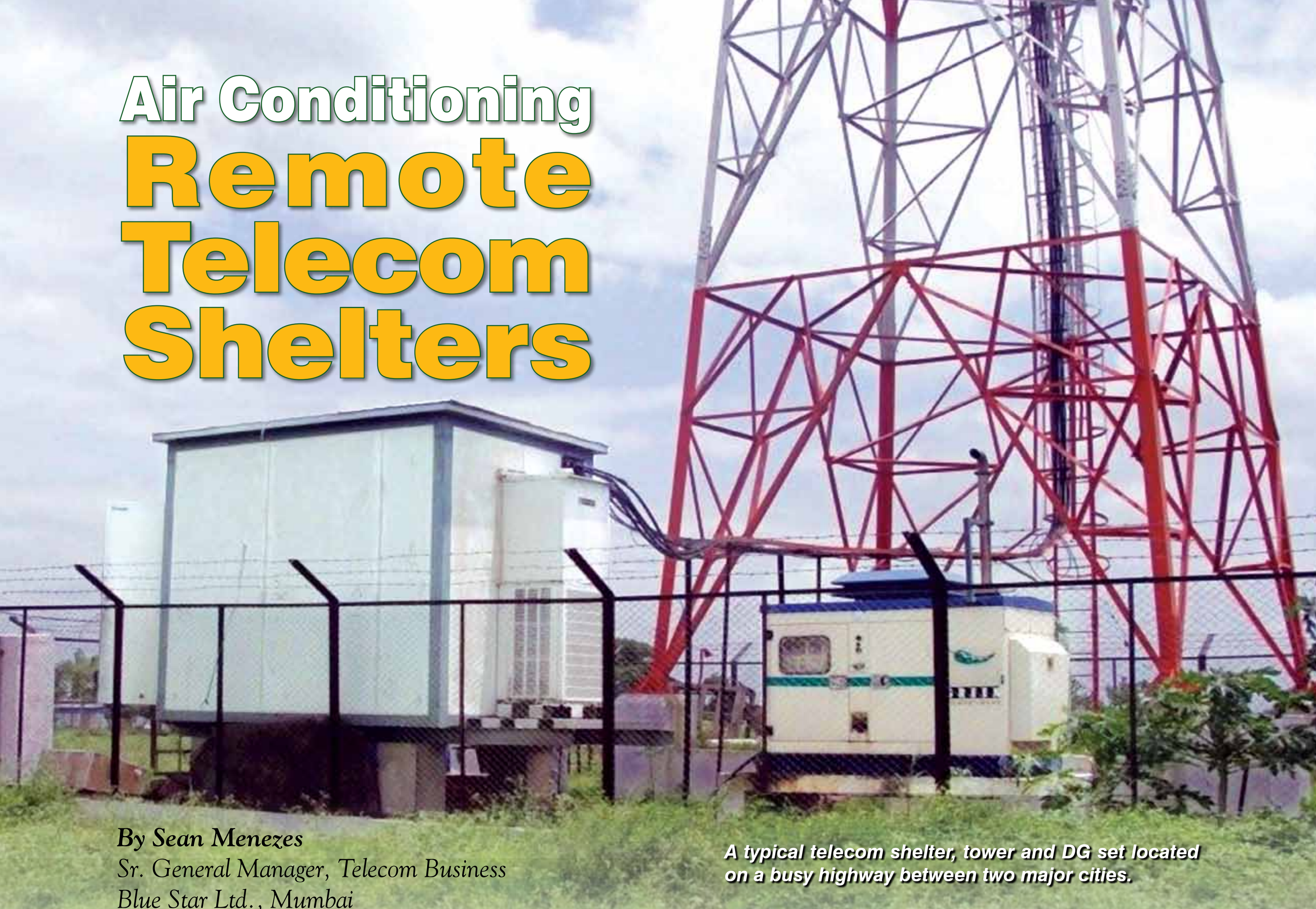
Air Conditioning Remote Telecom Shelters



A typical telecom shelter, tower and DG set located on a busy highway between two major cities.

