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A MEASUREMENT OF THE FAST LUMINESCENT DECAYS OF THE MV-50 L.E.D.

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A MEASUREMENT OF THE FAST LUMINESCENT DECAYS OF THE MV-50 L.E.D.

John F. Sutton

ABSTRACT

The fast luminescent decay of the MV-50 GaAs-doped Si light emitting diode has been studied. The MV-50 provides a fast, inexpensive, bright and convenient light source for calibration of fast optical timing systems. A simple passive electronic module is described which allows driving the light source directly by a laboratory pulse generator.

A MEASUREMENT OF THE FAST LUMINESCENT DECAYS OF THE MV-50 L.E.D.

During fabrication and performance analysis of a delayed coincidence apparatus employed to study atomic decays, the need arose for a bright, reliable, inexpensive, and fast (~1 nsec. decay time) light source with known characteristics. Such a light source would be convenient for verifying linearity and risetime of the system. Attempts were made to use the brighter lines of neutral helium excited by a pulsed electron beam, but these attempts were abandoned because of insufficient brightness, insufficient speed, or both.

The Monsanto MV-50 light emitting diode (LED) seemed to show promise in fulfilling the requirements. It generates typically 2.57×10^3 cd/m^2 (750 ft.-L) illumination @6500Å with 20 ma. excitation current, has proved extremely rugged and reliable, and has a nominal decay time of ~1 nsec. In addition, the low price, 85¢, is attractive.

To determine the decay characteristics of the MV-50, ten units, representing at least two different manufacturing lots, were used in succession as the light source in a delayed coincidence apparatus. Each LED was mounted inside a BNC cable connector with three resistors in the circuit of Fig. 1. The resistors provide both attenuation and impedance matching to a 50 ohm coaxial cable so that the light source can be driven directly by a fast (0.3 nsec risetime) 10 volt pulse generator such as the E-H model 125A. The delayed coincidence apparatus employed[1] consists of a pulse generator, photomultiplier tube, constant fraction timing discriminator, time-to-pulse-height converter, and a multi-channel analyzer (MCA). This system is believed to have a timing linearity of $\lesssim 1\%$ and a full scale calibration accuracy of $\lesssim 1\%$.

Figure 2 is a typical curve obtained using the apparatus described above. It represents the decay of the LED light intensity as a function of time after cutoff of the excitation current. The initial curve rounding is due to convolution of the exponential with the transit time spread response curve of the PMT. The actual decay curve appears to be an almost pure exponential for approximately two decades, followed by an irregular shape, in qualitative agreement with the optical excitation measurements of Redfield, Wittke, and Pankove[2]. The mean of the measured decay times for ten LED's was 1.06 nsec., where the decay time is defined as the slope of the exponential portion of the decay curve. The maximum deviation from this value was ~43%, and the average deviation from the mean was ~13%.

The decay times were calculated by least squares fitting an exponential to the exponential portion of each of the LED decay curves. It was found, however, that a sum of two exponentials fit the data much better than did a single exponential. The mean of the measured values of the longer decay times was ~3.3 nsec., with a maximum deviation from the mean of ~48% and an average deviation of ~20%. The shorter lifetime was $\lesssim 0.71$ nsec. with a maximum deviation of ~13%, and an average deviation of only ~5.7%. Evidently the fast component varies very little from diode to diode compared with the variations in the values of the longer lifetimes and/or the relative magnitudes of the two components.

The excitation pulse width for all of the data runs was 8 nsec. Doubling the pulse width increased the peak brightness but had a smaller effect on the measured decay times than the unit-to-unit differences described above.

From the above data one may conclude that the unit-to-unit variations in the apparent single decay times of the MV-50 are great enough (up to ~43%) to preclude use as a precision, off the shelf time calibration reference. The significance of the very repeatable fast component obtained when the data are fit to two exponentials is hard to judge, for the theoretical details of the luminescence properties of GaAs-doped Si are not fully understood. The MV-50 does, however, provide a bright, fast, and convenient source of light with an almost exponential characteristic for approximately the first two decades of decay which can be used to check PMT transit time spreads and system linearities and to place an upper bound (of ~1.5 nsec.) on system risetimes.

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2. D. Redfield, J. P. Wittke, and J. I. Pankove, Phys. Rev. B, 2, 1830, (1970).

