



DESIGN AND PRODUCTION OF TELEMETRY SYSTEM WITH A PATCH ANTENNA ARRAY HAVING HIGH-GAIN AND CIRCULAR POLARIZATION

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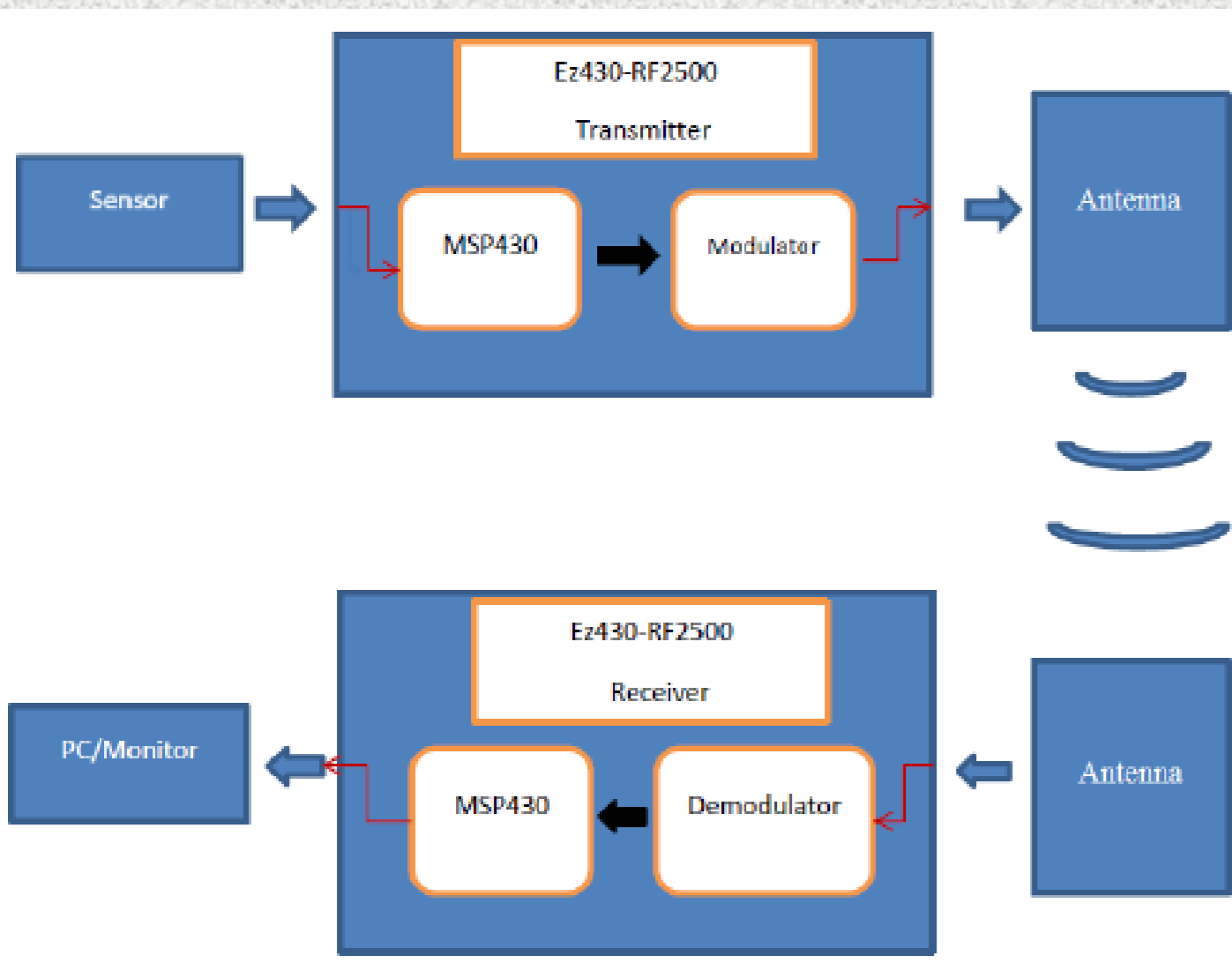
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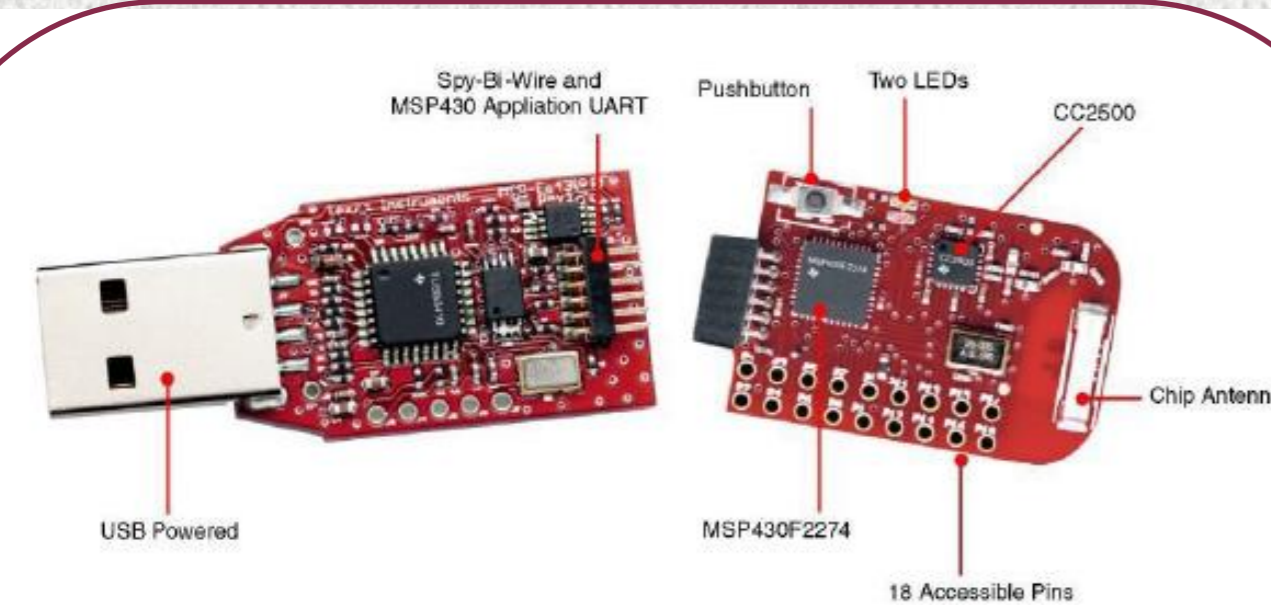
INTRODUCTION

