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Performance Analysis and Efficiency of Television Broadcast Transmitting Signals in Lagos Environs: A Case Study of LTV 8

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ABSTRACT

In this paper, an attempt is made to investigate the performance of a television broadcast transmitter. This study focuses on Harris transmitter since our case study is based on Lagos Television 8. This type of transmitter uses the inductive output tube and discussions will be based on the various components that enhances the mode of operation, the differences between the analog and digital operation, and represent the log book reading obtained from the Harris transmitter installed in LTV 8 for six month in order to calculate the efficiency of the transmitter. Deductions of various charts and graphs to illustrate the performance rating and efficiency and also state some maintenance and troubleshooting measures of the transmitter will be presented. This study will equally highlight the limitation of an analogue transmitter compared to a digital transmitter. Digital information takes up less bandwidth than an analogue signal and greatly reduces interference and other problems, in terms of picture and sound quality.

Keywords: *Harris transmitter, Performance Efficiency, Digital systems*

1. INTRODUCTION

Radio and Television Broadcasting, is a primary means by which information and entertainment are delivered to the public in virtually every nation around the world. The term *broadcasting* refers to the airborne transmission of electromagnetic audio signals (radio) or audio visual signals (television) that are accessible to a wide population via standard, readily available receivers. The term has its origins in the medieval agricultural practice of “broadcasting,” which refers to planting seeds by scattering them across a field.

Broadcasting is a crucial instrument of modern social and political organization. At its peak of influence in the mid-20th century, radio and television broadcasting was employed by political leaders to address entire nations. Because of radio and television’s capacity to reach and influence large numbers of people and owing to the limited spectrum of frequencies available, governments have commonly regulated broadcasting wherever it has been practised.

In the early 1980s, new technologies—such as cable television and videocassette players—began eroding the dominance of broadcasting in mass communication, splitting audiences into smaller, culturally distinct segments. Previously, the only means of delivering radio and television to home receivers, broadcasting is now just one of the several delivery systems available to listeners and viewers. Sometimes *broadcasting* is used in a broader sense to include delivery methods such as wire-borne (cable) transmission, but these are more accurately called “narrowcasting” because they are generally limited to paying subscribers.

2. Experimental Setup

2.1 Transmitter

The transmitter amplifies the video and audio signals, and uses the electronic signals to modulate, or vary *carrier waves* (oscillating electric currents that carry information). The carrier waves are combined (duplexed), and then sent to the transmitting antenna, usually placed on the tallest available structure in a given broadcast area. In the antenna, the oscillations of the carrier waves generate electromagnetic waves of energy that radiate horizontally throughout the atmosphere. The waves excite weak electric currents in all television-receiving antennas within range. These currents have the characteristics of the original picture and sound currents. The current flows from the antenna attached to the television into the television receiver, where they are electronically separated into audio and video signals. These signals are amplified and sent to the picture tube and the speakers where they produce the picture and sound portions of the program.

The transmitter superimposes the information from the electronic television signal onto carrier waves by modulating (varying) either the wave's amplitude which corresponds to the wave's strength or the wave's frequency, which corresponds to the number of times the wave oscillates each second. The amplitude of one carrier wave is modulated to carry the video signal (amplitude modulation, or AM) and the frequency of another wave is modulated to carry the audio signal (frequency modulation, or FM). These waves are combined to produce a carrier wave that contains both the video and audio information. The transmitter first generates and modulates the wave at a low power of several watts. After modulation, the transmitter amplifies the carrier signal to the desired power level, sometimes many kilowatts (1 kilowatt equals 1,000 watts), depending on how far the signal needs to travel, and then sends the carrier wave to the transmitting antenna.

