the expression "low noise" refers to the quality of the first stage input amplifier transistor. The quality is measured in units called Noise Temperature, Noise figure, or Noise factor. Both noise figure and noise factor may be converted into noise temperature. The lower the noise temperature, the better. So an LNBC with noise temperature of 100K is twice as good as one with 200K.

Also the expression "Block" refers to the conversion of a block of microwave frequencies as received from the satellite being down-converted to a lower (block) range of frequencies in the cable to the receiver. Satellites broadcast mainly in the range 4 to 12 to 21GHZ.

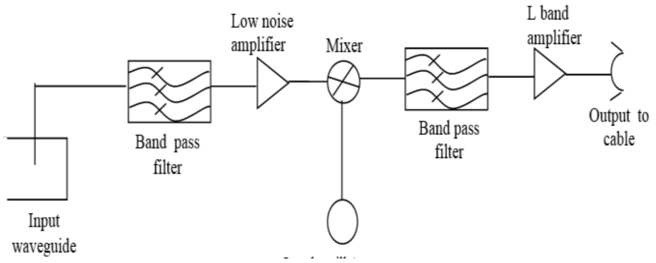

Fig. 1.0: Low noise block down converter diagram

The diagram Fig. 1.0 shows the input waveguide on the left that is connected to the collecting feed or horn. There is a vertical pin through the broad side of the waveguide that extracts the vertical polarization signals as an electrical current. The satellite signals first go through a band pass filter that allows only the intended band of microwave frequencies to pass through. These microwave frequencies are then sent to the low noise amplifier where it's being amplified and sent to the mixer. At the mixer, all that has come through the band pass filter and amplifier stage is severely scrambled up by a powerful local oscillator signal to generate a wide range of distorted output signals, that includes additions, substractions, and multiples of the wanted input signals and the local oscillator frequency. Amongst the mixer output products are the difference in frequencies between the wanted input signals and the local oscillator frequencies. The second band pass filter selects these and feeds them to the output L band amplifier and into the cable.

Output Frequency = Input Frequency - Local Oscillator Frequency

In some cases, it is the other way round, so that;
Output Frequency =Local oscillator Frequency -Input Frequency

The later is used when the output spectrum is inverted
Microwave Satellite Signals do not easily pass through walls, roofs or even glass windows. Satellite antennas or dish are required to be outdoors, and the signals need to be passed, indoor through cables. When radio signals are sent through coaxial cables, the higher the frequency, the more losses occur in the cable per unit of length. Therefore, the signals used for satellite are of such high frequencies (in the multiple giga hertz range) that special cable types or waveguides would be required and only significant length of cables leaves very little signals left on the receiving end. For the reception of wide band satellite television carriers, typically 27MHZ wide, the accuracy of the frequency of the LNBC local oscillator needs only be in the order of ± 500KHZ, so low cost dielectric oscillators may be used.
For the reception of narrow bandwidth carriers or ones using advanced modulation techniques such as 16-QAM highly stable and low phase noise LNBC local oscillators are required.

VIII. LOW NOISE BLOCK (LNBC) FREQUENCY STABILITY

All LNB's used for satellite TV reception use dielectric resonator stabilized local oscillators (DRO) that resonates at the required frequency. The DRO when compared with a quartz crystal is relatively unstable with temperature, and frequency accuracies may be +/- 250KHZ to as much as +/- 2 MHZ at Ku band. This variation includes both the initial value plus variations of temperature over the full extremes of the operating range. Fortunately most TV carriers have quite wide bandwidth (Like 27MHZ) so even with 2MHZ error, the indoor receiver will successfully tune the carrier and capture it within the automatic frequency control capture range.
If you want an LNB for the reception of narrow carriers, say 50KHZ wide, there will be a problem since the indoor receiver may not find the carrier at all or may even find the wrong one. In this case you need a rather clever receiver that will sweep slowly a range like +/- 2MHZ searching for the carrier and trying to recognize it before locking on to it. Alternatively, it is possible to buy a phase lock loop (PLL) LNB's that has a far better frequency accuracy. The PLL LNB's have internal crystal oscillator or rely on an external 10MHZ reference signal sent up the cable by the indoor receiver. PLL LNB's are more expensive. The benefit of using an external reference PLL LNB is that the indoor reference oscillator is easier to maintain at a stable constant temperature.

