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Performance Assessment of Digital Transmission along NITEL Exchange Route

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Abstract: Performance test carried out along the Calabar- EPZ Nigeria Telecommunications Limited (NITEL) Digital Exchange Route shows good agreement of signal strength. The result also shows that the route is in a very good condition. It also shows that voice transmission along this route has good voice clarity with a Bit Error Rate (BER) in order of 10^{-3} which requires a Signal to Noise Ratio (SNR) of about 16 dB to achieve the error performance level. The route has a bandwidth of about 34 MHz, which makes transmission faster along this route and makes it easy to carry other transmission data. Findings show that the network manageability of this route is very good.

Key words: Nigerian Telecommunications Limited, bit error rate, signal to noise ratio, bandwidth

INTRODUCTION

The IEEE defines transmission as the propagation of a signal, message, or other form of intelligence by any means such as optical fibre, wire or visual.

In digital transmission, the information content of a digital signal is concerned with discrete state of the signal such as the presence or absence of a voltage, or a contact is the open or closed position. This digital signal is discretely variable over time. That is, ideally, the signal is either a pulse, or not a pulse at any given time. There are no in-between states for this digital signal as the analogue signal. The signal is given meaning by assigning numerical values to the various states. Usually, the series of the discrete pulses represents one bits and zero bits. How the ones and zeros are carried through the network depends on whether the network is electrical or optical. In electrical networks, one bits are represented as high voltage and zero bits are represented as null, or low voltage. In optical networks, one bits are represented by the presence of light and zero bits are represented by the absence of light (Goleniewski, 2001).

The digital signals undergoes certain modulation techniques such as Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK) and Phase Shift Keying (PSK) at the transmitter to translate signals to the level acceptable by the transmission medium. On the receiver side, the modulated signal is demodulated to recover the intelligence. The modulation and demodulation process in digital transmission is carried out by CODEC. If this signal is sent over a transmission medium, it suffers from distortion, attenuation and degradation. However, with a digital signal, this corruption can be corrected. Repeaters are added along the transmission medium to correct the corrupt signal. The repeater recreates the digital signal. This ability to recreate the original signal and thus eliminates the effect of the noise is a key attribute that distinguishes digital signal transmission from analogue signal transmission. This attribute provides the ability to transmit voice over great distances without the signal suffering from degradation due to transmission (Poland, 2005).

Theory: The process of any digital transmission is based on sampling, quantization and coding (Siemens, 1998).

Sampling: The cornerstone of an explanation of how PCM work is the Nyquist sampling theorem which states: If a band limited signal is sampled at a regular interval of time and at a rate equal to or higher than twice the highest significant signal frequency, then the sample contains all the information of the original signal. Mathematically, $f_s = 2f_m$ where f_s is the sampling frequency and f_m is the highest frequency component of the signal.

Quantization: The quantization process provides a way of assigning some voltage value from negative to positive range of values to the PAM generated through the process of sampling in other for the signal to be coded. Generally the process of quantization introduces an error into the process which could be up to half a quantum step between the actual signal and the quantized value (John, 2001).

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Coding: Coding of signals are done based on pseudologorithmic curve made up of linear segment imparts from finer granularity to low level signal and less granularity to the higher level signal. The logarithmic curve follows one of the two laws, A-law and the μ-law (Roger, 1999). The curve for A-law may be plotted from the formula

$$F_A(x)\left(\frac{A/x/}{1+\ln(A)}\right)0 \le /x/ \le \frac{1}{A}$$

$$F_A(x)\left(\frac{A+\ln/Ax/}{1+\ln(A)}\right)\frac{1}{A} \le /x/ \le$$

where, A = 87.6 (Roger, 1999)

The A-law is used with E1 system which is the Europeans PCM standard using a 32 channel system. The A-law curve is plotted using

$$F_\mu(x)\frac{\ln(1+\mu/x/)}{\ln(1+A\mu)}$$

where, x is the signal input amplitude and μ = 100 for T_1 system and 255 for DSI system (Roger, 1999). The T_1 and DSI systems are the old and new North American Digital standard for PCM hierarchy using a 24 channel system, respectively.

The Calabar- EPZ NITEL Nigeria digital exchange route studied for this work uses optical line transceiver 34 and digital signal multiplexer that modulates a 2Mbits/s signal and transmits at 34 Mbits/s. This route has no regenerative station between the 2 exchanges and it employs the principle of PCM/TDM modulation techniques based on ON/OFF shift keying modulation techniques.

The objective of this work is to access the performance of a typical digital transmission route and to determine the effect of the transmission medium employed on the performance of this route.

Digital transmission techniques: Generally, almost all signals in nature are produced by analogue source (Greg, 1998). In voice telephony, the voice band necessary to convey intelligence in human speech is only between 300-3400 Hz as defined by IEEE/CCITT. This analogue signal is needed to be converted to digital signal prior to the transmission of the signal. Basically, the analogue signal to be converted to digital signal involves four steps. The four steps include band limiting, sampling, quantizing and coding (Siemens, 1998).

