Smart Classroom-cum-Laboratory - The Effective Teaching and Learning Process of Communication

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Abstract— The virtual reality is being used more in the educational system, enabling the student to find out, to explore and to build his own knowledge. Teaching analog and digital communication virtually through a PC is much more welcomed by the institution. By designing virtual classroom for teaching and learning purpose of communication, one student can imagine and visualize the actual things and concepts behind the real world communication field. And after that by using virtual laboratory a student can implement all the processes involved in communication.

Now-a-days all the instruments which are involved in communication field are not available in the institutions and after that some instruments are also not working properly. By using this virtual laboratory all the things can be possible and the procedures of doing the practical will be easier than the traditional processes.

Here we are using the National Instruments LabVIEW software for the purpose of designing a smart classroom-cum-Laboratory. By using this and wi-fi internet all the students can learn this subject very easily.

Keywords— Internet, LabVIEW, Smart Classroom-cum-Laboratory, Teaching and Learning process of communication.

I. INTRODUCTION

In this scientific age, we are in need of quick and accurate solutions in all the fields, which is not possible in our day today life. So, Virtual labs and e-learning is the key of success. Now Virtual and remote laboratories extend their utility for the modern aspects of teaching and learning in the engineering field. After that technical teaching with more accurate solutions often require the use of expensive laboratory and teaching materials which are frequently beyond the reach of many students. Students are also necessary to go to laboratories, which offer the appropriate facilities, according to a strict timetable. For these reasons, the need for alternative methods arise for teaching such as a smart classroom-cum laboratory via the Internet. Laboratory activities are important components for the analysis of digital and analog communication in engineering field as well as to trend the fresh communication engineers in the company. Students are expected to incorporate what they learn in their lectures to facilitate their thinking in lab activities that would be homologous to the content By designing this smart classroom students will be able to know the real things which are happening behind the communication and they can clear the doubts themselves through the internet.

Also by designing this a teacher can teach the subject easily by accessing the internet. He/she can guide the students by using his/her PC when they do the practicals.

II. DESIGNING PROCEDURE

In this virtual laboratory all theories and practical are connected to the internet and each theory and practical contains a radio button. That is the control panel window of the classroom-cum-laboratory. When teacher will teach the students he/she will first publish that VI in internet by using web publishing tool (embedded or snapshot mode) of LabVIEW. Then the students can access all the theories and lab manuals corresponding to a particular topic.

The overall process is divided into 3 sub processes. They are

   i. Controlling part of the window
   ii. Laboratory or Theory part of the window
   iii. Extra features added window

Here all the windows are inter dependent to each other. After that all of them are depending upon the proper internet connections and the building of the server.

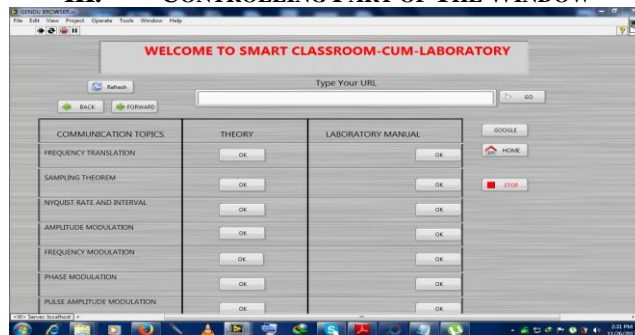### III. CONTROLLING PART OF THE WINDOW

Fig. 1 Control Panel Window (upper part) showing the radio buttons related to a particular topic
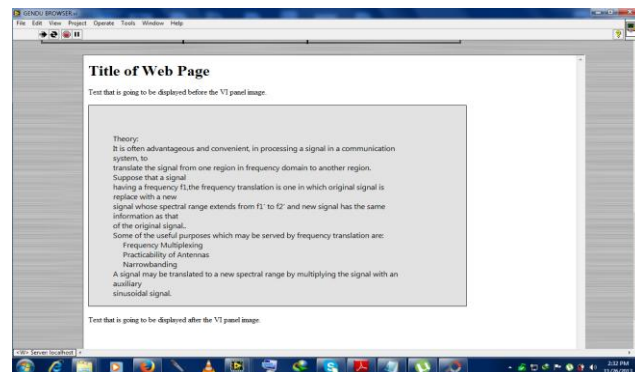

