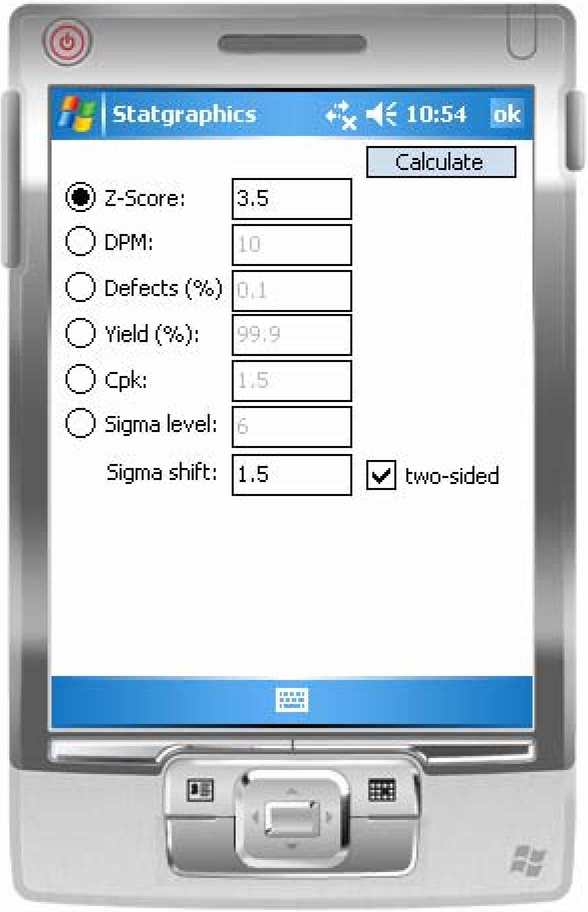
Six Sigma Calculator

The *Tools* menu provides access to a *Six Sigma Calculator*. The calculator facilitates the conversion between different metrics used in *Six Sigma* quality improvement projects. It is controlled by the following dialog box:



To use the calculator, select one of the six radio buttons, enter a value in the corresponding edit field, and press the *Calculate* button. The corresponding values of the other quality performance metrics will be displayed to the right of the edit fields.

The important input fields on the calculator are:

- **Sigma shift**: a multiple Δ by which the process mean is assumed to shift over time above and below its long-term mean.

- **Two-sided**: whether to calculate two-sided probabilities. This box should be checked if the process has both upper and lower specification limits that are located at equal distances from the process mean. Note: for asymmetrically placed upper and lower limits, treat the process as having two one-sided limits and combine the results.

As an example, suppose a process creates widgets with a mean length of $\mu = 10.5$ cm and a standard deviation of $\sigma = 0.02$ cm. Suppose also that the specification limits are 10.5 ± 0.1 cm. Assume that the process shifts from its long-term mean by as much as $\Delta = 1.5$ times σ over a long period of time, ranging between 10.47 and 10.53.

Assuming the worst possible scenario, the distance from the process mean to the specification limits may be as small as 3.5σ. This corresponds to a Z-score of

$$Z = \frac{USL - \mu}{\sigma} - \Delta = \frac{10.6 - 10.5}{0.02} - 1.5 = 3.5 \quad (1)$$

Entering *3.5* into the *Z-Score* input field, selecting *two-sided*, and pressing *Calculate* generates the following results:

The results displayed are:

- **Z-Score**: the number of standard deviations *Z* between the process mean and the specification limit or limits.

- **DPM (defects per million):** the average number of widgets out of every million that are expected to be outside of the specification limits. If *p(d)* is the proportion of defective widgets, then

$$DPM = 1{,}000{,}000\ p(d) \qquad (2)$$

- **Defects (%):** the average percent of the widgets that are expected to be outside of the specification limits, calculated from

$$Defects\ (\%) = 100\ p(d)\ \% \qquad (3)$$

- **Yield (%):** the average percent of the widgets that are expected to be within the specification limits, equal to

$$Yield\ (\%) = 100\ (1 - p(d))\% \qquad (4)$$

- **Cpk:** the one-sided capability index, calculated from

$$Cpk = \frac{USL - \mu}{3\sigma} = \frac{Z}{3} \qquad (5)$$

- **Sigma level:** the process sigma level, calculated from

$$Sigma\ level = Z + \Delta \qquad (6)$$

In the example, the process would be estimated to generate approximately 233 defects out of every million produced, which equates to a *Sigma Level* of 5.0.

Calculations

Percent Defective

One-sided

$$p(d) = 1 - \Phi(Z) \tag{7}$$

Two-sided

$$p(d) = 1 - \Phi(Z) + \Phi(-Z - 2\Delta) \tag{8}$$

where $\Phi(Z)$ is the standard normal cumulative distribution function.

Z-Score

One-Sided

$$Z = \Phi^{-1}\left(1 - p(d)\right) \tag{9}$$

Two-sided

Solve (8) numerically for *Z* given *p(d)*.