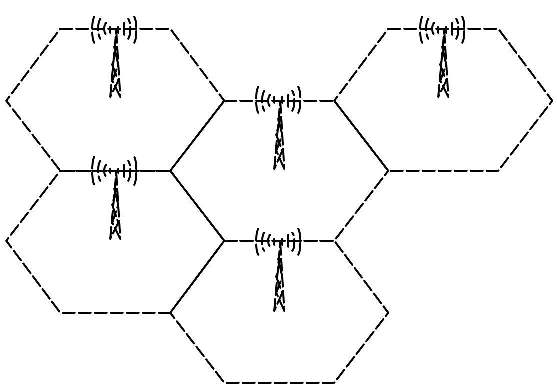
Application Note AN-21

Keeping Cell Phones On the Air

What do you get when you combine state of the art electronic equipment, a 100 foot antenna that doubles as a lightning rod, and a raw utility feed?

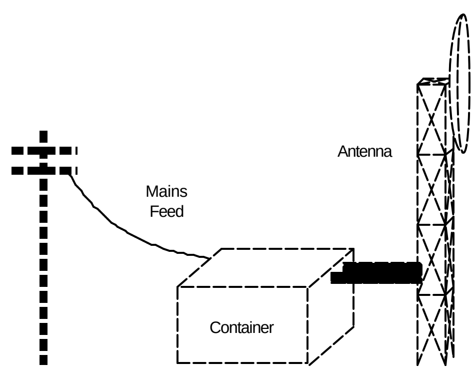
Power Quality Problems!

That's what many telecommunications companies are finding as they install state-of-the art cellular phone systems world-wide. Cellular telephone systems depend upon the reliable operation of radio base stations at the center of each cell. These base stations need high quality power to stay operating in all atmospheric and electrical conditions.



The operation of the base stations, and the operation of the cellular system on the whole, is controlled by a central telecommunications computer and controller called a ***Switch****.*

A typical base station site consists of a tower and antenna(s), a small building or container that houses the base station equipment, and a dedicated electrical feed from the utility.



A tower, 100 feet (30 M) or taller, is installed to raise the antennas to the proper height. Electric power is provided via a dedicated service, directly from the nearest utility feeders without the buffering effect of building power distribution systems. If there are tall buildings near the center of the cell, the cellular provider can lease space on the building rooftop, and take advantage of the building height. The container can be supplied power from within the building, usually from a distribution panel on the top floor.

Grounding (Earthing)

Clearly, a base station needs good grounding! Whether installed on a rooftop or on the ground with a tower, the base station is a prime candidate for a direct lightning strike, as well as indirect lightning effects. Cellular system designers are well aware of this, and have devised various earthing systems to direct lightning transients to earth. These include multiple electrodes, buried ground rings, and multiple point connection of key sub-systems and components to the grounding system.

On a rooftop, it is often not practical to connect the base station directly to earth (which may be hundreds of feet away! Instead, the base station components are grounded together, and the total system is bonded to the building ground system.

But even well grounded systems are vulnerable to "back door" grounding problems. The base station is fed from an electrical system that may or may not have an earth connection to the Neutral Conductor. In ground level stations if this connection can be made at the service entrance to the station, there should be no problem obtaining low common-mode voltages.

Rooftop sites are another matter! The main building N-G bond if present, is usually in the basement - often hundreds of conductor-feet away from the base station. This long run from the N-G bond, combined with deliberate earth loops designed to prevent lightning damage, spells trouble for the base station. High levels of N-G voltage, ground impulses, and electrical noise can be expected at Rooftop sites!

