What is the input total harmonic distortion for your battery charger?

By William K. Bennett

Electronic equipment that contains switching elements can generate harmonic distortion that is reflected back onto the ac supply lines in a building or facility. This is true, for example, of computer power supplies, and also of SCR phase-controlled battery chargers. Harmonic distortion refers to currents and voltages flowing in the ac wiring that are multiples of the normal line frequency (50 or 60 Hz) - for example, 120 Hz (second harmonic, 2 x 60 Hz) or 180 Hz (third harmonic, 3 x 60 Hz). Like freeloading relatives, these harmonic currents don't do any work, but they can cause extra stress.

When the switching components in these types of equipment turn on and off, ac current harmonics are generated within the equipment. The *current harmonics* are translated into *voltage harmonics* by the impedance of the ac wiring connecting the equipment to the ac supply. The higher the impedance of the supply wiring, the higher the *voltage* harmonic distortion will be. The *voltage harmonic distortion* can be a problem if it creates extra heating in transformers and in the power supplies of other connected equipment.

Most equipment that operates on the ac supply can tolerate up to 5% voltage THD (total harmonic distortion) without difficulty. In most industrial installations, the supply wiring has a low enough impedance so that the voltage THD generated by a battery charger doesn't approach the 5% value. This is true even for the 3-pulse SCR/SCRF product.

The table below presents the worst-case "textbook" values for current harmonic distortion for the types of rectifier circuits used in phase-controlled battery chargers. These numbers are for rectifiers operating at full resistive load, with no battery and no series inductor (L1). At other than full load, the harmonic content varies, in a predictable but complex manner. The table totals the harmonics through the 13th harmonic; higher harmonics are very small contributors. The last two columns show the lowest harmonic component, which is usually the major contributor to distortion. Remember that these harmonic currents usually result in less than 5% total *voltage* harmonic distortion.

The good news is that the presence of the charger main inductor (L1) reduces harmonic currents, and the harmonics are often lower than the textbook values. It's impossible to predict exactly what the harmonic content for any charger will be, because the exact load conditions and operating point are unknown. For this reason, we show the maximum theoretical numbers in the table. The 3-pulse design (SCR/SCRF) is the worst offender for input harmonic currents; if input harmonics are a sensitive issue, specify the AT30 series. Where available, the table also shows typical test results for a charger at full load.

MODEL	MAXIMUM CURRENT THD @ FULL LOAD	TYPICAL THD @ FULL LOAD	PRINCIPLE HARMONIC	
			NUMBER	PERCENT
SCR/SCRF 3 Phase	64%	54%	2nd	50%
AT Series 3 Phase	28%		5th	20%
All Single Phase	43%	25%	3rd	33%

Table data from harms_2.xls