



**Document Reference: AN060019VS1**

## **Understanding Percent Impedance**

### **Required Equipment:**

Baldor VS1 & H2 Series AC drives and reactors

### **Introduction:**

Drives use semiconductor devices for electrical power conversion. These devices are sensitive to power surges, voltage spikes, current surges, line distortion and power anomalies, all of which may have detrimental effects on semiconductor device operation. Line inductance reduces power surges. Inductive power circuit components such as reactors, inductors, chokes and transformers reduce rate of current change in the circuit and are used to “condition” power circuit. Inductance is often expressed in value of “percent impedance”.

### **Definition:**

Percent Impedance or Percent IZ (%IZ) is the voltage drop due to impedance, at rated current, expressed in a percent of the rated voltage.

### **Discussion:**

Baldor drives require certain line impedance for three important reasons:

1. Minimum inductance is necessary for proper commutation of semiconductor devices.
2. Line inductance reduces power sub-transient and transient surges.
3. Impedance reduces available short circuit current in case of malfunction.

Drives Installation and Operation Manuals list necessary minimum impedance and short circuit ratings. What do these impedance percentages really mean? As stated in the above definition, percent impedance is always expressed at rated base current. It is very important to understand that recommended percent impedance is based on drive full load current rating and not the reactor, transformer, or other device current rating.

Here are few examples:

A. 10HP, 460V, 14A, Baldor VS1SP410-1B inverter drive requires 1% impedance and is rated for 5kA short circuit current. That means that line voltage drop at current level at 14A should be at 4.6V.

B. 10HP, 460V, 18A, Baldor line reactor LRAC01802 with 3 % impedance will have 13.8V voltage drop when conducting 18A.

C. 100kVA, 460V, 125A, power distribution transformer with 5% impedance and serving several drives will have 5% or 23V drop at full load of 125A.

### **Calculating line impedance**

The purpose of these examples is to illustrate the importance that percent impedance in drives application must be evaluated on drive current rating base. Lets us further examine the above examples. Let us assume that the 10HP, 460V, 14A drive above is the only load on this 100kVA transformer. How much will voltage drop on the transformer when transformer is loaded only with 14A of drive's current? In order to calculate this drop we use the simple ratio formula. If 125A drops 23V, then 14A will drop  $14A/125A * 23V$  or 2.6V. This value 2.6V is less then recommended drive input line impedance voltage drop of 4.6V. The conclusion is that 5% impedance 100kVA transformer does not meet the requirement of 1% impedance for 10HP drive.

### **Evaluating short circuit impedance**

Power source impedance is also an easy way to evaluate available short circuit rating. In the above example, we have discussed the VS1, 10HP, 460V drive which has listed short circuit rating of 5,000A symmetrical RMS (root means square) current. Let us conduct a simple short circuit study. Let us assume that 100kVA transformer has unlimited power available from the utility on the primary side (which is mostly a case in short circuit studies) and let us assume that there are no rotating motors on this power system to contribute to short circuit level (which is not a case in most short studies). In this circuit with the assumptions made, the phase to phase of short circuit in the drive, at the simplest calculation will be full load current divided by percent impedance or  $125A/.05=2500A$ . The available short circuit current is less then drive listed short circuit rating. There is no reason for concern. Now let us look at 200kVA, 250A, transformer with 4% impedance. Short circuit current on the drive feed from this transformer would be 6.3kA, more then drive short circuit rating. Installing this 10HP drive on 200kVA transformer possibly compromises drive short circuit rating and increases the possibility of drive failure.