By Sean Menezes
Sr. General Manager, Telecom Business
Blue Star Ltd., Mumbai

With 315 million mobile phone subscribers as of October 2008 and a predicted 8 to 10 million new connections every month, it is anticipated that up to half our population or one in every two citizens of our one billion plus country will own a mobile phone by the middle of 2012. This article describes the role that air-conditioning has to play in facilitating the uninterrupted operation of telecom-related equipment housed within what are commonly called as Telecom Shelters, located in different topographies – deserts, plains, hilly areas and even mountain ranges in varied climatic conditions.

Going back to 1995... The first cell phone arrived in India. It was a matter of prestige to possess one. Calls, back then were charged at Rs. 16/- a minute and a little lower for incoming. The number of users was a drop in the ocean then...

Move over to 2008, and over 300 million mobile users find it difficult to imagine life without a cell phone... Telecom companies are constantly in a race to provide more talk time for fewer rupees. Incoming calls are free, at least intrastate... It may not be long, before they become free throughout the country.

This telecom revolution started in India in 1995-96 in the metros. Hutchison Max and BPL in Mumbai, Essar and Bharti in Delhi, RPG and Skycel in Madras and Koshika and Spice in Kolkata were the first movers. By 1997, the various 'circles' had developed. The Telecom Regulatory Authority of India (TRAI) allowed only two players per circle besides the government owned BSNL.

With the Universal Service Access License (USAL), almost all major

About the Author

Sean Menezes has been associated with telecom air conditioning, since it started in India, in 1995-96. He has worked closely with various equipment manufacturers like Ericsson, Motorola, Siemens. to understand telecom applications and develop a suitable air conditioning solution. He joined Blue Star in 2002 and was responsible for Blue Star's foray in telecom air conditioning.

players including India's largest business group, Reliance has a pan-India presence.

Being involved with air conditioning for telecom in India since the very beginning, I have tried to explain in this article the parallel evolution of the AC equipment for this application.

The Telecom Infrastructure

The telecom infrastructure can be divided into two categories:

- Active Infrastructure – The electronic equipment, microprocessor hardware and telecom switches come under this category. The type of equipment depends on the population strength that it caters to. Since telephone signals are relayed through microwave, a "line of sight" contact through an antenna is required. In densely populated cities, where there are enough high-rise buildings, these antennae are simply located on a roof top. However, for plain terrains, these antennae need to be elevated and so telecom towers are built for holding these antennae in place at a height of 40 m and above.
- Passive Infrastructure – All the paraphernalia that is not directly involved with the communication activity, but is necessary for its functioning comes under this category. It includes telecom shelters and telecom towers.

What are Telecom Shelters?

A telecom shelter (TS) is an insulated, weatherproof enclosure erected to house the dust and temperature sensitive active infrastructure equipment. It is a PUF insulated sheet metal enclosure resting on a masoney foundation. As a rule, it is designed to sustain floor loads of 3000 kg/m^2 and shelter walls are designed to withstand wind speeds of 200 kmph.

The earliest shelters were imported from Europe and were very expensive (nearly Rs. 15 lac for one shelter). Slowly, indigenous production started and costs naturally came down. The generally accepted specification of TS panels in India is 0.6 mm thick galvanized pre-painted sheets with 60 mm thick PUF insulation. Costs have now reduced to less than a tenth of the initial costs!

Earlier, each telecom service provider had their own set of passive infrastructure. As a result, multiple towers could be seen in one locality, causing unnecessary duplication of resources. With economization setting in, these days this passive infrastructure is shared by two or more providers.

These telecom shelters and towers are built either by the telecom companies or by other players who are solely in the business of setting up passive infrastructure for telecom.

The standard dimensions of a TS are 3 m length x 2.5 m width x 2.7 m height. Since these shelters house dense microprocessor based equipment and that too of multiple players, they generate a fairly large heat load in spite of a progressive reduction in the heat dissipation of equipment.