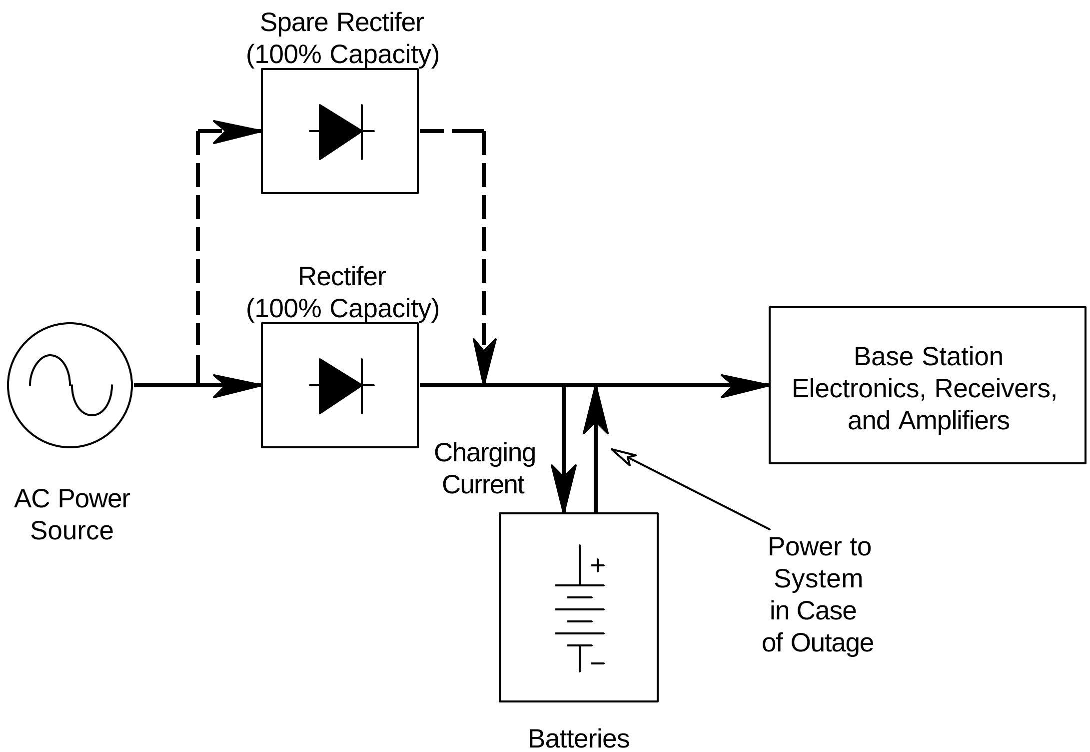
To minimize the potential for electrical system earthing problems, many base stations make use of an isolation transformer based power conditioner to develop a ***Separately Derived Source*** within the base station building or container. Use of such a device ensures that the telecommunications system is not affected by remote N-G bonds, poor electrical installations, and other common "grounding" problems.

Batteries are Supplied

Have you ever noticed that when your electric supply gets cut due to a storm or other problem, the phone system is often still up and running? Long before the advent of Uninterruptible Power Supplies (UPS), telecommunication engineers ran the Telecom equipment from DC power, using large DC batteries which keeps the system up and running until the utility power returns.

