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Performance Evaluation of NTA Benin Analogue Transmitter in Edo State Nigeria

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Abstract: This research work is a performance evaluation of the Nigeria Television Authority (NTA) Benin analogue Transmitter in Edo State Nigeria. In this work, the radio frequency (RF) forward Power for Vision and sound, the radio frequency (RF) reflected power for vision and sound, the input and output temperature of the transmitter and the field effect transistor readings (current, Voltage and temperature) were obtained directly from the analogue transmitter for a period of one month(July 2013). The average RF forward vision and sound powers of the transmitter were 4.5kw are 99w respectively while the input and output temperature of the transmitter were 27^{o}c and 32^{o}c at 12noon, 27^{o}c and 32^{o}c at 5pm and 26^{o}c and 30^{o}c at 6am. The result shows that none of the power amplifier module could pass the supposed amount of current of 18A for optimal performance. However the voltage across each module was 28V which indicates that the transmitter performed satisfactorily.

Keywords: Analog, Transmitter, Television, Power, Vision

I. INTRODUCTION

Information transmission has been an important part of our everyday lives since the dawn of the information age. Radio technology was born out of the experimental verification of the existence of electromagnetic waves by the German Physicist Heinrich Hertz at the end of the 19th century. Modern technology used to transmit information is based on the fundamental principles that Hertz discovered [1]. All types of information transmission, including the "one -way" transmission used in broadcasting; involve feeding a radio frequency (RF) signal to an antenna. This is the essence of the basic type of transmitter used to emit electromagnetic waves. In the real world, however, a transmitter used for broadcast applications, for example is much more complex in terms of its functions and design.[2] The different transmitter components must be carefully coordinated. There are many quality parameters that are critical in ensuring that a proper output signal is delivered. A transmitter is a device that develops the RF signal, increases it to a useful power level, and adds modulation where necessary for carrying information, and then delivers to the load. Television transmitters may be analogue or digital [3]. A transmitter contains one or more power amplifiers, as well as ancillary circuits such as signal generators, frequency converters, modulators, signal processors, liberalizers and power supplies. The classic architecture employs progressively larger power modules to boost a low level signal to the desired output power. The generation of significant power at RF and microwave frequencies is required not only in wireless communications but also in applications such as jamming, imaging, RF heating and miniature direct current to direct current(dc/dc) converters. Each application has its own unique requirements for frequency, bandwidth, load, power, efficiency, linearity, and cost [4]. RF power can be generated by a wide variety of techniques using a wide variety of devices. The basic techniques for RF power amplification are via classes A, B, C, D, E and F amplifier schemes..Power amplifiers are combined into transmitters in a similarly wide variety of architectures, including linear, envelope tracking, out phasing. etc [5].The goal of RF is to transfer all the power to the load without loss. Any reflection critical parameter [6].

Any difference in impedance between circuit elements and the transmission line can cause reflection and loss of power. Insertion loss is another critical issue at radio frequency. To avoid insertion loss, manufacturers recommend about 7ft - Ib of torque to ensure good contact and minimal insertion loss between the connectors [7]. The effect of heat in performance degradation of a transmitter is another parameter of utmost importance. Here, the ambient temperature and the junction temperature (of the FETs), have a great role to play. [8]

A. Features of vision and sound signals

For radio transmission of the television signal and for some special applications, a RF carrier is modulated with the composite video signal (CVS). For TV broadcasting and system including conventional TV receivers, amplitude modulation, is used, whereas frequency modulation is employed for TV transmission via microwave links because of the higher transmission quality.

In most cases both modulation and demodulation take place at the IF, the vision IF being 38.9 MHZ and the sound IF 33.4 MHZ.- The modulation of RF carrier by the CVS is in the form of negative AM, bright picture points corresponding to a low carrier amplitude and the synchronous pulse to a maximum carrier amplitude.

B. Theory of rf power transfer

Every transmitter has some impedance into which it can deliver the most real power. If the antenna's impedance is different from this ideal value, more voltage and/or current will be required of the transmitter to get a given radiated power than if the load was matched to the transmitter [9]. This limits the maximum power of the transmitter. In RF applications, transmission lines are generally coaxial cables external to circuit boards and micro strips within circuit boards. These components have characteristic impedance. The expression of the characteristic impedance of a transmission line depends on the geometry of the conductors, the properties of the conductors, and the insulator holding or separating the conductors. For RF applications, the characteristic impedance of the transmission lines and the input and output

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impedance of components are designed to be 50ohms, 75 ohms. Impedance is used to optimize power transfer in a system, 75 ohms systems are designed for minimum attenuation in applications such as cable systems. Most RF wireless transmission systems optimized for power transfer are 50ohms characteristic impedance systems.

