Broadcast Antenna for Handsets

Final Report – Executive Summary

December 15th, 2010

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project objectives

The ultimate objective:

- to develop a reference design antenna system for broadcast radio and mobile DTV reception, which:
  - fits into a handset
  - covers FM radio and TV (low and high VHF, UHF) frequency bands

The objectives of this project phase:

- to develop an initial antenna system, which:
  - fits into a handset form factor
  - is predicted to work at frequencies in the radio and TV bands
- demonstrate feasibility of such an antenna system in terms of:
  - impedance matching in required operating bandwidth: for FM and HD Radio channels in the FM band and for a TV channel in VHF and UHF TV bands
  - antenna efficiency, which would be possible within the size constraints
- note that electronic switching or tuning may be utilized in final design but was not tested during this phase

main project tasks

To achieve the project objectives TTP undertook the following activities:

- reviewed NAB requirements for the broadcast receiver antenna system – from a number of perspectives:
  - the radio and DTV broadcast environment, based on the FCC requirements
  - typical handheld devices and their usage
  - requirements for interfacing with broadcast tuner chips
- identified a number of potential approaches for VHF and UHF antennas
- selected & prototyped the most promising of the potential approaches
- tested the prototype antennas and optimised them for the target frequency bands
  - antenna efficiency was tested at several discrete frequencies across each band
- documented the antenna subsystem performance

main challenges

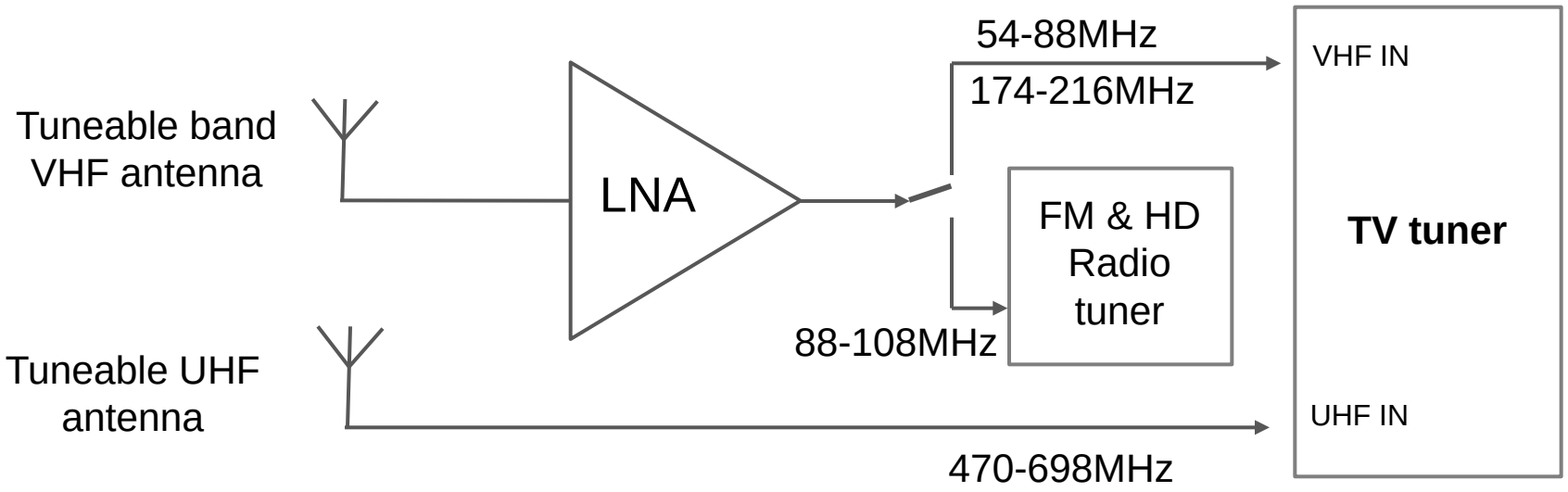
The challenges in achieving the project objectives include:

