Electromagnetic Field Pulses Radiated by Lightning Processes

Amitabh Nag* (1), Vladimir A. Rakov (1), Brian A. DeCarlo(1,2), Dimitris Tsalikis(1)
(1) Department of Electrical and Computer Engineering, University of Florida, Gainesville, FL, USA
(2) Presently at Sikorsky Aircraft Corporation, Stratford, CT, USA

Measurements of electromagnetic fields produced by cloud and ground lightning discharges have been performed at the lightning observatory on the University of Florida Campus in Gainesville, Florida, since 2004. At present, the measurement station includes electric field, electric field derivative (dE/dt), magnetic field derivative (dB/dt), high frequency (HF), very high frequency (VHF) and x-ray measurement systems. We have characterized electromagnetic signatures of various lightning processes, some for the first time. Microsecond- and submicrosecond-scale pulses in electric field records of both cloud and cloud-to-ground lightning discharges were examined. We found that about one-quarter of the pulses had total durations less than 1 μs. Further, we documented pulse trains that were characteristic of preliminary breakdown in negative cloud-to-ground flashes but were not followed by return-stroke pulses. We assume that such trains are manifestations of the initiation of downward negative stepped leaders that fail to propagate all the way to the ground and refer to these events as ‘‘attempted first cloud-to-ground leaders’’.

Cloud lightning discharges that produce both (1) single bipolar electric field pulses (so-called Narrow Bipolar Pulses or NBPs) having typical full widths of 10 to 20 μs and (2) intense HF-VHF radiation bursts (much larger than those from any other cloud-to-ground or “normal” cloud discharge process) are referred to as Compact Intracloud Discharges or Energetic Intracloud Events. The majority of intense VHF radiation producers occur in isolation (within a few hundred milliseconds) from any other lightning process, but we found some to occur prior to, during, or following cloud-to-ground or “normal” cloud lightning discharges. An example of NBP followed by a cloud-to-ground flash is shown in Figure 1.

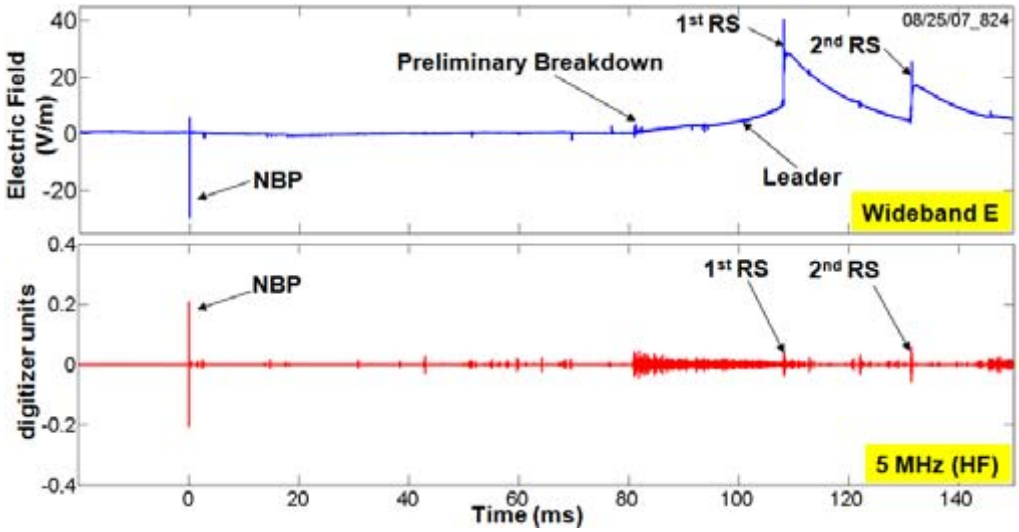

Figure 1. NBP followed by a cloud-to-ground discharge that occurred during a thunderstorm on August 25, 2007.