C. Forward and reflected powers

A standing wave on a transmission line can be thought of as being composed of two traveling waves, one moving toward the load (the forward wave) and one moving in opposite direction (the reflected wave): These waves moving through the transmission line interfere with one another to produce the standing wave.

The average power transmitted along a line and delivered to the load is P_R = $^1/a$ ReVI*. Where V and I are total voltage and current and the asterisk denotes a complex conjugate.[10]

For a lossless line for which $Z_0$is real then

$$P_R = \frac{1}{2} Re \frac{|V^i|^2}{Z_O}\left(1 + \Gamma e^{-j2\beta d}\right)\left(1 - \Gamma^* e^{j2\beta d}\right) \text{............(1)}$$

$$P_R = \frac{1}{2} Re \frac{|V^i|^2}{Z_O}\left(1 - |\Gamma^2|\right) \text{..........(2)}$$

As $\Gamma e^{-j2\beta d} - \Gamma^* e^{j2\beta d}$ is purely imaginary. The first term is the power in the incident wave

$$P_R = \frac{1}{2} Re \frac{|V^i|^2}{2Z_O} \text{...........................(3)}$$

The second term represents the power in the reflected wave. Maximum power is delivered to the load when the load is matched to the line

($Z_r = Z_0$; $\Gamma = 0$) because then all the power in the incident wave is absorbed by the load. To deliver the same power to the load when reflections are present requires more power in the incident wave;

$$\frac{P_R}{P^t} = 1 - |\Gamma|^2 = \frac{4SWR}{(1+SWR)^2} \text{..............(4)}$$

Equation 4 gives the ratio of power P_R which is absorbed by the load to power, P^twhich would reach the load if the system (transmission line and load) were matched. A system gives the greatest power capability.

II. DATA COLLECTION AND PRESENTATION

The following quantities were obtained from the Nigerian television authority(NTA) analogue television transmitter in the month of July 2013

1. RF - Forward power for vision and sound
2. RF - Reflected power for vision and sound
3. Temperature input
4. Temperature output
5. FET readings (current, voltage and temperature).

Table I..Power Amplifier RF Forward Vision and Sound Power

	12 NOON		5PM		6AM		THRESHOLD VALUE	
DATE	VISION	SOUND	VISION	SOUND	VISION	SOUND	VISION	SOUND
1/5/10	4.5KW	100W	4.6KW	101W	4.4KW	100W	10KW	1000W
2/5/10	4.6KW	102W	4.6KW	102W	4.6KW	105W	10KW	1000W
6/5/10	4.5KW	100W	4.5KW	100W	4.6KW	101W	10KW	1000W
7/5/10	4.6KW	97W	4.6KW	97W	4.6KW	99W	10KW	1000W
8/5/10	4.4KW	97W	4.6KW	97W	4.5KW	97W	10KW	1000W
9/5/10	4.5KW	98W	4.4KW	98W	4.6KW	98W	10KW	1000W
10/5/10	4.5KW	94W	4.4KW	94W	4.6KW	97W	10KW	1000W
11/5/10	4.6KW	94W	4.5KW	94W	4.6KW	98W	10KW	1000W
12/5/10	4.6KW	96W	4.5KW	96W	4.5KW	98W	10KW	1000W
13/5/10	4.6KW	97W	4.6KW	97W	4.9KW	100W	10KW	1000W
14/5/10	4.6KW	99W	4.3KW	99W	4.5KW	98W	10KW	1000W
15/5/10	4.5KW	97W	4.6KW	97W	4.7KW	98W	10KW	1000W
16/5/10	4.7KW	97W	4.7KW	97W	4.7KW	97W	10KW	1000W
17/5/10	4.7KW	97W	4.6KW	98W	4.6KW	105W	10KW	1000W
18/5/10	4.9KW	103W	4.7KW	103W	4.6KW	98W	10KW	1000W
19/5/10	4.7KW	98W	4.6KW	103W	4.7KW	100W	10KW	1000W
20/5/10	4.2KW	105W	4.6KW	107W	4.3KW	104W	10KW	1000W
21/5/10	4.3KW	105W	4.7KW	98W	4.3KW	105W	10KW	1000W
22/5/10	4.3KW	103W	4.2KW	103W	4.1KW	103W	10KW	1000W
23/5/10	4.1KW	100W	4.3KW	97W	4.2KW	103W	10K,W	1000W
24/5/10	4.4KW	102W	3.9KW	103W	4.3KW	-102W	10KW	1000W
25/5/10	4.4KW	104W	4.1KW	101W	4.6KW	103W	10KW	1000W
26/5/10	4.4KW	102W	4.3KW	100W	4.2KW	102W	10KW	1000W
27/5/10	4.1KW	100W	4.1KW	105W	4.2KW	101W	10KW	1000W
28/5/10	4.2KW	100W	4.2KW	103W	4.2KW	103W	10KW	1000W
29/5/10	4.3KW	105W	4.1KW	97W	4.2KW	103W	10KW	1000W
30/5/10	4.3KW	107W	4.1KW	97W	4.3KW	99W	10KW	1000W
31/5/10	4.4KW	102W	4.4KW	102W	4.4KW	100W	10KW	1000W
Average	4.5KW	96W	4.4KW	100W	4.5KW	101W	10KW	1000W