- gain / efficiency of an electrically small antenna, which could fit into a handheld device
- bandwidth of an electrically small antenna – to accommodate a TV broadcast channel (6 MHz wide), particularly for VHF TV
- radiated tests of an electrically small antenna
  - minimising the affects of feeding cables
- integration into a real handheld device
  - space for the antenna
  - antenna detuning by surrounding components, caseworks and the user hand/body
  - interference from the phone electronics

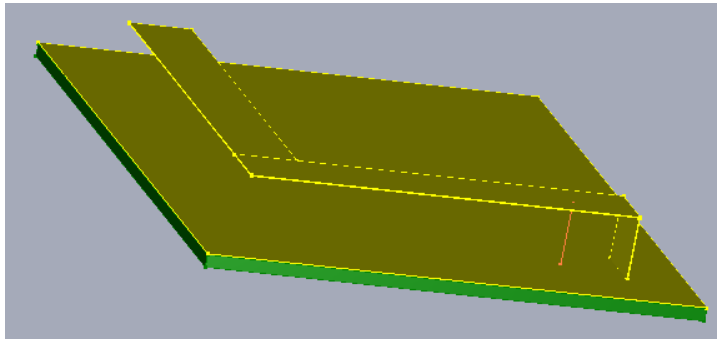
“one size fit all”?

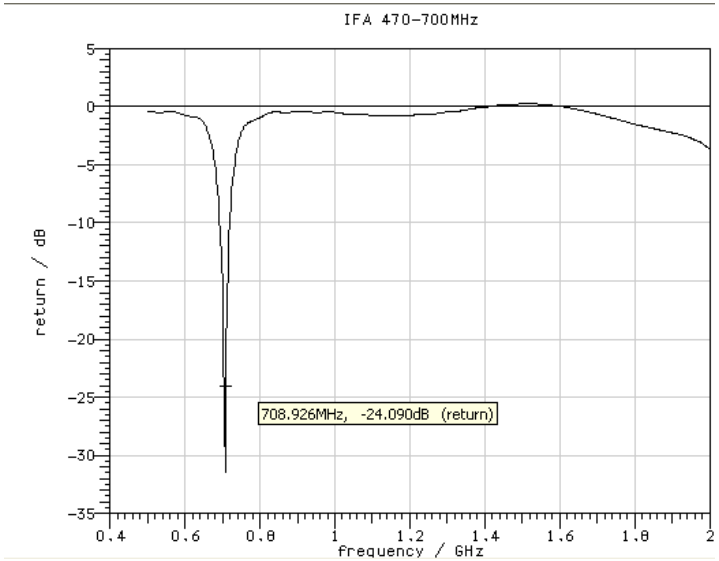
Feasibility of a single antenna to cover all bands was assessed, and it was found that:

- majority of TV tuners:
  - have separate VHF and UHF inputs
  - do not include analog FM or HD Radio tuner
- hence, separate antennas are acceptable for UHF & VHF bands



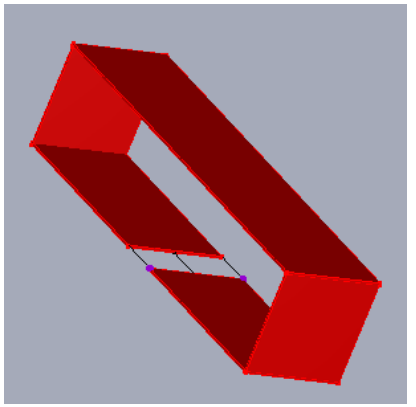
electromagnetic modelling of antenna structures