IX. LOW NOISE BLOCK (LNB) SUPPLY VOLTAGES

The DC voltage power supply is fed up the cable to the LNB. Altering this voltage could possibly change the polarization of the LNB a less commonly, the frequency band. Voltages are normally 13 volts or 19 volts. Perfect weather proofing of the outdoor connector is essential, otherwise corrosion would occur rapidly. It should be noted that both the inner and outer conductors must make really good electrical contact, since high resistance can cause the LNB to switch permanently into the low voltage state. Very peculiar effect can occur if there is poor connections amongst multiple cables, left alone on LNB, and to transmit block up converter (BUC) module as they go and return, DC supplies may become mixed up and the wrong voltage applied across the various items. The electrical connections at the antennas between the LNB and the BUC chassis are often indeterminate and depends on screws in waveguide flanges etc. Earth loop current may also be a problem. It is possible to find 50HZ mains current on the outer conductors. Such stray currents and induced RF fields from nearby transmitters and cell phones may interfere with the wanted signal inside the cables. The quality and smoothing of the DC supplies used for the LNB's is important.
Some LNB's such as those from Invacom, incorporate a receive bandpass, transmit band reject filter at the front end. This provides both good image reject response for the receive function, but also protects the LNB from spurious energy from the transmitter which may destroy the LNB.

X. LOW NOISE BLOCK (LNB) PHASE NOISE

All modern dielectric resonator stabilized local oscillator (DRO) LNB's are sold as "Digi-ready". This means that some attention has been paid in the design, to keep the phase noise down so as to facilitate the reception of digital TV carriers. The phase noise of DRO LNB's is still far worse than the phase lock loop (PLL) LNB's. What good noise performance is really needed for is for the reception of low bit rate digital carriers and for digital carriers using high spatial efficiency modulation methods like 8-PSK, 8-QAM, or 16-QAM modulation, which reduces the bandwidth required but need more power from the satellite, a bigger receiving dish and better quality PLL type oscillator in both the transmit and receive chains.
It is possible for an LNB to physically freeze due to ice build-up in very low temperature, obscuring the signal. This is only likely to occur when the LNB is not receiving power from the satellite receiver (i.e no programmes are being watched). To combat this, many satellite receivers provide an option to keep the LNB powered while the receiver is on standby. Examples of input frequency band.
All the above illustrates a simple LNB, with one low noise amplifier (LNA) and LO frequency. More complex LNB's exist, particularly for satellite TV reception, where people

wish to receive signals from multiple bands, alternative polarizations and possibly simultaneously.

XI. OVERLOADING AN LNB

If you have a very large dish, say 7m diameter that points or aims at a satellite whose signals or reception are intended for a small dish antenna (say 70cm diameter), then the 20 dB increase in the total power of the signals into the LNB may be sufficient to overload some of the transistor amplifier stages inside. Because this is not always obvious, it is wise to measure the composite output power of the LNB using a power meter and comparing it with the 1dB compression point given by the manufacturer. Alternatively, you can do an antenna pattern test on both a high power and a low power satellite. Any non linearity problem with the high power satellite is then clearly visible. Special low gain or high power output level LNB's are available for use with large dishes.

XII. TYPES OF THE LOW NOISE BLOCK CONVERTER (LNBC) USED FOR SATELLITE RECEPTION

There are basically four (4) broad types of the low noise block converter (LNBC) that are in application. They include

- The Universal LNBC
- The standard north America KU-band LNBC or the standard Linear LNBC
- The North America direct broadcast satellite (DBS) LNBC.
- The C-band LNBC

XIII. THE UNIVERSAL LNBC

The universal LNB can receive both polarization and the full range of frequencies in both the KU and C-satellite band. Some models can receive both polarizations simultaneously through two different connectors, and others are switchable or fully adjustable in their polarization. Below are the specifications of the universal LNB.

* Local oscillator: 9.75 and 10.6GHZ
* Frequency : 10.7 – 12.75GHZ
* Noise figure: 0.7db
* Polarization: Linear

FIG 2: THE CAMBRIDGE "PLATINUM" GEO UNIVERSAL G57 LNB[3]

They are different categories of the universal LNBC that are used for different functions. It includes:

- Twin output universal LNB
- Dual LNB or monobloc LNB
- Quad – output or Quad Universal LNB
- Octo universal LNB
- Quattio Univeral LNB

XIV. "TWIN-OUTPUT" UNIVERSAL LNB

As the name implies "twin-output", it provides two outputs to feed two separate receivers for independent workings. Each output can be switched independently by 13-17 voltage input by the individual receiver to change polarization and by 22KHZ to change the band. This type of LNB is sometimes offered with an adapter to fit it to an oval sky mini dish. It is not designed to focus on an oval dish, so its performance when the signal is compromised by bad weather will not be optimal.

