The following is a post from Michael Maytum dated 19 March 2008 on the IEEE SPD Committee Forum: **10/350: Marketing Ploy or Useful Test Waveshape.**

Analysis of Karl Berger's Direct Lightning findings

The reference of Cianos, N., and E. T. Pierce, "A Ground-Lightning Environment for Engineering Usage," Stanford Research Institute, Menlo Park, California, August 1972 often occurs in documents on direct lightning strikes. This document can be obtained from the National Technical Information Service (http://www.ntis.gov/). Professor M. A. Uman was involved and the work was carried out for Bell Telephone Laboratories and the U.S. Army Safeguard System Command. This comprehensive piece of work resulted in partial rejection of previously accepted values. Summarized below are the author's thoughts on Berger's earlier 1955, 1961 and 1969 work. "Positive currents get a special mention because of the widely held misconception that the current in positive strokes is usually of very high value. Examination of all Berger's data for positive currents shows there is an apparent separation into a large number of quite small currents and a few instances of high currents. Tall structures experience more positive flashes than does open ground and, the taller the structure, the greater the chance of high-current positive strokes. Thus, Berger's measurements made at a tall structure are likely to be especially misleading as regards positive flashes. Berger et al return stroke current waveform measurements have been widely quoted and used. However, many lightning experts have reservations as to measurement validity, particularly for the first stroke. Subsequent Fisher and Uman measurements appear to justify the mistrust of Berger's results. Optical observations on positive strokes show upward leaders of nearly I km in length. Such lengthy upward leaders from open ground seem unlikely. Thus, any application of the San Salvatore (Berger) results, on positive strokes, to normal lightning environments is dubious. Readers are encouraged to obtain a copy of the 156 page report to understand the contexts of these comments. Cianos and Pierce arrived at maximum lightning values of 250 kA peak, half value time 250 μs and 70 C - Table 3 page 59 (these values are not necessarily correlated). The applied severe three-stroke lightning model has peak currents of 200 kA, 100 kA, 100 kA, time to half value (all 3) = 40 μs, i^2.t = 1.2E6 J, Qs = 40 C and Qf = 200C. Because this is a three stroke simulation the equivalent i^2t time to half value is 40 μs and the equivalent Qs time to half value is 140 μs. In later years, there were further warnings that Bergers positive lightning data should not be relied on and some rejection of other Cianos and Pierce material. The 1998 book "The Electrical Nature of Storms" by D. R. MacGorman, W. D. Rust, gives the 1982 measurement results of Garbagnati and Lo Piparo. They found two categories of positive flash. Berger put all his 26 measurements into one category and the book authors are unclear as to why Berger allocated a single category to his positive lightning measurements. The document "Analysis and Assessment of Peak Lightning Current Probabilities at the NASA Kennedy Space Center, by D.L. Johnson, W. W. Vaughan, May 1999 uses the lightning statistics and procedures from five published reports dealing with lightning probabilities and the Kennedy Space Center pad area. The document Figure 1 shows the distribution of peak currents for first return stroke and subsequent strokes. A six years study of Cloud-Ground lightning for Cape

Canaveral space launch complex #40 was analyzed and published by Chai ("Survey of CGLSS/SLC40 Lightning Data and Retest Criteria," IEEE 1997 International Symposium on Electromagnetic Compatibility, Austin, TX, pp. 391-396, August ! 8-22, 1997). His paper covers 6200 Cloud-Ground events. The measured absolute maximum peak currents were -284 kA and +144 kA and the mean values were -30.9 kA and +23.3 kA. Some 94.5 % of flashes were negative and 5.5 % positive. The probability for natural lightning current >200 kA to occur within 5 miles of complex each year is estimated to be 0.051 % (I event in 950 years). The NASA report states that much disagreement exists as to which lightning peak current probability curve (of Figure 1) to use. It states that, with exception of Uman's positive stroke curve and the Cianos plots, the more recent probability curves parallel each other. Bergers plots (not in Figure 1) run parallel with the Cianos curves for negative lightning and parallel with Uman's curve for positive lightning. Perhaps the most damaging criticism comes from Professor V. A. Rakov (University of Florida). At ICLP 2000, Rakov states in the "Positive And Bipolar Lightning Discharges: A Review" paper: "A reliable distribution of positive-lightning peak currents is presently unavailable. The sample of 26 directly measured positive-lightning currents analyzed by Berger et al. (1975) [K. Berger, R.B. Anderson, and H. Kroninger, "Parameters of lightning flashes" Electra, vol. 80, 23-37, 1975] is apparently based on a mix of (1) discharges initiated as a result of junction between a descending positive leader and an upward connecting negative leader within some tens of meters of the tower tip and (2) discharges initiated as a result of a very long upward negative leader from the tower making contact with an oppositely charged channel inside the cloud." So there you have it. TC 81 formulated its positive (10/350) lighting stroke from Berger's Electra number 41 (1975) and 69 (1980) article data, which is now widely regarded as suspect. Not only that, the variation of positive lightning that occurs around the World, such as between Japan and South Africa, were ignored in the formulation of an International standard.

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In 1964, after graduating with a first class honors degree in electrical engineering from Loughborough, England, Michael Maytum worked on the design of semiconductor test equipment for magnetrons and television pick-up tubes. He joined Texas Instruments Limited (UK) in 1969 as an Applications Engineer and in 1978 became Applications Manager. In 1986 he was elected a Senior Member Technical Staff. For the last forty years he has consulted on semiconductor power devices used for protection and switching. He has held and still does hold officer positions for standards development in the IEEE, IEC, ITU-T and BSI (British Standards Institute), see Annex Officer Positions in Standards Organizations. He has authored twenty-one Application Reports, eight papers, contributed to four books and been granted 13 patents