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Appraisal of Analogue Transmission along NITEL Exchange Route

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Abstract: The Nigerian Telecommunications Limited (NITEL) analogue exchange route that has been studies is Calabar-Ogoja. Result showed good agreement of signal strength. It also shows that the assessed analogue route has a Signal to Noise Ratio (SNR) of 30 dB as against expected figure of about 40 dB. It shows the transmission equipment working condition is approaching its tolerance limits due to aging. It was also found that the network manageability of this route is very poor.

Key words: Nigerian Telecommunications Limited, signal to noise ratio, multiplexing

INTRODUCTION

Transmission may be defined as the electrical transfer of a signal message, or other from of intelligence from one location to another through a medium. Generally, information can be transmitted through a medium either as an analogue or as a digital signal.

Analogue transmission implies continuity, as contrasted with digital transmission, which is concerned with discrete states. In analogue transmission, the information content of an analogue signal is conveyed by the value or magnitude of some characteristics of the signal such as amplitude, frequency or phase of a voltage, the amplitude or duration of a pulse. Examples of typical analogue transmitted signals are those in AM and FM radio (Roger, 1999).

Analogue transmission employs certain modulation techniques such as, Amplitude Modulation (AM), Frequency Modulation (FM) and Phase Modulation (PM) at the transmitter to translate signals to the level acceptable by the transmission medium. At the receiver, the modulated signal is demodulated to recover the intelligence or the information content of the information bearing signal. During this transmission, as the analogue signal moves across the distance, it loses power and becomes impaired by many factors depending on the medium of transmission. This causes the signal to be attenuated and distortion is introduced. The result is that a received signal has a lower quality than the transmitted signal (Davies, 2005).

Since, signals get attenuated with distance, amplifiers are spaced at distance between the transmitter and receivers depending on the medium to the analogue signal to its original level. As the signal arrives at the amplifier, it is not only attenuated but it is also impaired and noisy. One of the problems with a basic amplifier is that it is a dumb device. All it knows how to do is to add power, so it takes a weak and impaired signal, adds power to it and brings it back up to its original power level. But along with an increased signal, the amplifier passes along an increased noise level. So in analogue network, each time a signal goes through an amplifier, it accumulates noise (Goleniewski, 2001). Goleniewski (2001) also noted that the network manageability of analogue transmission is poor since a lot of labour is needed for maintenance and control of analogue transmission because of poor management information.

Theory: The instantaneous voltage for a frequency modulated voltage is given by (Kennedy and Davies, 1999).

$$V = A\sin(\omega_c t + m_f \sin\omega_m t) \qquad (1)$$

where, V = instantaneous voltage, A = amplitude, $\omega_C t$ = carrier frequency, m_f = modulation index, sin $\omega_m t$ = modulated frequency. Eq. (1) is sine of a sine function, Bessel equation is employed in its solution. This gives an infinite number of sidebands as well as the carrier frequency. The lower sidebands components of the frequency modulated wave are employed for voice transmission while the upper sidebands are suppressed. Generally, analogue voice transmission is accomplished by the process of Frequency Division Multiplex (FDM). In FDM, the available channel bandwidth is divided into number of non overlapping frequency slot usually 12 voice channel bank. Each frequency slot or bandwidth segment carries a single information-bearing signal in this

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case voice signal. Each voice channel is a 4 KHz bandwidth sufficient to accommodate the standard 300 Hz-3400 KHz voice channel. The 12 voice channels are multiplex with 9 Radio carrier Frequency (RF) associated with each channel to form a group. Five of these groups are then multiplexed to form a super group containing 60 × 16 voice channels. This process is repeated to generate up to four more level. At the top of hierarchy lies the jumbo group multiplex containing 10.800 voice channels.