The frequency of carrier waves is measured in hertz (Hz) which is equal to the number of wave peaks that passed by a point every second. The frequency of the modulated carrier wave varies, covering a range or band of about 4 million hertz, or 4 megahertz (4 MHz). This band is much wider than the band needed for radio broadcasting, which is about 10,000 Hz or 10 kilohertz (10 kHz). Television stations that broadcast in the same area send out carrier waves on different bands of frequencies each called a channel, so that the signals from different stations do not mix. To accommodate all the channels which are spaced at least 6 MHz apart, television carrier frequencies are very high. Six MHz does not represent a significant chunk of bandwidth if the television stations broadcast between 50 and 800 MHz.

In the United States and Canada, there are two ranges of frequency bands that cover 67 different channels. The first range is called very high frequency (VHF), and it includes frequencies from 54 to 72 MHz from 76 to 88 MHz, and from 174 to 216 MHz. These frequencies correspond to channels 2 through 13 on a television set. The second range, ultrahigh frequency (UHF) includes frequencies from 407 MHz to 806 MHz, and it corresponds to channels 14 through 69. However, channel 37 is used for radio astronomy and medical telemetry equipment, not for television broadcasting (6). When the transition to all-digital television broadcasting is complete, channels 52 through 69 will no longer be used for television signals. These frequencies may become available for other uses such as wireless communication.

The high-frequency waves radiated by transmitting antennas can travel only in a straight line, and may be blocked by obstacles in between the transmitting and receiving antennas. For this reason, transmitting antennas must be placed on tall buildings or towers. In practice, these transmitters have a range of about 120 km (75 mi). In addition to being blocked, some television signals may reflect off buildings or hills and reach a receiving antenna a little later than the signals that travel directly to the antenna. The result is a ghost, or second image, that appears on the television screen. Digital transmission, however, eliminates ghosts and snow since the picture that results is recreated from a digital code, not from analog waves. Television signals may also be sent clearly from almost any point on Earth to any other—and from spacecraft to Earth—by means of cables, microwave relay stations, and communications satellites.

Figure 1: Harris Transmitter

2.2 Disparities between Analog and Digital Signals

Analog and digital modulation standards are different in their characteristics. Although analog TV and digital TV systems both use amplitude modulated RF, there are some importance practical differences. Analog systems have two distinct RF signals on FM aural signal and an AM visual signal. Since the aural Radio Frequency carrier is frequency modulated, the power is invariant and does not require linear amplifiers. Most CCIR standards use negative amplitude visual power output. With analog television systems, the average RF power level will vary significantly as picture level varies. Table below shows the visual RF peak-to-average power ratio (PAR) expressed in dB for three analog TV systems.

Table 1-Visual Peak to Average Power Ratios for ANALOG TV SYSTEMS

CCIR system	NTSC-M	PAL-G	PAL 1
Blanking (dB)	2.23	2.24	2.14
Mid-Gray (dB)	5.14	5.06	4.54
White (dB)	7.55	7.34	6.79
Total power variation (dB) (white to black)	5.32	5.10	4.65

The wide variation of average visual power in analog transmitter caused by picture level variation results in several design challenges. The DC power supplies for the RF power amplifiers must include load regulation for the varying current drawn by class AB stages. The RF power amplifiers must be designed to accommodate the thermal changes caused by varying RF power. If not properly compensated for, unacceptable picture distortions can occur including overshoots, line tilt and field tilt.

Another key difference is in the peak to average power ratio (PAR).In digital systems, the PAR remains a steady figure when measured over a long period. For DVB-T, the PAR figure is somewhat independent of filtering. With the 8-VSB ATSC signal, the PAR is set by the roll off factor of the spectrum sharing filter. In practice, the peaks to average ratio are as noted in the table 2.

Table 2-Peak to Average Power Ratios of Digital Systems

DTV SYSTEM	DVB-T	ATSC
PAR(99.9% OF TIME)	4.5dB	7.0dB

The relatively high peak to average ratios of current digital modulation schemes results in relatively high peak power handling requirements for transmitter RF stages. Amplifier non-linearity and pre-correction are important design an aspect of good performance is to be achieved. In practice the types of pre-correction needed for both analog and digital systems are the same. Both phase and amplitude corrections are required over the bandwidth and the modulation range. For optimal performance, however, the adjustment of such correction will be different for analog and digital systems. For example, analog visual modulation does not approach RF carrier pinch-off as does digital.

