TECHNIC INC
47 Molter Street
Cranston, Rhode Island 02910-1032
401-781-6100 • info@technic.com • www.technic.com

Specification for Bar Code Symbols on Electrodeposits

(Excerpted and adapted from "Elements of a Bar Code System" Agilent Technologies Application Note 1013)

A bar code system is comprised of six major elements; symbology, media, printer, operator, scanner, and decoder. Successful implementation of a bar code system requires a thorough understanding of the interaction of the system elements and careful consideration in the selection of the system elements. Although there are a variety of bar code symbology structures, they share basic requirements and technology. The binary data is encoded by the reflectivity of the bars and spaces. Here the logic zero data is presented as a reflective surface and the logic one data is presented as a non reflective surface. The bar code is scanned by moving a small spot of light across the bars and spaces. The output signal of the scanner is determined by the difference in the reflectivity of the bars and spaces. The small size of the illuminated area makes the scanner much more sensitive to printing flaws than the naked eye. This places requirements on the printer tolerances and inking that are more stringent than those for printing human readable characters.

For the purpose of this discussion we will focus on the issues of primary concern and related to the media (substrate) and the printer interaction. The composition of the media (spaces) and ink (bars) is also important, as it will determine the contrast or difference in the reflectivity, between the bars and spaces at the wavelength of the scanner. An acceptable contrast must be planned into the system design to ensure the scanner will be able to differentiate between the bars and spaces. It is worthwhile noting that the contrast for the scanner may be very different than the contrast perceived by the human eye. A symbol clearly visible to the eye may be invisible to some scanners. This phenomenon precludes the use of traditional visual inspection as a means of estimating contrast for scanning systems.

Media Selection

Bar code symbols can be printed on a wide variety of media. The most commonly used media in industrial applications are adhesive labels, cards, and documents. Since the media is an optical storage device, optical characteristics should dominate the selection criteria. The most important optical specifications to consider are the surface reflectivity of the media at a specific optical wavelength and the radiation pattern. A third optical parameter to consider is transparency or translucency of the media. The final criterion for consideration is the durability of the media. These last two criteria are typically not variables in our application and will not be included in further analysis.

The surface reflectivity of the media is defined by the amount of light reflected when an optical emitter irradiates the media surface. Optimally, the media should reflect between 70% and 90% of the incident light. A white media is commonly used to achieve this high reflectivity over a wide range of wavelengths. Consequently, the media reflectivity is given as R_W. The optical pattern of light that leaves the media surface describes the reflected radiation pattern. A shiny or specular surface will result in a narrow radiation pattern whereas a dull or matte surface will provide a broad or diffuse pattern. Media which have a narrow radiation pattern should be avoided because this may cause operational problems for the scanner. Specifically, the intense reflected light at near perpendicular angles may saturate the scanner electronics while mirror-like reflection at large scan angles may provide little light back to the scanner, making the media look like a bar instead of a space. A dull, or matte surface is recommended to ensure a radiation pattern, which will be acceptable to the scanner over the range of scan angle.

A surface reflectivity meter can measure reflectivity and radiation pattern. Such instruments are manufactured by the Macbeth Division of EG&G and Photographic Sciences. Using optical reflective sensors manufactured by Agilent Technologies can create a lower cost solution to the reflectivity meter. Figure 11 shows a circuit that uses a HEDS-1000 reflective sensor, an operational amplifier, and a voltmeter to measure reflectivity at the 700 nm wavelength of the sensor. Note that 700 nm is the wavelength used by many visible red hand held scanners, including Agilent Technologies HEDS-30XX series of wands. A similar optical sensor with a near-infrared wavelength, compatible with Agilent Technologies HEDS-32XX high-resolution wands, is also available upon request.

The circuit described in Figure 11 converts the reflected 700 nm optical signal into a voltage that can be measured by the voltmeter. The system can be easily calibrated by using a well-specified diffuse optical reflector, such as Kodak 6080 reflective paint, to set a 0-1 V signal for 0-100% reflectivity. The calibration procedure begins by zeroing the meter when the sensor is not pointed toward a surface (zero reflectivity). The sensor is then placed at a distance of 4.27 mm from the Kodak 6080 painted surface and the gain control is adjusted to read 0.99 volts. Once calibrated, the meter will provide reflectivity measurements for any diffuse media. If a shiny media is used, the calibration procedure is invalidated as the reflected optical signal may exceed 100%.

The radiation pattern of the reflected light can also be determined using the meter presented in Figure 11. To accomplish this task, the surface should be placed perpendicular to the sensor at the distance, which results in the maximum reflected signal (approximately 4.27 mm). The surface plane of the media is then rotated about the axis perpendicular to the optical axis of the sensor, maintaining a constant distance between the sensor and the point at which the emitter is focused on the surface. As the surface is rotated through an arc, the variation in output signal versus angle of rotation will describe the radiation pattern.