FIG 3: THE TWIN-OUTPUT UNIVERSAL LNB

XV. "DUAL BAND" OR "MONOBLOC LNB"[9]

The "dual band" or monobloc LNB comprises of two universal LNB's fixed together at a small angle in a single housing. This type of LNB has a single output and the actual satellite signal is selected by the receiver which sends a Dis Eqc (22KHZ) pulsed tone up the LNB cable. So only one satellite transmission can be viewed at a time. Only one "F" connector is used, a single coaxial cable connects to the digital receiver which must be able to use Dis Eqc signaling to select which LNB is to be used. Normally used on an 80cm dish to receive Astra at 19.2^{0}E and Hotbird at 13^{0}E (but not simultaneously).

FIG 4: THE DUAL BAND OR MONOBLOC LNB

XVI. "QUAD-OUTPUT" OR "QUAD UNIVERSAL LNB

The Quad-output" or "Quad Universal LNB can feed four separate receivers. Each receiver has independent control of polarization and band through 13-17 volts switching and 22KHZ ON/OFF respectively. This LNB is used with the new sky Digiboxes that have two LNB inputs and internal hard drives for recording a programme while you watch another. Two LNB outputs go to this "sky plus" Digibox and the other two LNB outputs can go either to two standard Digiboxes or to one other "sky plus" Digibox. This type of LNB is that used for the DSTV personal video.

FIG. 5: THE "QUAD-OUTPUT" OR "QUAD UNIVERSAL LNB[3]

3.5.1.4 "Octo" Universal LNB

The "Octo" universal LNB is similar to the "Quad" except that is has eight (8) independent outputs whereas the former has four (4). Both having similar working operations.

FIG 6: THE "OCTO" UNIVERSAL LNB[4]

XVII. "QUATTIO" UNIVERSAL LNB

The "Quattio" universal LNB has four (4) fixed outputs used only in "headend". One LNB supplies a head end digiboxes. The four (4) outputs of the Quattro LNB are as follows:

- Horizontal polorisation low band
- Horizontal polarization high band
- Vertical polarization low band
- Vertical polarization high band

The four (4) outputs of the Quattro LNB should not be connected directly to a receiver unless you want to restrict viewing to just one of the four options. Even if you do, the receiver may not work. Its not a good idea. Use the Quad instead. No Quattro LNB is manufactured to fit a sky minidish. It always requires a (roughly) circular dish.

FIG. 7: THE QUATTRO UNIVERSAL LNB [4]

XVIII. THE STANDARD NORTH AMERICA KU-BAND LNB OR STANDARD LINEAR LNBC

The standard north America ku-band or standard linear LNBC covers a smaller frequency range, and a better noise figure can be produced. Pay TV operators can also supply a single fixed polarization LNB to save a small amount of expense. Below are the specifications for this LNB type;

- Local oscillator: 10 75 GHZ
- Frequency : 11.7 – 12.2GHZ
- Noise figure: 0.5db
- Polarization: Linear

XIX. THE NORTH AMERICA DIRECT BROADCAST SATELLITE (DBS) LNB

The direct broadcast satellite (DBS) dishes uses an LNB that integrates the antenna feedhorn with the LNB. Small diplexers are often used to distribute the resulting intermediate frequency (IF) signal (usually 950 to 1450MHZ) piggy-backed in the same cable TV wire that carries lower-frequency terrestrial television from an outdoor antenna. Another diplexer then separates the signals to the receiver of the TV set, and the integrated receiver/decoder (IRD) of the DBS set-top box. The specifications for the DBS LNB are illustrated below:

- Local oscillator: 11.25GHZ
- Frequency: 12.2-12.7GHZ
- Noise figure: 0.7dB
- Polarization: Circular

XX. THE C-BAND LNB

The C-band LNB is used for receptions in the C-band range. Below are the specification for the North-America C-band LNB.

- Local oscillator: 5.15GHZ
- Frequency: 3.4-4.2GHZ
- Noise figure: ranges from 15 to 100 kelvins(uses Kelvin ratings as opposed to dB rating).
- Polarization: Linear

Aside these known and used LNB types, there are special ones that are not commonly used except the need for them arises. As a general rule, any standard LNB will work with a circular (prime focus) dish or an offset focus dish which is taller than it is wide (which "looks" circular when viewed by the LNB). However, a dish which is wider than it is tall will need a special LNB.