Fig. 2 Same Control Panel Window (below part) showing the access of theory and lab manuals to a particular topic
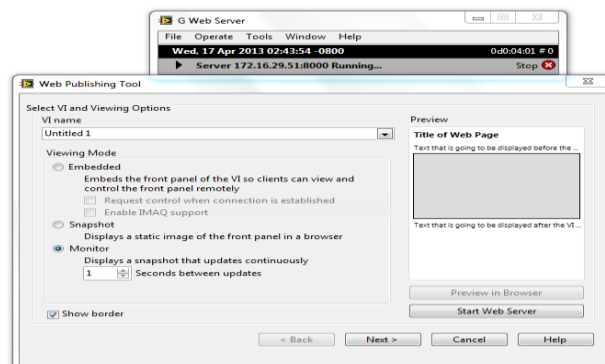

Fig. 3 Web Publishing Tool with Running of G-web Serve

But when a student wants to do the practical he has to open that particular VI which will be accessed later by the teacher. They are main communication functional VI by using LabVIEW, which are given below in detailed.

IV. LABORATORY OR THEORY PART OF THE WINDOW (COMMUNICATION FUNCTIONAL VI DESIGNING)

The processes like frequency translation, Amplitude, Frequency and phase modulation and demodulation, Pulse modulation and demodulation are designed by using LabVIEW software.

FREQUENCY TRANSLATION

It is the basic process of communication system. By this process the signal is translated from one region in frequency domain to another region in frequency domain without changing the information. The real life applications which are dependent upon this frequency translation are:

  i. Practicability of Antenna
 ii. Narrow banding
iii. Frequency division multiplexing.

If the message signal and carrier signal are considered as

$V_m(t)=A_m Cos\ \omega_m t$ and $V_c(t)=A_c Cos\ \omega_c t$,

Then the frequency translated signal will be

$Vm(t)Vc(t)=K[(exp\ j(\omega c+\omega m)t) +$

$exp\ -j(\omega c+\omega m)t +\ exp\ (j(\omega c-\omega m)t)+$

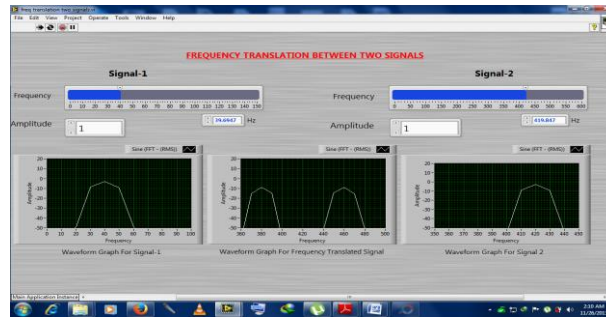$(exp(\ -j(\omega c-\omega m)t)]$

Fig. 4 Front panel of frequency translation between 2 signals

In multiple frequency translation we use a single carrier but a band or a number of frequencies, which are translated generally to a higher domain so that they help in the practicability and reducing the size of antenna.
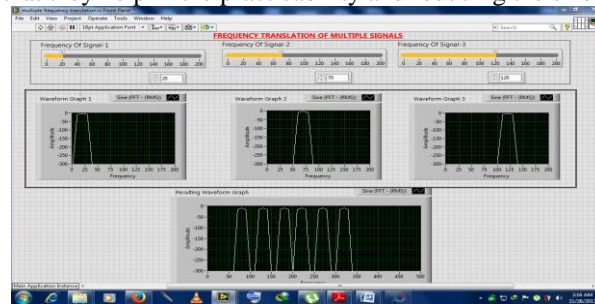

Fig 5 Front panel of frequency translation of multiple signals

SAMPLING THEOREM (NYQUIST CRITERIA)

Sampling is generally defined as a process which is used to convert a continuous time signal to discrete time signal. Sampling theorem states that a band limited signal of maximum frequency ω_m, can be recovered from its sampled version provided that the sampling frequency (ω_s) is greater than equal to $2\omega_m$.

i.e. $\omega_s >= 2\omega_m$

Nyquist rate is also called Nyquist rate. It is the minimum sampling frequency required to recover the original signal.

i.e. $(\omega_s)min = 2\omega_m$ rad/sec.

Nyquist interval is defined as the maximum sampling period required to recover the signal.