With the aid of a low-pass filter the audible frequencies are band-limited to 300-3400 Hz. The electronic switch takes samples from the telephone signals at regular intervals. Nquist (1928), showed that if an analogue signal is to be sampled with error free and no loss of information that the sampling frequency must be greater than or equal to twice the highest frequency component of the analogue signal. An international sampling frequency of 8000 Hz was defined for the frequency band of 300-3400 Hz used in telephony. The interval between two sampling values of the same frequency band is 125 μs (1/8000 Hz). Every 125 μs (= 1/8000 Hz) an electronic switch is closed for a short period of time. This generates a sample in each case. A pulse amplitude signal (PAM signal) is thus obtained at the outlet of the electronic switch.

The PAM generated at the outlet of the electronic switch is quantized and the whole range of possible amplitude values is divided into quantized intervals. Generally, 256 quantized levels are generated for telephony. The quantized intervals are numbered into + 256 in the positive range and -256 in the negative range of the telephones signal and the appropriate quantizing interval is determined for each sampled the next stage is the encoding of the quantized intervals. During the encoding, every quantized level of the PAM signal is converted into an 8 binary code for transmission.

At the transmitter, the coded signal is modulated using any of the digital modulation techniques. This allows for multiplexing of several signals. This is one method for increasing utilization of communication channel by allowing several signals to be transmitted at the same time through a single channel. Sharing of the communication channel may be done using any of the access techniques based on frequency, time, code or phase.

The modulated digital signal is sent over a transmission medium. The sent digital signal suffers distortion, attenuation and degradation. This results in the loss of quality just like analogue transmission systems does (Davies, 2005). Due to these looses along the transmission medium repeaters are spaced along the transmission path at a specific distance intervals. This recreates the digital signal. Usually, the repeaters use a threshold to determine the location of the pulses. If the signal rises above the threshold level, that moment is judged to be the start of a possible pulse. If the repeater sees a pulse at its sample point (measures the signal voltage to be greater in amplitude than the threshold level) then it creates an entirely new pulse to transmit. In this case, the original digital signal is faithfully regenerated (Poland, 2005).

MATERIALS AND METHODS

This work was carried out with the use of:

OLTS 34 and DSMX 2/34 digital optical transmission equipment linking Calabar-EPZ NITEL (NOW TRANSCORP) exchange.

Line equipment OLTS 34 (optical line transceiver 34) is an optical transmission system operating at a bit rate of 34Mbits/s. This digital transmission equipment linking Calabar and EPZ NITEL exchange employs a transmission techniques based in time division multiplexing, where digital signal time division multiplexing stages are in terms of bits, megabits etc. The system is operated with an external voltage that is maintained between-48V and -60V. The system modulates a 2 mbits s^{-1} signal to 34 Mbits/s before it transmits the signal. The operation is based on single-mode transmission and it employs an optical Lower Power Lazer Diode (LPLD). It selects appropriate rated converters for an optical wavelength of 1310 nm (Siemens, 1993).

The data transmitted using OLTS34 and DSM×2/34 digital optical transmission equipment were collected at the Calabar exchange of NITEL Nigeria for 21 days from October 25th to November 14th, 2006 with the aid of the Personal Computer (PC) attached to the System Monitoring Unit (SMU) of the digital equipment and a voltmeter which measures the laser current, which is converted linearly to a voltage measured on LD bias test point with the assistance of some NITEL technical staff.

The transmission logbook of the equipment 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 parameters measured with OLTS 34 optical transmission equipment were as follows: laser current, optical output transmit power, optical receive power, inter channel cross talk, idle channel noise, BER for E_1 level, Absolute overall loss.

Ten calls were made from Calabar NITEL exchange to EPZ 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.

RESULTS

Transmission data based on (OLTS34 Optical transmission equipment) were collected for the Calabar- EPZ NITEL digital exchange route for 21 days in order to asses the performance of a digital network. The average values of the readings were shown in the following Fig. 1 and Table 1-4.

Table 1 shows the average optical laser current in the transceiver position 3 and 4. Table 2 shows the average optical output transmits power and the optical receives power of the transceiver position three and four measured in dbm. Table 3 shows the average inter-channel cross talk of the digital optical transmission equipment while Table 4 represents the average readings of the idle channel noise of the equipment. Figure 1 shows the variation of E_1 bit error rate taken at the PCM channel bank for the PCM 30 channels against the PCM channel bank with the maximum channel BER of 0.03dB and minimum 0f 0.01 dB. Table 5 shows the average readings of absolute overall lose readings of a five four wire PCM system. All the digital readings taken were within the specified range.