Just to prove the point, above is a typical "universal" LNB used with a sky "mini dish". The mini dish is oval in shape, being much wider than it is high. Inside that plastic rain cover is the actual LNB. The difference in scalar ring height (red arrows) should be noted. The side projections allows the LNB to focus on a wide area in the horizontal plane, while the top and bottom projections are longer and focus LNB on a narrower area in the vertical plane. This LNB is designed specifically for an oval dish and will give very poor results with a dish that is roughly circular or a dish that is taller than it is wide.

Here is another comparison shown above, the SX1019 LNB on the left that has circular scalar rings inside the feedhon. It is designed to be used with a nearly circular dish. The SX1019/S on the right is designed specifically for a sky mini dish which is wider than its height. This type of LNB can also be used with a Raven dish of a similar shape to the sky mini dish. Both LNB's are made by Philips. The one on the right, however, is branded "skyware".

Below is an obsolete Philips SC519QS/S dual output LNB, that used to be supplied with the SKY-plus system with adaptors for the minidish.

The red arrow points to the special oval shaped "scalar" steps in the feedhorn. These causes the LNB to focus exactly on the oval shape of the "mini dish", using the full dish area but without picking up reflections from the wall behind. This type of LNB would not give good results with a circular dish. Some dealers offer a standard twin output or Quad output LNB with an adaptor to fit the "mini dish". The adaptor fits a treat. Unfortunately, the LNB will not give optimum performance and could give a "rain drop-out" during bad wheather. The LNB above has a spigot that fits into the sky mini dish arm. The LNB's rotational position or "skew" can be adjusted by slack kening the two screws that secures the spigot and twisting the LNB until best signal quality is achieved.

The LNB below has a single screw, but the principle of operation is the same with the one above. A sky LNB will often have graduated marks from 1 to 5 as a guide to alignment. Starts at 3 and twist each way to locate the best position.

XXI. TESTING OF THE LOW NOISE BLOCK CONVERTER (LNBC)

I THINK MY LNB IS FAULTY. HOW CAN I TEST? The only way to fully test an LNB is to fit it to a suitably aligned dish and connect a satellite receiver. Then check to make sure every channel is there. If no channels are missing and if it continues to work through a hot day and cold night, the LNB is fine. However, if some channels still appear to be missing (with a known good LNB), this could be the fault of the cable, the receiver, or the dish (distorted or misaligned). So then you need to use the process of elimination by swapping the dish, the cable, and the receiver (for a different make/model as some receivers won't work correctly with some LNB's). It should also be noted that some wall-plate connectors can also cause "channels missing" problems.

It can also be tested using a satellite finder power meter. By pointing the LNB up at outer space (clear sky), the noise temperature contribution from the surroundings will be negligible, so the meter reading will be corresponding to the noise temperature of the LNB, say 100k (K means degree Kelvin, above the OK absolute zero temperature). If you then point the LNB at your hand or towards the ground, which is at a temperature of approximately 300k, then the noise power reading on the meter should go up, corresponding to approximately 400k (100k + 300k).

It should be noted that LNB's may fail on one polarization or on one frequency band and that the failure mode may occur at certain temperatures. If you choose to replace an LNB in a VSAT (very small aperature terminal) system, check the transmit reject filter and supply voltage, if you don't want to be one of those people who keeps blowing up LNB's trying to find a good one.

XXII. SYSTEM DESIGN

The design of the low-noise block converter (LNBC) consist of a high performance self-oscillating mixer made from a MESFET with a dielectric resonator that functions as both oscillator and a mixer and thus reduces the cost and number of components to manufacture the down converter.

The design steps includes the following:

- Providing an RF amplifier for amplifying an RF satellite signal.
- Coupling a self-oscillating mixer to the RF amplifier for down-converting the RF satellite signal to an Intermediate frequency (IF) were the self-oscillating mixer functions as both an oscillator and a mixer.
- Providing an IF amplifier for amplifying the IF signal.

