



TECHNICAL NOTE ONE

The HRT and How it Removes The 3rd Harmonic Neutral Current.

The Problem

In theory balanced 3 phase loads should have zero neutral current: however this is only the case with linear loads (loads that draw a current proportional to the supply voltage sinewave). Over the last 10 to 15 years, due mainly to the proliferation of computers, microprocessor systems and power electronics the majority of loads are now non-linear.

These non-linear loads draw very large current pulses at the peak of the supply voltage and contain mainly third harmonic components. When these loads are spread over the three phase supplies the currents in each load add instead of subtracting in the common neutral cable.

This 3rd harmonic neutral current, may exceed the line current by up to 180% and can be the most dangerous harmonic present in a building's wiring. High levels of 3rd harmonic currents have been shown to cause overheating of neutral cables, burnt out transformers, nuisance tripping of circuit breakers and computer crashes due to high N-E voltages.

The Solution

The 3rd harmonic rejection transformer (HRT) is an auto transformer that comprises of 6 identical windings (two per phase) connected such that the windings "zig" and "zag" from the common neutral to each line. Zero sequence currents such as the 3rd harmonic will normally add in the neutral conductor and circulate in the primary delta windings of any supply side 3 phase transformers. Through flux cancellation within each pair of windings, the HRT provides a lower impedance parallel path for these zero sequence currents to flow. This removes them from the supply side neutral and returns them back to the loads via the phase conductors. If measurements are made before and after the installation of an HRT the 3rd harmonic neutral currents between the HRT and the load could well increase by 10 to 15% but the input 3rd harmonic neutral current should show a reduction of between 40 and 80% depending on site configuration and supply impedance. To minimise the circuit





TECHNICAL NOTE ONE

If the site is made up of many separate computers and electronic loads the best approach that has been found to work is to fit a small HRT at each sub circuit. This will minimise the 3rd harmonic neutral currents present in the building and hence the supply voltage distortion due to volt drops along the neutral cable. The ground to neutral voltage will also be reduced at each computer load.

The negative side with this approach is the cost. Using one 400 Amp HRT will cost approximately 40% less than using, say, four separate 100 amp HRT units mounted close to the loads or sub circuits.

The HRT attracts the 3rd harmonics away from the supply source by having lower impedance than that of the supply at the 3rd harmonic. If the supply impedance is very low small three phase, low cost, AC reactors can be connected in the phase lines or the neutral to assist the HRT.

Another way to increase the supply impedance is to feed the HRT from the output of a K rated isolation transformer. These tend to be large and expensive compared to a 3 phase reactor.

There are cases however where the use of a K rated transformer and HRT are the best solution. These include:-

1. If the load is a mixture of variable speed drives (AC or DC) and single phase switched mode loads. (i.e. computers). In this case there will be very high levels of 3rd harmonic (phase to neutral) currents and 5th/7th (phase to phase) harmonic currents. The K rated transformers can be used to cancel the 5th and the 7th by phase shifting and the HRT used to reduce the 3rd harmonic (neutral) currents.
2. The K rated transformer can be used to step up or step down the supply voltage to allow for cable volt drops, equipment supply requirements or isolation (noise/spikes).

Typical field measurements carried out on the primary and secondary winding of an HRT transformer are listed in table 1.





TECHNICAL NOTE ONE

Table 1 Typical multi HRT site measurements.

HRT Position	Currents Before HRT's Installed				Currents After HRT's Installed			
	Red Phase	Yellow Phase	Blue Phase	Neutral	Red Phase	Yellow Phase	Blue Phase	Neutral
Main Riser 1	8.8A	23A	5.7A	23A	6.1A	21.5A	9.4A	18A
Main Riser 2	18A	17A	5.9A	20A	7.7A	10A	10A	13A
Main Riser 3	22A	35A	51A	46A	29A	32A	40A	11A
Distribution Unit 1	31A	33A	12A	45A	20A	29A	20A	17A
Distribution Unit 2	27A	29A	38A	43A	10A	22A	30A	24A
Distribution Unit 3	17A	14A	17A	16A	14A	15A	18A	9.5A
Distribution Unit 4	19A	1A	1A	19A	14A	7.5A	7A	8.5A
Main UPS	257A	185A	120A	213A	216A	172A	144A	63A

Notes

1. The above measurements were taken at a London Bank with five floors of computer systems.
2. In all cases the 3rd harmonic neutral current was substantially reduced even when the phase currents are unbalanced.
3. The total voltage harmonic distortion was reduced from over 9% to less than 3%.
4. The UPS 3rd harmonic neutral current has been reduced from 213A to 63A, the complete site is running cooler, and the phase balance and power factor have been improved.

