Investigation of Direct UWB Excitation of TE_{01}-Mode Transmitting in Long Pipes with Holes and Slots

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In this paper, the TE_{01} mode directly excited by a planar antenna in the pipe is investigated. The generated ultra-wide band (UWB) frequencies are from 8 to 12 GHz. The multi-frequency waves are transmitted in the pipe, which is 200 cm long, 20 cm in diameter and has a large rectangular slot of 5×30 cm (Fig. 1). The study is of great importance for accurate radar level measurement in bulk storage tanks where pipes with slots, holes and rough conjunctions are frequently present. In real-life world the level measurement accuracy of sub-mm requires the field excitation in pipes should be as perfect as possible, which means other modes like TE_{11}, TE_{02} and etc. should be suppressed substantially. Furthermore, the excitation should be robust enough to cope with disturbances from rough welding conjunctions and slots of the pipe. The conventional way of generating wideband TE_{01} mode is to use waveguide-based mode-converter, which is generally cumbersome. In this investigation, we adopted the planar structure-based microstrip patch array antenna with ultra-wide frequency band (Fig. 2-L). The results of the simulation study using FDTD show that the wave propagation in the pipe is completely dominated by TE_{01} mode (Fig. 2). Other modes are suppressed below -10 dB for the case of disturbances from conjunctions and slots. It is also shown that along excited field the big slots cause an insertion loss of -50 dB. The experimental verification is carried out using Enraf X-band planar radar antenna. The real measurement result shows the maximum measuring error from distance of 48 cm to 3 meters is $\pm$ 0.8 mm [Fig. 3]. The results from FDTD and measurement for planar TE_{01} antenna are agreed well.

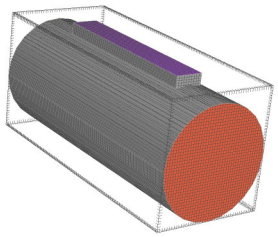
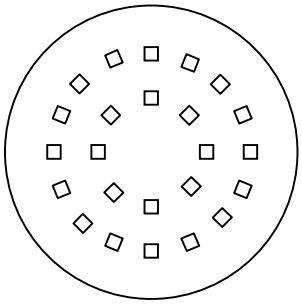


Fig 1. Finite difference mesh for the pipe with slot



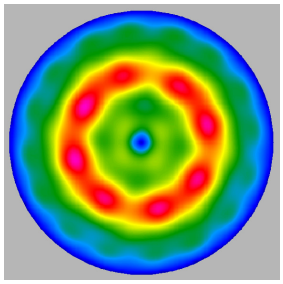


Fig 2. Planar patch antenna (L); E-pattern in propagation (R)

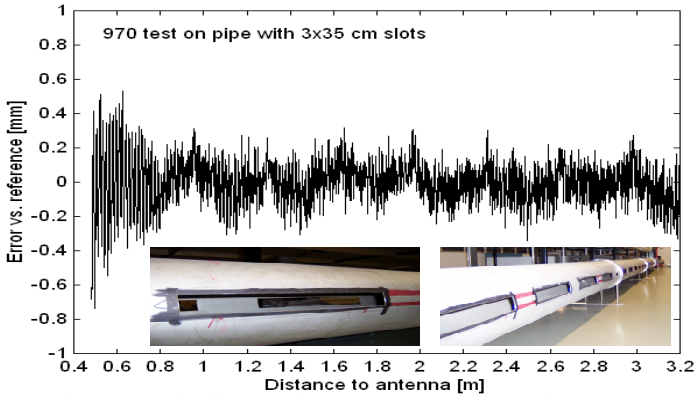


Fig 3. Result of radar distance measurement with compact planar TE_{01} antenna in pipe with large rectangular slots