OSCILLOSCOPE WAVEFORM

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Oscilloscope

'The changing voltage caused by sound waves can be displayed on a Oscilloscope. The oscilloscope shows changing voltage on the vertical axis. The horizontal axis shows a change of time.

Sound waves are longitudinal waves but the wave on the oscilloscope looks like a transverse wave.'[114]

'An Oscilloscope is used to display the waveform of various musical instruments, and vocal music in order to show the effect of frequency and wave shape on the sound.

An Oscilloscope with a large screen can be connected directly to a microphone or to the output of an audio amplifier or function generator to illustrate, the waveforms produced by various sounds.

Sine waves can be produced with tuning fork or with electronic function generator. Anyone with perfect pitch should be able to identify the frequency of musical notes.

Different musical instruments have different type of waveform which can be observed from Oscilloscope. One can illustrative frequency modulation and amplitude modulation. The different result of waveform for different instrument for same frequency, is called "Overtone" by musicians and "Harmonics" by physicists.

Harmonics are integral multiples of the fundamental frequency, but overtones may or may not be related to the fundamental in a simple way. In most string and wind instruments, the overtones form a harmonic series, but in percussion instrument such as the drum, the overtones are more complicated and less "Harmonics".

The combination of overtones is what gives each musical instrument its characteristic quality or timbre. '[115]

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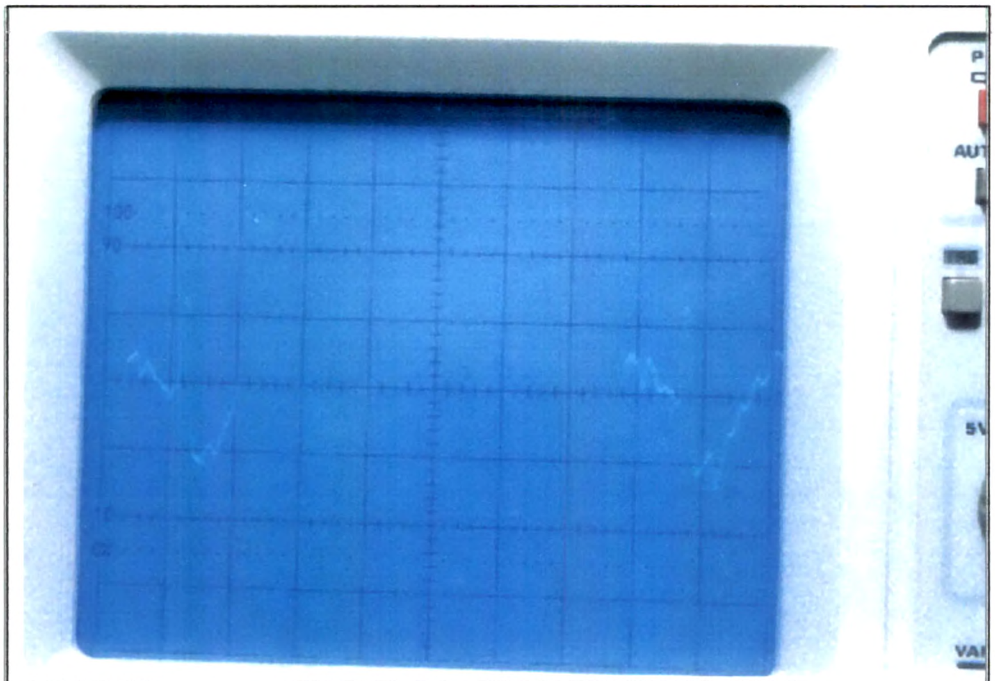
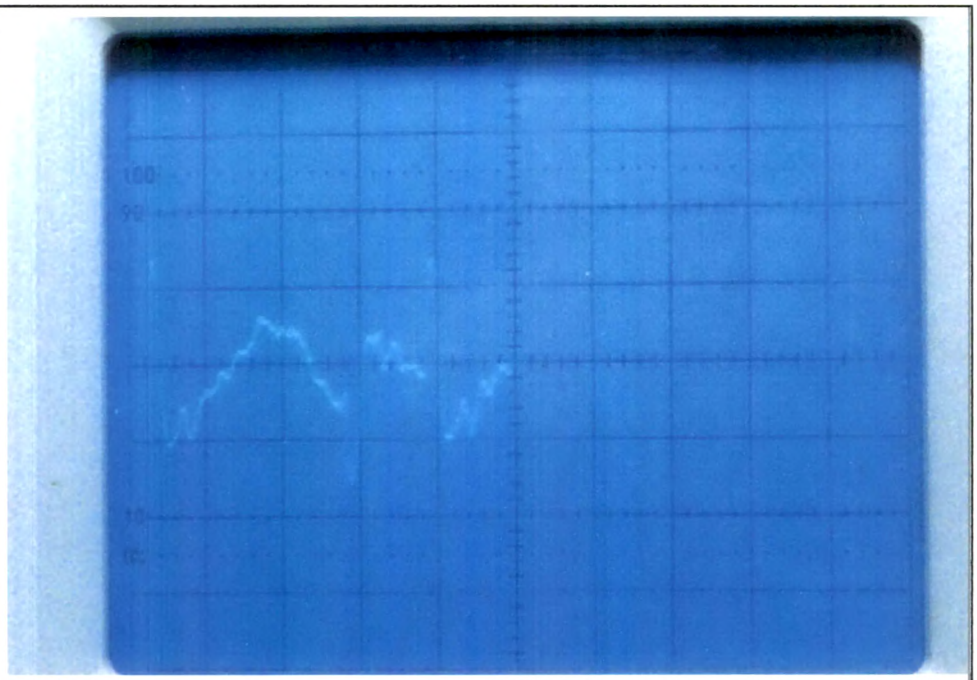
[114] Coordinated Science-Physics by Mary Jones,P.110
[115] http://sprott.physics.wisc.edu/demobook/chapter3.htm

