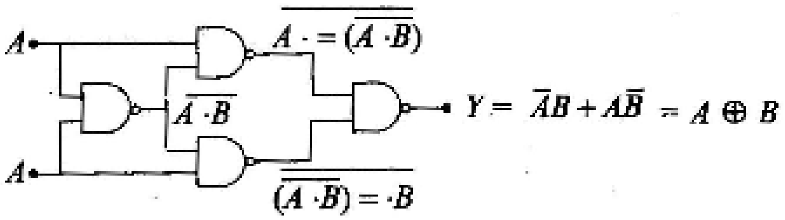
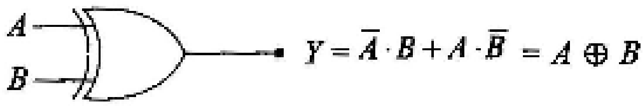
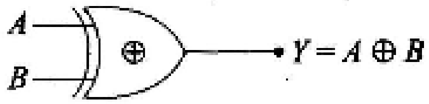
⇒ **Implementation of a two-input XOR-function with NAND-gate:**



Logic symbol:



or



Truth Table

Input		**Intermediate Output**				**Final Output**
A	B	$\bar{A}$	$\bar{B}$	$Y_1 = \bar{A}B$	$Y_2 = A\bar{B}$	$Y = Y_1 + Y_2 = \bar{A}B + A\bar{B}$
0	0	1	1	0	0	0
1	0	0	1	0	1	1
0	1	1	0	1	0	1
1	1	0	0	0	0	0

From truth table, it can be observed that, output Y is 1 only when one of two inputs is 1 but not both. Hence, the name XOR (exclusive OR) gate.

XOR operation is called mod-2 addition, and rules of addition are:

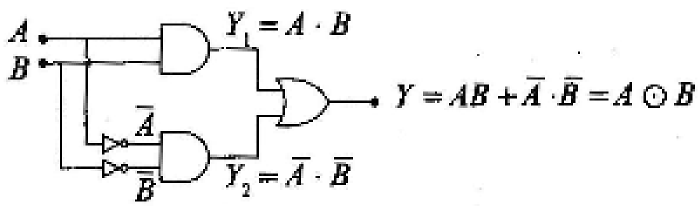
$0 \oplus 0 = 0 \qquad 0 \oplus 1 = 1 \qquad 1 \oplus 0 = 1 \qquad 1 \oplus 1 = 0$

From these rules we conclude that mod-2 addition is a binary addition if we neglect to take into account the carriers.

Exclusive–NOR-gate (or Ex-NOR or XNOR-gate)

The Boolean expression for XNOR is $Y = A\cdot B + \bar{A}\cdot\bar{B} = A \odot B$

Implementation:



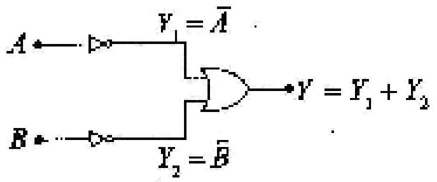
XNOR or Equivalence operation is denoted by '⊙'

Truth Table

Input		Inter Output				Final Output
A	B	$\bar{A}$	$\bar{B}$	$Y_1 = AB$	$Y_2 = \bar{A}\bar{B}$	$Y = Y_1 + Y_2 = A \odot B$
0	0	1	1	0	1	1
1	0	0	1	0	0	0
0	1	1	0	0	0	0
1	1	0	0	1	0	1

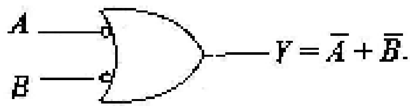
From truth table, it can be observed that output Y is 0 when one of the two inputs is 1 and Y is 1 when both the two inputs are 0 or 1.

Bubbled OR-gate



If the output of two NOT-gate is fed to input of an OR-gate, the resulting arrangement is called bubbled OR-gate as shown:

Logic symbol:



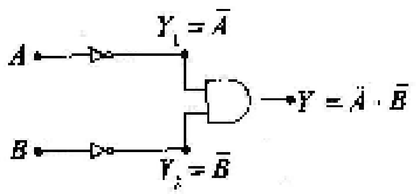
Truth Table

Input		Inter Output		Final Output
A	B	$\bar{A}$	$\bar{B}$	$Y = \bar{A} + \bar{B}$
0	0	1	1	1
1	0	0	1	1
0	1	1	0	1
1	1	0	0	0

Since the truth table for bubbled OR-gate and that for NAND-gate are identical which means that the bubbled OR-gate produces the same output signals as the NAND-gate, therefore, each NAND-gate can be replaced by a bubbled OR-gate and vice-versa.