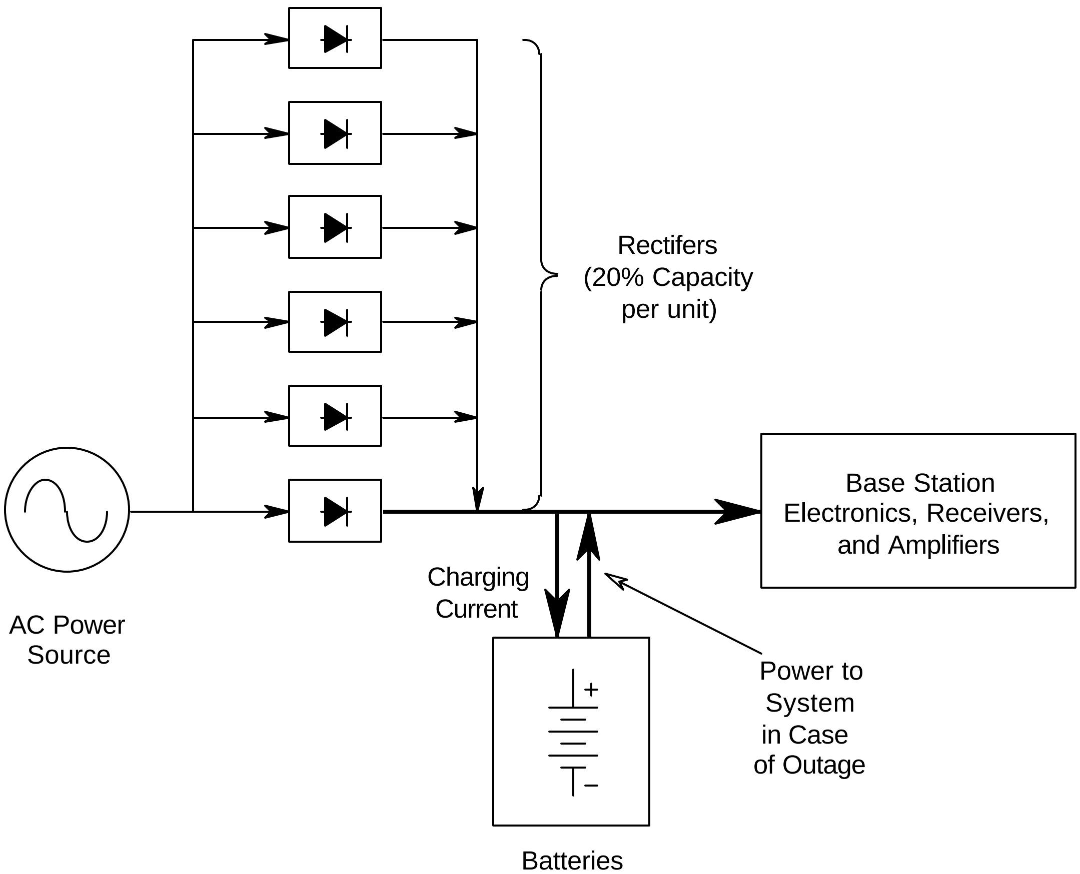
Rectifier Systems

Telecom systems normally operate directly from the electrical system, with the batteries "floating" in reserve - ready to supply the load when power is interrupted. Rectifiers convert AC to DC power and have been used for decades but the telecommunications industry has lead the development of smaller, smarter, and more reliable "switch mode" rectifier systems.



In an older type of system, the rectifier is a large power supply, rated for full system power. These older rectifiers use Diodes or SCR's to convert the AC power to DC power. Even though these types of rectifiers are fairly rugged, a second rectifier was often added to provide redundancy. The total installed capacity of the rectifiers is then 200% of the required capacity.

With the advent of newer electronic power devices, such as the BiPolar Transistor and the Metal Oxide Semiconductor - Field Effect Transistor (MOSFET), new “smart” rectifier designs became practical. Lower power rectifiers that could be operated in parallel, with the benefits of current sharing, compact modular design, power factor correction, soft start and high efficiencies. With a bank of smaller rectifiers in parallel, N+1 redundancy could be built in by adding one or two extra units. If any unit failed, the system would continue to operate because of this redundancy.



With these new rectifiers the total installed capacity need only be 120% to 140% of the full power (as opposed to 200% with older designs) for the same level of redundancy and reliability. In addition, the smaller rectifier modules could be more easily removed and repaired than larger rectifiers. Modern rectifier systems for telecommunications now make use of these new rectifier designs.

The Cost of the New Designs

There is one down side to the new rectifier designs. Rectifier electronics (transistors and MOSFET's) are more sensitive to impulses and voltage transients than the older SCR type rectifiers. Excessive impulses can result in damage to these switches. As a result, the AC Mains often needs to be protected with clean grounds and impulse clamping devices (filters, surge suppressors, etc.). Most rectifiers have some level of transient protection built-in, but this is often insufficient for bad lightning areas, or developing countries with a less stable electrical system.

Power Conditioning for Mobile Telecom Systems

One might think that a Telecom system, with its excellent grounding and battery back-up, has no need for power conditioning. However, Telecom systems can benefit from the proper level of power conditioning including:

A. An ***Isolation Transformer*** is key to develop a Separately Derived Source. This eliminates concerns about common-mode voltages, created by remote N-G bonds, poor N-G bonding at the service entrance, and ground currents caused by multiple earth connections, and loose neutrals.

B. ***Filters*** and ***Surge Suppression*** are used to attenuate AC impulses. This prevents damage to the transistors and MOSFETs at the heart of the new rectifier modules.

C. In addition to these benefits, the forward thinking system designer can take advantage of "Site Prep in a Box", using a power conditioning system with all the power distribution, indicators, and controls needed. This reduces installation time and cost. These issues are key in a large cellular system, where dozens or hundreds of base station sites need to be installed in a short time in remote, hostile environments.