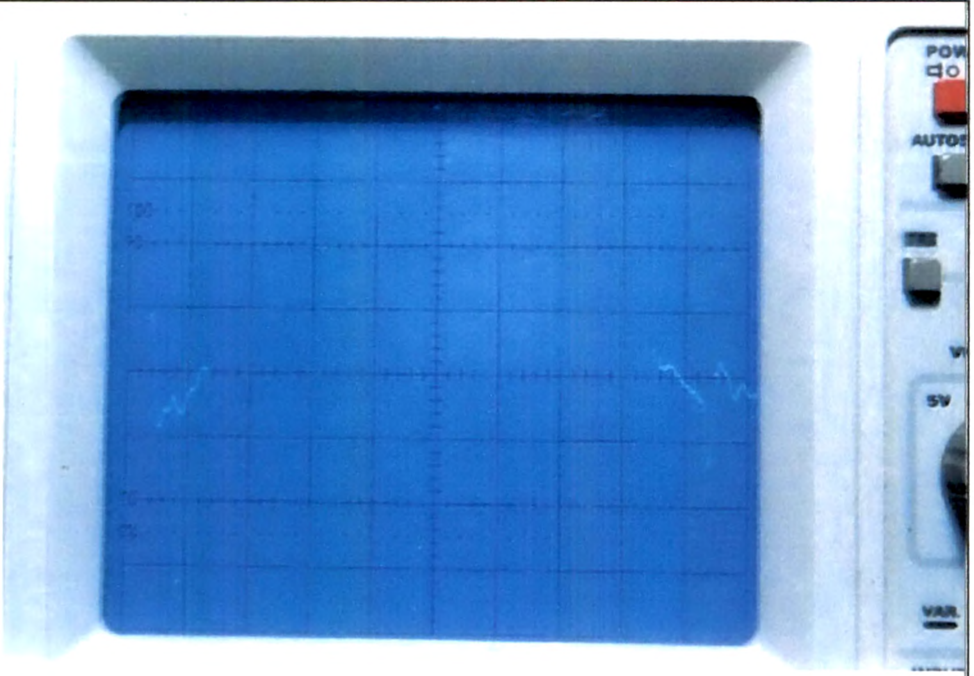
PHOTOGRAPHS OF OSCILLOSCOPE WAVEFORM



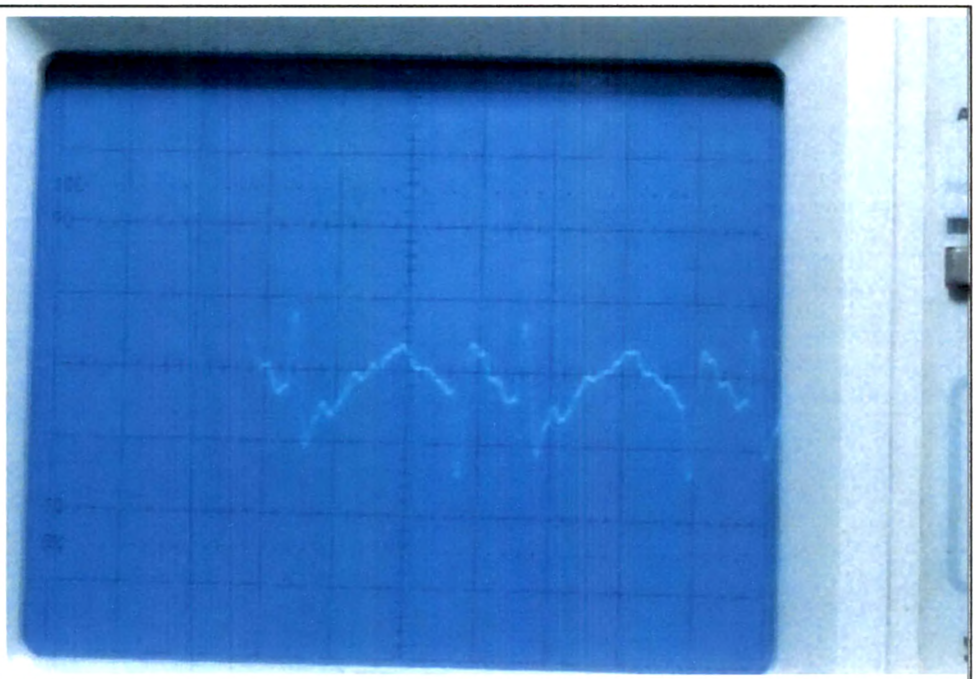