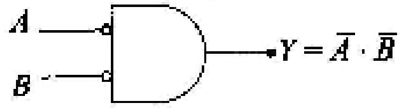
i.e. NAND gate ≡ Bubbled OR-gate

Bubbled AND-gate



If the output of two NOT-gate is fed to input of an AND-gate, the resulting arrangement is called bubbled AND-gate as shown below:

Logic symbol:

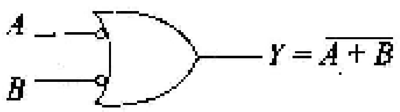


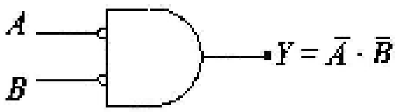
Truth Table

Input		Inter Output		Final Output
A	B	$Y_1 = \bar{A}$	$Y_2 = \bar{B}$	$Y = \bar{A} \cdot \bar{B}$
0	0	1	1	1
1	0	0	1	0
0	1	1	0	0
1	1	0	0	0

Since the truth table for bubbled AND-gate and that for NOR-gate are identical, which means a bubbled AND-gate produces the same output as a NOR-gate, therefore, each NOR-gate can be replaced by a bubbled AND gate and vice-versa.

i.e. NOR-gate ≡ Bubbled AND-gate

i.e. 

$\equiv$


22.11 PRINCIPLES OF COMMUNICATION

22.11.1 Analog Communication

1. Analog communication system involves analog electronic circuit, where the output voltage changes continuously according to input voltage variations.
2. In this communication, the output voltage can have an infinite number of values. A continuously varying signal (voltage or current) is called an analog signal. Due to many valued output, the analog operation is less reliable.

22.11.2 Digital Communication

1. Modern communication systems involve digital electronic circuits and digital signals. A signal that can have only two discrete values (*i.e.*, ON or OFF) is called a digital signal.
2. A square wave is a digital signal, because this signal has only two values, *viz.*, +5 V and 0 V. A digital circuit expresses the values in digits 1's or 0's. Hence, the name digital is given.
3. Digital operation is more reliable than many valued analog operations.

22.11.3 Radio Communication

1. In radio communication, an audio signal from a broadcasting station is sent over a great distance to a receiver. Audio signal cannot be sent directly over the air for appreciable distance, even after converting into electrical signal. At audio frequencies, the signal power is quite small and radiation is not practicable.
2. The radiation of electrical energy is practicable only at high frequencies, e.g., above 20 kHz. Therefore, if audio signal is to be transmitted properly, some means must be devised which will permit transmission to occur at high frequencies while it simultaneously allows the carrying of audio signal. This is achieved by superimposing electrical audio signal on high frequency carrier wave. This process is called modulation.
3. At the radio receiver, the audio signal is extracted from the modulated wave by the process called demodulation.
4. The process of radio communication involves three steps:
   (a) Transmitter
   (b) Transmission of radio waves
   (c) Radio receiver

22.11.4 Need for Modulation

1. In order to radiate a frequency of 20 kHz directly into space, we would need an antenna length of 15,000 m. This is impractical. On the other hand, if a carrier wave of 1000 kHz is used to carry the signal, we need an antenna length of 300 m only.
2. As the audio signal frequencies are small, therefore these cannot be transmitted over large distances if radiated directly into space (because of their small energy). But, when the audio signal is modified by a high frequency carrier wave, it permits the transmission over large distances.
3. At audio frequencies, radiation is not practicable because of poor efficiency. However, efficient radiation of electrical energy is possible at high frequencies, thus making wireless communication feasible.

22.11.5 Demodulation

1. The process of recovering the audio signal from the modulated wave is known as demodulation. If the modulated wave after amplification is directly fed to the speaker, no sound will be heard. It is because the diaphragm of the speaker is not at all able to respond to high frequency of modulated wave. This implies that audio signal must be separated from the carrier at a suitable stage in the receiver and fed to the speaker for conversion into sound.
2. A demodulator or detector circuit performs essentially two functions:
   (a) It rectifies the modulated wave, i.e., negative half of the modulated wave is eliminated.
   (b) It separates the audio signal from the carrier.

