Input paper: [[1]](#footnote-1) ENG4-9.12.3

Input paper for the following Committee(s): check as appropriate Purpose of paper:

**□** ARM **🗹** ENG **□** PAP **□** Input

**□** ENAV **□** VTS **🗹** Information

Agenda item [[2]](#footnote-2) 9

Technical Domain / Task Number 2 …………………………………

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An Alternative Implementation of Modified Allard Method

# Summary

The accepted way of calculating the effective intensity is to apply the Modified Allard Method to a dataset, and use its maximum value as the effective intensity of a flash. The method requires the use of a convolution method, which applies a function that represents the human visual system to the flash data in the time-domain.

The technique summarised below uses a Fast Fourier Transform (FFT) method of converting the signal and the human visual system response function to perform the equivalent to MAM in the frequency domain. The result is a much quicker calculation that is suitable for large datasets.

## Related documents

IALA Recommendation E-200-4 – Effective Intensity

# Background

The accepted way of calculating the effective intensity is to apply the Modified Allard Method (MAM) to a dataset, and use its maximum value as the effective intensity of a flash. The method requires the use of a convolution method, which applies a function that represents the human visual system to the flash data.

This method has been used for many years, but there is a known limitation which results in the calculation taking a very long time to complete for large datasets, This is problematic for practical purposes, and has, perhaps, limited the use of MAM more widely in the community.

With the use of PWM for LED light control, higher rates of data capture are required to ensure that flash profile is accurately captured. This creates a large body of data, even for short periods of measurement, that then require processing through MAM. The convolution method of MAM makes this slow and cumbersome.

# Frequency Domain Analysis

R&RNAV have recently been adopting a different approach to applying MAM to large datasets. The approach relies on the well-understood fact that convolution in the time-domain is equivalent to multiplication in the frequency domain.

## Summary of Technique

The technique requires the use of complex numbers, Fast Fourier Transform (FFT) and the inverse Fast Fourier Transform (IFFT). These functions are readily described in Digital Signal Processing (DSP) resources, and will not be described further here.

The steps to be taken are as follows:

1. Create and populate an array of values of q(t) that is the same length as that of the signal array.
2. Expand the signal and q(t) arrays so that their lengths are equal to the next highest value of 2N, where N is an integer. Fill the extra space with zeros.
3. Double the length of the signal and q(t) arrays, again filling the extra space with zeros.
4. The values of the signal and q(t) arrays will form the real parts of the imaginary numbers supplied to the FFT routine. The imaginary part are all set to zero.
5. Transform both the signal and q(t) imaginary numbers using FFT.
6. Perform an imaginary number multiplication on the results of the two FFT transformations.
7. Transform the imaginary number multiplication result using IFFT.
8. Using only the real part of the IFFT result, multiply the values by the sampling period.
9. The result is an array equal to the result of MAM. The maximum value is the effective intensity.

This process produces exactly the same result as that of the convolution process of MAM. This fact can be used to ensure that the technique has been implemented correctly.

# Performance

Despite the more complex method of preparing the data, transformations and multiplications, the technique has proved to be much faster than the convolution method with equal accuracy. As an example, using a 5,000-point dataset in Excel, an optimised MAM convolution routine took approximately 3.1 s to calculate the effective intensity. By applying the technique described above to the same data, the calculation took just 0.23 s. For an 80,000-point dataset, the above technique took just 4.5 s. The convolution method did not even finish!

Clearly, technique allows for much better handling of medium to large datasets, as can be generated with high sampling rates needed for accurately measuring lights using PWM.

# Action requested of the Committee

The Committee is requested to consider the technique for inclusion in the Guideline on calculating the effective intensity for flashing lights, ENG7-9.12.2.

1. Input document number, to be assigned by the Committee Secretary [↑](#footnote-ref-1)
2. Leave open if uncertain [↑](#footnote-ref-2)