Use of USAF Resolution Targets

Introduction

The 1951 USAF resolution targets are commonly used to determine the limiting resolution of optical devices. The limiting resolution is the highest spatial frequency (density of lines) which can be seen using the system under a specific set of operating conditions.

Target Description

The pattern used in the USAF 1951 target consists of 3 dark lines against a light background (or sometimes vice versa). These patterns occur in pairs which have vertical and horizontal orientation of the three lines.

The pair of horizontal and vertical line patterns is called an element, and the elements are collected into groups. The groups are numbered, as are the elements within the group. A specific element is identified by stating the group number and the element number, eg. 3/2 indicates group 3, second element.

Group 0 element 1 has a spatial frequency of 1 cycle per millimetre, that is a dark and a light line in the target together have a width of 1 millimetre. The full width of the pattern for element 0/1 is therefore 2.5 mm.

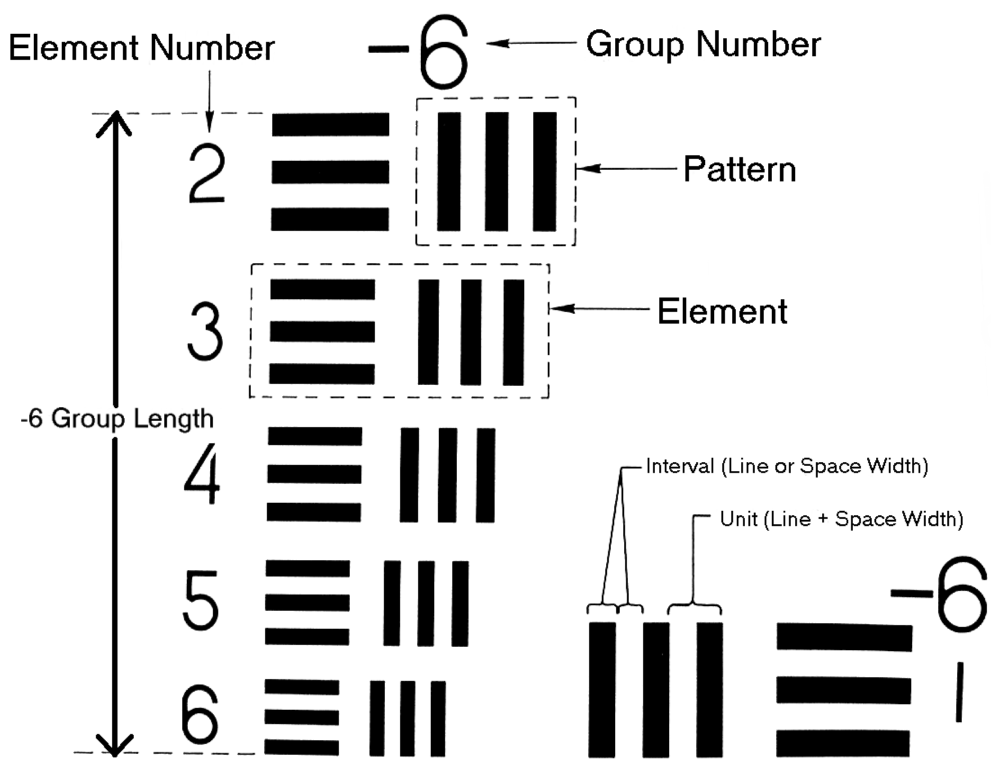

Figure 1 : Sample USAF 1951 Target Elements

The resolution of a particular element in line pairs per millimetre (or cycles per millimetre) can be computed using the following formula.

$$R = 2^{K + \frac{N-1}{6}}$$

where K is the group number and N is the element number. It is immediately evident from this formula, that group 0 element 1 has a spatial frequency of 1 cycle per millimetre. It is also evident that moving up a whole group implies an increase in spatial frequency of 2 times.

Contrast

The USAF 1951 printed targets are typically available in three contrast levels They are

- High Contrast – 100 : 1 (D = 2.00)
- Medium Contrast – 6.3 : 1 (D = 0.80)
- Low Contrast – 1.6 : 1 (D = 0.20)

The value of D is the density of the black portion of the target. The contrast ratios are the ratios of the reflectivity of the light part (typically background) of the target to the reflectivity of the dark part.

Target Applications

USAF 1951 targets can be used both in the field and in the laboratory. It is usually of interest to convert the spatial frequency of the target itself to a more meaningful value – either the spatial frequency in the image plane of the system under test, or the angular frequency in object space. When comparing a number of night vision devices for example, it is useful to use angular frequency (cycles per milliradian) as a measure of performance. On the other hand, if a system is to be compared with the theoretical performance predictions, it may be more useful to convert to spatial frequency in the image plane. Both conversions are very simple and can be performed as follows.

Conversion of Target Resolution to Image Resolution

$$R_I = \frac{R f_c}{f_o}$$

where R is the target resolution as computed above, R_I is the resolution in the image plane of the system under test, f_c is the focal length of the collimator used (substitute the target distance if a collimator was not used), and f_o is the focal length of the system under test.

Conversion of Target Resolution to Angular Resolution

$$R_A = R f_c$$

where R is as above, R_A is the angular resolution in object space and f_c is the focal length of the collimator used (again, substitute the target distance from the lens under test if a collimator was not used). To get the answer in cycles per milliradian, ensure that the resolution is in cycles per millimetre and the collimator focal length (or target distance is in metres).