SWAR:SA__ TIME(T) 7.6__FREQUENCY(1/T)_131.5_



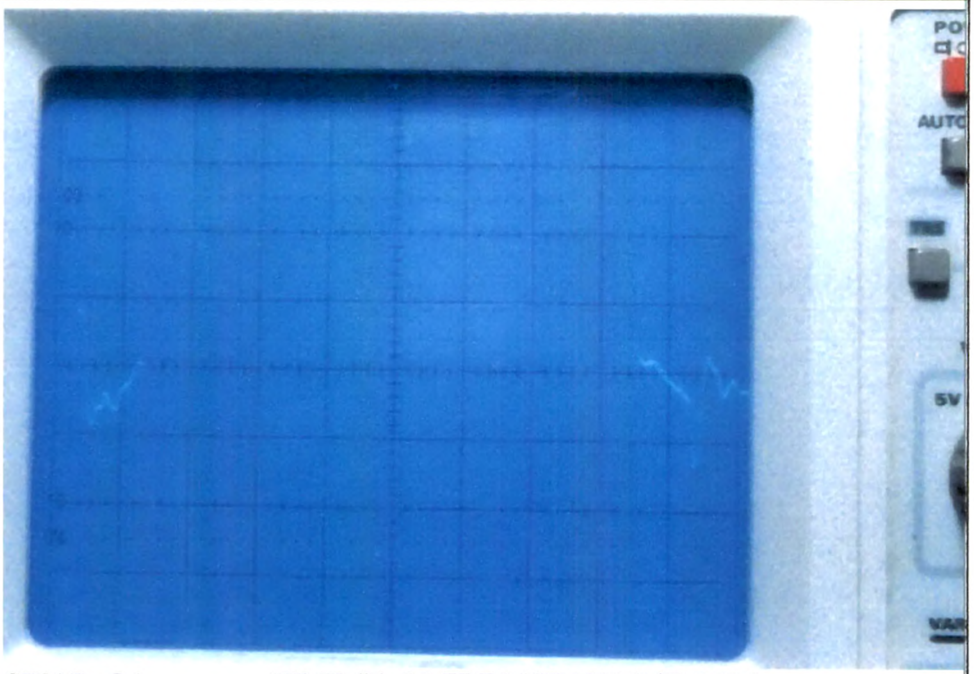
SWAR: RE KOMAL__ TIME(T) 7.2__FREQUENCY(1/T) 138.8