The Calabar-Ogoja (NITEL) analogue route considered for this utilizes radio facilities operating at a Radio Frequency (RF) 6 GHz and has 5 repeater stations operating at Intermediate Frequency (IF) of 70 MHz spaced along the route which is about 320 km and transmit at supper group level. Because of problem facing communication along this route, this research was carried out in order to determine the problem facing communication along this route. The research was carried out by taken some readings, studying daily log report book along this route and comparing the readings taken the equipment manufacturer specification. Throughout the measurement the pilot frequency for all the stages was maintained within the specified limit to avoid frequency jamming.

The objective of this work is to determine the performance of a typical analogue link and to assess the efficiency and factors affecting the transmission quality along this route.

Analogue transmission principle: Generally, almost without exception, the message or piece of information produced by a source invariably occurs in non-electrical form and is the result of some physiological or physical phenomenon. Examples include the physiological or physical output of telephony and radio. The human voice, for example, can typically generate frequency from 100-10.000 Hz for a bandwidth of 9.900 Hz. But the ear does not require a vast range of frequency to elicit meaning form ordinary speech; the vast majority of sound we make that constitute intelligible speech fall between 250 and 3.400 Hz. Hence, the CCITT/IEEE define a voice band channel suitable to accommodate all the intelligibility in human speech or analogue data for voice transmission in the range of 300-3.400 Hz.

The analogue signal from the source is transferred to the transducer to generate a corresponding electrical signal for the purpose of telecommunication. Ordinary human voice cannot travel far distance before it gets totally attenuated. The transducer output corresponding to such message waveform as speech will vary continuously over some arbitrary but finite amplitude range depending upon the loudness of the speech and the gain characteristics of the microphone (Greg, 1998).

The signal from the output transducer is not generally suitable for transmission over long distances. This signal in its analogue or either digital form is feed into the transmitter to modify the frequencies from the input transducer to those which can be used for transmission. To achieve this objective, the transmitter performs several signal processing operations including amplification, filtering and modulation. The most important of these is modulation, a process designed to match the properties of the transmitted signal to that of the medium (channel) through the use of carrier wave. The actual method of modulation varies from one system to the other depending on the requirements to be met. At the transmitter the effects of channel noise is minimized through the use of large signal power and bandwidth and by use of waveform that last for long durations. After processing the signal, the transmitter then couples it onto the channel (medium of transmission) in the form of transmitted signal.

The medium of transmission also called transmission channel covers the path between the transmitter and the receiver. It is electrical connection between the transmitter and the receiver. It bridges the distance from source to destination. The channel may be a pair of wires, a coaxial cable, a radio wave or a laser beam. Due to the non-ideal nature of the communication channel, it causes certain unwanted and undesirable effects which invariably corrupt the information bearing signal. One of such effects is attenuation which is the progressive decrease of signal power with increasing distance. Other factors which degrade the system performance and causes error include distortion, noise and interference. As a result this amplifier are spaced at some kilometer intervals along the transmission medium to restore the signal back to its origin form.

The receiver performs the opposite function of the transmitter. It extracts the desired signal from the channel by the process called demodulation or decoding and delivers it to the output transducer. At the receiver, the signal is amplified and some error correction are made before the signal is delivered to the output transducer. The output transducer converts the electrical signal to acoustic wave and delivers such to the destination, the end user.

MATERIALS AND METHODS

The analogue microwave transmission equipment linking Calabar-Ogoja NITEL exchange with a distance of approximately 320 km employs telettra MUX to modulate and demodulate the analogue signal. It also employs the Bell ITT radio operating at a Radio Frequency (RF) of 6 GHz and has 5 repeater stations working at Intermediate Frequency (IF) of 70 MHz space between Calabar and Ogoja and is operated with a power supply of -16V at 14 mA with a tolerance level of 10%. This equipment employs the transmission technique based on frequency division multiplexing, where by the signal undergoes different frequencies stages such as audio, group and super group as encountered with this equipment. The data relating to transmission data are available via the meters attached to the equipment.