Telecom shelters or "cell sites" as they are commonly referred to in telecom parlance, are located in several clusters across cities and towns. The size of each cluster is determined by the subscriber base and the call traffic each cell site is required to handle. A cluster servicing a small C class town would require just 15-20 telecom shelters as compared to several thousand shelters for a city like Mumbai.

Telecom shelters are also erected on highways to carry telecom traffic seamlessly across the country. These sites are usually placed at 20 to 40 km "hops" from each other, depending on the topography and terrain the calls are being routed through.

Business Potential for HVAC Manufacturers/ Contractors

There are two components of this passive infrastructure that are related to the HVAC&R business. One – the telecom shelters themselves, and the other – the air conditioning of these shelters to ensure 100% uptime of the equipment housed inside. Supply of shelters has now become a commoditized, low cost business, due to the presence of local vendors who can supply the PUF panels and erect the shelter at site. However, air conditioning of the shelters is a specialized business and requires engineering expertise.

The remaining part of this article is dedicated to my experience in this field and the process of evolution to the present day solution for air conditioning of these shelters.

The Evolution of Air Conditioning Solutions for TS

Room Air Conditioners

When it all first started in India, passive infrastructure providers, telecom companies and AC contractors were all fairly ignorant of the AC requirements of a typical TS in our tropical weather. Everybody settled for standard comfort conditions of 23 + 2° C as the indoor condition of a TS. The earliest TSs were equipped with 2 window ACs and manned by security guards who would try to equalize the run hours of both the ACs based on their judgment. Not unlike the way ATM outlets are operated today!

We soon realized that this was not the right solution. For one, the SHF in a TS is very high and the standard air flow from a window AC is insufficient to dissipate this heat. The other problem was that of infiltration of dust and humidity, which was again detrimental to the sensitive electronics. Due to uninterrupted operation, the compressors would come under stress resulting in frequent failures and expensive down times. Operating costs were also very high.

Split Air Conditioners

Subsequently the window AC was replaced by two split ACs operated by a programmable timer. The biggest advantage of this was that the size of the puncture in the

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shelter wall was small and so moisture ingress and dust infiltration was considerably controlled. Nonetheless, we had not yet found a solution to the high SHF which was causing the compressors to run non-stop, and eventually failing frequently. Operating expenses still remained a concern.

High Cfm Units

We now graduated to installing high cfm ceiling suspended or floor mounted ductable units with a potential free contact to transmit failures via a controller to the maintenance station. This reduced dependability on man power. We also introduced leak proof flanges to further reduce infiltration of dust and humidity.

Finally, the Right Solution!

All the above solutions evolved from the adaptation of existing products and there was an urgent need to create the right product for telecom shelter applications. Lack of consistency in the quality of installation teams created severe problems as the roll outs moved into remote areas and hilly terrains since all these units required refrigerant piping and wiring to be done at site.

This prompted us to zero base and develop a solution which was an easy-to-install "plug & play" unit, which was factory wired and factory charged. We developed a twin circuit system that had inbuilt redundancy, with a modular construction. The unit was externally mounted outside the shelter and this enabled easy access to components requiring service and maintenance. Thus, the maintenance crew would not need to enter the shelter which could now be kept safely locked and free from tampering. See *Photo 3*. This innovation also freed up valuable space within the shelter to accommodate more electronic switching equipment. This product was well received by the Telecom industry and all telecom roll outs saw conventional solutions being replaced by this one.

Focusing on Energy Efficiency and Reducing Op-Ex

After the initial euphoria of heralding the telecom revolution in India subsided, it was time to take stock and slowly the truth about the huge power consumption and its effect on operating costs started being felt. It was time for the AC designers and other equipment providers to come together to address this issue.