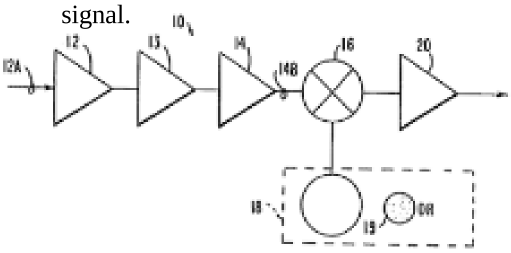

Fig. 7a: Schematic Block Diagram of a prior art low noise block down converter.

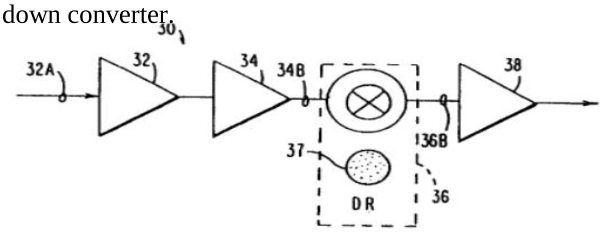

Fig 7b: Fig. 4.0: Schematic Block Diagram of a prior art low noise block down converter.

In figure 7a, down converter 10 includes low noise amplifiers 12, 13 and 14, mixer 16, oscillator 18 and IF amplifier 20 Input 12A of amplifier 12 is coupled to a super high frequency RF signal (e.g. 12GHZ or 22GHZ) from a feed horn mounted at the focal point of a reflector dish. The RF signal at input 12A is amplified by cascaded amplifiers 12, 13 and 14. The amplified RF signal at output 14B of amplifier 14 is then mixed with an oscillating signal from external and independent oscillator 18 at mixer 16 to produce a modulated intermediate frequency (IF) signal (e.g. 900 to 2,500MHZ or 1.1 to 1.6GHZ for 12GHZ and 22GHZ RF signals respectively) at output 16B of mixer 16. Oscillator 18 has high Q dielectric resonator (DR) 19 for stabilization. The mixer IF signal is then amplified by IF amplifier 20 to provide an amplified IF signal for coupling.

In order to provide acceptable gain and noise characteristics for direct broadcast satellite (DBS) applications at 10-12 GHZ, down converter 10 typically includes three amplifiers 12, 13, and 14 employing GaAs based high election mobility transistor (HEMTs) or metal semiconductor field effect transistor (MESFETs). DBS applications typically requires 50dB of conversion gain (at least) and 1.5dB of noise figure (at most) over the RF frequency range (e.g. 10 to 12GHZ).

In the present design, figure 7b shows a down converter 20 includes low noise amplifier 32 and 34, self-oscillating mixer 36 and IF amplifier 38. In comparison to down converter 10 of fig. 7a , down converter 30 includes one less low-noise amplifier (12,14 or 16) and does not include an independent oscillator similar to oscillator 18. However, the down converter 20 still provides acceptable conversion gain and noise figure characteristics. Input 32A of amplifier 32 is coupled to the super high frequency RF signal. The RF signal at input 32A is amplified by cascaded amplifier 32 and 34. The amplified RF signal at output 34b of amplifier 34 is then coupled to self-oscillating mixer 36 to produce the modulated intermediate frequency (IF) signal at output 36B of mixer 36/ self-oscillating mixer 36 includes high – Q dielectric resonator (DR) 37 for stabilization. The IF signal is then amplified by IF amplifier 38 to provide an amplified IF signal for coupling. In accordance with the present invention, because mixer 36 provides conversion gain (instead of conversion loss as in fig 4.0), the down-converter of the present design eliminates the need for a third stage of low noise amplification of the RF signal from the feedhorn prior to mixing. Hence, the number of components in the down-converter is reduced over the prior art and therefore the complexity and cost of design is also reduced. Such a design therefore also inherently improves the manufacturing yield since there are less low-noise amplifiers per receiver (for the same amount of RF conversion gain) which has the potential to become defective. As such, the low-noise block down –converter of the present invention provides high performance for low cost.