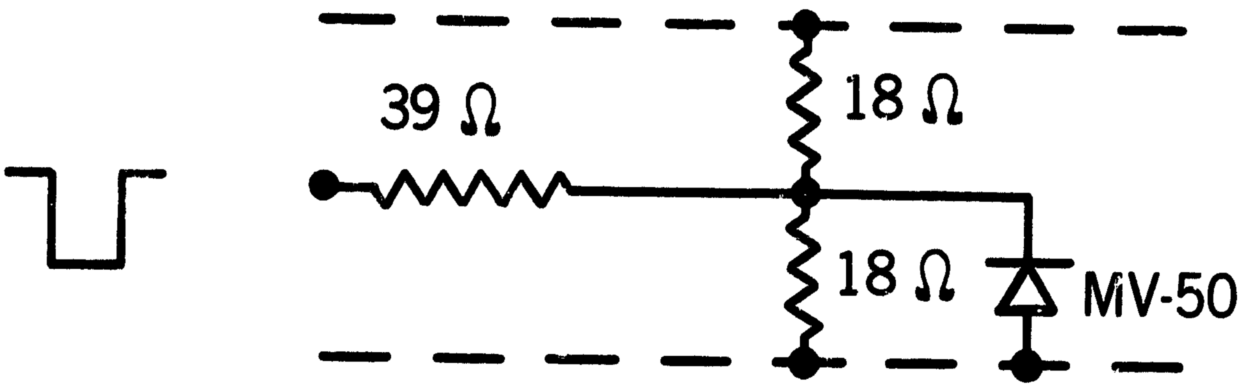

Figure 1. LED Assembly Schematic

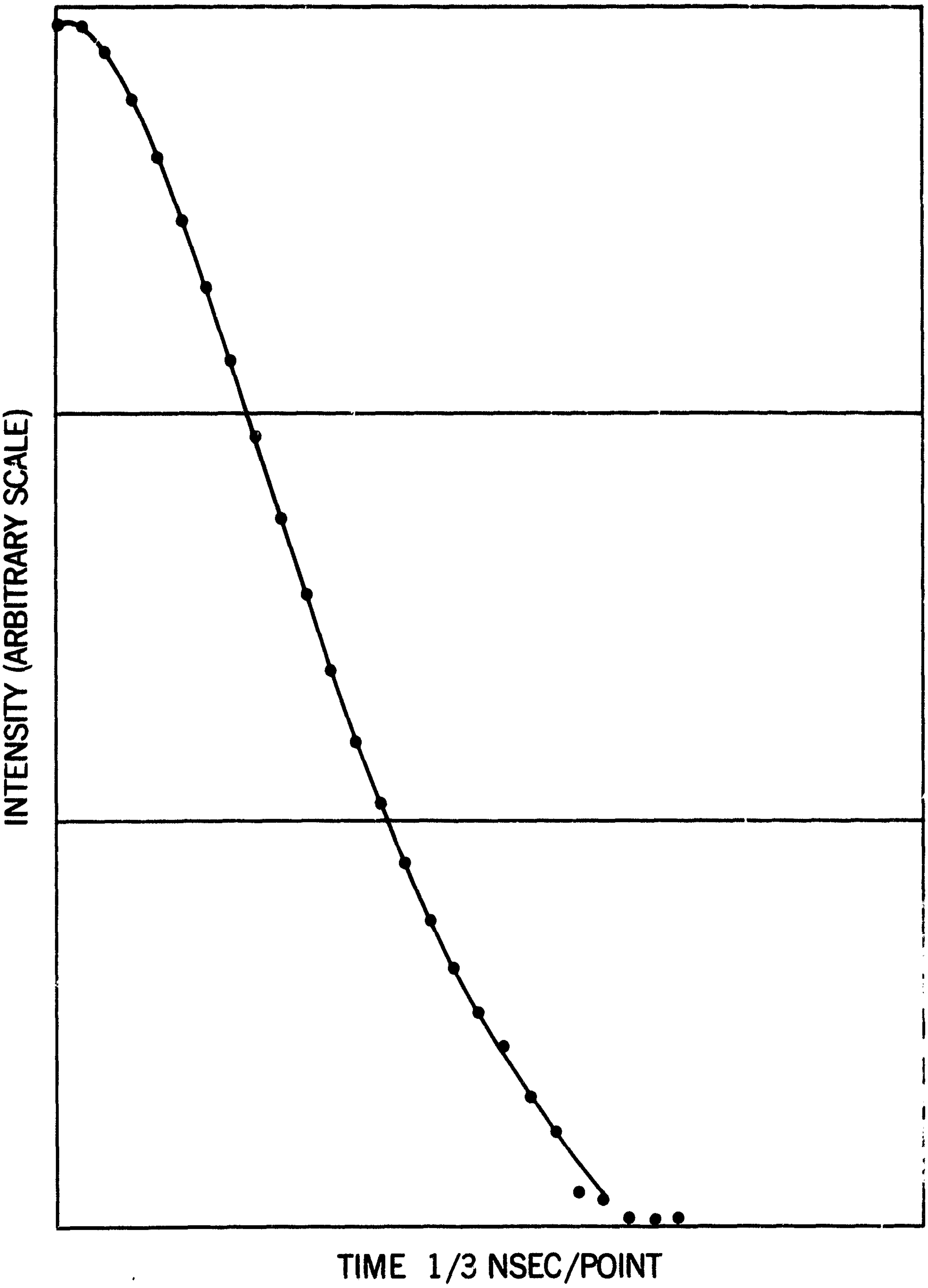

Figure 2. LED Luminescence Decay Curve
semilog scale