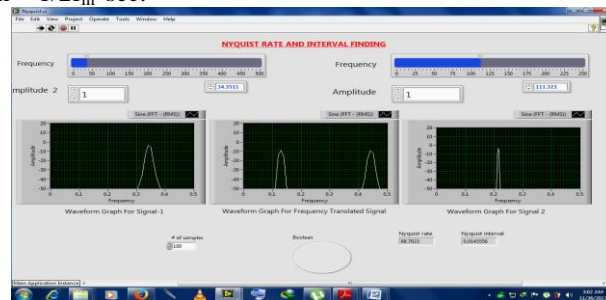i.e. $(T_s)max = 1/(f_s)min = 1/2f_m$ sec.

Fig 6 Front panel of Nyquist rate and interval finding

ALIASING EFFECT

When $\omega_s < 2 \omega_m$ then it is not possible to recover the original signal. Because some low frequency components are occupied by some of the high frequency components. This type of effect is called Aliasing Effect.
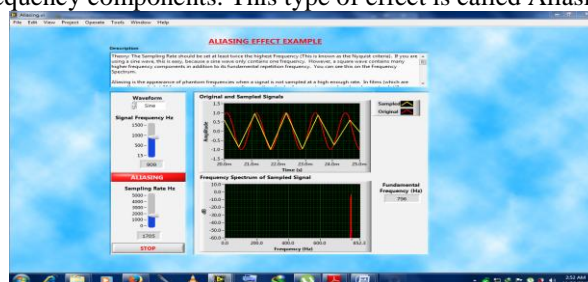

Fig 7 Front panel of example of Aliasing Effect

AMPLITUDE MODULATION

Amplitude modulation (AM) is a modulation technique used in electronic communication, most commonly for transmitting information via a radio carrier wave. The block diagram of the AM technique is:
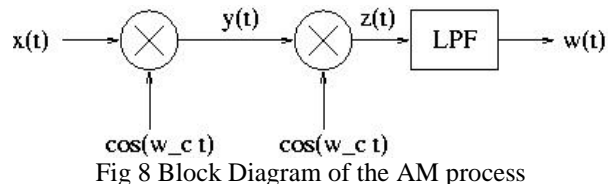
Fig 8 Block Diagram of the AM process

AM works by varying the strength (amplitude) of the transmitted signal in relation to the information being sent. For example, changes in signal strength may be used to specify the sounds to be reproduced by a loudspeaker, or the light intensity of television pixels. This contrasts with frequency modulation, in which the frequency of the carrier signal is varied, and phase modulation, in which the phase is varied, by the modulating signal.
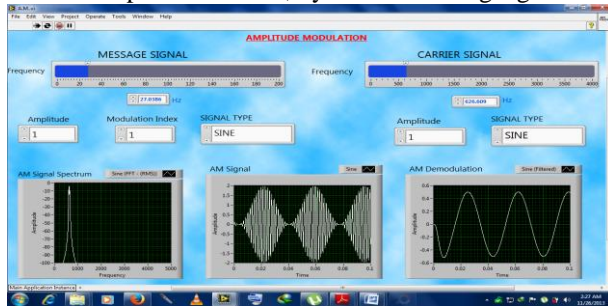

Fig 9 Front panel of Amplitude Modulation

DSB-SC GENERATION

Double-sideband suppressed-carrier transmission (DSB-SC) is transmission in which frequencies produced by amplitude modulation (AM) are symmetrically spaced above and below the carrier frequency and the carrier level is reduced to the lowest practical level, ideally being completely suppressed.

In the DSB-SC modulation, unlike in AM, the wave carrier is not transmitted; thus, much of the power is distributed between the sidebands. DSB-SC transmission is a special case of double sideband reduced carrier transmission. It is used for radio data systems.
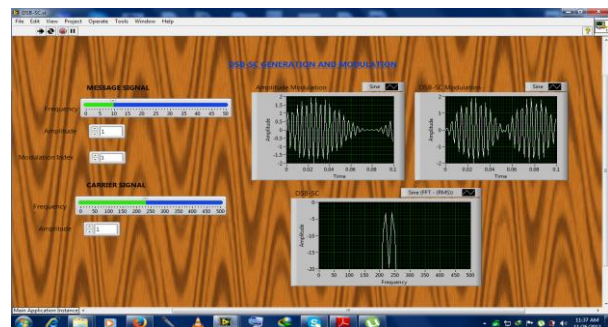

Fig 10 Front panel of DSB-SC Generation

SSB MODULATION AND DETECTION

In radio communications, single-sideband modulation (SSB) or single-sideband suppressed-carrier (SSB-SC) is a refinement of amplitude modulation that more efficiently uses transmit power and bandwidth.