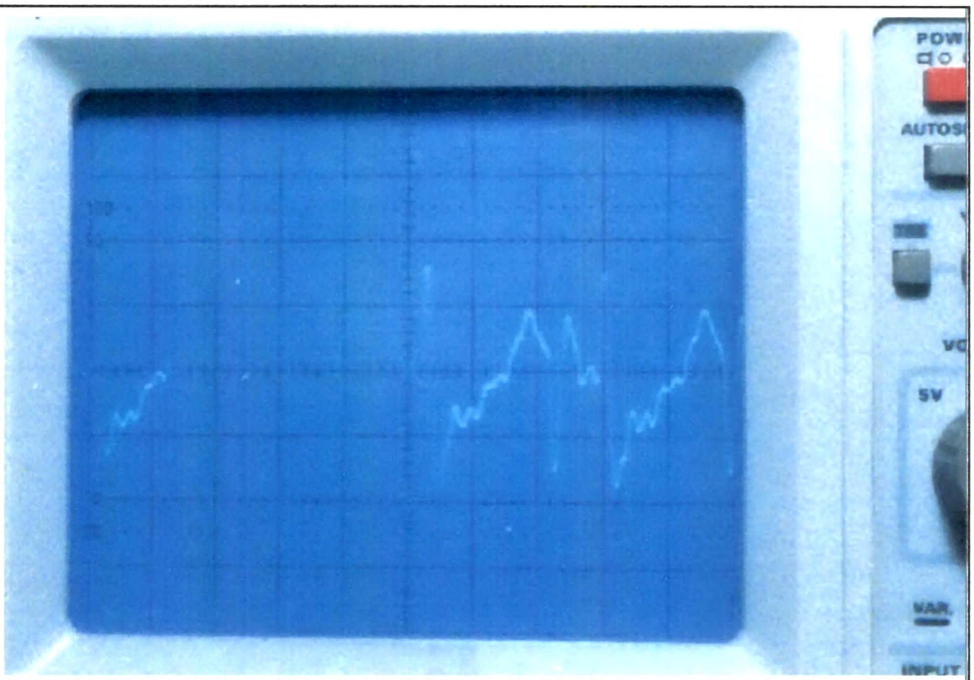
SWAR RE   TIME 6.8   FRFREQUENCY 147



SWAR: GA KOMAL TIME (T) 6.4 FREQUENCY(1/T) 156.25

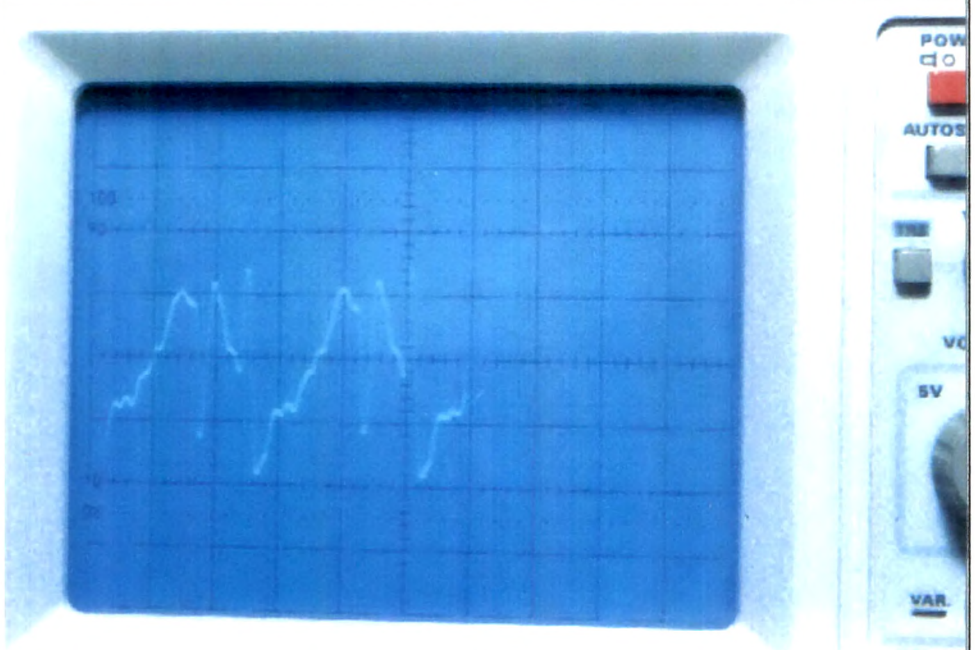


SWAR: GA___ TIME (T) 6.1 FREQUENCY (1/T) 163.9