From the above, self-oscillating mixer 50 includes band pass filter 52, RF matching network 54, GaAs based MESFET 56, dielectric resonator (DR) 57 and IF matching network 58. MESFET 56 is configured having a common source 56A with parallel feedback from drain 56B to gate 56C to provide the necessary oscillation conditions at drain 56B and gate 56C. the feedback path is made possible by coupling through Dr 57, preferably having a relative permittivity and Q-factor greater than about 45 and 4,500 respectively. (The Dr can be modeled as an RLC parallel resonant circuit with transformer coupling to the MESFET gate and drains). The common source configuration is chosen because oscillator 50 would function similar to a MESFET mixer with conversion gain when an RF signal is injected into gate 56C and an IF signal is extracted from drain 56B, except however, there is no external and independent local oscillator (LO) required. The LO frequency and non-linear frequency mixing are all generated by the MESFET without the need for extra components. In accordance with the present design, the DR not only determines the oscillation frequency, but also stabilizes it as well against temperature variation. Band pass filter 52 is designed and inserted between the two-stage low noise RF amplifier and the MESFET (of the self-oscillating mixer) to reject the image frequency associated with the low noise RF amplifier. RF matching network 54 is designed to match MESFET 56 to the RF amplifier. Generally, RF matching network 54 and band pass filter 52 are designed to reduce the effect of RF matching on the oscillation conditions of the self-oscillating mixer.

XXIII. SYSTEM SPECIFICATION

From the block diagram of the low noise block down converter discussed in chapter three, the following equations were generated for various components for the complete actualization of the lower (block) range of frequencies in the cable to the receiver.

The angle that the component wave must have with respect to the input waveguide in order to satisfy the conditions for the input waveguide propagation is expressed as

$$\cos\theta = \frac{\lambda}{2a} \text{ - } (1)$$

Where λ = wavelength of the wave on the basis of the velocity of light (3×10^8m/s)

a =width of the waveguide

Because the component waves that can be considered as building up the actual fields in the waveguide all travel at an angle with respect to the axis of the guide, the rate at which signal propagates down the guide is less than the velocity of light. This velocity with which signal propagates is called the group velocity (Vg) and is expressed as;

$$\frac{Vg}{c} = \sin\theta = \sqrt{1-\left(\frac{\lambda}{2a}\right)^2} \text{ ------ } (2)$$

Where C = velocity of light (3×10^8m/s)

We also have it that;

$$\frac{\text{wavelenght in guide}}{\text{wavelenght in fiee space}} = \frac{\lambda g}{\lambda} = \frac{1}{\sin\theta} \text{ ------ } (3)$$

Where λg = guide wavelength

Substituting eqn(3) into eqn (2)

$$\text{Hence } \frac{c}{Vg} = \frac{\lambda g}{\lambda} = \sqrt{1-\left(\frac{\lambda}{2a}\right)^2} \text{ ----------------------} (4)$$

It should be noted that in the Smith chart solutions of waveguide problems, λg should be used. For making moves, and not the free-space wavelength λ. The velocity with which the wave appears to move past the guides side wall is called the phase velocity (Vp). It has a value greater than the speed of light. It is only an “apparent” velocity. However, as it is the velocity with which the wave is changing phase at the side wall. The phase velocity (Vp) and group velocity (Vg) are related by the fact that;

$$\sqrt{Vp\,Vg} = \text{Velocity of light ------------------------ } (5)$$

The filter designed for this process are 65mW, 0.4-2.3GHZ band pass filter for satellite receivers. The band pass filter is suitable for use as a receiving or transmitting filter for one or several receiving or transmitting channels.

The band pass filter can be used for the following:

- To improve the isolation of transmitters
- To increase the isolation of transmitters
- To suppress noise side bands and inter modulation products
- As a duplexer component.

The band pass filter consist of 4 high Q resonators designed as a GSM transmitter/receiver preselector filter in order to suppress interfering transmitting signals on an adjacent amplifier or code division multiple access (CDMA) frequency band.

Fig 8 is a typical attenuation curves for the band pass filter.

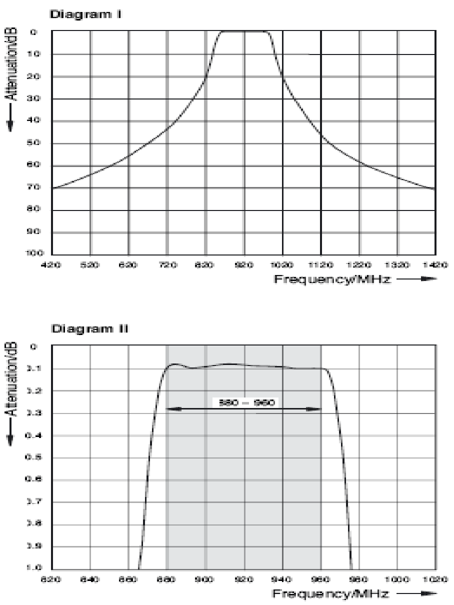

Fig 8 Characteristics Filter Ranges

The characteristics of this filter ranges from its broad pass band range with low insertion loss, stop band attenuation, steepened filter curve through additional poles.