Optimizing Indoor Design Conditions

As stated earlier, the very first telecom shelters were air conditioned using design conditions of 23 + 2°C. Those were the days when our inexperience and unavailability of reliable equipment prevented us from questioning our design assumptions. Instead of venturing and experimenting with sacrosanct, documented figures and risking breakdown of the costly equipment, we preferred to play it safe.

As time passed, our confidence increased with experience and so did the reliability of electronic telecom equipment. Slowly, owners, suppliers and AC vendors alike, started thinking of energy savings and optimization of op-ex costs.

Photo 2

Photo 3

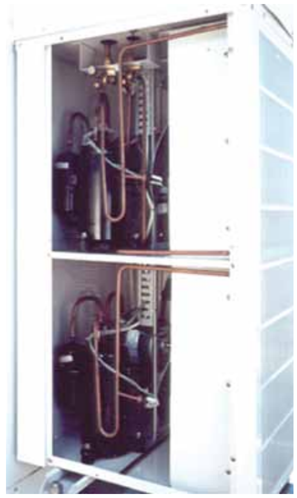

Photo 2 shows the twin circuit unit mounted outside a TS and Photo 3 shows its internal view.

The Concept of Zoning

At this point, let us revisit the interior layout of a typical TS. It is shown in *Figure 1*. Out of the various components seen in the block diagram, a discussion between various equipment suppliers and their proactive interest in working towards energy optimization led to some conclusions. For one, battery manufacturers unanimously declared a temperature of 27°C as the optimum temperature for its efficient operation. The BTS, micro wave and power plant section got zoned together, their manufacturers having confirmed that temperatures of 32°C maximum was adequate for these components.

Normal ACs are not recommended for operation beyond 25°C to 27°C due to a fear of discharge pressures becoming excessively high and causing compressor failures. To take care of the new design conditions of 32°C, the refrigeration system had to be modified. A suction pressure regulator was added to normalize the pressure on the suction side and the condenser was dramatically oversized to limit the rise in discharge pressure.

By increasing the indoor design conditions from the earlier operating temperature of 24°C to 32°C, the overall capacity of the refrigeration system could be reduced and this translated into a considerable saving on op-ex.

However, VRLA batteries are sensitive to temperatures exceeding 27°C. Hence, they need to be isolated in a separate zone having its own dedicated refrigeration system, in order to optimize on the performance and life of the batteries.

Free Cooling

The concept of free cooling was initially resisted due

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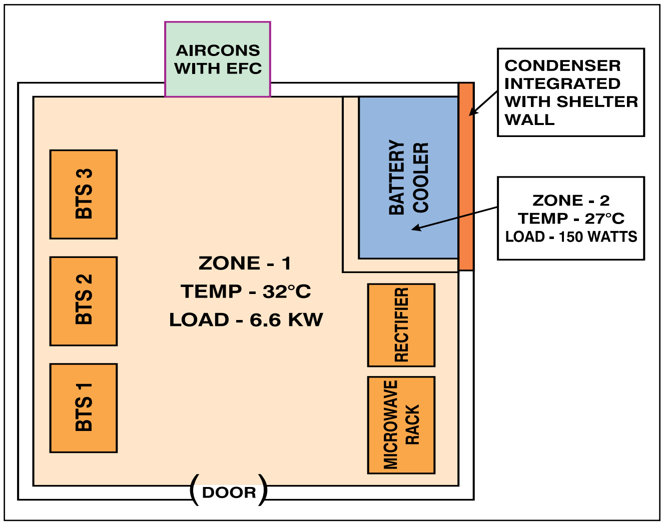

Figure 1 : Schematic arrangement - two zone shelter.

to a perceived fear of increased humidity. But it can be proved that even if ambient RH is excessively high, the high indoor sensible heat causes it to stabilize after coming indoors. Our psychometric calculations proved that, if 32°C was the acceptable temperature within the shelter, then for ambient temperatures of 26°C and lower, there was no need to run the compressor. If, as in the case of some players, indoor temperatures of up to 35°C are acceptable, then free cooling would be effective for even ambients as high as 29°C, reducing op-ex costs by a further 20%.

