Power Factor and Phase Angle Errors

Measuring loads with high power factors (0.8 to 1.0) is generally more accurate than measuring loads with low power factors (below 0.5). In general, the lower the power factor, the greater the error caused by **phase angle errors** in the current transformer or the WattNode.

Computing Error

First, we need an equation to compute the power measurement error as a function of the **power factor** and the **phase angle error**.

- **Phase Angle** - th
- **Power Factor** - PF - Ratio of real to apparent power. This is the same as cos(th), where **th** is the phase angle between voltage and current.
- **Phase Angle Error** - E
- **Actual Power** - P = V * I * cos(th) = P * I * PF
- **Measured Power** - Pm = V * I * cos(th + E)
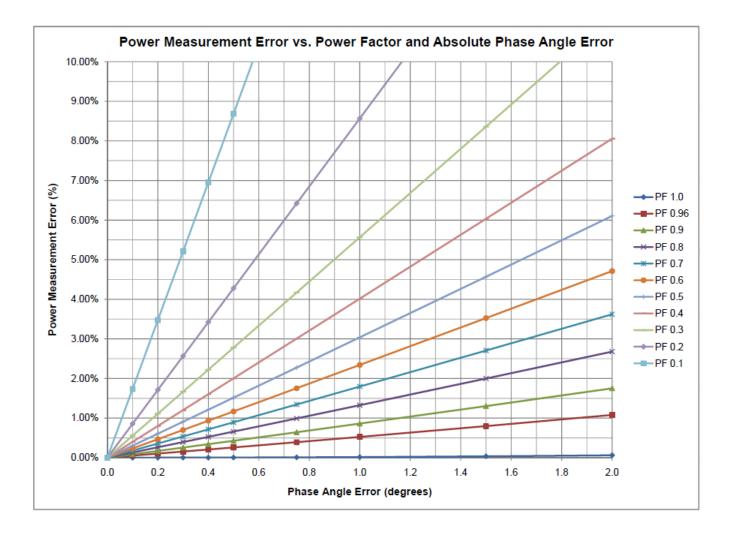- **Power Error Percent** - Perr% = 100 * (Pm - P) / P
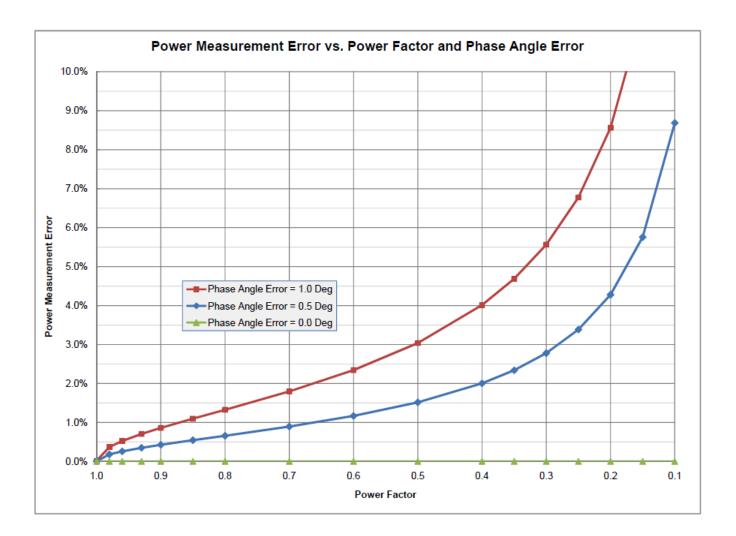
Trigonometric Identities Used:

- tan(a) = sin(a) / cos(a)
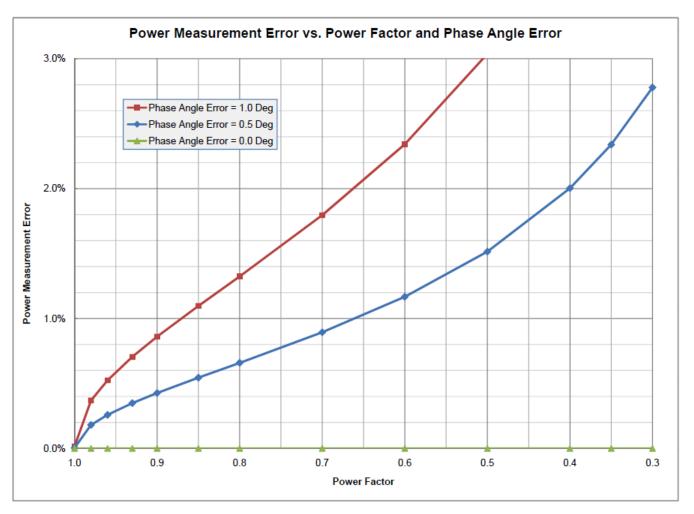- cos(a + b) = cos(a) * cos(b) - sin(a) * sin(b)

Solving for **Perr%**:

```
Perr% = 100 * (Pm - P) / P

              V * I * cos(th+E) - V * I * cos(th)
Perr% = 100 * ----------------------------------
                     V * I * cos(th)

 ( divide all terms by V * I )

              cos(th+E) - cos(th)
Perr% = 100 * -------------------
                    cos(th)

 ( expand cos(th+E) )

              cos(th)*cos(E) - sin(th)*sin(E) - cos(th)
Perr% = 100 * -----------------------------------------
                            cos(th)

 ( divide all terms by cos(th), use tan(th) = sin(th) / cos(th) )

Perr% = 100 * (cos(E) - tan(th)*sin(E) - 1)
```

Note: we have assumed that the phase angle error adds to the phase angle - for analysis purposes, we should determine if the error is larger when positive or negative.

Plugging this result into the Excel spreadsheet above and graphing results in:

Power Measurement Error vs. Power Factor and Absolute Phase Angle Error

Power Measurement Error vs. Power Factor and Phase Angle Error

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