A clear picture of different band pass filters are shown below.

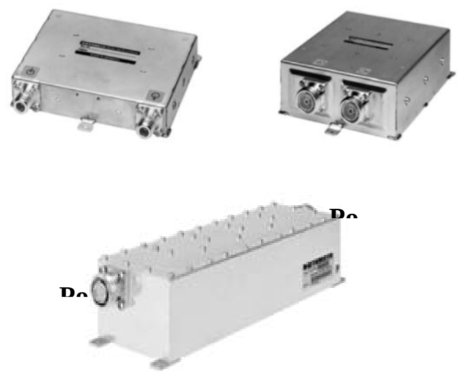

Fig 9 Bandpass Filter

XXIV. SYSTEM IMPLEMENTATION

MATLAB software has been of help in the implementation of this work. It is the software that was used to model the mathematical equation order to generate the equivalent graphs associated with the model.

XXV. SIMULATION RESULTS

Fig 10 shows the plot of the original input waveguide as received from the satellite. There is a vertical pin through the broadside of the waveguide that extracts the vertical polarization signals as an electrical current.

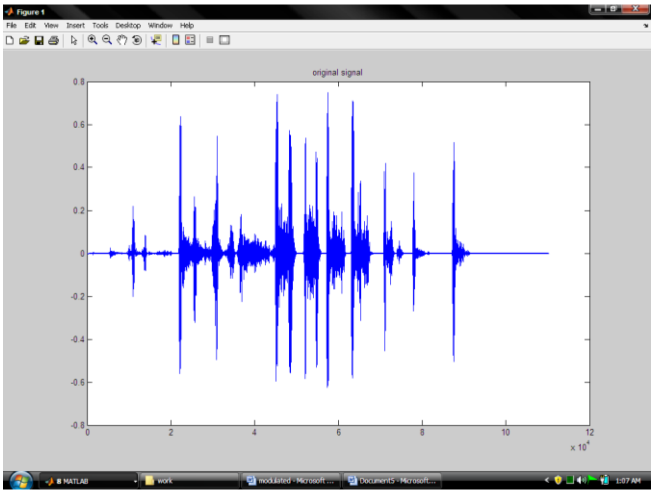

Fig. 10: The Plot of Original Input Waveguide

Fig 11 Shows the plot of the corrupted signal. As a result of noise and other factors the signals are being corrupted. A plot of these corrupted signal is shown below;

Fig 12 Shows the plot of the filtered signal as passed to the low noise amplifier, where it is being amplified and then forwarded to the mixer.