Amplitude modulation produces an output signal that has twice the bandwidth of the original baseband signal. Single-sideband modulation avoids this bandwidth doubling, and the power wasted on a carrier, at the cost of increased device complexity and more difficult tuning at the receiver.

There are 2 methods two eliminate one of the sidebands, one is filter method and other one is phasor method. The process of selective filtering of the upper or lower sideband is difficult due to the stringent filters required, especially if there's signal content close to DC. This experiment will discuss the alternative, the phasing method, which uses a Hilbert Transformer to implement SSB Modulation.
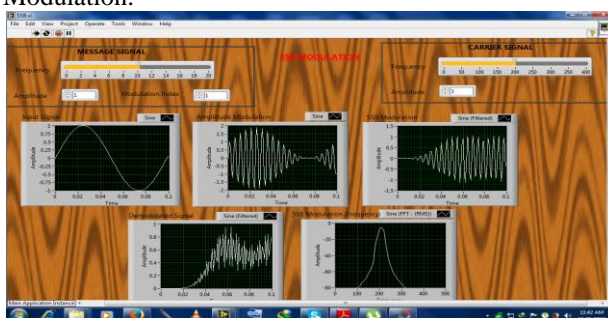

Fig 11 Front panel of SSB Generation and Detection

VSB MODULATION AND DETECTION
Vestigial sideband modulation is a compromise between DSB and SSB. In this process one pass band is passed almost completely where as only a residual portion of the other side band is retained in such a way that the demodulation process can still reproduce the original signal.
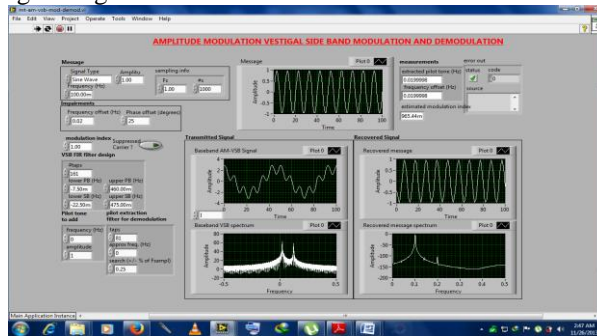

Fig 12 Front panel of VSB Modulation

FREQUENCY MODULATION

If the information to be transmitted (i.e. the baseband signal) is $x_m(t)$ and the sinusoidal carrier is $x_c(t) = A_c \cos(2\pi f_c t)$, where f_c is the carrier's base frequency, and A_c is the carrier's amplitude, the modulator combines the carrier with the baseband data signal to get the transmitted signal:

$$y(t) = A_c \cos\left(2\pi \int_0^t f(\tau)d\tau\right) = A_c \cos\left(2\pi \int_0^t [f_c + f_\Delta x_m(\tau)]\,d\tau\right)$$
$$= A_c \cos\left(2\pi f_c t + 2\pi f_\Delta \int_0^t x_m(\tau)d\tau\right)$$

In this equation, $f(\tau)$ is the instantaneous frequency of the oscillator and f_Δ is the frequency deviation, which represents the maximum shift away from f_c in one direction, assuming $x_m(t)$ is limited to the range ± 1.

$$h = \frac{\Delta f}{f_m} = \frac{f_\Delta |x_m(t)|}{f_m}$$

Where f_m is the highest frequency component present in the modulating signal $x_m(t)$, and Δf is the peak frequency-deviation—i.e. the maximum deviation of the instantaneous frequency from the carrier frequency. If $h \ll 1$, the modulation is called *narrowband FM*, and its bandwidth is approximately $2f_m$.
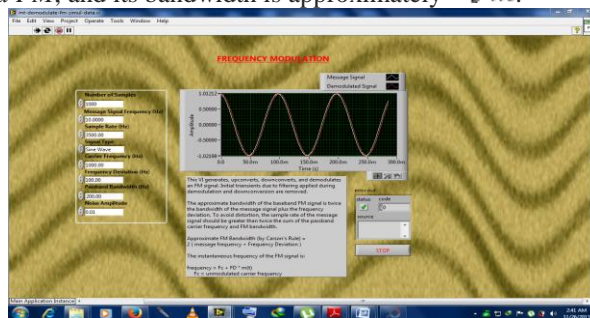