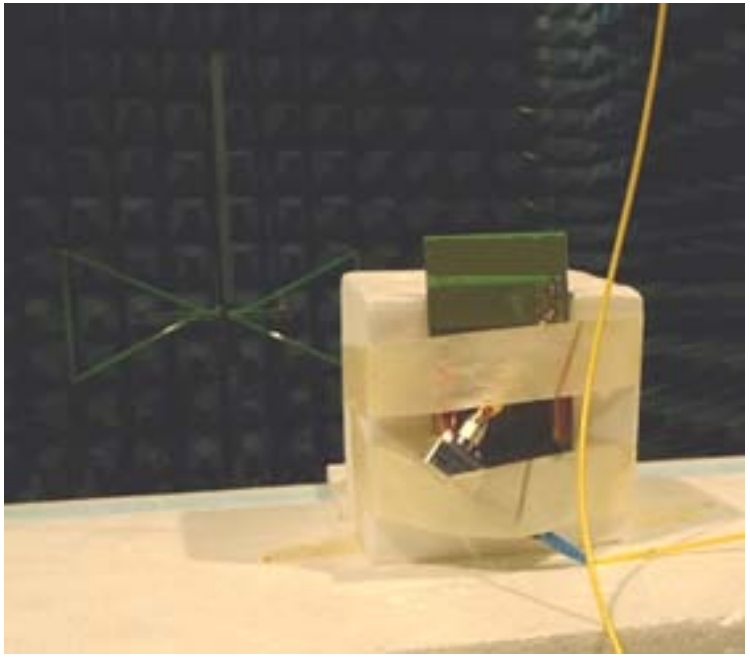
Simulated return loss vs frequency

- Extensive computer simulations have been performed in the project, which helped to eliminate some antenna structures and predict performance of prototypes
- Tuning/matching circuits have been simulated to assess the feasibility of tuning the structures across each target band
- Mutual influence of antennas, covering different frequency bands, have been simulated:
  - the effects in a handset are minimal, provided the appropriate spacing and mutual orientation of antennas are implemented.



radiated tests

- radiated performance of prototype antenna has been tested in a calibrated fully anechoic chamber
- antenna efficiency was measured and its radiated pattern was plotted at a number of frequencies
- the prototype PCB for radiated antenna tests
  - to simulate a phone envelope: 50 x 100 mm
  - to accommodate most candidate antennas



main project findings

- no single antenna structure is found that can operate in all target bands efficiently
- simulations and prototype tests showed that identified antenna structures do not cover the entire bands, hence antenna tuning is required in all bands
- covering several bands, combining in one antenna structure:
  - the UHF antenna needs to be a separate structure from the VHF antenna
- a number of tuner ICs have been identified with a particular focus on the emerging HD Radio and ATCS-M/H technologies
  - but no broadcast TV tuner has been identified, which provides built-in antenna tuning

preferred antenna implementations

- the following antenna types have been selected after testing a range of prototypes:
  - VHF bands:
    - a ferrite core active antenna, which can operate in all target VHF bands
    - switched with capacitors between three VHF bands
    - will need tuning with a varactor within the bands
  - UHF band:
    - a compact antenna made of stamped sheet metal
      - offers a good compromise between the physical area taken by the antenna in a handset and its performance
      - tuneable with a varactor in the entire UHF band.

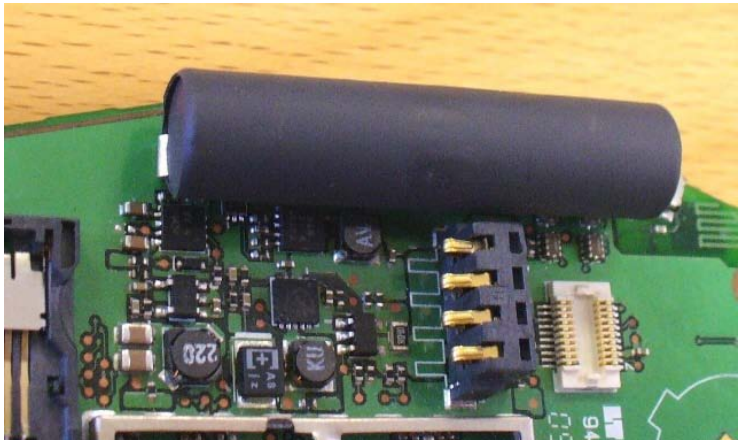
VHF antenna characteristics (1)

