GROUNDING FOR CAT UPS SERIES 300

GROUNDING CONFIGURATIONS

There are three commonly used grounding methods around the world for 3 phase power systems. These are the following:

1. 3 wire wye solidly grounded
2. 4 wire wye solidly grounded - 3 phases plus neutral
3. Impedance grounded – 3 phases, no neutral and a resistor between the neutral point of the source and ground.

Cat UPS has been designed to work with all of these standard grounding configurations. The standard configuration for Cat UPS Series 300 480V systems is 3 wire solidly grounded and. The standard for 380-415V systems is 4 wire solidly grounded. Impedance grounding can be easily accommodated, although it will initially require an SER until we see how frequently we need this version.

There are other non-standard grounding methods such as “wild leg” delta grounded, corner grounded delta and ungrounded delta. These are obsolete methods but can still be found, mostly in older industrial areas. As with most other UPS systems, Cat UPS requires an upstream isolation transformer for the UPS and bypass before it can be connected to these power systems.

Figure 1 shows a 3 wire wye connected solidly grounded power system. The neutral point of the 3 phase system is connected directly to ground neutral conductors are not run from the source.

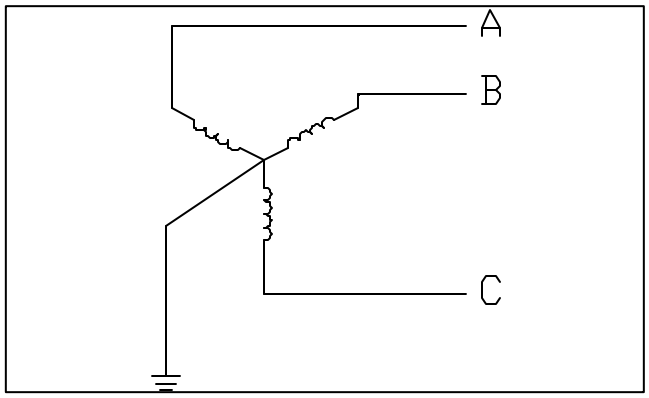

Fig 1: 3 Wire Wye Connected With Solid Ground

Figure 2 shows a 4 wire wye connected solidly grounded system. It is the same except that a neutral is run form the source so that loads can be connected line to neutral as well as line to line. A 480V 4 wire system is often shown as 480/277V or 277/480V because the line-to-line voltage is 480V and the line to neutral voltage is 277V. Similarly, in a 400V, 4 wire, wye connected system is often shown as 400/230V or 230/400V and a 208V 4 wire system is shown as

208/120V or 120/208V.Three phase Systems designated 480/240V, 460/230V or 440/220V are “wild leg” systems. They are not wye connected and cannot be used with a Cat UPS without an upstream isolation transformer. Wild leg and corner grounded systems are shown in Figure 3.

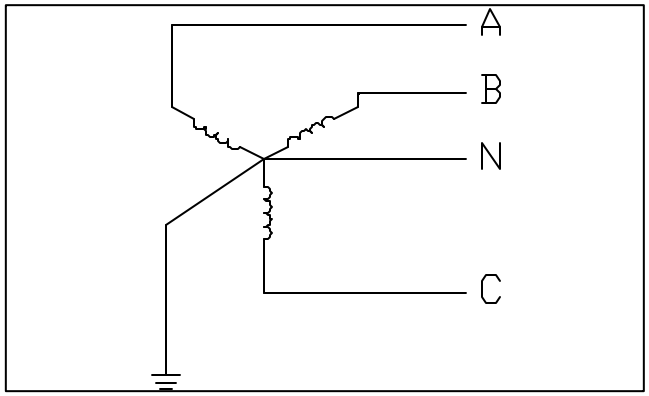

Fig 2: 4 Wire Wye Connected with Solid Ground

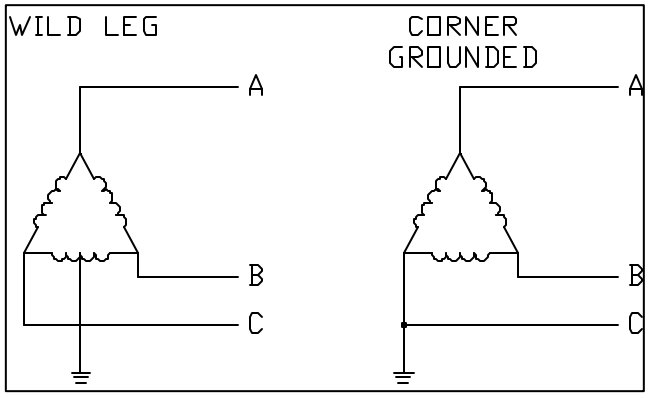

Fig: 2 Incompatible Grounding Configurations

Impedance grounded systems have a resistor between the neutral point of the source and ground. The idea is to limit the current of a ground fault to a low value, typically less than 10 amps, so that a ground fault can be indicated and located, but the system can continue to operate. **Neutrals are prohibited in impedance grounded systems**. Figure 4 illustrates an impedance grounded source (sometimes called high impedance grounded).

