Broadband Common-mode Filters Design for GHz Differential Signals Using Defected Ground Structures

Differential signals have played an important role in high-speed digital circuits because of their high immunity to noise, low crosstalk, and low electromagnetic interference (EMI). Several high-speed serial link formats, such as PCI Express II, Gigabit Ethernet, or OC-192, have the data rates over 5 Gb/s under the differential signal transmission. However, in practical circuits, the common-mode noise due to the timing skew or amplitude unbalance along the differential signal paths is unavoidable. In this talk, a novel GHz common-mode filter is proposed based on the coupled defected ground structures. The basic theory of the defected ground effect on the common-mode signals is first explained. The wideband behavior using three coupled defected ground structure will then be shown. The benefits of the common-mode filter applied in GHz differential traces with cables attached are both theoretically and experimentally demonstrated. It is found the common-mode noise can be reduced by the filter over 15 dB from 3.6 to 9.1GHz and over75% of amplitude in the time domain. More important, the differential signal integrity, in terms of insertion loss and group delay in the frequency domain and eye diagrams in the time domain, is not degraded within the wide bandwidth. The radiation caused by the common-mode current on the attached I/O cables is also efficiently suppressed by 10 dB on average within the designed stopband.