The data transmitted using analogue microwave transmission equipment using telettra MUX and Bell ITT radio were collected at the Calabar exchange of NITEL for 21 days from October 25th-November 14, 2006 with the aid of the selective meter and other meters attached to the analogue equipment with the assistance of some NITEL technical staff. The transmission logbook of the equipments was also considered so as to compare the readings with that specified by the equipment manufacturer. The average values of the readings were calculated for the transmitted the received signal obtained and other important transmission levels based on the equipment specified.

The analogue measurements using (analogue microwave transmission equipment using telettra MUX and Bell ITT radio) include: Audio level, group level, supergroup level, R.F. output and receive, level, return loss, thermal noise and signal-to-noise ratio (SNR).

Ten calls were made from Calabar NITEL exchange to Ogoja NITEL exchange during the measurement period to note the effects of transmission, medium, transmission techniques and possibly environmental and human influence on the received signal quality. The report of some NITEL staff that went on daily routine to check the performance of the analogue route and the repeaters stations were also obtained for the purpose analyses.

RESULTS

In order to appraise the performance of an analogue network measurements were taken for the Calabar-Ogoja NITEL analogue exchange route based on analogue microwave transmission equipment using "telettra" MUX and "Bell ITT" radio were collected for 21 days and the average readings were presented in the following tables. Table 1 shows average readings taken on 12 channel voice bank which has a channel pilot as 84.08 kHz with a 5,000 kHz master oscillators in which a 12 kHz at-23±0.5 dB is derived to generate the group and super group carries. The channel bank has a frequency band of 60-108 kHz basic group, which is then fed into the group combiner at 43±5 dBm with impedance of 75Ω. During the period under review (October 25th to November 14th, 2006) the transmitted levels and received levels on the channel bank were within tolerance for all the channels for the analogue route between Calabar and Ogoja.

Table 1 shows the audio channel level with maximum value of -24dB and minimum value of -31dB. It also shows the audio transmit level having maximum value of -10dB and minimum value of -18dB and audio receive level having a maximum value of 8dB and minimum value of 1 dB. As indicated in Table 1, all readings are within the system specification limit. Table 2 represents average readings taken on the group bank, which makes one out of the 16 group bank level required to form a super group. The group bank consists of five twelve-voice channel banks. The pilot frequency for the group bank is a 444 kHz at -30±0.5dB and has 750Ω impedance with a frequency band of 312-552 kHz. It shows a group level with a maximum value of -34dB and minimum of -41dB. As indicated in table 2 the levels and impedance for all the group banks were within specified range. Table 3 represents average reading taken on super group level. The pilot frequency here is a 1552 kHz at -30±0.5 dBV with impedance of 75Ω and has a frequency bank of 60-4028 kHz, which is then fed to the input of the radio at

Table 1: Average values of the twelve channel voice including the transmit and receive level

Channels	Channel carries (kHz)	Channel Levels (-27± 5 dB)	Channel frequency (kHz)	Tx Levels (-14±5 dB)	Rx Levels (4±5 dB)	Impedance (Ω)	Remarks
1	132	-23	108	-17	1	600	Ok
2	128	-30	104	-17	7	600	Ok
3	124	-31	100	-11	6	600	Ok
4	120	-24	96	-18	8	600	Ok
5	116	-31	92	-17	1	600	Ok
6	112	-24	88	-11	7	600	Ok
7	108	-31	84	-11	1	600	Ok
8	104	-24	80	-17	2	600	Ok
9	100	-23	76	-11	7	600	Ok
10	96	-31	72	-10	2	600	Ok
11	92	-23	68	-11	8	600	Ok
12	88	-31	64	-18	7	600	Ok

Table 2: Average values of the group level

Group	Carrier frequency (kHz)	Levels (-37±5 dB)	Impedance (Ω)	Remarks
1	420	-34	750	Ok
2	468	-40	750	Ok
3	516	-33	750	Ok
4	564	-35	750	Ok
5	612	-41	750	Ok

