## Digital Angular Measurement

Place the instrument on a tripod, level the bulbs and push the button and the display shows the present angles $\mathrm{H}+\mathrm{V}$. Angle measurement: <i>l know what it is, I know what it does, but how does it work? <<i>

Up until a few decades ago surveyors had to rely on optical-mechanical components for accurate measurement of horizontal and vertical angles. Glass circles were divided by thin marks, a nonius unit made possible interpolation for improved accuracy and small mirrors brought the necessary daylight into the heart of the instrument. The operation of such instruments required specialised knowledge and computations such as corrections had to be done externally, following tedious procedures. In todayâ $€^{\mathrm{TM}}$ s instruments all optics are replaced by electronic components that allow the user to make measurements quickly and easily, whilst computations are done by microprocessor. Of the original system, only the glass circle remains. However, the marks are engraved as black/white blocks read out by CCD array. Controlled by microprocessor and using image-processing and pattern-recognition methods, the angles are recorded as digital data and visualised on a LCD (Liquid Crystal Display) screen, fed into a data logger or transmitted to a processing unit. The size of the black/white blocks is the same everywhere along the circle, and today the angle is usually measured by counting the number of black/white transitions (incremental method).

The way in which the glass circle is divided into black/white blocks is not completely standardised and depends on the manufacturer. One Leica system, for example, has 1,152 engraved marks encoded into 128 sectors, every sector consisting of one sector mark and seven identification marks with binary encoding from 0000000 to 1111111 and one parity mark. To count the number of black/white transitions, about $1 \%$ ( $=4 \mathrm{gon}$ ) of the circle is covered by the CCD array. Using red light from LED (Light Emitting Diode) and a mirror, the marks are projected onto the CCD linear array. To ensure uniform illumination the LED is mounted in a ball-centred receptacle that allows for tilting and displacement. The CCD linear array consists of 128 pixels arranged linearly along a length of 3.2 mm . The control logic is timed by three commands generated by the microprocessor: the first starts the reading from the CCD array, the second orders the CCD array to switch from one pixel to the next, and the third ensures that each pixel is read out from the preamplifier. Preamplifier output (128 different voltages, depending on pixel amplitude) is measured and transmitted to the microprocessor for additional calculations.

Read out takes approximately 3 ms , and integration time (the time during which the CCD array is â€ loadedâ $€^{\mathrm{TM}}$ with photons) is approximately 2 ms . The integration time determines how many photons charge the CCD. The difference between the horizontal and vertical measuring system acts as a compensating mechanism in the optical path of the vertical-angle measurement system. Neither in the vertical nor in the horizontal measuring system are the electronic parts moved relatively to the alidade, so that all electronics are fixed to it. The Vertical and Horizontal array boards have the same circuitry but different packaging.

Thanks are due to Leica and Topcon for providing information and illustrations.

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[^0]:    https://www.gim-international.com/content/article/digital-angular-measurement