Ferrite core active antenna:

- prototype dimensions: 35mm long, 8mm dia.
- takes little PCB space – some components can be placed within the antenna envelope
- a relatively broadband antenna:
  - can cover 32MHz at -30dBi level
- antenna gain:

  -25 dBi in Band II (FM)
  -17 dBi in Band III (VHF TV)
- power consumption: 3-6mA at 3V

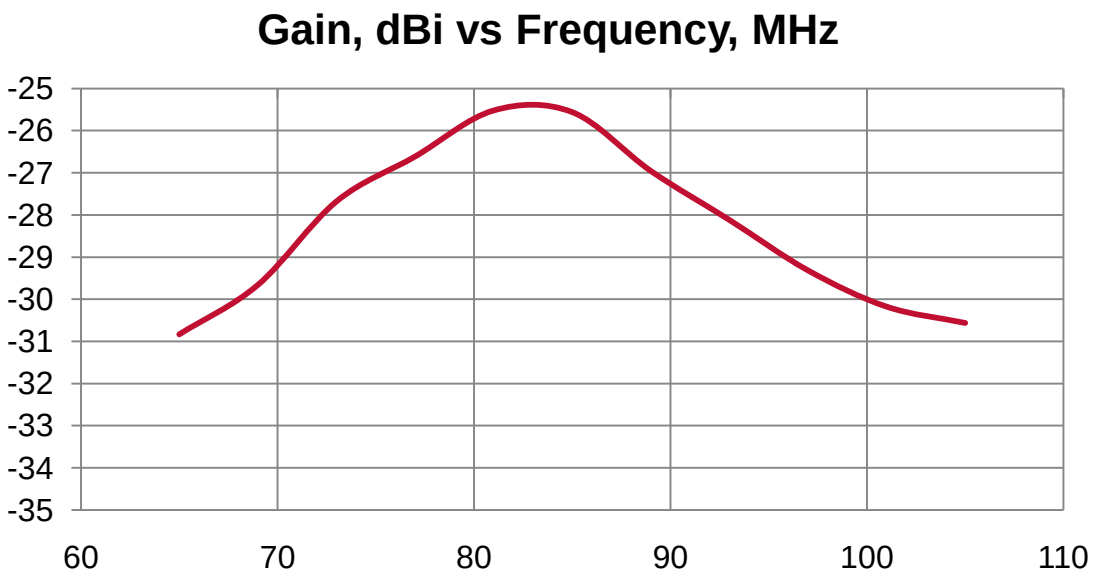
(photos depict antenna form factor but details are proprietary)

