Measure Power In 3-Phase Systems

Use A DSO To Measure Power In 3 Wire, 3-Phase Systems

The power dissipated in a 3wire, 3-phase load can be determined using a LeCroy 4 channel oscilloscope by measuring two phase currents and two line voltages. For example, looking at the schematic in figure 1, the total power dissipated in a 3 –phase motor can be determined by measuring V_{AC}, V_{BC}, I_A and I_B.

$$\mathbf{P_T\ (t) = v_{AC}(t)\ i_A(t) + v_{BC}(t)\ i_B(t)}$$

This can be verified using the following mathematical derivation:

$$\mathbf{P_T = v_{AN}(t)\ i_A(t) + v_{CN}(t)\ i_C(t) + v_{BN}(t)\ i_B(t)}$$

but, using Kirchoff's current law;

$$\mathbf{i_A+i_B+i_C = 0} \quad \text{or} \quad \mathbf{+i_C = - i_A - i_B}$$

$$\mathbf{P_T(t) = v_{AN}(t)\ i_A(t) - v_{CN}(t)\ i_A(t) - v_{CN}(t)\ i_B(t) + v_{BN}(t)\ \ i_B(t)}$$

$$\mathbf{P_T\ (t)\ = v_{AC}(t)\ i_A(t) + v_{BC}(t)\ i_B(t)}$$

The line voltages, $v_{AC}(t)$ and $v_{BC}(t)$ are measured using a differential probes. The phase currents, i_A and i_B, are measured using current probes. This requires an oscilloscope with 4 input channels.

Each product term for the total instantaneous power is computed using waveform math. The average power can be determined by using the measurement parameter, mean, to take the average value of each product term. The sum of the mean parameters is the total average power dissipated by the 3-phase motor. Note that this works only for a 3 wire connection. The neutral or center tap (CT) can be connected as long as no current flows through that connection.

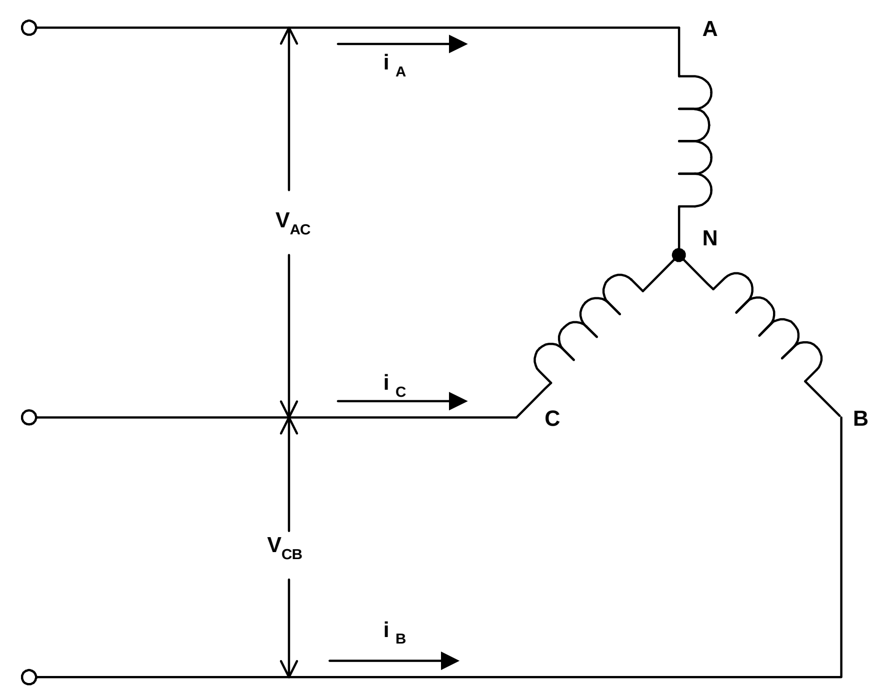

Figure 1 – Measuring power in a 3 wire, 3-phase load using 2 current and 2 voltage waveforms

Figure 2 shows a power measurement for a 3-phase permanent magnet (PM) motor for a hard disk drive. The motor was configured in a WYE connection but the center tap carried no current. The top trace, channel 1, is the line voltage, $\mathbf{v_{AC}(t)}$**,** the next trace down, channel 3, is the phase current, $\mathbf{i_A(t)}$, channel 2 is the line voltage, $\mathbf{v_{BC}(t)}$, and channel 4 is the phase current, **)** $\mathbf{i_B(t)}$.