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Table II. Power Amplifier RF Reflected Vision and sound Power

	12 NOON		5PM		GAM		THRESHOLD VALUE	
DATE	VISION	SOUND	VISION	SOUND	VISION	SOUND	VISION	SOUND
1/5/10	0W	1W	1W	1W	1W	1W	200W	20W
2/5/10	1W	1W	1W	1W	1W	1W	200W	20W
6/5/10	1W	1W	1W	1W	1W	1W	200W	20W
7/5/10	1W	1W	1W	1W	1W	1W	200W	20W
8/5/10	0W	1W	1W	1W	1W	1W	200W	20W
9/5/10	1W	1W	1W	1W	1W	1W	200W	20W
10/5/10	0W	1W	1W	1W	1W	1W	200W	20W
11/5/10	1W	1W	1W	1W	1W	1W	200W	20W
12/5/10	1W	1W	1W	1W	1W	1W	200W	20W
13/5/10	1W	1W	1W	1W	1W	1W	200W	20W
14/5/10	0W	1W	0W	1W	1W	1W	200W	20W
15/5/10.	1W	1W	1W	1W	1W	1W	200W	20W
16/5/10	1W	1W	1W	1W	1W	1W	200W	20W
17/5/10	0W	1W	1W	1W	1W	1W	200W	20W
18/5/10	1W	1W	1W	1W	1W	1W	200W	20W
19/5/10	1W	1W	1W	1W	1W	1W	200W	20W
20/5/10	0W	1W	0W	1W	1W	1W	200W	20W
21/5/10	0W	1W	1W	1W	1W	1W	200W	20W
22/5/10	0W	1W	0W	1W	1W	1W	200W	20W
23/5/10	0W	1W	1W	1W	1W	1W	200W	20W
24/5/10	0W	1W	0W	1W	1W	1W	200W	20W
25/5/10	0W	1W	0W	1W	1W	1W	200W	20W
26/5/10	0W	1W	1W	1W	0W	1W	200W	20W
27/5/10	0W	1W	0W	1W	0W	1W	200W	20W
28/5/10	0W	1W	0W	1W	1W	1W	200W	20W
29/5/10	0W	1W	1W	1W	1W	1W	200W	20W
30/5/10	0W	1W	1W	1W	1W	1W	200W	20W
31/5/10	0W	1W	1W	1W	1W	1W	200W	20W

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Table III. Transmitter Temperature Readings