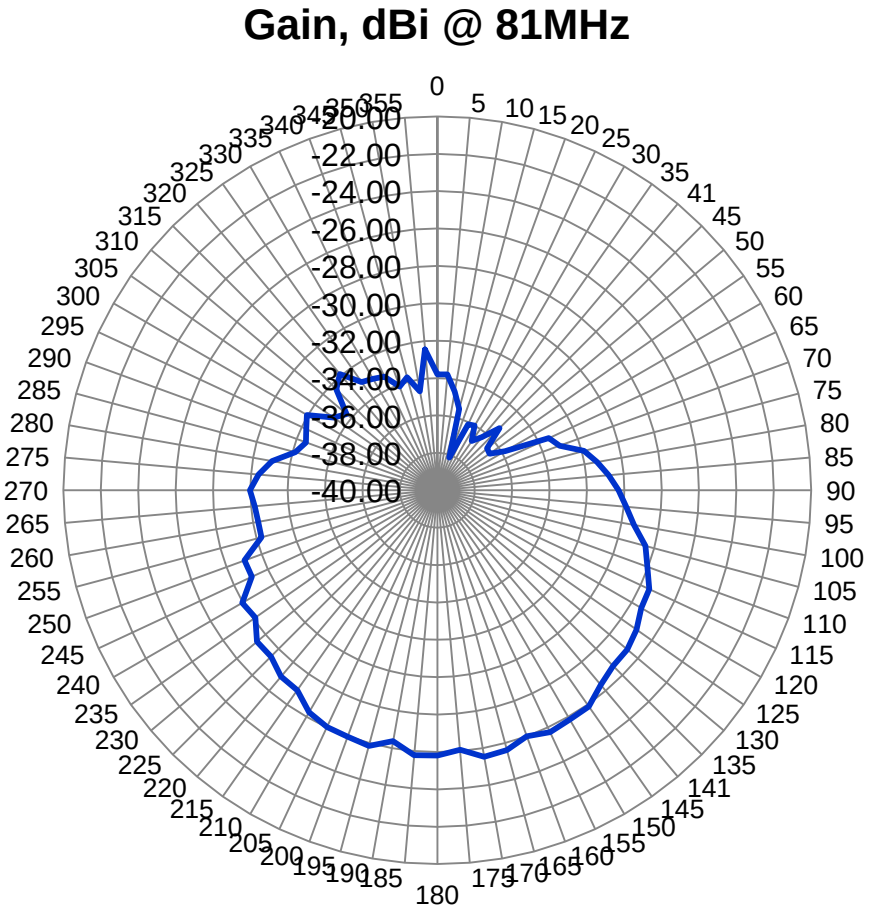


VHF antenna characteristics (2)