Fig 13 Front panel of Frequency Modulation

PHASE MODULATION
PM changes the phase angle of the complex envelope in direct proportion to the message signal. If message signal to be sent is $m(t)$ and the carrier onto which the signal is to be modulated is: $c(t) = A_c \sin(\omega_c t + \phi_c)$ This makes the modulated signal is $y(t) = A_c \sin(\omega_c t + m(t) + \phi_c)$ The mathematics of the spectral behavior reveals that there are two regions of particular interest:

• For small amplitude signals, PM is similar to amplitude modulation (AM).
• For a single large sinusoidal signal, PM is similar to FM, and its bandwidth is approximately

$$2(h+1)f_M$$

Where $f_M = \omega_m/2\pi$ and h is the modulation index defined as $h = \Delta\theta$
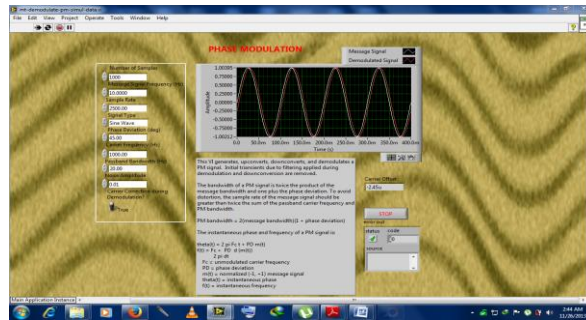Here, $\Delta\theta$ is the peak phase deviation.

Fig 14 Front panel of Phase Modulation

PULSE AMPLITUDE MODULATION

Pulse-amplitude modulation (PAM) is a form of signal modulation where the message information is encoded in the amplitude of a series of signal pulses. It is an analog pulse modulation scheme in which the amplitudes of a train of carrier pulses are varied according to the sample value of the message signal. Demodulation is performed by detecting the amplitude level of the carrier at every symbol period.
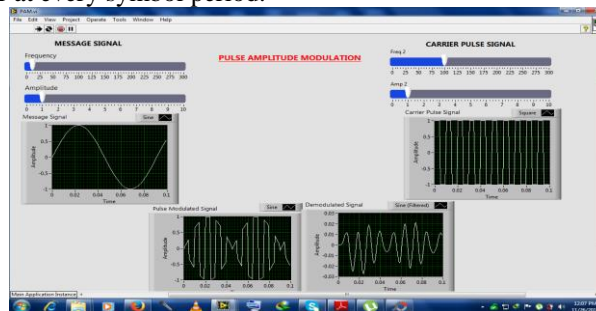

Fig 15 Front panel of Pulse Amplitude Modulation

PULSE POSITION MODULATION

Pulse-position modulation (PPM) is a form of signal modulation in which M message bits are encoded by transmitting a single pulse in one of 2^M possible time-shifts. This is repeated every T seconds, such that the transmitted bit rate is M/T bits per second. It is primarily useful for optical communication systems, where there tends to be little or no multipath interface.
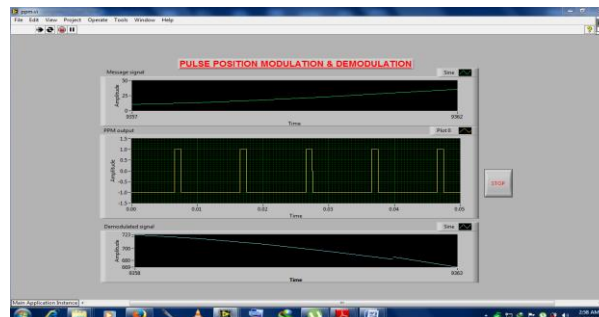