	12 NOON		5PM		6AM		THRESHOLD VALUE	
DATE	INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT	INPUT	OUTPUT
1/5/10	29°C	33°C	27°C	31°C	27°C	31°C	40°C	60°C
2/5/10	27°C	31°C	25°C	30°C	24°C	29°C	40°C	60°C
6/5/10	28°C	32°C	28°C	32°C	27°C	31°C	40°C	60°C
7/5/10	28°C	32°C	27°C	28°C	26°C	31°C	40°C	60°C
8/5/10	28°C	33°C	29°C	33°C	27°C	31°C	40°C	60°C
9/5/1.0	28°C	33°C	27°C	32°C	26°C	31°C	40°C	60°C
10/5/10	29°C	34°C	28°C	33°C	27°C	31°C	40°C	60°C
11/5/10	29°C	33°C	30°C	35°C	27°C	31°C	40°C	60°C
12/5/10	29°C	34°C	30°C	34°C	27°C	31°C	40°C	60°C
13/5/10	29°C	34°C	27°C	32°C	26°C	30°C	40°C	60°C
14/5/10	29°C	33°C	29°C	34°C	27°C	31°C	40°C	60°C
15/5/10	29°C	33°C	29°C	34°C	27°C	32°C	40°C	60°C
16/5/10	28°C	33°C	29°C	34°C	27°C	31?C	40°C	60°C
17/5/10	28°C	33°C	28°C	32°C	24°C	28°C	40°C	60°C
18/5/10	26°C	31°C	27°C	31°C	27°C	31°C	40°C	60°C
19/5/10	26°C	33°C	27°C	32°C	27°C	31°C.	40°C	60°C
20/5/10	24°C	28°C	25°C	29°C	24°C	28°C	40°C	60°C
21/5/10	25°C	29°C	26°C	31°C	25°C	30°C	40°C	60°C
22/5/10	27°C	31°C	27°C	31°C	25°C	30°C	40°C	60°C
23/5/10	28°C	3-3°C	28°C	32°C	25^{U}C	30°C	40°C	60°C
24/5/10	27°C	32°C	28°C	32°C	26°C	30°C	40°C	60°C
25/5/10	25°C	30°C	27°C	32°C	25°C	30°C	40°C	60°C
26/5/10	27°C	31°C	27°C	30°C	26°C	30°C	40°C	60°C
27/5/10	26°C	30°C	25°C	29°C	25°C	29°C	40°C	60°C
28/5/10	27°C	32°C	27°C	31°C	25°C	29°C"	40°C	60°C
29/5/10	26°C	30°C	28°C	32°C	25°C	29°C	40°C	60°C
30/5/10	25°C	29°C	25°C	28°C	26^{U}C	30°C	40°C	60°C
31/5/10	25°C	29°C	25°C	29°C	24°C	28°C	40°C	60°C
Average	27°C	32°C	27°C	32°C	26°C	30°C	40°C	60°C

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Table IV. Transmitter "FET Reading"

	A	B	C	D	E	F	G	H	I	J	K	L	Optimal values
1	o/c	0A	o/c	3A	o/c	6A	6A	4A	9A	0A	2A	o/c	18A
2	o/c	0A	o/c	6A	o/c	5A	6A	5A	5A	0A	2A	o/c	18A
3	o/c	0A	o/c	8A	o/c	6A	6A	5A	12A	0A	0A	o/c	18A
4	o/c	0A	o/c	6A	o/c	4A	5A	4A	0A	5A	6A	o/c	18A
5	o/c	0A	o/c	9A	o/c	5A	5A	5A	12A	5A	0A	o/c	18A
6	o/c	0A	o/c	7A	o/c	6A	5A	0A	0A	0A	7A	o/c	18A
Voltage (v)	o/c	0v	o/c	29v	o/c	28v	29v	30v	29v	29v	29v	o/c	28V
Temp (°C)	o/c	0°C	o/c	16°C	o/c	16°C	12°C	30°C	20°C	29°C	39°C	o/c	28°C

A. Explanation of table iv

A to L denotes the power amplifier(PA) modules, so there are twelve PA modules in this VHF transmitter. Each PA modules contains six Field Effect Transistor (FET) and each FET has own card. O/C means "out of circuit", a condition used indicate that a particular PA module has been withdrawn fr circuit. The optimal values are the supposed values of current, voltage, temperature of the power amplifiers to guarantee satisfactory performance, they are not measured values. It can therefore be observed that thecurrents in the FET of TABLE IV are excessively low compared to the supposed 18A. And even some of the FETs are not drawing current from the circuit, hence the zero ampere readings. This therefore is the major factor responsible for the unacceptably low power output of the transmitter.

III. DISCUSSION

A. Discussions of TABLES I and II

1. TABLEI, contains all the values of RF forward power for vision and sound. The measurements were taken three times in a day for a period of one month (July 2013). From this table the net average forward vision is computed as

$$\frac{4.5+4.4+4.5}{3}=4.5KW$$

This implies that the transmitter can only deliver an average RF vision power of 4.5KW to the load as against the 10KW threshold value. This is poor and the overall performance of the transmitter is below average using this parameter.