In this project, a telemetry system at ISM band (2.4 GHz) is designed with a low cost and low-power consumption wireless module (ez430 RF2500), and a 4x4 microstrip patch array antenna is designed and produced to increase the range of the communication. The high-gain and circularly polarized antennas on the stationary transmitter and receiver part of the system make the increase in range about 80 meters. The mentioned wireless telemetry system is realized for the application of temperature monitoring and control, and successful results are obtained. In this way, wireless telemetry systems, which can be used in the industry, are designed with low cost.

BLOCK DIAGRAM (SYSTEM OVERVIEW)



EZ430-RF2500 WIRELESS MODULE



- Low cost, low power consumption (2 AA batteries, maximum 20 mA current)
- Frequency: 2400-2484 MHz
- RF power output (-30 to 0 dBm; default -12 dBm)
- Internal chip antenna gain: 1 dB
- Effective range: 5 - 10 dB
- Replaceable antenna structure (microstrip transmission lines)

DESIGN CALCULATIONS

Friss Transmission Equation

$$\frac{P_r}{P_t} = G_t G_r \left(\frac{\lambda}{4\pi R} \right)^2 \quad G = \left(\frac{4\pi R}{\lambda} \right)^2 \frac{kT\Delta f}{P_t} SNR$$

$P_t = -12$ dBm, $f = 2.4$ GHz, $\Delta f = 84$ MHz, $SNR = 30$ dB, $R_{min} = 80$ m

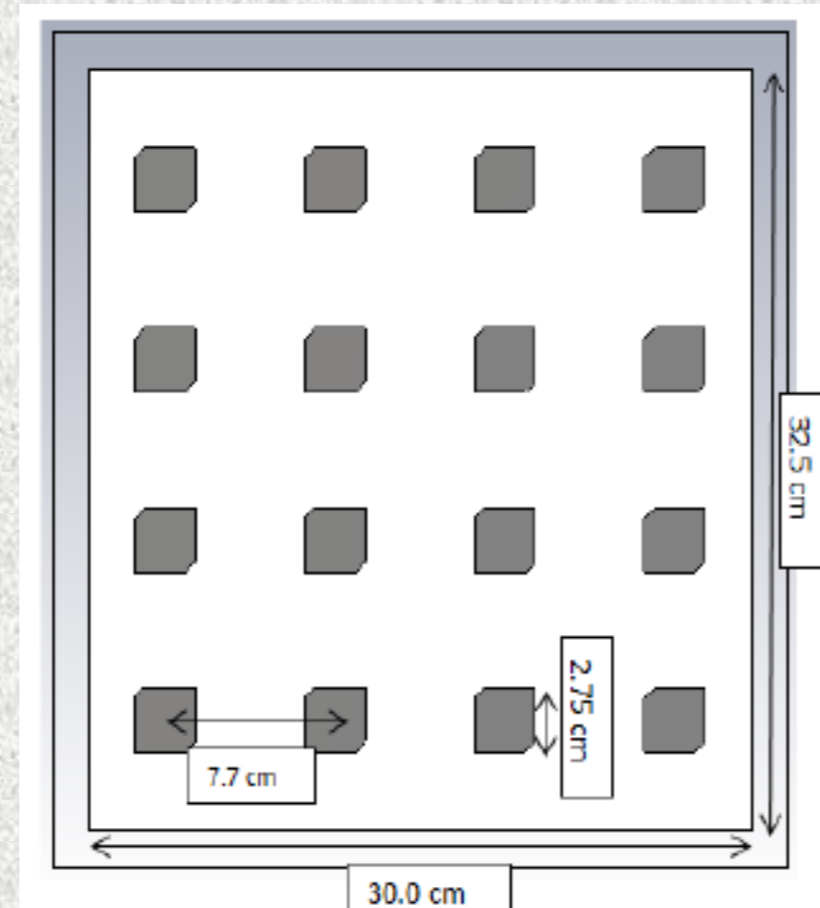
Gain we need: $G \approx 13$ dB

Double check: Effective range of 5 meters for 1 dB gain; so 13 dB gain will give 75 meters range.