Ferrite core active antenna

- frequency response and antenna pattern in FM band

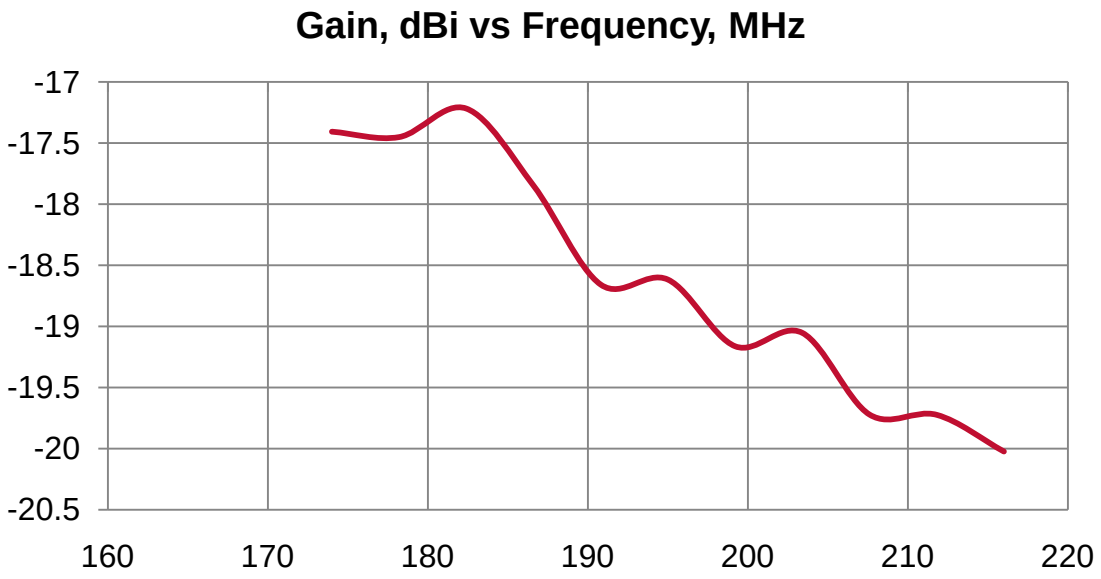


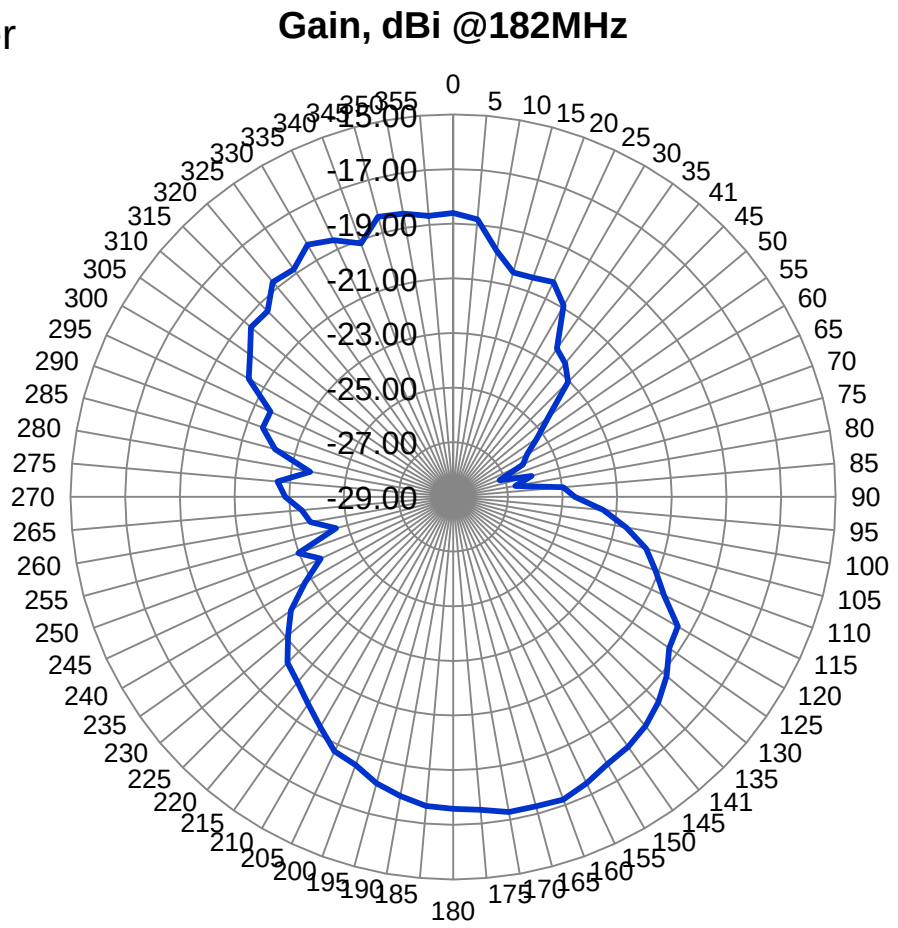


VHF antenna characteristics (3)

