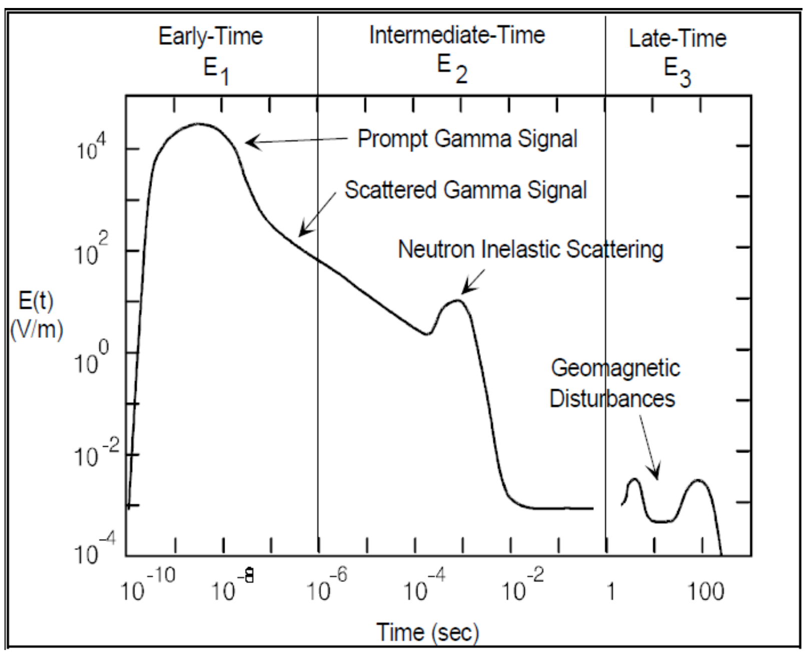
# Coupling of (H)EMP into RF-Antennas

Nuclear explosions in or above the earth's atmosphere produce an intense electromagnetic pulse (EMP) by the physical phenomenon known as "Compton effect or Compton scattering". This electromagnetic pulse is termed as nuclear EMP or ( NEMP ), while a detonation caused at an altitude above 40km creates a pulse known as high-altitude EMP (abbreviated as (H)EMP). The typical (H)EMP is defined as a combination of three consecutive pulses (E1 early time, E2 intermediate time, E3 late time), as shown in the graph below.




Depending on the altitude of the explosion and of the weapon design characteristics, the (H)EMP is distributed over a large or very large area. For a burst height of 40km the (H)EMP is spread over an area of 1.6 x $10^6$ $km^2$ . When the burst height is 400 km, the (H)EMP will be spread over 15 x $10^6$ $km^2$ on the earth's surface. The environmental effects of the (H)EMP can make entire electronic systems susceptible to upset or permanent damage. To take precautions against the electromagnetic pulse it is important to understand the coupling mechanism of the harmful pulse onto RF systems.

For localized systems, such as a RF- receivers or transmitters the dominating response mechanism is the early-time E1 field. The later time E2, and E3 field components become important for systems such as electrical power systems, in which conductors of several hundreds of kilometers exist and can effectively couple to these low-frequency fields. For this reason this calculation tool only deals with the E1 early-time (H)EMP environment.