Table 3: Average values of the supergroup level

Super group channel	Carrier frequency (kHz)	Levels (-30±5 dBv)	Impedance (Ω)	Remarks
1	612	-27	75	Ok
2	Unmodulated	-33	75	Ok
3	1116	-26	75	Ok
4	1364	-33	75	Ok
5	1612	-32	75	Ok
6	1860	-25	75	Ok
7	2108	-26	75	Ok
8	2356	-34	75	Ok
9	2604	-26	75	Ok
10	2852	-33	75	Ok
11	3100	-33	75	Ok
12	3348	-27	75	Ok
13	3596	-26	75	Ok
14	3844	-33	75	Ok
15	4092	-27	75	Ok
16	4340	-34	75	Ok

Table 4: Average values of other analogue measurement including the RF transmit and receive level

Return loss ≥20 dB	3rd Harmonic distortion ≥80 dBmo	Thermal noise ≥85 dBmo	S/N ≤40 dB	R.F input level (-34±5 dBm)	R.F output level (-30±5 dBV)
28	89	94	30	-40	-33

level test point -63±5 dBm. As indicated in Table 3 all readings were within tolerance level. Table 3 shows the super group level with maximum value of -27 dB and minimum value -34 dB, with unmodulated channel 2. All readings are within the equipment tolerance limit.

Table 4 represents the average readings of other analogue measurements taken during investigative period which include both transmit and receive level of the equipment. The readings were all within the specified limit.

DISCUSSION

All the results (Table 1-4) gave good signal strength, since they are within the equipment tolerance level. However, they show that all the reading are approaching the tolerance limits of the equipment, due to the aging of the equipment. This brings about an increase in the noise level of the equipment and thus reducing the signal to noise of the equipment to about 30 dB from the expected 40 dB. To further investigate the performance level of the equipment and the transmission route, ten call were made on different days from the Calabar primary centre (carrier room) to EPZ primary center (carrier room) for all the calls made only one went through and was characterized by echo and noise. The echo and noise is attributed to the 5 repeaters spaced along the route, since the repeater is known to add power to weak signals and passes along an increased noise level and also the aging of the equipment. In an attempt to know why only one call went through from all the ten calls made, the transmission capacity of the equipment used was considered. From Table 3, it is shown that the equipment has the capacity to carry 900 voice conversations at a time since one of the super group channels remained unmodulated. One super group channel consists of 60 voice channels, which gives a total of 60×15 voice channels. This capacity has never been occupied for conversation along this route. Hence, after studying some daily log reports of NITEL on the performance of this route was studied and it was found that the route was seriously neglected. In most cases there is a power outage at the repeaters stations and most of the generators at the repeaters stations are bad, in this case the signal sent could not amplify and sent from one repeater station to the next. There was also ineffective means of communication between the Calabar and Ogoja primary exchange. This factors shows that the management of analogue network is poor. Goleniewski (2001) noted that the network manageability of analogue transmission is poor and a lot of labour is needed for maintenance and control of analogue transmission because dumb analogue devices do not provide management information streams that allow the device to be remotely managed. Also, this route is faced with problem of line of sight due to tall trees, tall buildings and tilt in the receiving antenna due to wind blowing which characterized this period of rainy season in this part of the country (Adeosin, 2004).

The Calabar-Ogoja NITEL route Nigeria has a total frequency band of 60 Hz-4028 kHz which gives approximately a total bandwidth of about 4 MHz.

From the result it can be said that analogue transmission equipment will work optimally when variation for all the levels at all stages of modulation is closely to the specified standard and that as the variation approaches the maximum variation limit, this will allow noise to be generated in the system, thus leads to deterioration of the quality of the signal to be transmitted which will thus result in low SNR value.

CONCLUSION

The results showed good agreement of signal strength for the analogue transmission. However, theresults from the analogue equipment shows that the equipment is aged with alls the readings approaching the tolerance limits of the equipment. With ten calls made from Calabar NITEL primary exchange, it shows that the NITEL analogue route is in a bad condition.

The Calabar-Ogoja route has the capacity to carry 900 Voice Frequency Channel (VFC) at a time.

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