2.3 Transmitter amplification for Solid State and IOT.

Manufacturer of television transmitter use what is commonly termed separate amplification or externally duplexed operation. Such systems employ completely independent paths of amplification. For the visual RF signal and the aural RF signal. Externally duplexed systems are simple, easy to implement and can provide very good performance. By using separate amplification, amplifiers can be optimized properly for visual or aural operation resulting in the highest system power efficiency. A less often used approach for analog transmitters is common amplification. The technique is frequently employed for lower power (up to about 2KW) solid state transmitters as it is less costly to implement. Also, nearly all current high power IOT transmitter designs now use

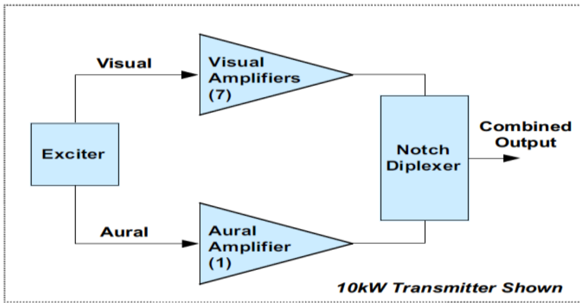

Figure 2: Externally Duplexed Transmitter

common amplification for analog operation. Modern pre-correction techniques allow very good inter-modulation performance and freedom from visual and aural cross modulation. Figure 2 depicts a simplified RF flow diagram for an externally duplexed 10KW transmit.

Figure 3 shows a common amplification transmitter RF block diagram. Note that the notch diplexer has been replaced with a filter. The inter-modulation distortion filter is used to reduce any unwanted third order inter-modulation products created by non-linearities in the class AB power amplifier stages.

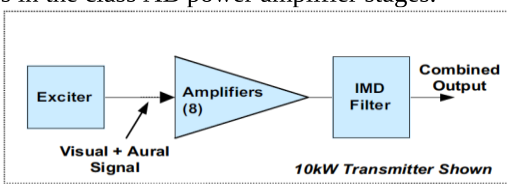

Figure 3 – Combined Amplification Transmitter

3. Results and Discussion

In this study, we analyse and interpreted data collected during inspection and other data collected from the log sheet reading. It reflects the efficiency of the inductive output tube at commissioning and the six month reading (twenty-six weeks) from the log sheet. Graph and chart were used to illustrate how the readings performed well and the performance rating was deduced. It should be noted that the daily readings for six month was converted to an average weekly report by applying mean formulae'

Mathematically, mean is calculated thus:

$$\bar{X} = \frac{\sum X}{n} \qquad (1)$$

3.1 Efficiency Measurement and Calculation

IOT is calculated by the using

$$\text{Efficiency (\%)} = \frac{\text{Power output}}{\text{Power input}} \times 100 \qquad (2)$$

Power output = The sum of peak of synchronization visual rated power plus average aural power.

Power input = Beam voltage ×collector current of the IOT when the visual signal is modulated to 50% APL (that is, mid-grey flat field or ramp/staircase of 50% APL and the aural is adjusted to the desired ratio).

Also we can apply the formulae below to calculate the figure of merit (FOM) or the percentage efficiency

$$\text{FOM} = \frac{PV + PA}{\text{Beam power}} \times 100\% \qquad (3)$$

PV = Peak synchronization vision power.

PA = Aural power

Beam power is the power used when the visual signal consists of a mid-grey picture and synchronization.