$$E(t) = E_0 k \left(e^{-\alpha t} - e^{-\beta t}\right)$$

Parameters of unclassified High Altitude Electromagnetic Pulse Standards

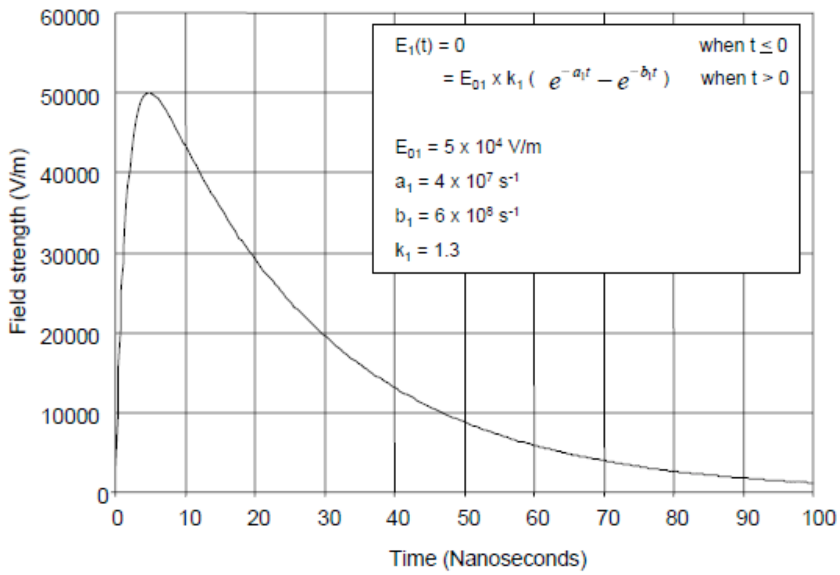
| Standard | E0 | α | β | k |
|---|---|---|---|---|
| ORNL-TM-2830 | 51.8 kV/m | $1.5 \times 10^{6}\ s^{-1}$ | $2.6 \times 10^{8}\ s^{-1}$ | 1 |
| Bell Labs (1960s) | 50 kV/m | $4 \times 10^{6}\ s^{-1}$ | $4.76 \times 10^{8}\ s^{-1}$ | 1.05 |
| Baum (1992) | 50 kV/m | $4 \times 10^{7}\ s^{-1}$ | $6 \times 10^{8}\ s^{-1}$ | 1.3 |
| IEC-77C (1993) | 50 kV/m | $4 \times 10^{7}\ s^{-1}$ | $6 \times 10^{8}\ s^{-1}$ | 1.3 |
| IEC-61000-2-9 (1996) | 50 kV/m | $4 \times 10^{7}\ s^{-1}$ | $6 \times 10^{8}\ s^{-1}$ | 1.3 |
| MIL-STD-464 E (1997) | 50 kV/m | $4 \times 10^{7}\ s^{-1}$ | $6 \times 10^{8}\ s^{-1}$ | 1.3 |
| VG 95371-10 (1995) | 65 kV/m | $3.22 \times 10^{7}\ s^{-1}$ | $2.07 \times 10^{9}\ s^{-1}$ | 1.085 |

Baum: Dr. Carl E. Baum

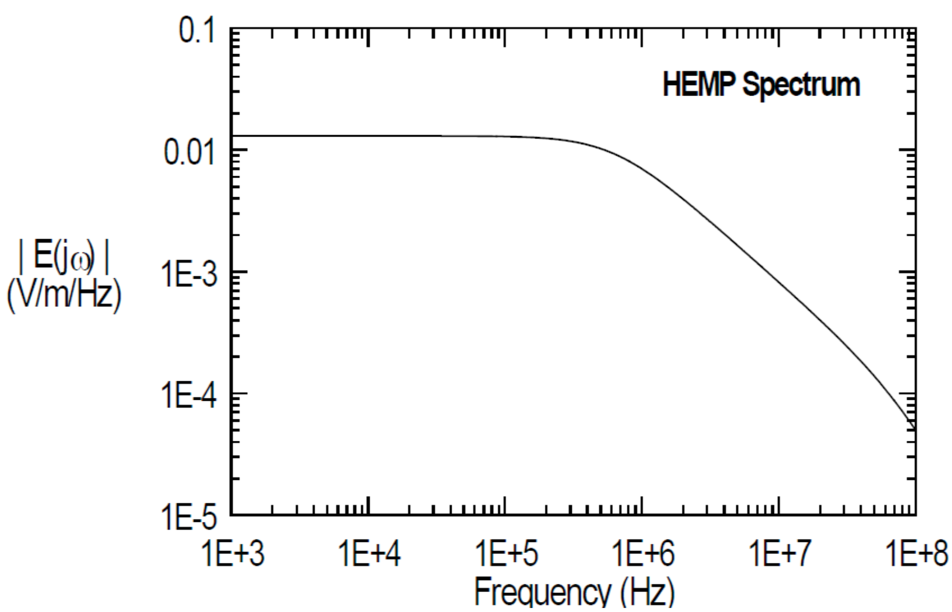
ORNL: Oak Ridge National Laboratory

VG: Verteidigungsgeräte Norm

Using the parameters defined by Carl Baum, by IEC or in the MIL-STD-464 leads to the equivalent double exponential transient (H)EMP pulse as shown below. The frequency spectrum of this transient is also shown.