The product terms are calculated in traces A and B. These traces represent the instantaneous line power. Trace C is the total power, calculated as the sum of traces A and B,

Note that the measurement parameter, MEAN, computes the average value of the source

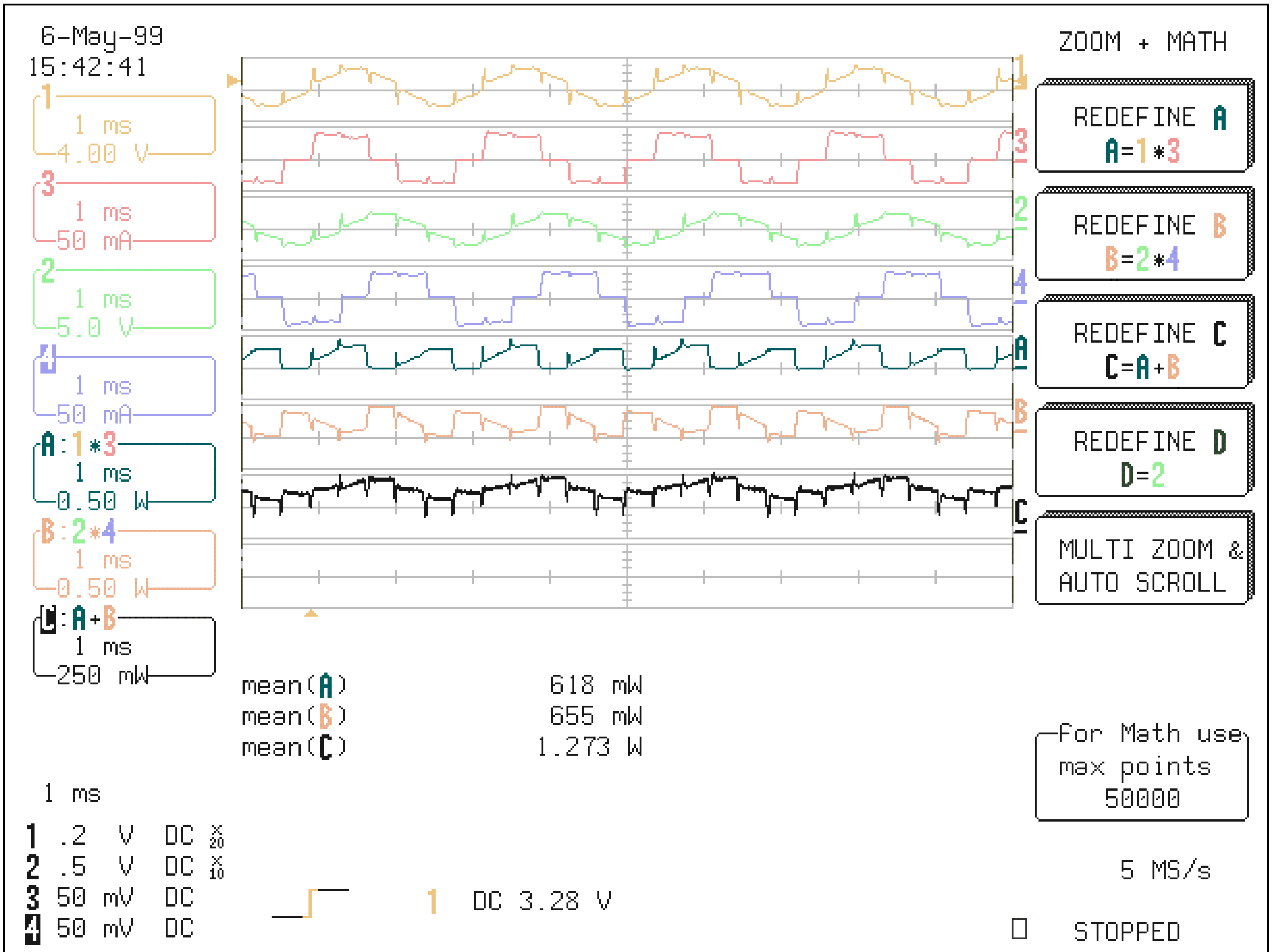

Figure 2 – Power measurement for a 3-phase permanent magnet motor in a hard disk drive.

waveform. In this example the average power of traces A, B, and C is being read using the parameter and appear below the waveform display. The total power was measured as 1.273 Watts.

The measurement of the line voltages was made using 2 LeCroy AP030, 15 MHz differential probes. Phase currents were measured using 2 LeCroy, AP015 50MHz, DC current probes.

The measurement was confirmed by measuring the individual phase voltages and currents, as described in the second equation presented on page 1. These measurements were made individually with the motor running under identical conditions. The total power using this technique was measured to be 1.288 Watts.

The ability to measure the power dissipation in a 3 phase motor with 2 voltage and 2 current measurements allows a 4 channel oscilloscope to be used in a single pass measurement. Another key to this measurement is LeCroy's ability chain multiple math operations together.