A paradigm for Ultra-Wide-Band/Short-Pulse matching by time-varying transmission lines

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In a transmit/receive system, the optimal matching of wave-source (actual source or an antenna) to a load through a transmission line (TL) system has been an extensively explored topic in the past. There are different possibilities to define optimal matching, for instance, one may seek it in terms of suppressing of reflections in the TL or alternatively, in the maximal delivery of power/ energy to/from the antenna/source to a load. For narrow-band signals, this matching can be achieved, for example, via quarter-wavelength sections of TLs or by some additional TL stubs. However, this matching approach is highly dispersive, and hence, its implementation to ultra-wideband/short-pulse (UWB/SP) signals may be challenging, requiring cumbersome circuitry networks. In this abstract we revisit the matching problem through a time-domain paradigm that uses time-varying TL for its implementation. Using this approach, we are able to achieve matching possibilities for short-pulse signals that are highly involved otherwise.

Assuming that an UWB/SP source and a load are connected via a time-varying TEM transmission line (TV-TL). In such a TV-TL, we consider that either the characteristic impedance and wave speed or, equivalently, the line's capacitance and inductance per unit-length vary in time. Correspondingly, the telegrapher equations are, conveniently, formulated for the electric and the magnetic fluxes instead of the TL's voltage and current [K.A. Lurie and V.V. Yakovlev, IEEE AWPL, 15, 1681-1684, 2016]. The resulting wave-equation with time-dependent coefficients, also, admits two characteristic wave solutions. Consider a scenario in which the TV-TL can be switched between two states, 1 and 2, that correspond to two sets of characteristic impedance and velocity (Z_1, v_1) and (Z_2, v_2). At some initial time t_0 the TL is in state 1 and the wave-source lunches a pulsed wave-field that propagates in the TL towards the load. Then, at $t_s > t_0$, while the pulse is propagating, the TL state is instantaneously switched into state 2. In this case, the continuity relations render that the originally excited forward propagating pulse splits into two compressed pulses, one is reflected back toward the source while the other continues to propagate forward towards the load.

In this work we discuss how to appropriately set the two states between which the TL can be switched to satisfy some matching criteria. Such setting can be chosen in alternative manners, however, we seek for a setting that corresponds to an optimal energy delivery from source to load. This optimality is for example, in view of the energetic efficiency of the source-load link with respect to the maximal available source energy and the energy change in the TL's due to the switching. In particular, the case of loads with small purely resistive part will be explored as representing "small" antennas. These issues and more will be discussed in the presentation.