Emergency Free Cooling (EFC)

Some of our models are engineered for this option, where the free cooling circuit comes on if either the compressor is off due to failure or in case there is a power supply breakdown. If the ambient temperature when this has occurred is below a preset temperature (usually 26°C to 29°C), the evaporator fan continues to run on a 48V DC source separately provided for the evaporator fan motor. A damper is automatically actuated by a DC actuator motor, that opens to 100% fresh air mode and thus provides normal air conditioning and ventilation to the telecom shelter. The positive pressure inside the TS ensures that the hot air is exhausted through the return air grill. It must be noted that the air flow required for effective heat removal (to achieve the same delta T) is higher and so the evaporator fan must be equipped with a VSD to be able to deliver additional air during the free cooling mode. A schematic shown in *Figure 2* will make this explanation clear.

Phase Change Materials (PCM)

Phase Change Materials (PCMs) are "latent" energy storage materials. They use chemical bonds to store and release heat. The thermal energy transfer occurs when a material changes from a solid to a liquid or from a liquid to a solid. This is called a change in state, or "phase." PCMs can give out latent heat at a wide range of temperatures from negative to positive. This 'heat-on-demand' requirement is satisfied by PCMs which work at specified temperatures.

Power failure is very common in our country. When the power fails, the temperature inside the shelter starts rising very rapidly due to heat generated by the equipment and also due to ambient conditions. In such cases, a combination of EFC and PCM is used to withhold this rise and limit temperatures to near tolerance levels.

Glauber's salt, soda ash, sodium acetate and paraffin wax are the most commonly used in PCMs. Although these compounds are fairly inexpensive, the packaging and processing necessary to get acceptable performance from them is complicated and costly. They do not offer a reliable pattern of releasing heat as the chemicals in these PCMs separate and stratify when in their liquid state. These PCMs have not always re-solidified properly. When temperatures dropped, they did not completely solidify, reducing their capacity to store latent heat. These problems have been addressed by packaging phase change materials in thin or shallow containers and by adding clumping agents. Many salt hydrate PCMs have the disadvantage that during extraction of stored heat, the material super-cools before freezing. This reduces the utility of the materials and if too severe, it can completely prevent heat recovery. They lose their heat storage property after some cycles. These types of PCMs, however, compare unfavourably with the newer generation of low-cost, highly efficient PCMs. Phase Change Materials perform best in containers that—when combined with the PCM – total 25 mm. The packaging material should conduct heat well; and it should be durable enough to withstand frequent changes in the storage material's volume as phase changes occur. It should also restrict the passage of water through the walls, so the materials will not dry out. Packaging must also resist leakage and corrosion. Aluminium,

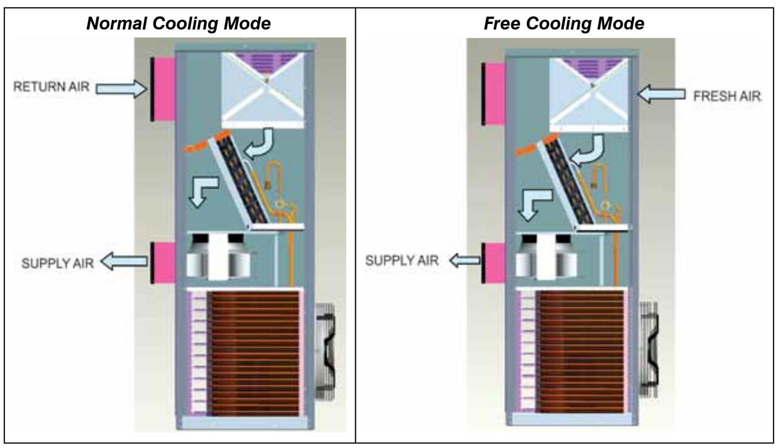

Figure 2 : Normal cooling and free cooling modes.