*Transient (H)EMP waveform (Baum, etc.)*




*Frequency response of (H)EMP waveform*

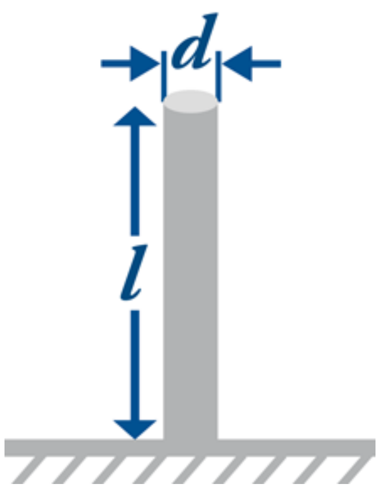
If the above transient pulse reaches the aperture of an antenna its energy will couple into the RF- system.

This program asks for the antenna lenght (l) and antenna diameter (d) in case of a monopol antenna (see picture a), and for the length (l) of one arm and the diameter (d) in case of half wave dipoles. The output will be presented as the worst case transient voltage or the short circuit current at the feed-point of the selected antenna.

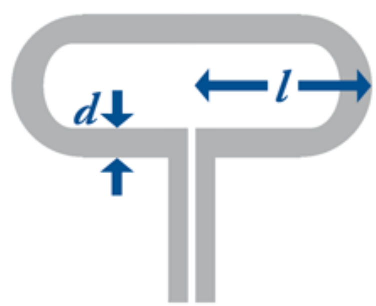
**Input:**

- length l (m)
- diameter d (mm)


Picture b: Folded Half-Wave Dipole

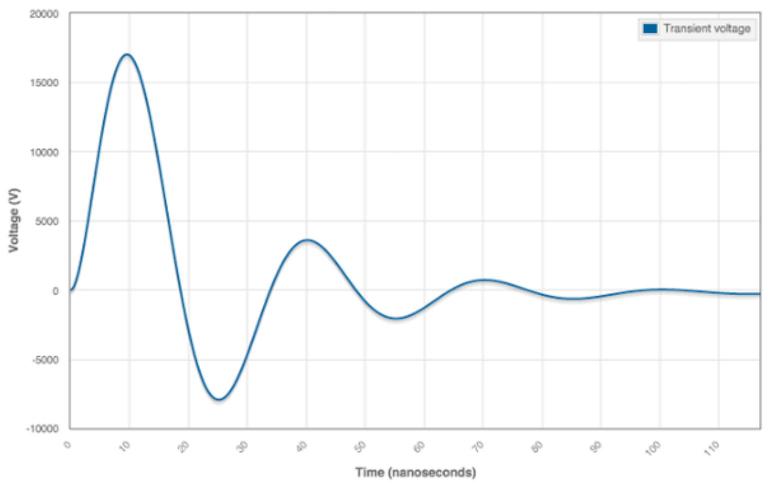



*Picture a: Monopole*

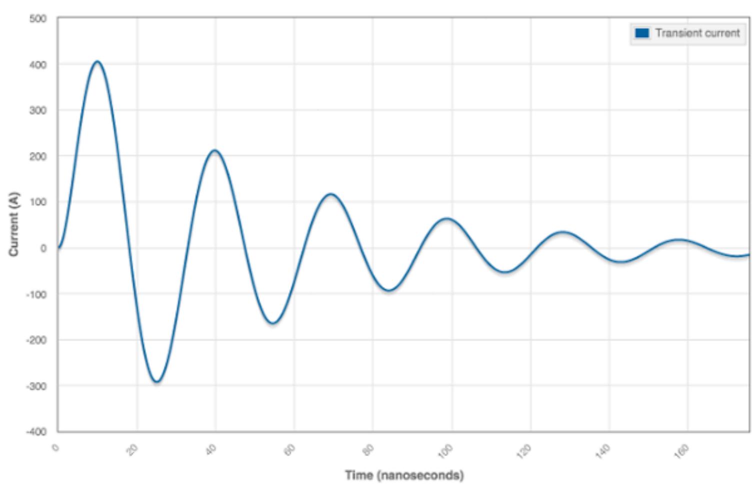



*Picture c: Dipole*

**Output:**
- transient voltage (V) at feedpoint
- transient energy (J)
- short circuit current (A)




*Worst case transient voltage (V) at antenna feedpoint*




Worst case short circuit current (A)