Ferrite core active antenna

- frequency response and antenna pattern in upper VHF band

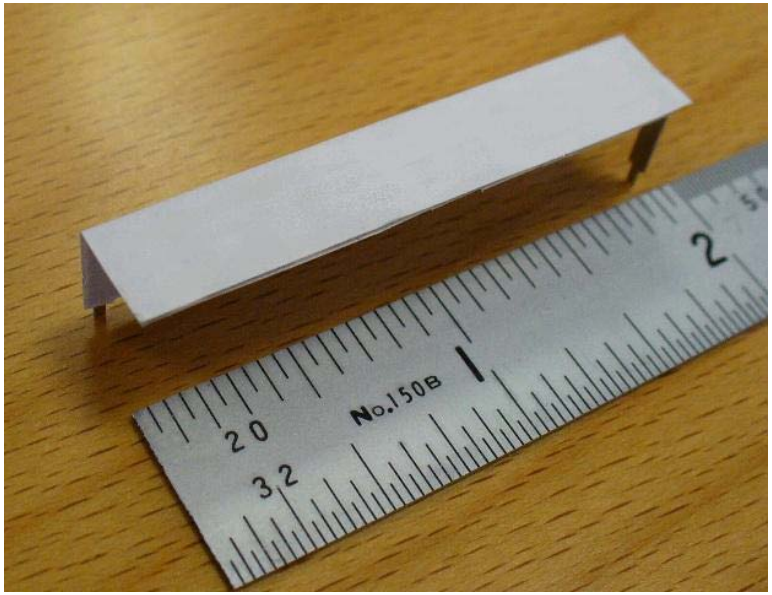


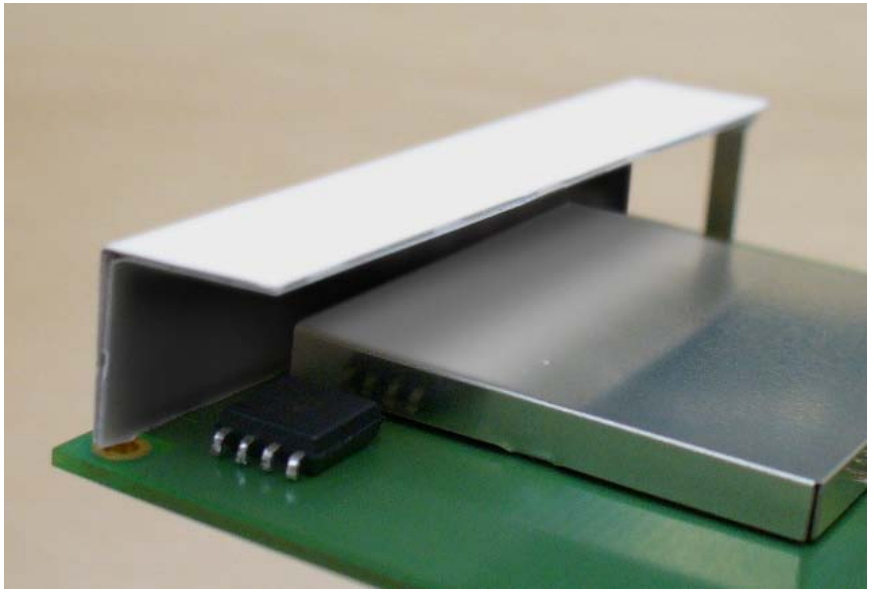


UHF antenna characteristics (1)

Stamped sheet metal UHF antenna:

- prototype dimensions: 48(L) x 8.5(W) x 9(H) mm
  - could be made smaller after further optimization
- easy to manufacture
- very low cost
- takes almost no PCB space, since it can be placed over components
- (photos depict form factor of antenna but details are proprietary)