Results

Table 3: Efficiency at Commissioning of Transmitter

COMPONENT	VALUES
AURAL 5(%)	103
VISUAL PEAK (%)	102
BEAM VOLT(V)	31.7
COLLECTOR CURRENT(A)	2.13

Calculation for commissioning or factory reading.

$$\text{EFFICIENCY} = \frac{PV+PA}{\text{Beam Power}} \times 100$$

Beam Power = Beam volt × Collector Current

$$Pv = 102\% = \frac{102}{100} \times 40KW = 40.8$$

$$Pa = 103\% = \frac{103}{100} \times 40KW = 41.2$$

Therefore, applying the formulae, we have:

$$\text{Efficiency} = \frac{40.8+41.2}{31.7 \times 2.13} \times 100$$

$$\text{Efficiency} = \frac{8200}{67.521} \times 100$$

Efficiency = 121.44%.

NOTE : 40KW was used above because that is the transmitter capacity of LTV 8. Also the same method was used in calculating the efficiency for opening reading and closing reading for the tables below.

Table 4: Efficiency for Opening Reading

WEEKS	AURAL READING	VISUAL READING	BEAMVOLT READING	COLLECTOR CURRENT READING
1	48	60	29.6	1.60
2	50	65	31.7	1.47
3	60	60	29.6	1.80

4	77	52	30.2	1.99
5	70	62	28.2	2.10
6	66	56	29.1	1.97
7	72	60	29.5	1.90
8	75	56	29.0	1.85
9	50	64	31.7	1.55
10	56	60	28.1	1.87
11	65	60	30.5	1.98
12	55	50	27.0	1.80
13	60	60	28.0	2.12
14	70	65	30.0	1.91
15	70	70	25.0	2.30
16	77	51	32.0	1.87
17	62	62	29.6	2.10
18	50	62	31.7	1.97
19	78	57	32.2	2.10
20	62	60	31.5	1.70
21	48	60	32.2	1.90
22	65	62	29.6	1.96
23	60	60	28.6	1.89
24	75	70	30.0	1.97
25	80	70	29.0	2.13
26	80	75	30.0	2.10

Table 5: Efficiency for Closing Reading

WEEKS	AURAL READING	VISUAL READING	BEAMVOLT READING	COLLECTOR CURRENT READING
1	46	62	29.6	1.58
2	50	66	31.8	1.45
3	60	60	28.6	1.90
4	80	54	32.2	1.99
5	73	64	29.0	2.00
6	68	57	29.1	1.95
7	71	62	29.5	1.90
8	78	62	29.0	2.00
9	52	67	31.8	1.65
10	68	61	27.1	1.97
11	70	65	31.0	1.88
12	60	55	28.0	1.85
13	65	60	28.0	1.96
14	75	70	30.0	2.00
15	75	70	25.0	2.40
16	80	53	32.0	1.74
17	62	62	28.6	1.87
18	50	66	31.8	1.68
19	79	58	32.2	1.74
20	66	62	31.7	85.1
21	50	62	32.2	1.50
22	65	62	28.6	1.85
23	60	60	29.6	1.68
24	75	75	30.0	2.10
25	85	75	30.0	600
26	80	80	30.0	600

Table 6: Efficiency of Result

WEEKS	OPENING READING	CLOSING READING
1	91.2	57..0
2	98.7	100.0
3	91.0	88.3
4	85.9	83.6
5	89.1	94.0
6	85.1	88.1
7	92.8	90.0
8	97.7	97.0
9	92.8	91.0
10	88.3	97.0
11	82.8	92.0
12	86.4	89.0
13	80.9	90.0
14	94.2	97.0
15	97.4	97.0
16	85.6	96.0
17	76.8	92.7
18	71.7	87.0
19	79.9	97.8
20	91.1	47.0
21	70.6	93.0
22	87.6	96.0
23	88.8	97.0
24	98.1	95.2
25	97.1	0.00
26	98.0	0.00