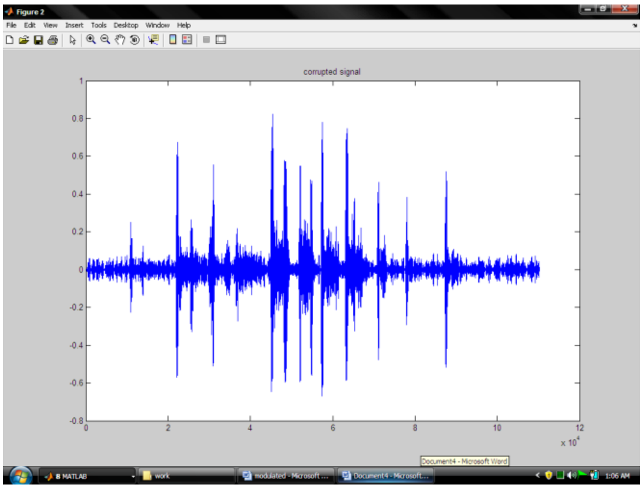

Fig.11: The Plot of Corrupted Signal

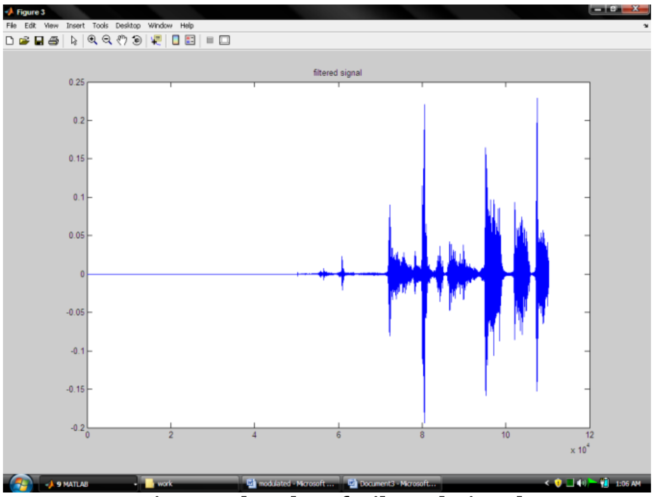

Fig.12: The Plot of Filtered Signal

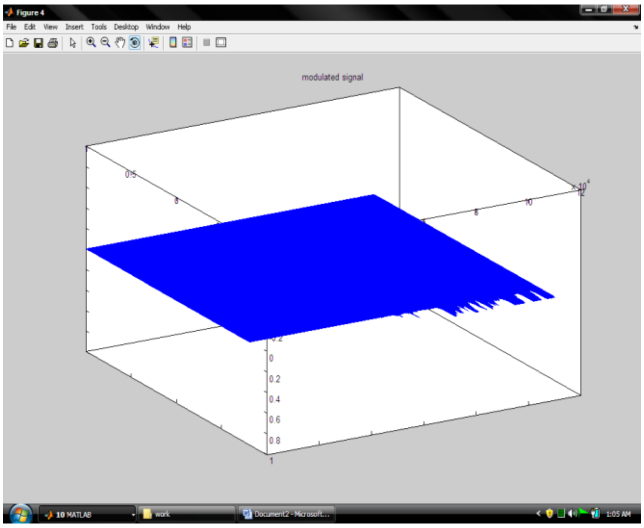

Fig. 13: The Plot of Modulated Signal

Fig. 13 shows the plot of the modulated signal as sent to the mixer, where all that has come from the first bandpass filter and amplifier stage are severely scrambled up by a powerful local osciallator signal to generate a wide range of distorted output.

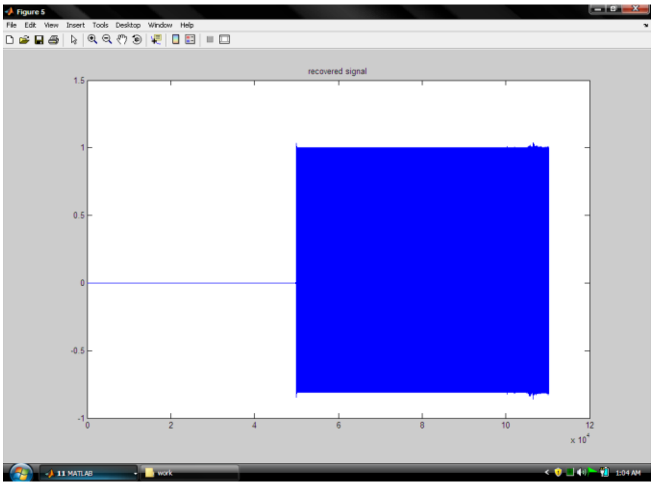

Fig. 14: The Plot of Recovered Signal

Fig 14 shows the plot of the recovered signal after modulation has taken place. From the mixer, the modulated signal is passed to the second band pass filter that selects the difference in frequencies between the wanted input signal and the local oscillator frequency and feeds them to the output L band amplifier and into the cable.

XXVI. SUMMARY AND CONCLUSION

The low noise block converter (LNBC) which uses the super heterodyne principle to take a wide block of relatively high frequencies, amplify and convert them to similar signals carried at much lower frequency called the intermediate frequency (IF) is easier and cheaper to design electronic the system is modelled as circuits that operates at these lower frequencies, rather than the very high frequencies IF satellite transmission.

In a single receiver residential installation, there is a single cable from receiver to LNBC, and the receiver uses different power supply voltages [14/18v] to select polarization and pilot tones [22KHZ] to instruct the LNBC to select one of the two frequency bands. In larger installations, each band and polarization is given its own cable, so there are 4 cables from the LNBC to a switching matrix which allows the connection of multiple receivers in a star topology using the same signaling method as in a single receiver installation.

XXVII. RECOMMENDATION

As more and more information is being handled in digital format, the future for satellite is also digital. In the near future, transmissions will take place in digital formation and this offers some advantages. The prime reason for digital broadcasting is that with analog broadcasting only one channel per transponder can be transmitted, whereas with digital broadcasting this can be 10 channels per transponder. This means a substantial cost reduction per channel. Due to compression techniques, more information can be put on the same channel bandwidth currently being used, which allows more flexibility.

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