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Photo 4 : One wall of a telecom shelter lined with PCM filled into aluminum pipes.

steel and polyethylene are common packaging materials.

Photo 4 shows one wall of a telecom shelter lined with PCM filled into aluminum pipes. As can be seen, the PCM wall is also fitted with DC operated fans that circulate the air over the material, even during power outages, thus cooling the shelter. To the best of my knowledge, the effective use of this technology is in a very primitive stage and no results confirming the extent of op-ex savings have been accurately documented so far.

Remote Monitoring and Control

These days all telecom shelters are typically unmanned, fully automated self-contained units. As such, it is important that failures be communicated as fast as possible so that relief can be rushed in. These are transmitted via micro wave through the RS 485 port on the unit mounted controller, to the centrally located Operation and Maintenance Center (OMC). Computer connectivity through the RS 485 enables remote monitoring and control from the OMC. Temperatures can also be regulated during seasonal loads, to maximize savings.

Range of Units Currently Used in TS Applications

In terms of construction, telecom ACs can be classified under the following types:

1. Single circuit units – The basic unit with only one cooling system.

2. Twin circuit units – they provide 100% standby capacity and consist of two independent cooling units housed in a single enclosure. They provide 100% redundancy at all times. Needless to say, they cost almost double the single units.

3. The construction of an EFC unit is explained earlier. They are heavily engineered with sophisticated controls and are therefore expensive. Typically an EFC unit costs nearly double the twin circuit unit. This is of course owing to its advantages of being able to provide cooling during power failures and the ability to function without standby capacity.

The heat loads generated in a TS for one, two or three BTS (base transceiver stations) as well as different operators (CDMA or GSM) are now well-known, standardized and documented. All the major telecom service providers have also standardized their specifications of ACs for the TS based on their priorities – be it low cost, efficient operation or sophistication. On our part we have also standardized models for each operator to ensure quick deliveries and to ease stocking up of spares. Typical lead times are in the range of 8 weeks and we ensure that we plan at the beginning of the year to ensure that we can meet our commitments.

For GSM operators, standard capacity is 1.25 ton per BTS while for CDMA operators, it is higher at 2 ton per BTS. In case of two BTS stations in one TS, 1.75 ton is a standard model. Most prefer to install a 100% standby unit to ensure 100% up time. Some cost conscious customers have standardized on a unique 0.9 ton model with emergency free cooling.

Table 1 lists the range and type of units available across various manufacturers in India.

Tonnage (Nom)	Twin-circuit		Single circuit		Single circuit +EFC	
	Rotary	Scroll	Rotary	Scroll	Rotary	Scroll
0.9	-	-	✓	-	✓	-
1.0	-	-	-	-	-	✓
1.25	✓	-	-	-	-	-
1.5	✓	✓	-	-	✓	-
1.75	✓	-	-	-	-	-
2.0	✓	✓	-	-	-	✓
3.0	-	-	-	-	-	✓

Table 1: Standard AC models for telecom shelters. Models are available in single phase as well as 3 phases.

Market Share of Different Units

Among the various types of units available today, the single circuit + EFC units are the most popular followed by the twin circuit units. Single circuit units, because of inherent disadvantages are favored only by infrastructure providers whose focus is mainly on first cost rather than running cost.

Table 2 provides an interesting comparision of how customer preferences have changed over the last decade or more, since we first started.

% Share of Year	Type of Unit			
	Twin Circuit	Single Circuit	Single Circuit + Free Cooling	Window / Split ACs
1995 – 2000	65%	-	5%	30%
2001-2005	75%	10%	10%	5%
2006- 2008	40%	10%	50%	-

Table 2: Market preferences of Telecom ACs- 1995 to date

Conclusion

The telecom industry is targeting at creating 700 million telecom users in India by 2012, the business potential for telecom ACs remains good and so does the scope for making more improvements to the construction, reliability and above all, operating efficiency of these units! ❖