22.12 TYPES OF MODULATION

22.12.1 Amplitude Modulation

1. When the amplitude of high frequency carrier wave is changed in accordance with the intensity of audio signal, it is called amplitude modulation. In amplitude modulation, only the amplitude of the carrier wave is changed but the frequency of the modulated wave remains the same, *i.e.*, carrier frequency.
2. The ratio of change of amplitude of carrier wave to the amplitude of normal carrier wave is called the modulation factor m, *i.e.*,

   Modulation factor,

$$m = \frac{\text{Amplitude change of carrier wave}}{\text{Amplitude of the unmodulated carrier wave}}$$

3. Modulation factor determines the strength and quality of the transmitted signal. The greater is the degree of modulation (*i.e.*, m), the stronger and clearer will be the audio signal.
4. If the carrier is over modulated (*i.e.*, $m > 1$), distortion will occur during reception.
5. The instantaneous voltage of AM wave is:

$$e = E_c \cos \omega_c t + \frac{mE_c}{2} \cos(\omega_c + \omega_s)t + \frac{mE_c}{2} \cos(\omega_c + \omega_s)t$$

   where, E_c = Amplitude of carrier

   mE_c = Amplitude of signal

   $\omega_c = 2\pi f_c$ = Angular velocity at carrier frequency f_c

   $\omega_s = 2\pi f_s$ = Angular velocity at signal frequency f_s

6. Important points regarding AM wave:
   (a) The AM wave is equivalent to the summation of three sinusoidal waves, one having amplitude E_c and frequency f_c $(= \omega_c/2\pi)$, the second having amplitude $mE_c/2$ and frequency $(f_c + f_s)$ and the third having amplitude $mE_c/2$ and frequency $(f_c - f_s)$.
   (b) The AM wave contains three frequencies, *viz.*, f_c, $f_c + f_s$ and $f_c - f_s$. The first frequency is the carrier frequency and two other frequencies, one higher and second lower than carrier frequency. Thus, the process of modulation does not change the original carrier frequency but produces two new frequencies $(f_c + f_s)$ and $(f_c - f_s)$ which are called side band frequencies.
   (c) The sum of carrier frequency and signal frequency, *i.e.*, $(f_c + f_s)$ is called upper side band frequency. The lower side band frequency is $(f_c - f_s)$, *i.e.*, the difference between carrier and signal frequencies.
   (d) In practical radio transmission, carrier frequency f_c is many times greater than the signal frequency f_s. Hence, the side band frequencies are generally close to the carrier frequency.
   (e) In amplitude modulation, band width is twice the signal frequency.

22.12.2 Power in AM Wave

1. Equation of AM wave reveals that it has three components of amplitudes E_c, $mE_c/2$ and $mE_c/2$ respectively. Obviously, power output must be distributed among three components.

2. Power of carrier wave: $P_c = \frac{E_c^2}{2R}$

   Total power of side bands: $P_s = \frac{m^2 E_c^2}{4R} \Rightarrow P_s = \frac{1}{2} m^2 P_c$

   Total power of AM wave: $P_T = P_c + P_s = \frac{E_c^2}{2R}\left[1 + \frac{m^2}{2}\right] = P_c\left[1 + \frac{m^2}{2}\right]$

3. Fraction of total power carried by side bands: $\frac{P_s}{P_T} = \frac{m^2}{2 + m^2}$

   (a) When $m = 0$, power carried by side bands = 0.

   (b) When $m = 1/2$, power carried by side bands = 11.1% the total power of AM wave.

   (c) When $m = 1$, power carried by side bands = 33.3% the total power of AM wave.

4. As the signal is contained in side band frequencies, therefore useful power is in the side bands. Above equations show that side band power depends upon the modulation factor m. The greater the value of m, the greater is the useful power carried by side bands.

5. The side band power represents the signal content and the carrier power is that power which is required as the means of transmission.

22.12.3 Limitations of Amplitude Modulation

1. Noisy reception
2. Low efficiency
3. Small operating range
4. Lack of audio quality

22.12.4 Frequency Modulation

1. In this modulation, it is only the frequency of the carrier wave which is changed and not its amplitude. The amount of change in frequency is determined by the amplitude of the modulating signal where as rate of change is determined by the frequency of the modulating signal.

   Louder the audio signal, greater the frequency change in modulated carrier. The rate of frequency deviation depends on the signal frequency.