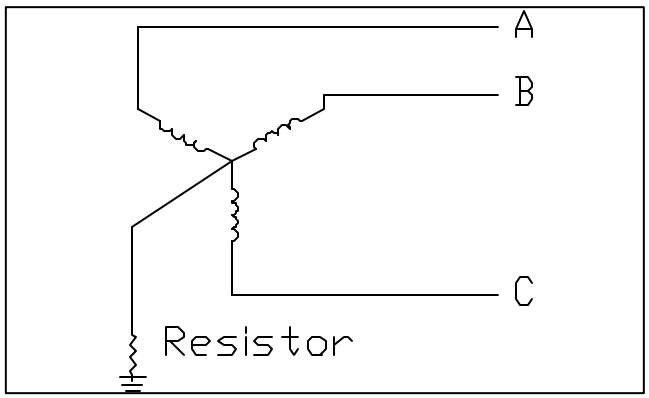

Fig 4: Impedance Grounded System

NORTH AMERICA

In North America, 480 volt systems are predominantly 3 wire solidly grounded. The loads are actually at 208/120V 3 phase, 4 wire and a transformer or power distribution unit (PDU) containing a transformer is normally installed down stream of the UPS to convert from 480V to 208V. In most cases the only loads that operate at 277V, the line to neutral voltage for 480V systems are fluorescent lighting. In most cases this voltage is derived using a 480V to 277V transformer because the loads are small compared to the other loads and it is cheaper to install lighting transformers than to run neutrals throughout the power system. Figure 5 shows a typical North American power system with conversion from 480V 3 wire to 208/120V 4 wire.

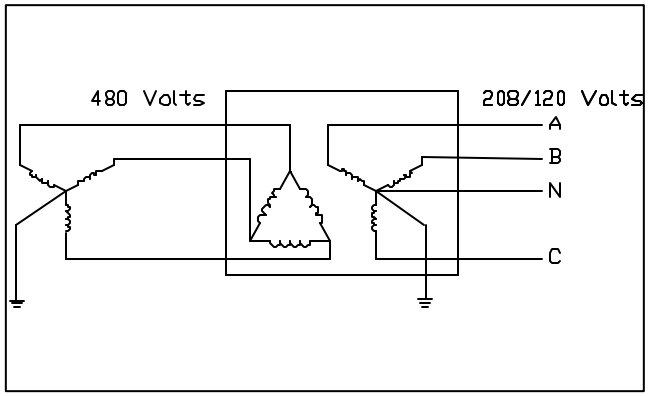

Fig 5: North American Power System

EUROPE AND OTHER 400V (ALSO 380V AND 415V) AREAS

In the parts of the world using 400V systems, the loads actually run on 400V 3 phase or 230V single phase power. Therefore, transformers are not used between the UPS and the loads. That means 4 wire electric distribution is almost universally used at this voltage level. 400V Power Systems look like Figure 2,

without intermediate transformation between the service entrance transformer and the loads.

Please remember that because of the bypass, UPS systems with 4 wire outputs must always have 4 wire inputs. Line interactive and standby UPS also need a neutral in 4 wire systems because the load is actually supplied by the input source of the UPS most of the time.

LINE INTERACTIVE VS DOUBLE CONVERSION AND STANDBY UPS
It is well known in the power industry that, except in certain special highly controlled situations, two wye transformer windings cannot be connected in parallel if their neutrals are connected, either directly or through ground. Large circulating currents will result from small differences in the transformers. Acceptable and bad source paralleling configurations are shown in Figure 6.