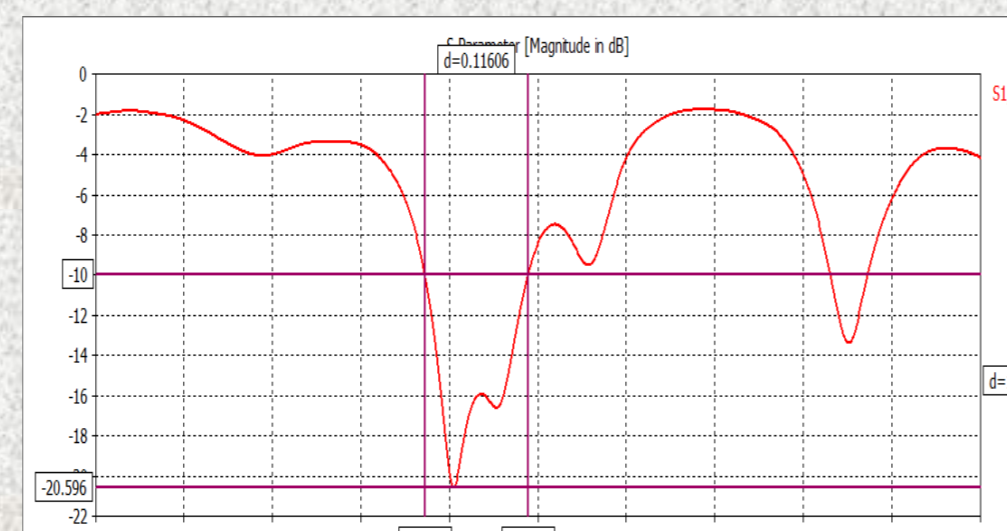
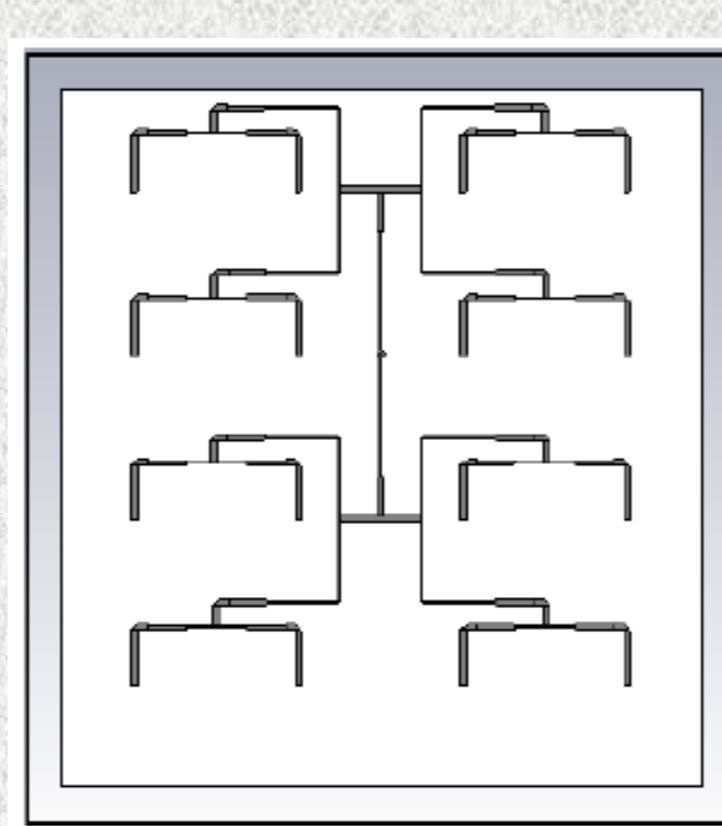
ANTENNA ARRAY and POWER DIVIDER