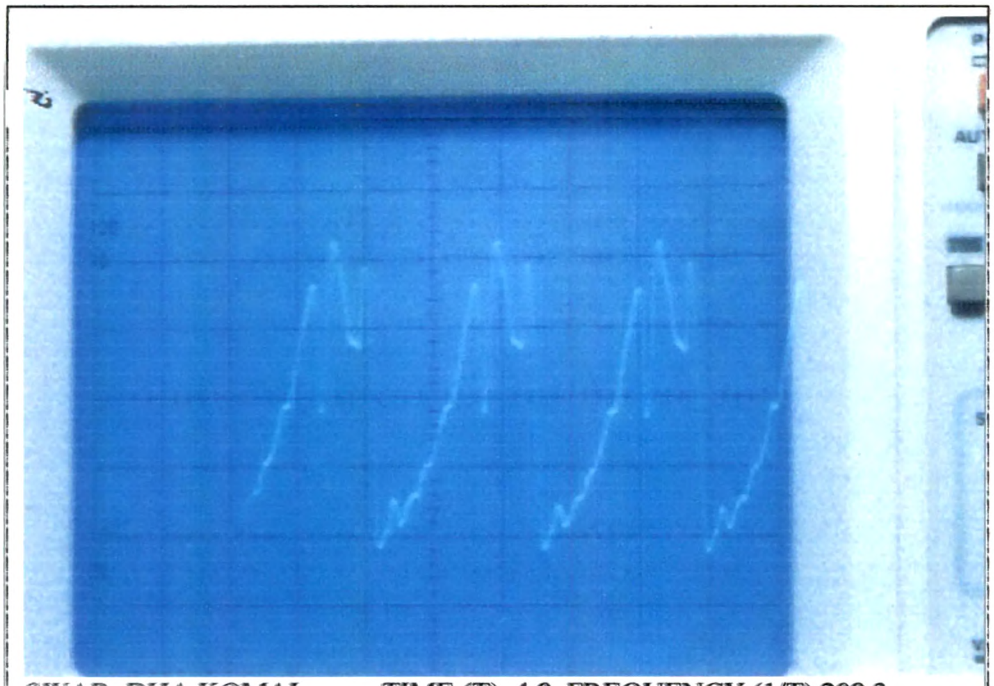


SWAR: MA___ TIME (T) 5.7_FREQUENCY (1/T) 175.4

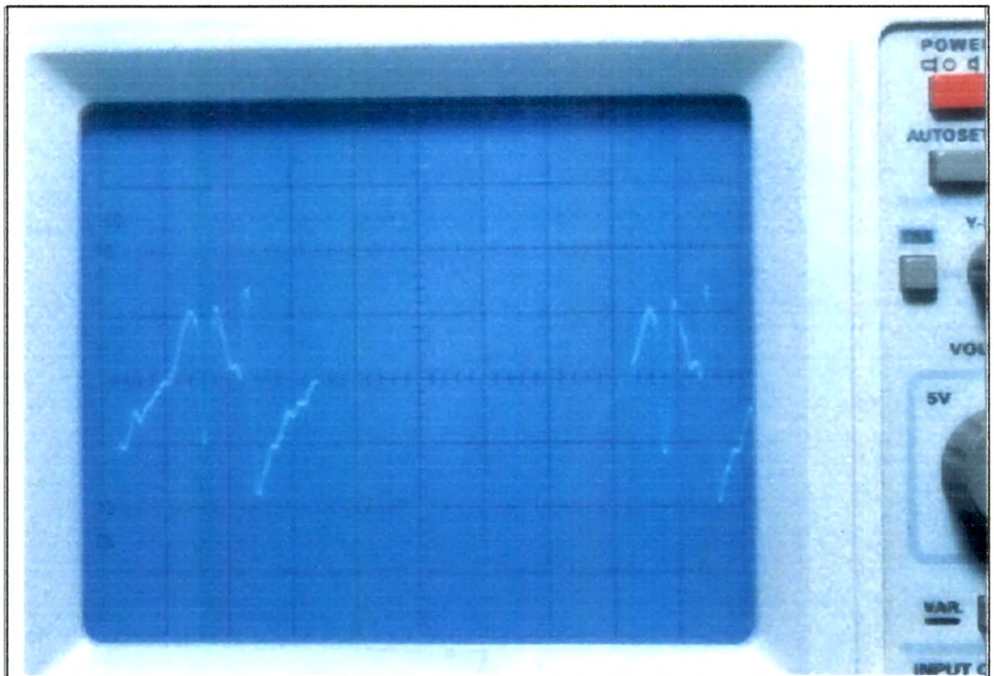
SWAR: MA TIVRA___ TIME (T) 5.4_FREQUENCY (1/T)_485.48



