

In this paper, mode composite waveguide (MCW) is proposed, which consists of inner and outer wave-guiding duo structures. The outer structure acts as a rectangular coaxial line suitable for lower frequency operation for its compact size, while the inner structure works as a rectangular waveguide suitable for higher frequency operation thanks to its simple structure and low loss. The MCW can propagate signals in the inner waveguide with  $TE_{10}$  mode and/or the outer waveguide with TEM mode depending on frequency to achieve optimal performance for both low- and high-frequency operations. In this paper, the fundamental waveguide parameters and higher order modes of the duo waveguides are examined. The proposed MCW prototypes are fabricated on a triple-layer PCB structure using the emerging substrate integration techniques. The MCW is fabricated and measured through the proposed microstrip line to the inner and outer waveguide transitions, and an MCW simultaneous feeding circuit is also presented. For this simultaneous feeding circuit, the good matching is achieved from 7.5 to 10.5 GHz for the low-frequency operation and from 25 to 39 GHz for the high-frequency operation, respectively.