Simulations in CST Microwave Studio

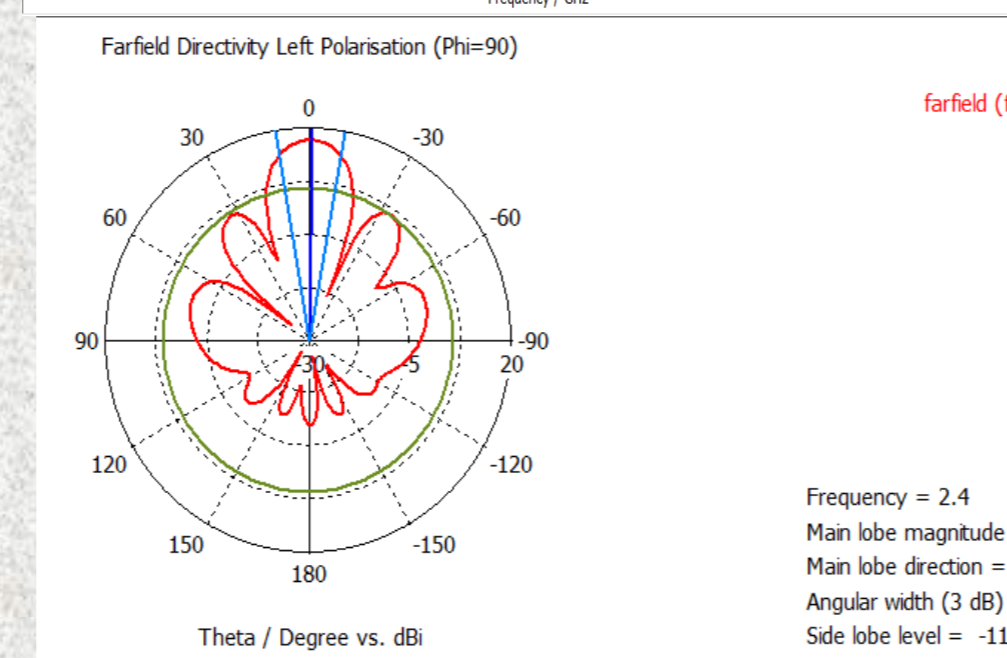
Antenna Array



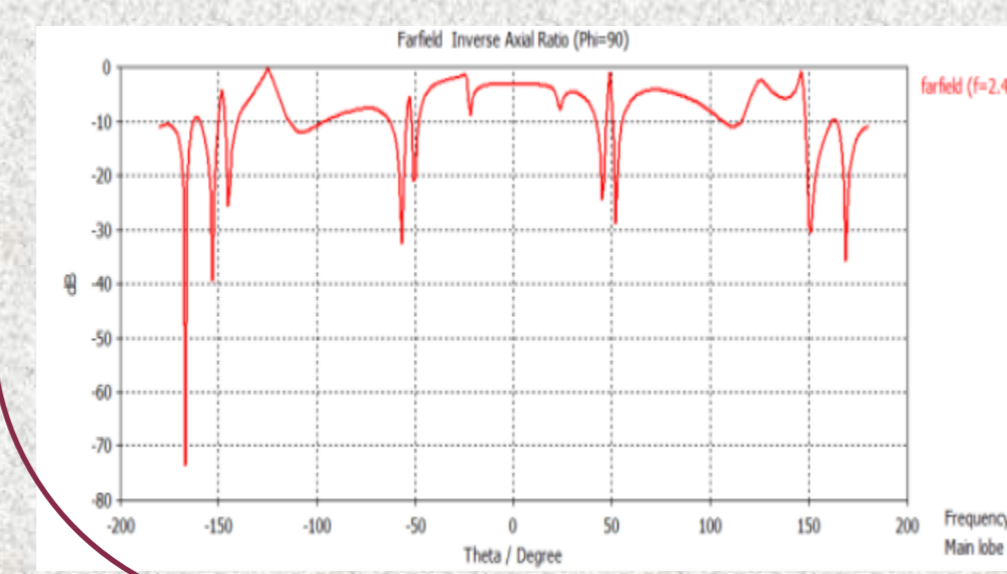
Power Divider



S11 parameter of the antenna is under -10 dB along the ISM Band. It means return loss of the antenna is lower than 10%