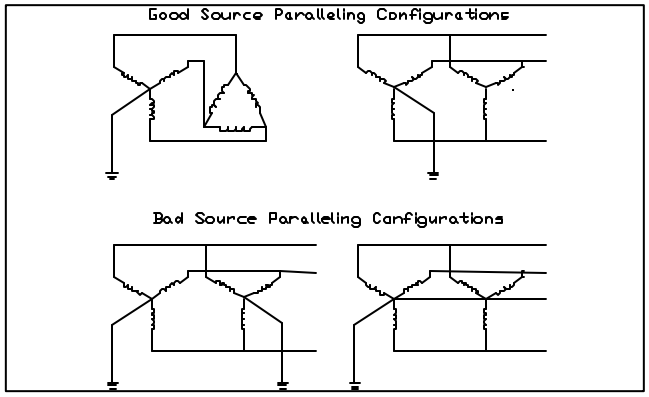

Fig 6: Good and Bad Source Paralleling

A double conversion UPS has no AC power connection between the inverter and the input source when the inverter is running. The DC bus separates them. That means the UPS can have a wye output, and its neutral can be either grounded (3 wire systems) or connected to the incoming neutral (4 wire systems). In a standby UPS such as the Cat Series 250 (our first Cat UPS product) We can also connect the output neutral to the incoming neutral because the inverter is running at low current when connected to the incoming power. This limits circulating currents to a very low level. Whenever the inverter is operating at high current, the UPS is disconnected from the incoming source and no circulating currents can flow.

A line interactive UPS is another story. The inverter operates at high current levels when connected to the utility. It normally supplies all of the reactive current for the load and whatever reactive current is needed to regulate voltage. The result is that the output of the inverter can only be connected to neutral when The UPS is disconnected from the input supply. It also means that in a 3 wire system the output of the UPS can't be solidly grounded because this is just like

connecting the neutrals together. The Cat UPS solves these issues using an innovative design. The Configuration for 3 wire systems is shown in Figure 7.

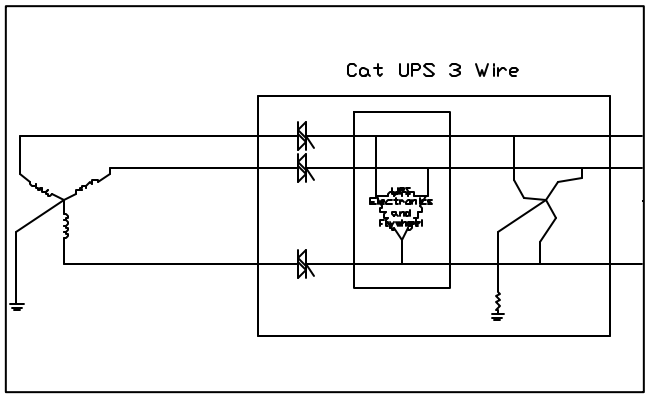

Fig 7: Cat 3 wire UPS

The resistor eliminates circulating currents during normal operation and keeps the output ground referenced during discharge. This configuration is solidly grounded during normal operation and impedance grounded during discharge. If we detect a low impedance ground fault condition during discharge, the UPS will shut down without being subjected to high fault currents. The grounding transformer is very small because the resistor limits current through the transformer to less than 10 amps under fault conditions. This solution keeps our efficiency high, eliminates high current stress on the UPS from ground faults, and requires no additional footprint and very little additional weight.

Figure 8 shows our optional configuration for 4 wire systems. The neutral is supplied from the source to the load, as in all 4 wire UPS. The difference is that when we disconnect from utility we must connect the neutral of the UPS Inverter to the Utility neutral to provide a complete circuit for single phase loads. This is the essentially the same thing as 4 wire switching which is used extensively in Europe between generators and utility. The Neutral is 2X rated. This requires a much larger grounding transformer than for the 3 wire system but it is still small compared to normal transformers because it only has to handle the neutral current for short periods of time. This will not increase the foot print of Multi-module systems and we estimate that it will also fit in the existing 300 kVA enclosure.

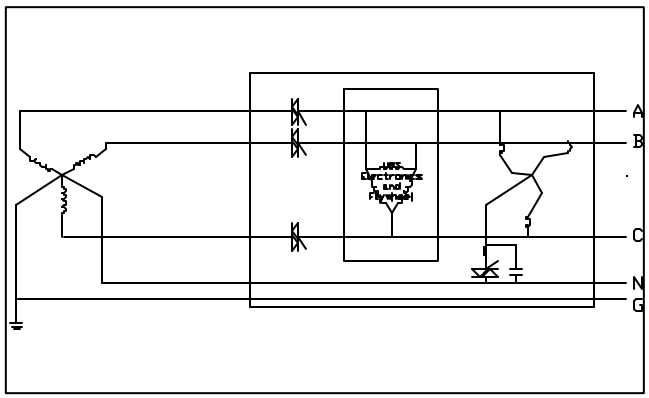

Fig 8: Cat 4 Wire UPS