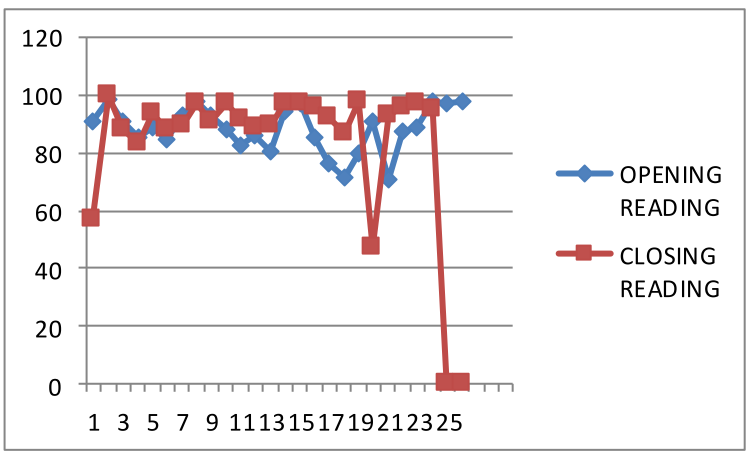

Figure 4: Line Graph to illustrate the Performance of the Efficiency Result

Performance Rating

From the graph above, we can deduce the rating of efficiency as follows

0-30	31-40	41-50	51-70	71-100
Poor	Fair	Good	Very Good	Excellent.

4. Conclusion

In this paper, we investigated the performance efficiency of Television broadcast transmitter, with specific emphasis on Lagos Televison 8. From the graph plotted for both opening and closing, it was shown that week 2 has the highest reading as 98.7 and week 21 has the lowest reading as 70.6. Conversely, the closing reading has week to be the highest with reading as 100 and weeks 25 and 26 has the lowest reading. The disparities of values in the opening and closing reading may be due to the level of signal strength and reception. Hence, the performance efficiency of TV broadcast via measured parameters, such as opening readings, closing readings, was asserted through key performance index of the TV broadcast readings.

Recommendation

Most developed countries have upgraded from analog operation to digital, in this paper we recommended that our television station take note of the components below in order to upgrade from continuous reading method to a discreet reading method for taking the reading of the data's and noting the performance of the transmitter. While there may be a very small penalty to pay for efficiency, common amplification provides an extremely attractive alternative to external duplexing when it comes to upgrade for digital operation. A typical externally duplexed transmitter is depicted in a simplified form in figure 5.

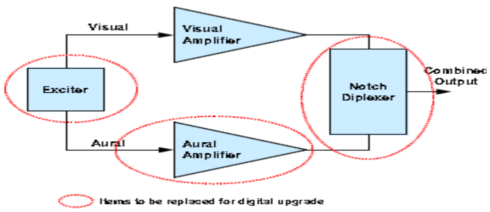

Figure 5: Externally Duplexed Transmitter Showing Changes request for Digital Upgrade

Conversion to digital will require replacement of the exciter/modulator and RF system. In addition, the aural RF path will need to be disabled or removed since it makes most sense to use the visual RF path for the digital signal. If power output needs to be maximized, the aural amplifiers may be used; however, the RF power dividers and combers will require replacement. Another drawback is the fact that the notch diplexer will be of no use; it must be replaced with a suitable mask filter. Other items such as power metering, peak detectors, etc., may also require replacement or adjustment. Upgrading a common amplification transmitter for digital service is depicted in figure 6

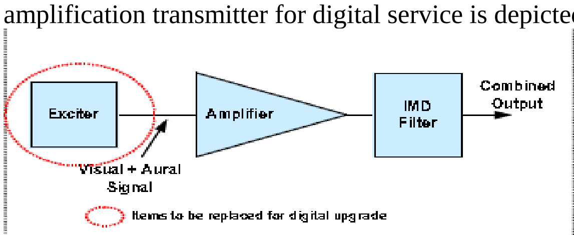

Figure 6: Common Amplification Transmitter Showing Changes required for Digital Upgrade

In this case, the upgrade path to digital is extremely straightforward. The exciter/modulator and possibly RF detectors and metering must be modified (or replaced) but the rest of the system requires no significant changes. The same RF path can be re-used; even the output filter may be used as the DTV mask filter, providing it was properly specified for both applications in the first place. It is clear that the common amplification approach offers a very elegant solution for a digital upgrade in the future. There will be far more re-use of the original system and because of this, the cost of conversion will be significantly lower.

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