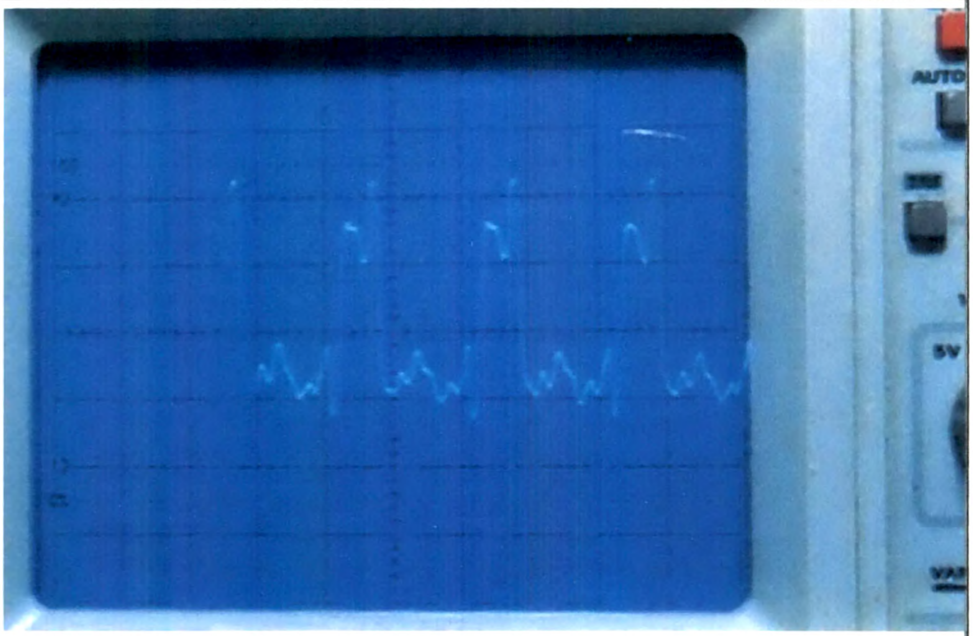
SWAR: PA______ TIME (T)_5.1_FREQUENCY (1/T) 196.07__



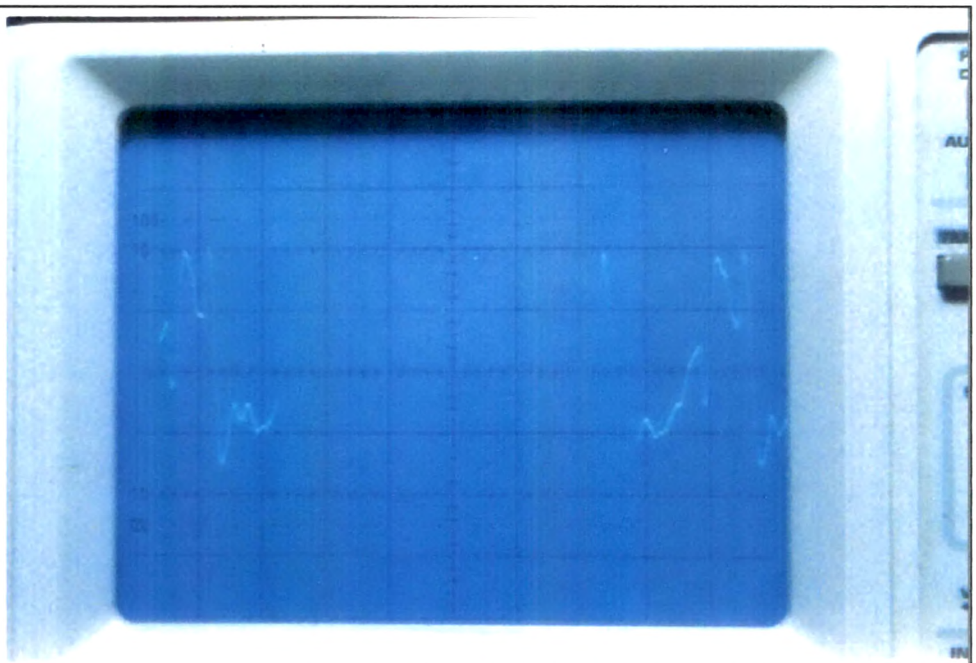
SWAR: DHA KOMAL_____TIME (T)_4.8_FREQUENCY (1/T) 208.3



SWAR: DHA TIME (T) 4.6 FREQUENCY (1/T) 217.3



SWAR: NI_KOMAL___ TIME (T) 4.3_FREQUENCY (1/T)_232.55__



SWAR: NI____ TIME (T) 4.0_FREQUENCY (1/T)__250

'It should be borne in mind that Indian had no means to know the frequencies of their notes until they came into contact with modern science. As in case musicians everywhere choose their own frequencies of notes and do not bother much about standard frequencies of notes. This standardization is used only in theoretical works.'[116]