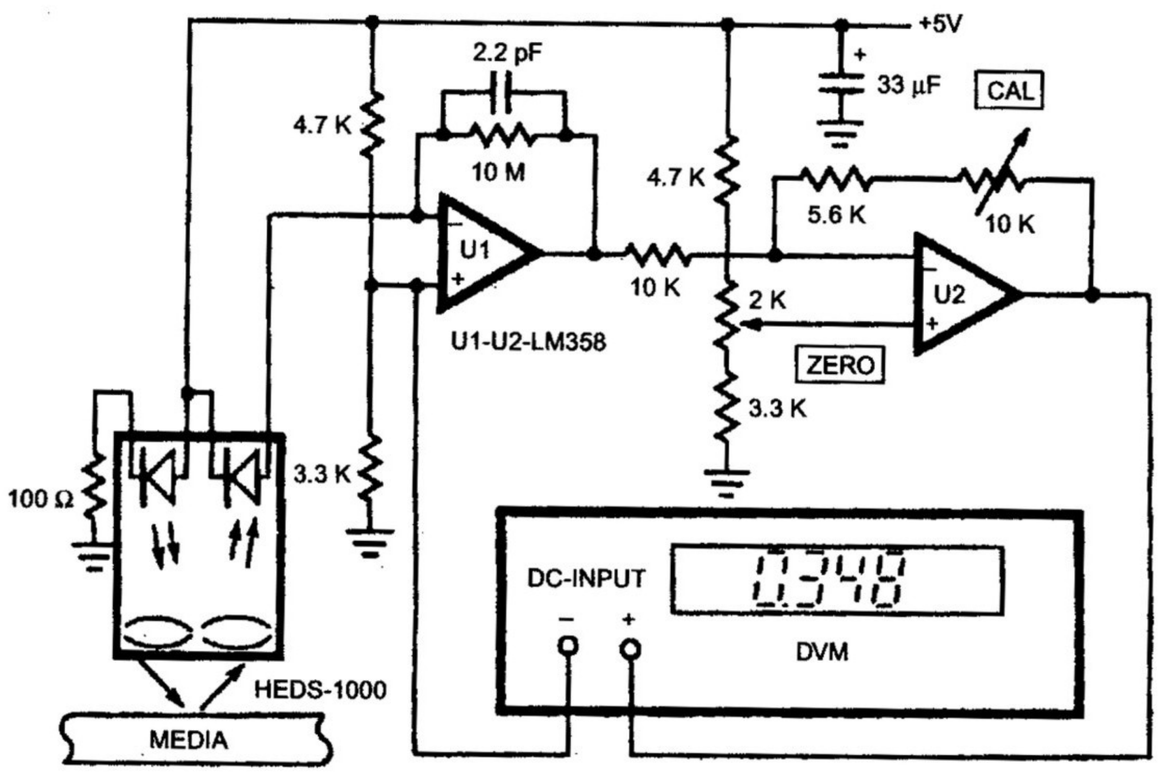

Figure 11. 700 nm Micro Reflectometer

Print Quality

The print mechanism, the ink and the media together determine the quality of the printed symbol. Assuming the printer is capable of the module resolution desired, the major factors influencing print quality are:

- Ink Spread/Shrink
- Ink Voids/Specks
- Ink Smearing
- Ink Non-uniformity
- Bar/Space Width Tolerances
- Edge Roughness

All of the above factors are potential sources of systematic errors that are constant from element-to-element and character-to-character and of random errors that are not constant. These errors must be closely controlled to ensure that the symbol will be easily scannable. It is particularly important to limit random errors as they contribute to invalid character decode resulting in a no-read fault.

Print Contrast

The ease of readability of a symbol is also influenced by the optical parameter referred to as print contrast. The output signal of the scanner is determined by the difference between the reflectivity of the bars (ink) and spaces (media). The interrelationship between the reflectivity of the media and the ink is referred to as the print contrast signal (PCS) and is defined as:

$$PCS = \frac{R_W - R_B}{R_W} \times 100\%$$

Where: R_W = reflectivity of the media (spaces) and
R_B = reflectivity of the ink (bars)

Good scannability of the bar code symbol is obtained when the PCS is greater than 70%. As stated in the media section, the minimum reflectivity of the media (R_W) should be 70%. If R_W is at the minimum recommended 70%, R_B must be less than 21% to achieve a PCS of 70%. Consequently, if $R_W > 70\%$ and $R_B < 21\%$ an adequate PCS will be certain. There are, of course, other combinations of R_W and R_B that will result in a PCS above 70%. It is apparent that either R_W or R_B must be controlled in order to provide an adequate PCS. Although media selection is very important, it is generally more practical to control the reflectivity of the ink.

As with any optical measurement of reflectivity, the value obtained for PCS is only valid for the wavelength specified. It is, therefore, important to measure PCS at a wavelength that is at, or near, the wavelength of the scanner being used. If the scanner has an infrared emitter, then carbon-based inks must be used to obtain adequate PCS. For dot matrix printers, OCR ribbons are recommended to achieve this contrast. Dye based black inks, on the other hand will provide adequate contrast for visible red and near-infrared emitters, but not for infrared emitters.
This information is provided as a general guideline and subject to onsite testing of specific equipment combinations. Test site evaluation is highly recommended to validate the performance of the entire bar code system chosen.