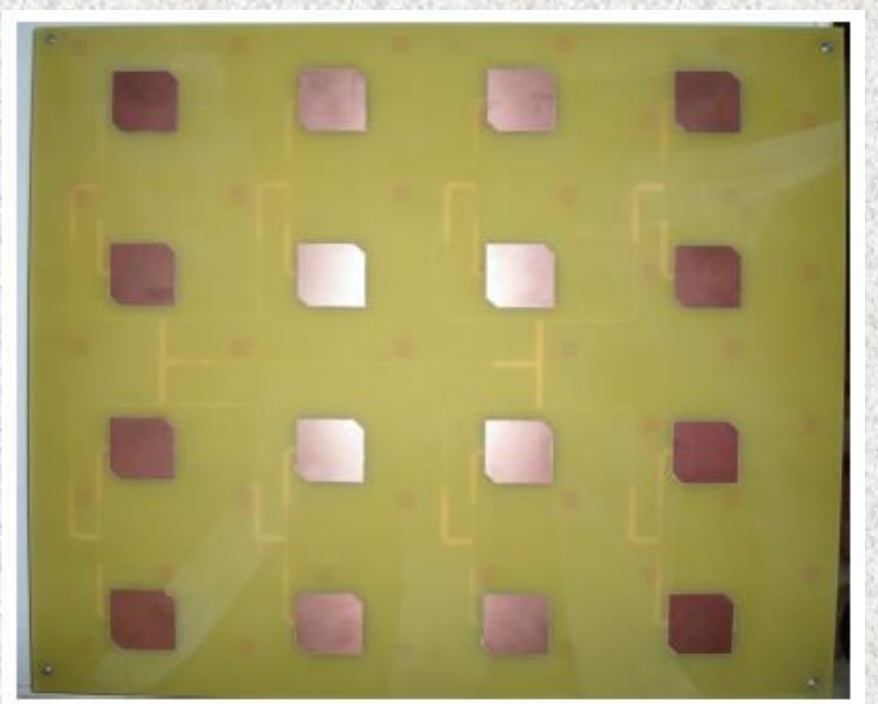
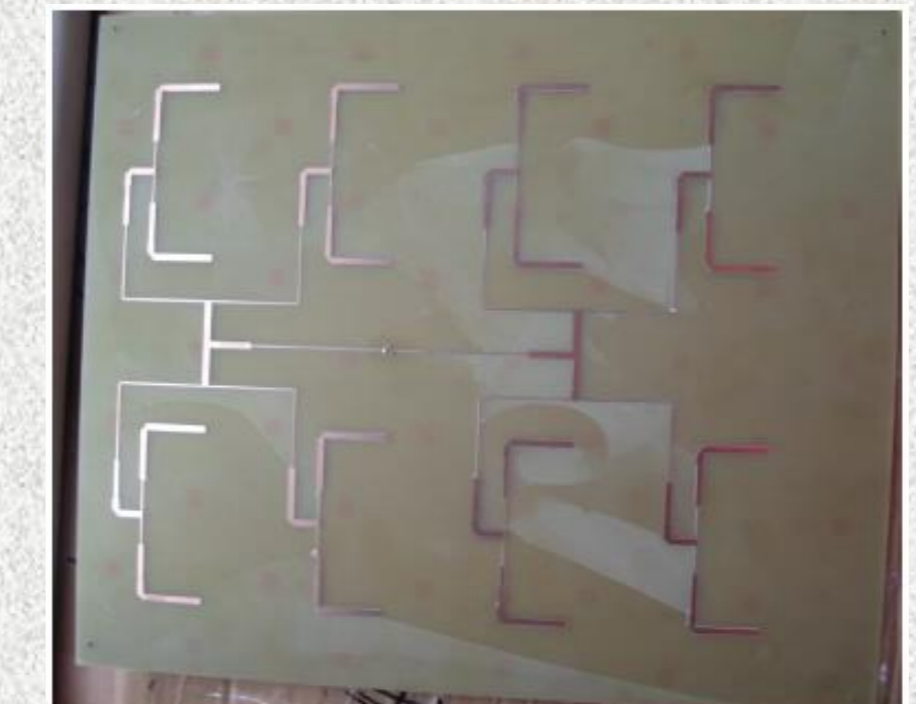
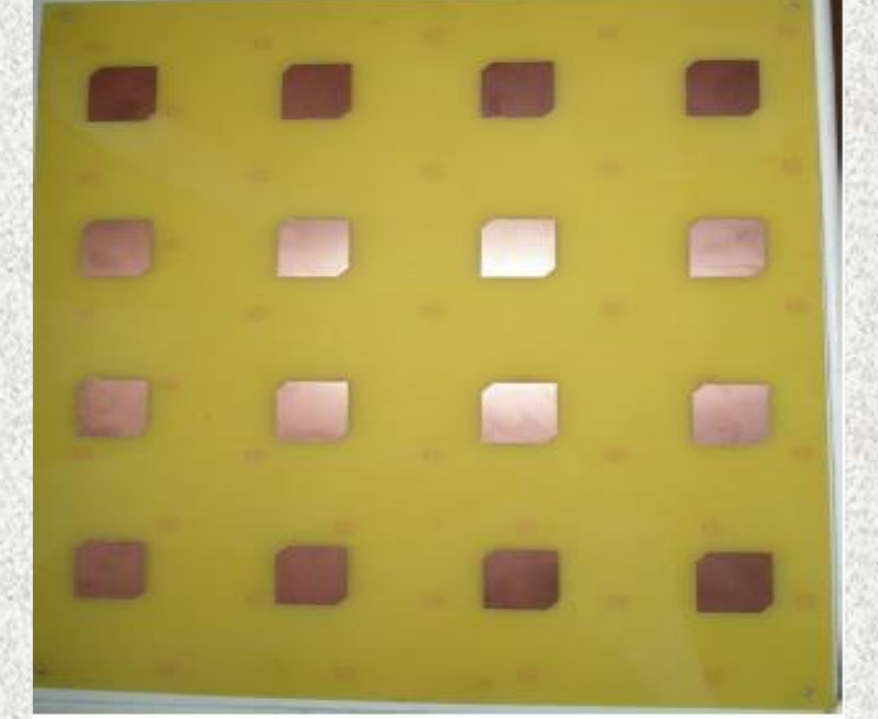