2. Also the average sound power can be computed as

$$\frac{96+100+101}{3}=99W$$

This implies the transmitter can only deliver an average of 99W sound power as against the 1000W threshold value. This is extremely too low and can manifest as poor signal strength at the receiver. There is also a great disparity between the vision to sound power ratio. The aural power supposed to be typically 10% of the vision power but comparison between 99W and 4.5KW shows that the aural power is just 2.2% of the vision power.

3. From the TABLEII, it can be seen that the maximum power lost to reflection at any time is 1 watt. (The threshold is the worst case value). It then means that there is virtually no power lost to reflection. Therefore in this transmitter system.

The poor output power level is obviously not as a result reflections

B. Discussion of TABLE III

From TABLE III, it can be observed that the maximum input temperature ever experienced is 30°C which is also below the 40°C threshold value. And the maximum output temperature ever experienced during this period is 34° as against the 60°C threshold value. It therefore means that the transmitter is operating within the acceptable temperature range and is not generating excessive heat. Therefore, temperature is not a contending issue in the performance of this transmitter. However, the performance could be improved if the input temperature is maintained at 18°C to 25°C.

C. Discussion of TABLE IV

The primary aim of the "FET Reading" is to know, the performance of each field effect transistor (FET) in each card of the PA modules.

The quantities measured while taking the FET readings are:

1. The voltage across each PA modules.
2. The current through each FET card (each PA module contains six FET cards).
3. The junction temperature associated with each power amplifier module.

The measurements were carried out and the measured values are shown in TABLEIV.

From TABLE IV, it can be observed that PA modules A, C, E, L are totally out of the circuit while PA module B is present in the circuit but is not working since all measured quantities are

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zeros with respect to it. The RF power contributions power modules A,B,C,E,L are absent and only power modules D, F, G, H, I, J, and K are working.

D. Discussion of Figure I

Figure I, is the bar chart of the RF Forward Vision Power of the transmitter. The vision power for 12 noon, 5pm and 6am and the threshold are plotted on same scale. The height of each bar indicates the magnitude of RF vision power which the transmitter can deliver at that instant of time. The legend at the right hand side of the bar chart is used to show the particular time of the day corresponding to each bar. The bars of the greatest magnitude indicates the threshold value of the vision power, this value is 10KW. From the bar chart, it can easily be observed that only an average of 45% of the vision power is attained. Therefore, the transmitter performance is below average.

E. Discussion of Figure II

Figure II, is the bar chart of the RF Forward Sound Power of the transmitter. The graph shows the sound power measured at 12 noon, 5pm and 6am and the threshold, all plotted on the same scale. The bar chart helps to describe the sound power level produced by the transmitter. It can be observed from the bar chart that less than 10% of the rated RF Sound Power is produced by this transmitter. It can also be observed that the RF sound power is relatively constant at all times. This is expressed in the bar chart since all the bars are about the same height. The maximum attainable RF sound power is 1000W. This is also known as the threshold value represented with the longest bars on the bar chart.

F. Discussion of Figures III,IV,and V

Figures III, IV and V are the cooling characteristic graphs of the transmitter. Each graph represent the different input and output temperature readings taken at 12 noon, 5pm and 6am respectively on daily bases for one month. The input and output temperature characteristics are both plotted on the same scale. The essence of the graph is to reveal the variation between the input and output temperature and to know if the transmitter is generating excessive heat at any particular time.

The following deductions can therefore be made:

(1) The output temperature increases with increase in input temperature and decreases in same manner therefore, greater power efficiency can be achieved by running the transmitter at input temperature of between 18°C to 25°C.

(2) At 6am, the transmitter input temperature is relatively 25°C. Therefore, the amplifiers will give the best output power at this temperature.

(3) It can also be deduced from the graphs that the highest input and output temperatures were experienced at 5:00pm because at this time the ambient temperature is higher and at this time, the transmitter components have heated up due to long time operation.