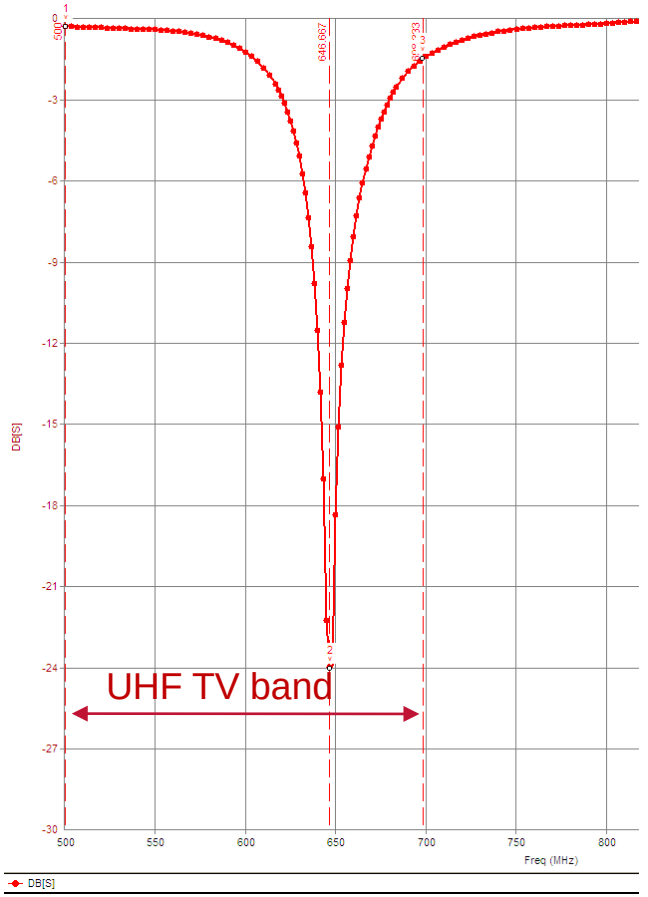


UHF antenna characteristics (2)

Stamped sheet metal UHF antenna:

- a relatively broadband input impedance match, can cover at least a quarter of the entire UHF band
- antenna gain:
- -1 dBi at 600 MHz (without a tuning capacitor)
- -5 dBi at 535 MHz (with a tuning capacitor)

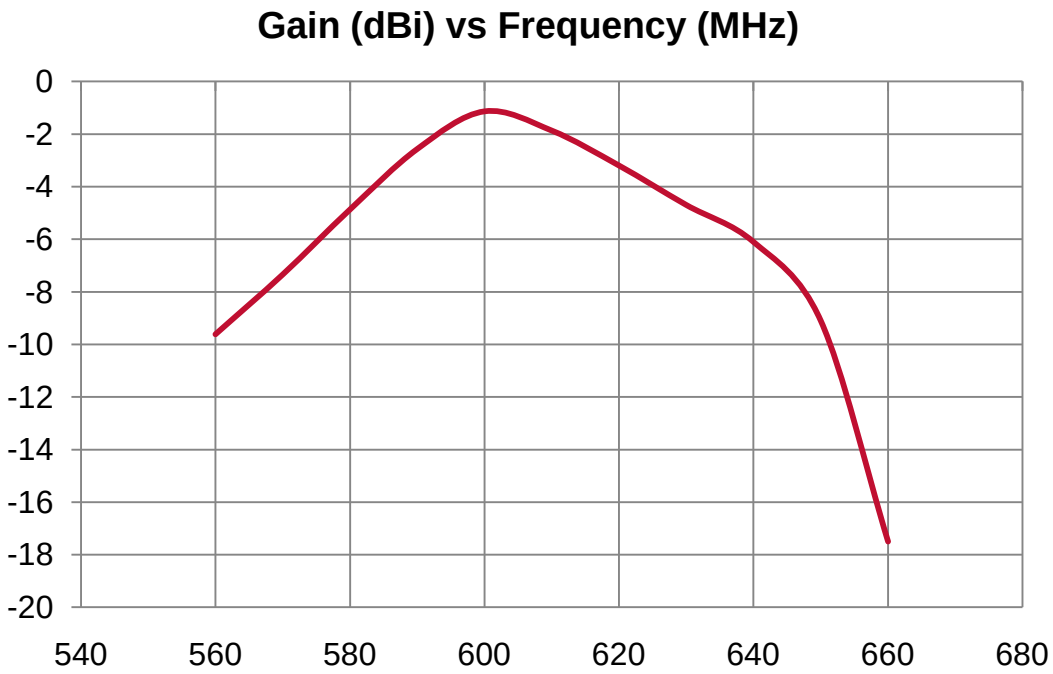
Return Loss, dB vs Frequency, MHz



UHF antenna characteristics (3)

Stamped sheet metal UHF antenna

- radiated gain response



- Antenna pattern – gain (dBi) at 600MHz
  - PCB – horizontal, polarization - horizontal