

# Computation of Cross-Axis Tilts

## 900 Series Biaxial Clinometers

### Tech Note

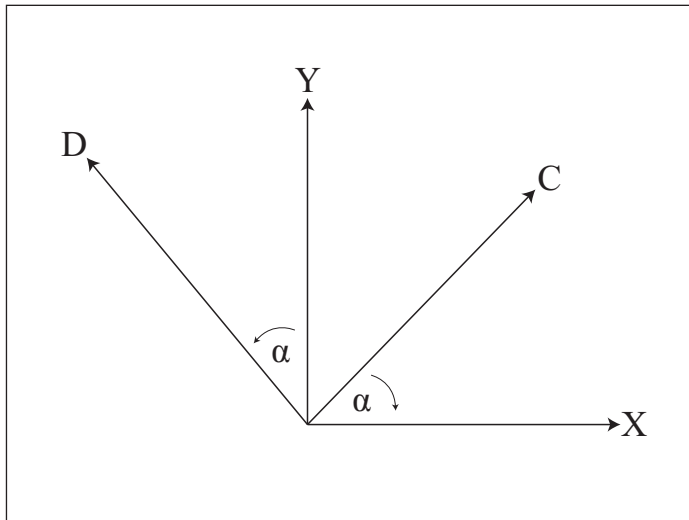


Figure 1. Plan View.

#### Assumptions

1. Planes XY and CD are initially horizontal.
2. Scale factors,  $S_x$  and  $S_y$ , for rotations in vertical planes parallel to X and Y directions are given.
3. Voltage outputs of X and Y channels,  $V_x$  and  $V_y$ , are: measured voltages minus bias (see below).
4. Bias voltages,  $B_x$  and  $B_y$ , have been measured. Bias voltages are the tiltmeter's X and Y outputs when it is perfectly horizontal. See Technical Note A-98-1004 for a detailed explanation.

#### Problem

1. Rotation occurs in a vertical plane parallel to direction C.
2. Find angle  $\alpha$ , which defines C direction.
3. Find amplitude of rotation,  $\theta_c$ .

#### Solution

For rotation in the X or Y directions, rotation amplitude is given by

$\theta_x = S_x V_x$  and  $\theta_y = S_y V_y$ , where  $S_x$  and  $S_y$  are the scale factors given in the user's manual or calibration certificate.

For rotation in the C direction we define new scale factors:

$$S_c' = S_x / \cos \alpha \quad \text{and} \quad S_c'' = S_y / \cos (90^\circ - \alpha)$$

The rotation amplitude in the C direction then becomes:

$$\theta_c = S_c' V_x = (S_x / \cos \alpha) (V_x) \quad [1]$$

$$\theta_c = S_c'' V_y = [S_y / \cos (90^\circ - \alpha)] (V_y) \quad [2]$$

Equating [1] and [2] and solving gives:

$$\frac{S_x V_x}{\cos \alpha} = \frac{S_y V_y}{\cos (90^\circ - \alpha)}$$

$$\frac{S_x V_x}{S_y V_y} = \frac{\cos \alpha}{\cos (90^\circ - \alpha)} = \frac{1}{\tan \alpha}$$

$$\alpha = \tan^{-1} \left[ \frac{S_y V_y}{S_x V_x} \right] \quad [3]$$

Substituting  $\alpha$  in equation [1] or [2] along with the known values of  $S_x$  and  $V_x$ , or  $S_y$  and  $V_y$ , gives the rotation angle,  $\theta_c$ .

#### Summary: Steps in Measuring Cross-Axis Tilt Angle, $\theta_c$

1. Measure bias voltages,  $B_x$  and  $B_y$ , on both tilt channels.
2. Subtract  $B_x$  and  $B_y$  from measured voltages to obtain corrected outputs  $V_x$  and  $V_y$  for use in eqns. [1] through [3].
3. Compute  $\alpha$  from equation [3] using known scale factors  $S_x$  and  $S_y$ .
4. Compute  $\theta_c$  from equation [1] or [2].