2. The frequency of a FM transmitter without signal input is called the resting frequency or centre-frequency (f_o) and is the allotted frequency of the transmitter or carrier frequency.

3. When the signal is applied, the carrier frequency deviates up and down from its resting value f_o. This change or shift either above or below the resting frequency is called frequency deviation (Δf).

4. The total variation in frequency from the lowest to the highest is called carrier swing (CS), *i.e.*, $CS = 2 \times \Delta f$
5. A maximum frequency deviation of 75 kHz is allowed for commercial FM broadcasting stations in the 88 to 168 MHz VHF band. Hence, FM channel width is $2 \times 75 = 150$ kHz. allowing a 25 kHz guard band on either side, the channel width becomes $= 2\,(75 + 25) = 200$ kHz.

22.12.5 Modulation Factor or Index

1. It is given by the ratio, $m_f = \dfrac{\text{Frequency deviation}}{\text{Modulation frequency}} = \dfrac{\Delta f}{f_m}$
2. Unlike amplitude modulation, the modulation factor here can be greater than unity.

22.12.6 Deviation Ratio

1. It is the worst case modulation factor in which maximum permitted frequency deviation and maximum permitted audio frequency are used.

$$\therefore \quad \text{Deviation ratio} = \frac{(\Delta f)_{max}}{f_{m(max)}}$$

2. For FM broadcast stations, $(\Delta f)_{max} = 75$ kHz and maximum permitted frequency of modulating audio signal is 15 kHz.

$$\text{Deviation ratio} = \frac{75\text{kHz}}{15\text{kHz}} = 5$$

3. For sound portion of commercial TV

$$\text{Deviation ratio} = \frac{25\text{kHz}}{15\text{kHz}} = 1.67$$

22.12.7 Percent Modulation

1. When applied to FM, this term has slightly different meaning than when applied to AM. In FM, it is given by the ratio of actual frequency deviation to the maximum allowed frequency deviation, *i.e.*,

$$m = \frac{(\Delta f)_{actual}}{(\Delta f)_{max}} \Rightarrow m \propto (\Delta f)_{actual}$$

It means that when frequency deviation (*i.e.*, signal loudness) is doubled, modulation is doubled.

2. Value of $m = 0$ corresponds to zero deviation, i.e., unmodulated carrier wave.

22.12.8 Pulse Modulation

1. Pulse modulation may be used to transmit analog information, such as continuous speech or data.
2. Pulse modulation may be subdivided into two categories: analog and digital.
3. The two types of analog pulse modulation are pulse amplitude and pulse-time modulation, correspond roughly to amplitude and frequency modulation.

22.12.9 Data Communication Modem

1. The modems are employed both at transmitting and receiving stations. The modem at the transmitting station changes the digital output from a computer to a form which can be easily sent *via* a communication circuit, while the receiving modem reverses the process.
2. The name modem is a contraction of the terms modulator and demodulator. As the name implies, both functions are included in a modem.

22.12.10 Propagation of Electromagnetic Waves in Atmosphere

On the basis of the mode of propagation, radio waves can be broadly classified as:

1. **Ground or surface waves:**
   (a) In ground wave propagation, radio waves are guided by the earth and move along its curved surface from the transmitter to receiver.
   (b) Ground wave propagation is useful only at low frequencies.
   (c) Below 500 kHz, ground waves can be used for communication within distances of about 1500 km from the transmitter.
   (d) AM radio broadcasts in the medium frequency band cover local areas and take place primarily by the ground wave.
2. **Space or tropospheric waves:**
   (a) In space wave propagation, radio waves move in the earth's troposphere within about 15 km over the surface of the earth.
   (b) The space wave is made of two components: a direct or line of sight wave, the ground-reflected wave.
   (c) The space wave is not continuously absorbed by the earth's surface. Hence, it can cover a greater range than the ground wave.
3. **Sky waves:**
   (a) In sky wave propagation, radio waves transmitted from the transmitting antenna reach the receiving antenna after reflection from the ionosphere.
   (b) Short wave transmission around the globe is possible through sky waves *via* successive reflections at the ionosphere and the earth surface.

