A.C. POWER DISTRIBUTION FOR OPTIMUM TRANSMITTER PERFORMANCE

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For many years, Harris engineers have recommended that the three phase power distribution system should be either a closed delta or WYE configuration to provide better radio and television transmitter performance by helping to prevent line unbalance. Operation with substantial voltage unbalance from line to line results in higher than normal signal-to-noise ratio in the transmitter output signal, increased three phase transformer heating, and overly hot three-phase motors.

Overheating From Line Unbalance

Even a device as simple as a three phase motor should be operated from a power line in which the voltage is balanced within 1 %. It takes only a 3.5% line unbalance to produce a 25% increase above normal temperature. A 5% unbalance will cause destructive temperature rises of 50% greater than normal!

Similar characteristics can be expected in the windings of a three phase power transformer down inside the cabinet of your transmitter. Transformers and motors can be designed with extra safety features where thermal rise is limited to acceptable levels; however, in this case, other transmitter parameters cannot be made acceptable at a reasonable cost.

Transmitter Noise Performance

The most difficult parameter to meet with power line unbalance is transmitter AM noise performance. Most large transmitters use six-phase or twelve phase high voltage power supplies. The energy storage capacitors are expensive to install and large stored energies make destructive faults inevitable. A good design will have sufficient energy storage capacitors to meet the specified signal-to-noise but not much more. When the equipment is then operated from an unbalanced line, the power supply ripple frequency will be twice the line frequency instead of six to twelve times. It becomes obvious that it would take three times as much energy storage to achieve the original performance goal.

The Causes of Line Unbalance

How does a line unbalance occur? It is a rare case in which a large commercial power producer would generate unbalanced voltage, so we must look elsewhere in the system. When you have large single phase power users on a power line this can cause uneven distribution of the line currents in the system. Uneven currents through balanced impedances will result in line-to-line voltage unbalance.

Another likely source of this problem can come from unbalanced impedances in the power distribution system. Unbalanced impedance will always be seen when an "open" delta three phase distribution system is used. Transformer design textbooks clearly show that the voltage regulation of an unbalanced system is poor.

Three Phase Delta Distribution Transformers

Figures 1 and 2 show closed and open delta systems. The closed delta impedance looking into each terminal (A, B & C) is exactly the same; but this is not the case in the open delta configuration. Depending on the impedances of the transformers in the open delta circuit, line voltage unbalance sufficient to impair satisfactory operation of the overall transmitter may result.

The only advantage of the open delta is lower cost, and this is partially offset by the fact that two transformers capable of 0.577 of the total kVA are required instead of three at 0.333 of the total kVA. Harris customers have experienced difficulties with open delta systems -- but when a third transformer was added to close the delta, the problems disappeared.

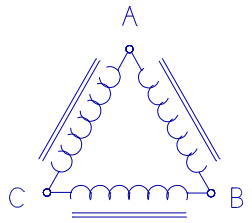

Figure 1. Closed Delta

There is another problem that can occur with an open delta system, and that is caused by lightning and switching transients. When lightning strikes or heavy loads are switched on a power distribution system, high voltage transients are propagated throughout the system. Unbalanced impedances will enhance these transients and can cause transmitter damage, particularly to solid state rectifiers.

Many transmitters are located at the end of a long AC transmission line which is highly susceptible to transient phenomena. Devices such as Metal Oxide Varistors are inexpensive and very effective in reducing overvoltage spikes. These units are limited in the amount of energy that can be dissipated, but will handle, if designed properly, very large currents. You can't take a direct lightning hit and still operate, but not many things will. Several Harris customers, upon installation of a third transformer and transient protection devices, have eliminated power line difficulties.

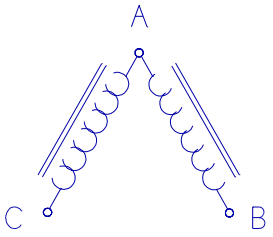

Figure 2. Open Delta

Three Phase WYE Distribution Transformers

The WYE connected system is also considered a symmetrical form of three phase power distribution. All impedances are balanced as seen from each terminal (see Figure 3). It is important when using a WYE connected system that the fourth wire (neutral) is connected to the mid-point of the system as shown in the diagram. When this connection is made it provides a path for the zero sequence currents as well as any harmonic currents that are generated due to rectification of the secondary voltages.

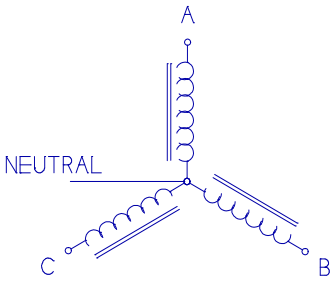

Figure 3. 4-Wire WYE

Today, many transformers are supplied with all of the primary terminals available so that either a delta or WYE connection can be made. Table 1 shows the different line-to-line voltages that are available with this configuration.

Table 1. Typical Line Voltages with Delta or WYE

Delta Connected Transformer	WYE Connected Transformer
210	364
220*	380*
230	400
240*	415*
250	433

* Typical voltages in some areas of the world.

In summary, both symmetrical power distribution systems are satisfactory because of their balanced impedances. Use either a closed delta or a four wire WYE system for maximum transmitter performance. Never use an open delta system just to cut costs. It could cost you dearly in the long run.

J. B. Pickard was AM Product Development Manager at Harris Broadcast Products Division (retired - 1994).