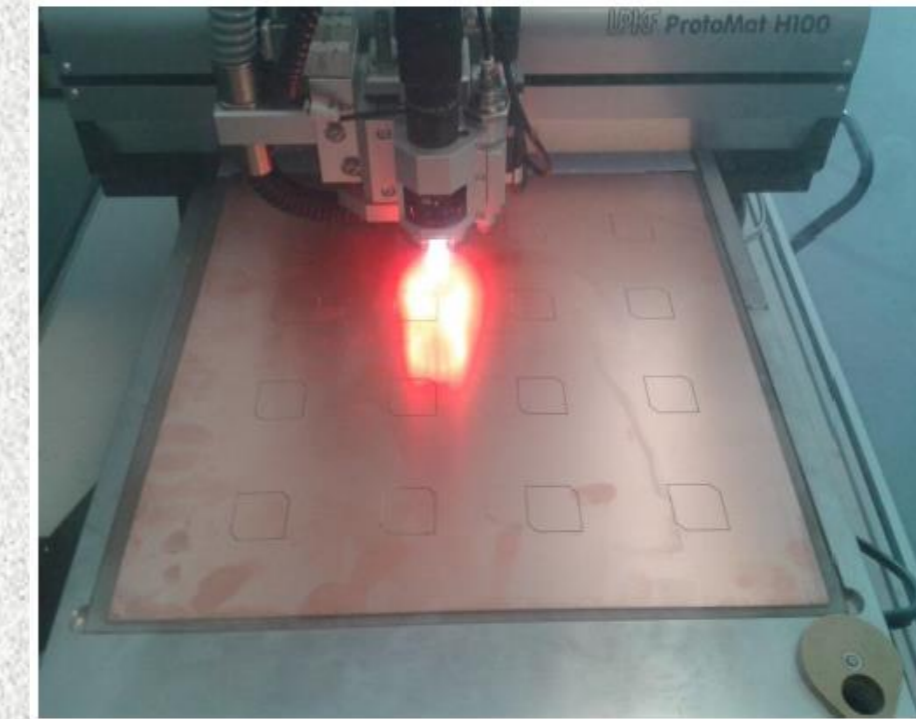
Antenna array that is designed and simulated in CST MW has 17 dB gain and 20° beamwidth