22.12.11 Satellite Communication

1. For sky wave propagation, usually the frequency band extending from 3 to 30 MHz is employed. Radio links over large distances over the earth's surface can be established by multi hop transmission. But reliable communication by means of sky waves is hampered due to problems like ionospheric disturbances, storms, etc. Artificial satellites offer reliable communication links over long distances. To an observer on the earth's surface the satellite appears to be stationary.
2. In satellite communication, the wave containing information is transmitted to the satellite from a transmitter located on the earth's surface. The signal is processed by the equipment kept in the satellite, amplified and retransmitted towards the receiving point on the surface of earth.
3. In satellite communication, FM is used and the carrier frequency is a few GHz. For such high frequencies, the antenna size is small and the signal is not significantly absorbed by the ionosphere. A large area on the earth's surface can be covered by the transmitter stationed on the artificial satellite.

Remote-sensing and its Applications

1. The technique of collecting information about an object from a distance, without making a physical contact with that object, is called remote sensing.
2. Applications of remote-sensing satellite:
   (a) It makes possible the repeated survey of vast areas in a very short time even if the area is otherwise inaccessible.
   (b) Ground-water surveys
   (c) Forest surveys
   (d) Preparing wasteland maps
   (e) Drought assessment
   (f) Estimation of crop yields
   (g) Detection of crop diseases
   (h) Spying work for military purposes

22.12.12 Optical Fibre Communication

1. A light beam acting as a carrier wave is capable of carrying far more information than radio waves and microwaves. In order to have an efficient communication system, one would require a guiding medium in which the information carrying light wave could be transmitted. This guiding medium is an optical fibre.
2. The optical fibres are hair-thin strands of specially coated glass. The diameter of each fibre is about 10^{-4} cm with refractive index 1.7. They can transit a laser or other light beam from one end to the other as a result of repeated total internal reflections at the glass boundary. Each fibre can carry as many as 2000 telephone conversations with extremely low losses.

3. Optical fibre communication is the transmission of information by the conversion of an electrical signal to an optical signal, the transmission of this optical signal along the length of optical fibre and then its reconversion to an electrical signal.

22.12.13 Communication System

A set-up that transfers information implicitly from one point to another is called communication system.

Communication systems are of three types:

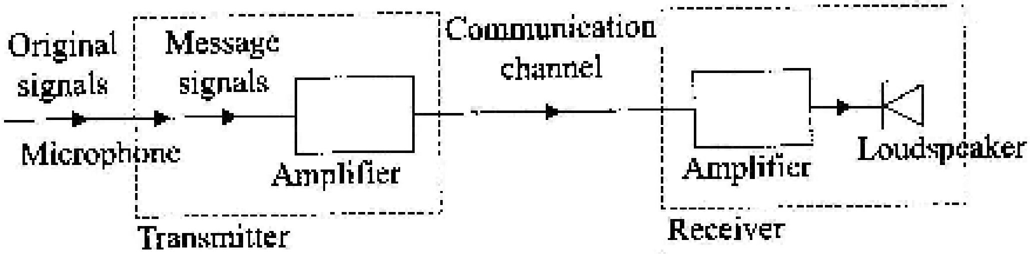
1. Electrical
2. Electronic
3. Optical

Major constituents of communication system are:

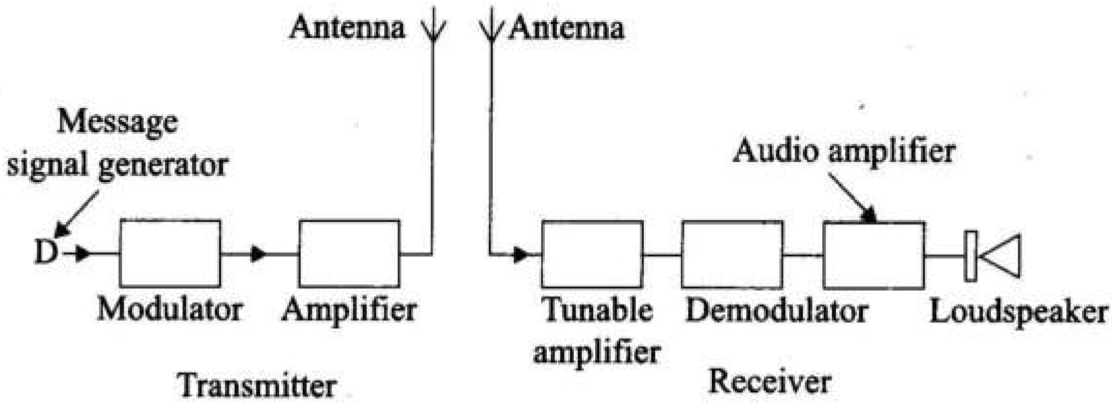
1. Transmitter
2. Communication channel
3. Receiver.