Frequency Measured by Oscilloscope

Swar	Time (ms)	Frequency (Hz)
SA	7.6	131.5
RE KOMAL	7.2	138.8
RE	6.8	147
GA KOMAL	6.4	156.25
GA	6.1	163.9
MA	5.7	175.4
MA TIVRA	5.4	185.18
PA	5.1	196.07
DHA KOMAL	4.8	208.3
DHA	4.6	217.3
NI KOMAL	4.3	232.55
NI	4.0	250
SA TAR	3.8	263.1

[116] Shruti and Swar by Jashbhai Patel.P.46

Frequency of Notes measured with the help of computer software.(Tune master)

Swar	Key color	Name	Frequency (Hz)
SA	White	C	131.89
RE KOMAL	Black	C # (D b)	138.62
RE	White	D	148.71
GA KOMAL	Black	D # (E b)	158.13
GA	White	E	165.54
MA	White	F	176.3
MA TIVRA	Black	F # (G b)	185.72
PA	White	G	198.51
DHA KOMAL	Black	G # (A b)	208.6
DHA	White	A	219.37
NI KOMAL	Black	A # (B b)	234.17
NI	White	B	248.3
SA TAR	White	C	263.78

Frequency Ratio (Interval)

'There was no steady drone accompaniment in ancient music Therefore, the relation of notes to the tonic, Sa, had not yet acquired so much importance as at present.

The relationship to the tonic becomes more important than the relation to contiguous note. A note is varied only when its relation to the tonic is varied.'[117]

Note	Ratio
SA-SA	$\frac{131.89}{131.89} = 1$
SA-RE KOMAL	$\frac{138.62}{131.89} = 1.05102$
SA-RE	$\frac{148.71}{131.89} = 1.12753$
SA-GA KOMAL	$\frac{158.13}{131.89} = 1.19895$
SA-GA	$\frac{165.54}{131.89} = 1.25513$
SA-MA	$\frac{176.3}{131.89} = 1.33671$
SA-MA TIVRA	$\frac{185.72}{131.89} = 1.40814$
SA-PA	$\frac{198.51}{131.89} = 1.50511$
SA-DHA KOMAL	$\frac{208.6}{131.89} = 1.58162$
SA-DHA	$\frac{219.37}{131.89} = 1.6632$
SA-NI KOMAL	$\frac{234.17}{131.89} = 1.77549$
SA-NI	$\frac{248.3}{131.89} = 1.88262$
SA-SA TAR	$\frac{263.78}{131.89} = 2$

'Hindu Desi music is essentially modal, which means that relations of sounds, on which the musical structure is built, are calculated in relation to a permanent note, the tonic. This does not mean that the relations between sounds other than tonic are not considered, but that each note will be established first according to its relation to the fixed tonic.'[118]

[117] The Music Of India: A Scientific Study by B.Chaitanya Dava, P.57
[118] Introduction to the study of Musical Scales by Alain Danielou P.152

Frequency given by Pt. Shrinivas, Pt. V. N. Bhatkhande & Western Notes.[119] Compared with Standard frequency and frequency obtained practically.

Swar	Pt. Shrinivas	Pt. Bhatkhande	Western Swar	Standard frquency*	Frequency (Hz) (Practical)#
SA	240	240	240	261.6	131.89
RE KOMAL	256 1	254 4	256	277.2	138.62
RE	270	270	270	293.6	148.71
GA KOMAL	301 17	288	288	311.1	158.13
GA	288	301 17	300	329.6	165.54
MA	320	320	320	349.2	176.3
MA TIVRA	344 8	338 14	337 ½	370.0	185.72
PA	360	360	360	392.0	198.51
DHA KOMAL	388 4	381 3	384	415.3	208.6
DHA	405	405	400	**440.0**	219.37
NI KOMAL	452	432	432	466.2	234.17
NI	452 4	452 4	450	493.9	248.3
SA TAR	480	480	480	523.2	263.78

* 'In 1939, an international conference met in London and agreed on A = 440 as a new standard universal use, at least in broadcasting. With this standard the frequencies of tones being determined, are given below in the Table.'[120]

Taken From Page No 57

[119] Raga Parichaya part – 3 By Prof. Harishchandra Shrivastv.

[120] Science and Music by Sir James Jeans.p.23,24

Observation

'Frequency for C (sa) varies from country to country. In England it is 273 Hz whereas in France it is 261 Hz. Physicists have adopted their standard pitch 512 Hz for C because 512Hz can be expressed as the exact power of 2, namely $2^9 = 512$ HZ.