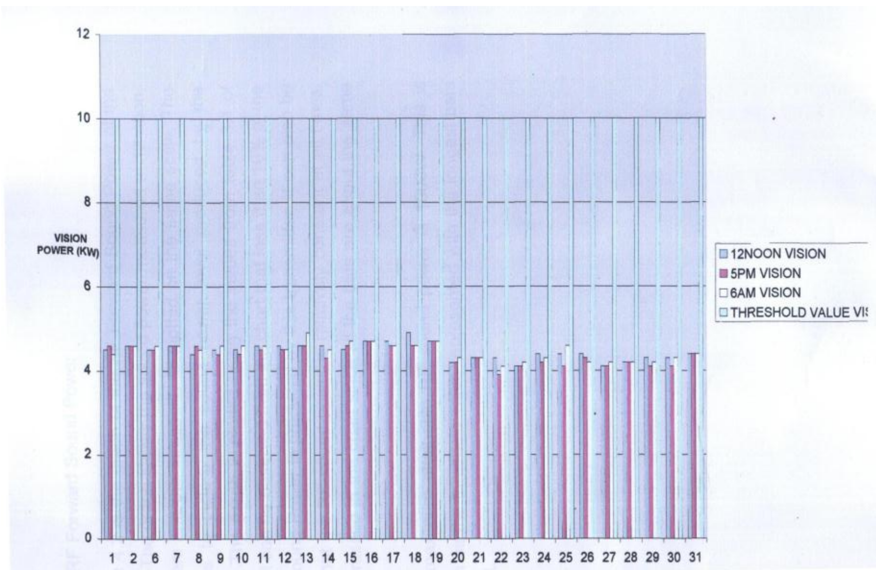

Figure I: RF Forward Vision Power Chart

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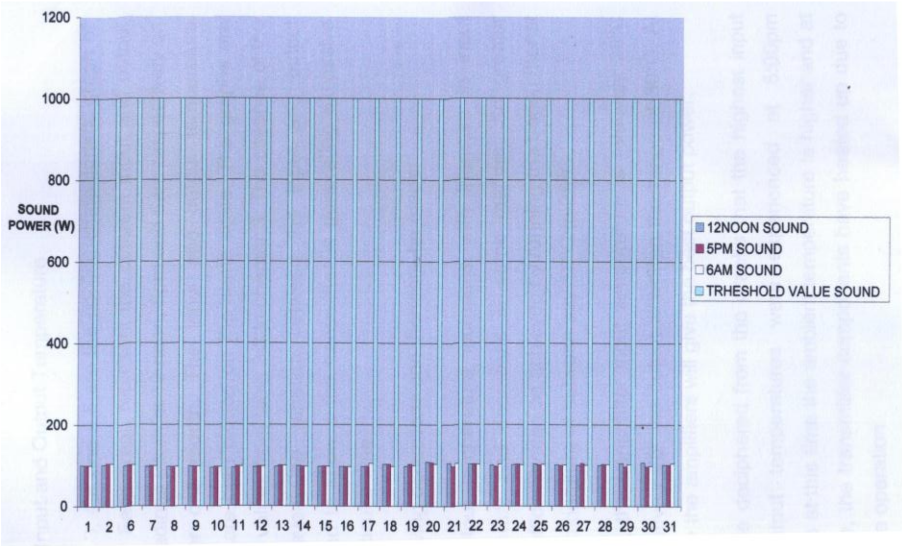

Figure II: RF Forward Sound Power Chart

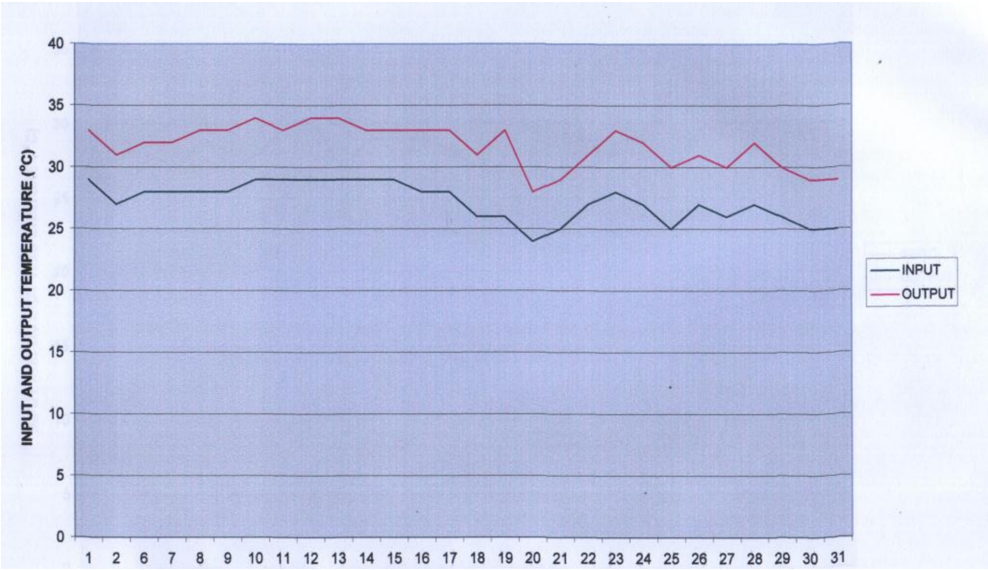

Figure III: Cooling Characteristics of the transmitter (12noon)