Transmitter

It is a device that transmits a message/signal over the communication channel to the receiver. If the distance between the source and receiver is of the order of several kilometers, audio frequency signals (20 Hz – 20 kHz) get attenuated before they reach the receiving end. In this situation message generated by the source is converted into electrical signals first. Wires or cables are used as communication channel. Transmitter is empowered with a transducer and an amplifier. Transducer is a device which converts energy in one form to another. Microphone and loud-speaker are transducers. Amplifier boosts up the power of the signal.



In case destination is at such a large distance that direct electrical connection between the source and receiver is not possible we adopt wireless system. In this arrangement we attach one more device in the transmitter called modulator. A modulator translates message signal to the radio frequency range. On the receiver side demodulator is used to translate radio signals back to original signal. Antenna is used on both sides to radiate and pick up signals respectively.



22.12.14 Message Signals

A time varying electrical signal generated by a transducer out of original signal is termed as message signal. Message signal is a single valued function of time that conveys information.

Main characteristics of a signal are:

1. Amplitude
2. Frequency
3. Phase

22.12.15 Line Communication

1. Transmission lines are used to interconnect points separated from each other. For example, interconnection between a transmitter and a receiver or a transmitter and antenna or an antenna and a receiver are achieved through transmission lines.
2. The most commonly used two wire lines are:
   (a) Parallel wire lines
   (b) Twisted pair wire lines
   (c) Coaxial wire lines
3. Parallel wire lines are used for transmission of microwaves. This is because at the frequency of microwaves, separation between the two wires approaches half a wavelength (*i.e.* $\lambda/2$). Therefore, radiation loss of energy becomes maximum.

PHYSICAL CONSTANTS

Some Fundamental Constants of Physics

Constant	Symbol	Computational Value
Speed of light in vacuum	c	3.00×10^{8} m/s
Elementary charge	e	1.60×10^{-19}C
Gravitational constant	G	6.67×10^{-11} Nm²/ kg²
Universal gas constant	R	8.31 J/mol.K
Avogadro constant	N_A	6.02×10^{23} mol^{-1}
Boltzmann constant	k	1.38×10^{-23} J/K
Stefan-Boltzmann constant	σ	5.67×10^{-8} W/m^2.K^4
Molar volume of ideal gas at STP	V_m	2.27×10^{-2}m^3/mol
Permittivity constant	ε_0	8.85×10^{-12} F/m
Permeability constant	μ_0	1.26×10^{-6} H/m
Planck constant	h	6.63×10^{-34} J.s
Electron magnetic moment	μ_e	9.28×10^{-24} J/T
Proton magnetic moment	μ_p	1.41×10^{-26} J/T
Bohr magneton	μ_B	9.27×10^{-24} J/T
Nuclear magneton	μ_N	5.05×10^{-27} J/T
Bohr radius	r_B	5.29×10^{-11} m
Rydberg constant	R	1.10×10^{7} m^{-1}
Electron compton wavelength	λ_c	2.43×10^{-12}m
Electron mass	m_e	9.11×10^{-31} kg or 5.49×10^{-4}u
Proton mass	m_p	1.67×10^{-27} kg or 1.0073 u
Ratio of proton mass to electron mass	m_p/m_e	1840
Electron charge-to mass ratio	e/m_e	1.76×10^{11}C/kg
Neutron mass	m_n	1.68×10^{-27} kg or 1.0087 u
Hydrogen atom mass	m_{1_H}	1.0078 u
Deuterium atom mass	m_{2_H}	2.0141 u
Helium atom mass	$m_{4_{He}}$	4.0026 u
Muon mass	$m\mu$	1.88×10^{-28} kg

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AIR 398


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AIR 419


ABHIJEET KUMAR
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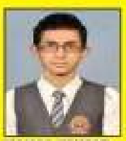
RISHI SAHANI
AIR 532

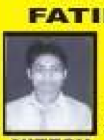

MANAS KUMAR
AIR 588


BINOD KUMAR
AIR 601

TOTAL SELECTIONS IN AIPMT IN 2016 = 32


MAHWISH FATIMA

AIIMS
AIR 1302
Roll No. 6719530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