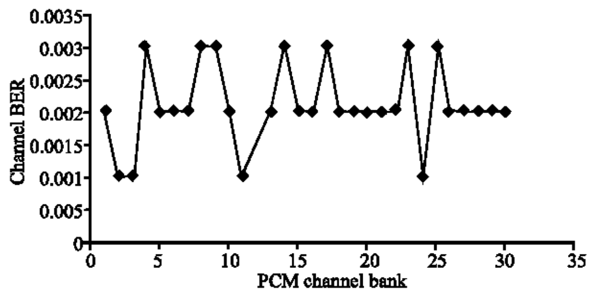

Fig. 1: Graph of BER against the PCM channel bank

Table 1: Optical laser current

Laser current	0.8-1.2V	Remark
TRCV 34 POS.3		
Measured current	1.047	Ok
TRCV 34 POS.4		
Measured current	1.136	Ok

Table 2: Optical transmit and receive power

Transceiver positions	Transmit power (-11-14 dBm)	Receive power (-17-20 dBm)	Remark
TRCV 34 POS.3			
Measured power	(-12.0)	(-17.8)	Ok
TRCV 34 POS.4			
Measured power	(-11.5)	(-17.3)	Ok

Table 3: Inter-channel cross talk

System	≥65 dBmo	Remark
1	64	Ok
2	63	Ok
3	65	Ok
4	63	Ok
5	65	OK

Table 4: Idle channel noise

System	≤65 dBmo	Remark
1	65	Ok
2	64	Ok
3	65	Ok
4	64	Ok
5	65	Ok

Table 5: Absolute overall loss of a four wire system

	System no		$\leq$30 dB		
Channel no	1	2	3	4	5
1	13.15	13.22	13.47	13.32	13.24
2	13.94	13.15	13.73	13.68	13.22
3	13.52	13.78	13.91	13.69	13.85
4	13.24	13.48	13.94	13.55	13.87
5	13.31	13.54	13.91	13.61	13.59
6	13.83	13.71	13.69	13.45	13.46
7	13.32	13.56	13.94	13.61	13.56
8	13.24	13.45	13.91	13.59	13.84
9	13.19	13.24	13.44	13.36	13.23
10	13.81	13.71	13.69	13.41	13.41
11	13.92	13.11	13.77	13.61	13.23
12	13.34	13.53	13.96	13.61	13.51
13	13.54	13.78	13.97	13.63	13.81
14	13.24	13.46	13.91	13.52	13.81
15	13.92	13.19	13.76	13.62	13.22
16	13.83	13.51	13.68	13.93	13.84
17	13.45	13.58	13.82	13.74	13.72
18	13.92	13.13	13.51	13.25	13.44
19	13.84	13.73	13.32	13.67	13.49
20	13.81	13.46	13.72	13.88	13.32
21	13.36	13.58	13.96	13.86	13.24
22	13.87	13.48	13.77	13.81	13.38
23	13.83	13.77	13.38	13.66	13.41
24	13.84	13.58	13.62	13.94	13.82
25	13.35	13.53	13.95	13.81	13.22
26	13.46	13.52	13.84	13.74	13.75
27	13.82	13.46	13.79	13.82	13.31
28	13.94	13.13	13.58	13.23	13.42
29	13.81	13.74	13.36	13.64	13.42
30	13.43	13.56	13.83	13.71	13.71

DISCUSSION

All the transmission parameters measured showed that the digital transmission route was in absolutely good condition. This can be seen from Table 1 and 2 with readings close to best level at which the equipment works perfectly. The best level at which the equipment works perfectly is the one closed to the highest maximum specification. Table 3 and 4 also gave a good signal strength with some of the values at the best working condition of the equipment and others so close to it. Figure 1 shows that most of the channels transmit maximum error of 2 bits per one thousand bits processed in one second. The noise level in a digital system is always associated with the BER, which is the ratio of the total number of bits wrongly sent to the total number of bits sent in a second. Within this it can be said that the digital route transmits less error. Hence the route is expected to be less noisy. From Table 5 it shows that the equipment works perfectly when the absolute overall loss of the 5 PCM systems is less than 30 dB. All the readings fall between 13.11 and 13.95 dB for the equipment. This is a good degradation loss since the equipment loss falls in order of 0.01 dB. Another problem that increased the noise level of a digital transmission is the regenerative station, since some of the signals may not be regenerated correctly. This is because a bit might be missing or mistakenly relating zero bits a one bit or vice-versa. With this, the BER specifications of regenerative stations are always higher than the one at the receiver. The BER of some repeater stations are specified as high as 10^{-12} (Roger, 1999). This route has no regenerative station between it, this is due to optical fibre employed as the medium of transmission along this route. Hence it is expected to deliver a high quality voice signal. This route has 480 Voice Frequency Channels (VFC) meaning that it can accommodate 480 conversation at a tine. Ten calls were made on different days from Calabar primary centre and Uyo primary centre and all calls went through with good clarity of voice signal with a Bit Error Rate (BER) in order of 10^{-3} which requires just about 16 dB signal to noise ratio achieve such a error performance level. This route is transmitting at a speed of 34 m bits^{-1} and employ ON/OFF shift keying with a bit equivalent to 1 Hz, which give the system a total bandwidth of about 34MHz.

CONCLUSION

The results showed good agreement of signal strength for the digital transmission. With ten calls made on digital route from Calabar NITEL primary exchange, it shows that the digital route is in a very good condition. The Calabar- EPZ has the capacity to carry 480 VFC at a time.

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