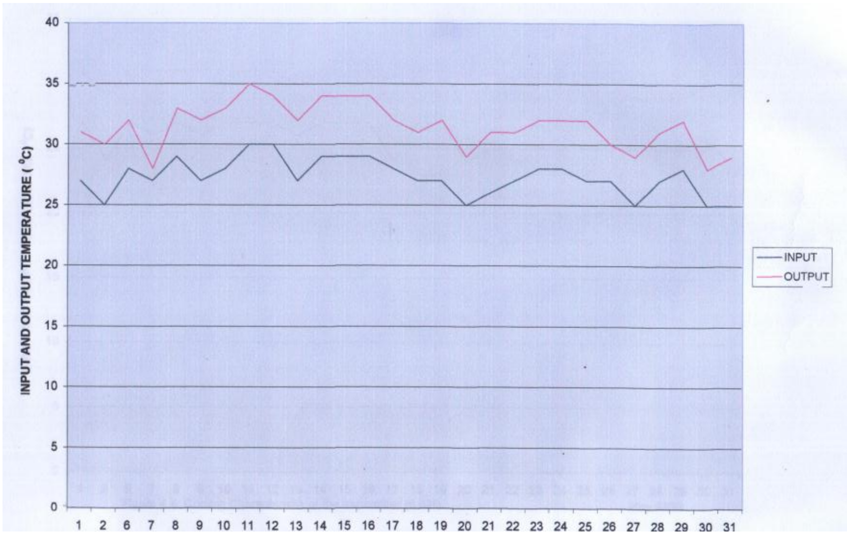

Figure IV: Cooling Characteristics of the transmitter (5PM)

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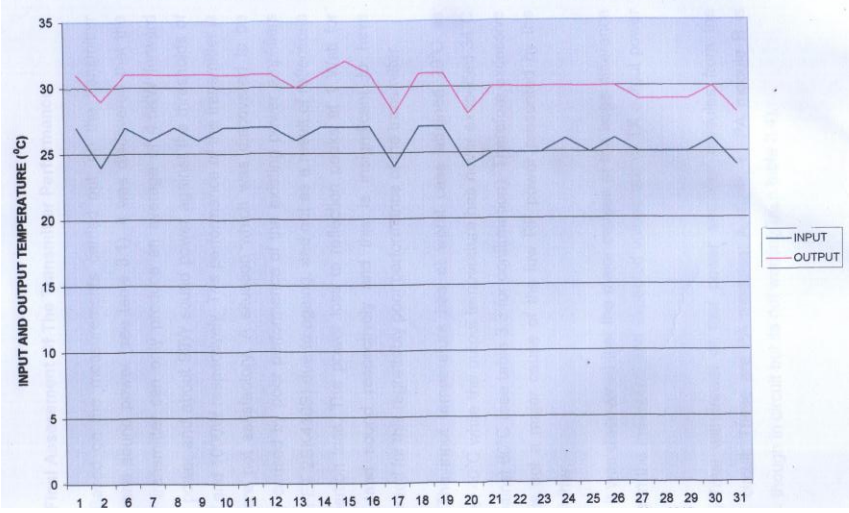

FigureV: Cooling Characteristics of the transmitter (6PM)

IV. CONCLUSION

The performance evaluation of analogue television transmitter wassuccessfully carried out in this work. Sources of RF losses and hindrancesto the generation of the required power level were critically examined.

To this end, measurements were carried out on the power amplifierRF forward and reflected powers to ascertain the amount of RFpower delivered to the load (antenna) for subsequent radiation. Theinput and output temperatures of the transmitter were also measuredto ascertain the level of heat generated by the internal circuitry of thetransmitter. The reliability of electronic components is highlydependent on the operating temperature therefore; the FET current andvoltage readings were taken so as to know which power amplifier isperforming well and which one is not.

Having carried out all the measurements, it was discovered that the transmitter sound power was below 10% of the rated value and the vision power was only 45% of the threshold. Therefore, the performance of the transmitter is not satisfactory.

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