Some scientific manufacturers once adopted a standard of 256 Hz for middle C, but musicians ignored it.'[121]

From the above reference, we can say that the frequency of Madhya 'Sa' is 256 Hz. Based on this frequency other frequency of notes are established with the help of interval.

In Indian Music and in Western Music scholar accepted frequency of Sa(C) as 240 Hz. The reason for assuming this frequency can be explained as under:

We already know three different types of tone and its interval.

Major Tone or Chtushrutik or Guru Swar	9/8
Minor Tone orTrishrutik or Laghu Swar	10/9
Semi Tone or Dwishrutik or Ardha Swar	16/15

Now if we check the frequency by lowering the frequency 256 Hz using three different intervals shown above we will get three different frequencies as:.

1 $$\frac{256}{9/8} = 256 \times \frac{8}{9} = 227.5$$

2 $$\frac{256}{10/9} = 256 \times \frac{9}{10} = 230.4$$

3 $$\frac{256}{16/15} = 256 \times \frac{15}{16} = \mathbf{240}$$

From the above three values only 240 is in the whole number and rest of two values are in decimal, which is unacceptable. Therefore, we have now two values for the frequency of Sa(C) 256 Hz and 240 Hz.

We know that interval 'Sa' with other notes are as under.

Sa	Re	Ga	Ma	Pa	Dha	Ni	Sa(tar)[122]
	9/8	5/4	4/3	3/2	5/3	15/8	2

It seems that scholars may have selected above two values to find out which value is more appropriate.

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[121] Culver, C.A., Musical Acoustics, New York : Mcgraw – Hill, 1956

[122] Shruti ans Swar by Jashbhai Patel, P.19

Let me work out calculations.

We take **<u>Sa = 256</u>** and find out frequency of other notes as:

$Re = \frac{256 \times 9}{8} = 288$

$Ga = \frac{256 \times 5}{4} = 320$

$Ma = \frac{256 \times 4}{3} = 341.33$

$Pa = \frac{256 \times 3}{2} = 384$

$Dha = \frac{256 \times 5}{3} = 426.66$

$Ni = \frac{256 \times 15}{8} = 480$

$Sa\ tar = \frac{256 \times 2}{1} = 512$

Now we take **<u>Sa = 240</u>** to find out frequency of other notes.

$Re = \frac{240 \times 9}{8} = 270$

$Ga = \frac{240 \times 5}{4} = 300$

$Ma = \frac{240 \times 4}{3} = 320$

$Pa = \frac{240 \times 3}{2} = 360$

$Dha = \frac{240 \times 5}{3} = 400$

$Ni = \frac{240 \times 15}{8} = 450$

$Sa\ tar = \frac{240 \times 2}{1} = 480$

If we compare both the set of frequency obtained by two different frequencies of Sa, the frequency of Sa = 240 will be more appropriate as frequency of other notes obtained by it are in whole number compared with the frequency obtained by Sa = 256 in which frequency of few notes are in decimal.

So the frequency of Sa = 240 can be considered as more appropriate value for easy calculations. It also implies that every male and female has frequency of his or her Sa as 240 Hz. However, practically it is impossible as frequency of female voice is always higher than male voice.

In Indian and Western music, frequency of Sa is considered as 240 but practically it is different and is around 263 Hz, which I have tried to find out from my research.

I found out frequencies of 12 notes by practical with oscilloscope and with the help of computer software. I found out frequencies of 12 notes of shruti box and got the almost similar result in both the cases.

Scholar like Pt.Srinivas and Pt.Bharkhande also assign frequency of 12 notes but their frequencies may be arrived from the method given above and not scientific reason was given.

Indian classical music Sa (reference note) is very important and there is freedom for artiste to choose his/her 'sa' according to his/her convenience. Generally, male singers choose Black one or black two key and female singer choose black four or black five key as their 'sa'. However, there was no frequency standard assign for these keys. In Indian classical music, Harmonium is used for reference 'sa' and there is not any tuning standard for harmonium is decided yet so artiste has to compromise with their voice and have to make their scale lower or higher according to Harmonium.

In my experiment, I tried to standardize all 12 notes and assign frequency using Shruti box, which may help in future while standardization of notes of Indian classical music will be done. As we are using note only 12 notes and 22 shrutis in one saptak but also using intermediate frequencies in Ragas so we cannot standardize whole saptak but atleast we can standardize our reference notes.

I assign frequency for

Black one key = 138.62 Hz

Black two key = 158.13 Hz

Black four key = 208.6 Hz

Black five key = 234.17 Hz