Fig 16 Front panel of Pulse Position Modulation

PULSE DENSITY MODULATION

Pulse-density modulation or PDM, is a form of modulation used to represent an analog signal with digital data. In a PDM signal, specific amplitude values are not encoded into pulses of different size as they would be in pulse code modulation (PCM). Instead, it is the relative density of the pulses that corresponds to the analog signal's amplitude. The output of a 1-bit DAC is the same as the PDM encoding of the signal.
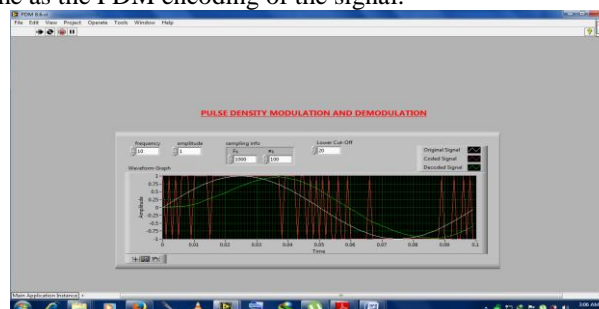

Fig 17 Front panel of Pulse Density Modulation

FREQUENCY DIVISION MULTIPLEXING

In telecommunications, frequency-division multiplexing (FDM) is a technique by which the total bandwidth available in a communication medium is divided into a series of non-overlapping frequency sub-bands, each of which is used to carry a separate signal. This allows a single transmission medium such as the radio spectrum, a cable or optical fibre to be shared by many signals.
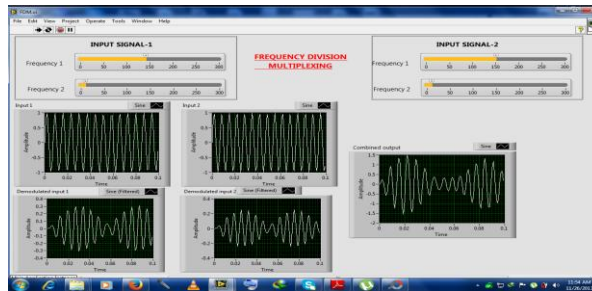

Fig 18 Front panel of Frequency Division Multiplexing

TIME DIVISION MULTIPLEXING

Time-division multiplexing (TDM) is a method of transmitting and receiving independent signals over a common signal path by means of synchronized switches at each end of the transmission line so that each signal appears on the line only a fraction of time in an alternating pattern.
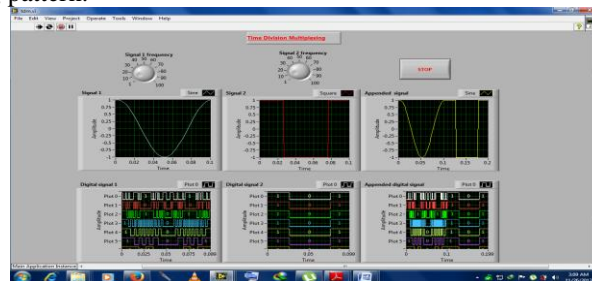

Fig 19 Front panel of Time Division Multiplexing

V. EXTRA FEATURES INCLUDED IN THE SMART CLASSROOM

In extra features first thing is the video showing to the students related to a particular topic. This can also be included in smart classroom, which is given below.
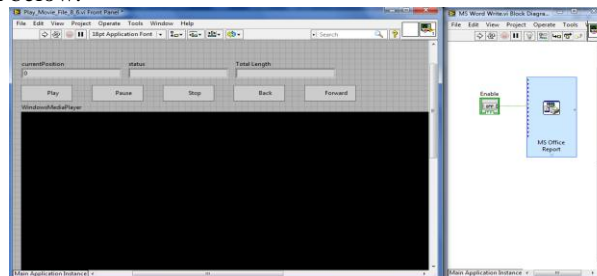

Fig 20 Front panel of playing video file and block diagram of opening of MS word File

By giving the video file path here we can play a video, and then we have to publish it in the internet to show the students. Second feature is writing something or conducting examination online. For this purpose we can enable the MS Office word file by LabVIEW. Then the student will write the solutions there. The VI for this purpose is given below.
Similarly we can add various features in this smart classroom-cum-laboratory, which will make it very effective for the communication purpose.

VI. CONCLUSIONS

By designing the smart classroom-cum-laboratory all the students as well as the teachers can get a good skill in their communication field. And also more valuable and expensive experiments can be done in virtual labs, which will reduce cost. By this a smart institution can be made by a little effort. And after that the students will get a real and accurate solution of the problems by using the virtual labs.

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