Axial ratio of the antenna is 5-8 dB in CST MW simulation results. The axial ratio values provide slight circular polarization

PRODUCTION and MEASUREMENTS

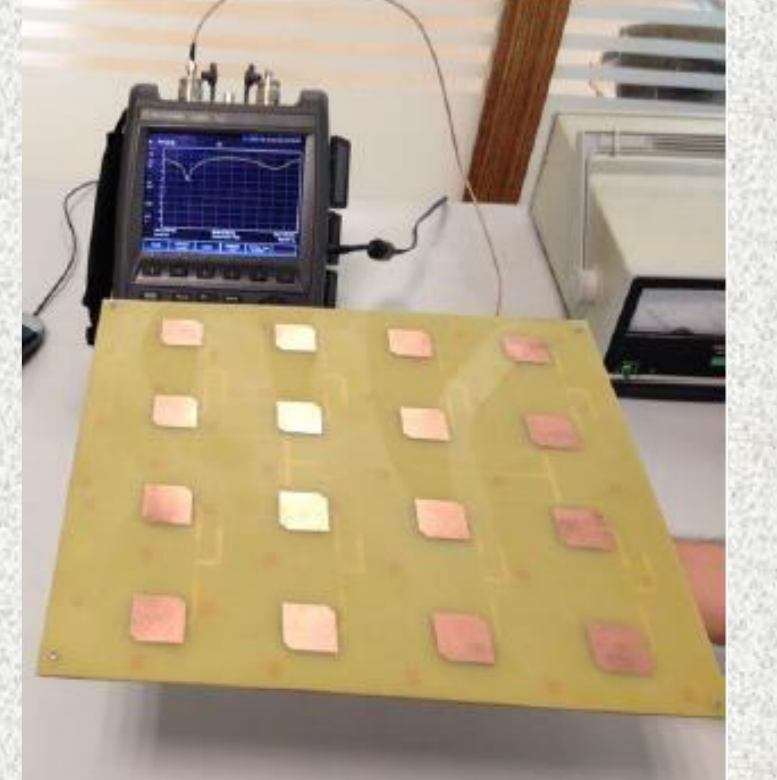
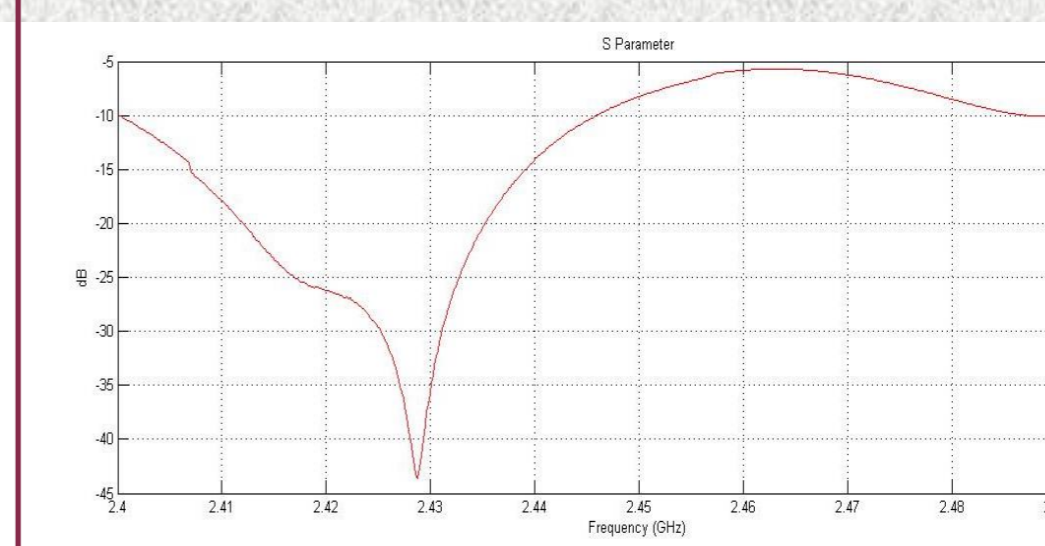
Manufactured Array and Divider



Measurements

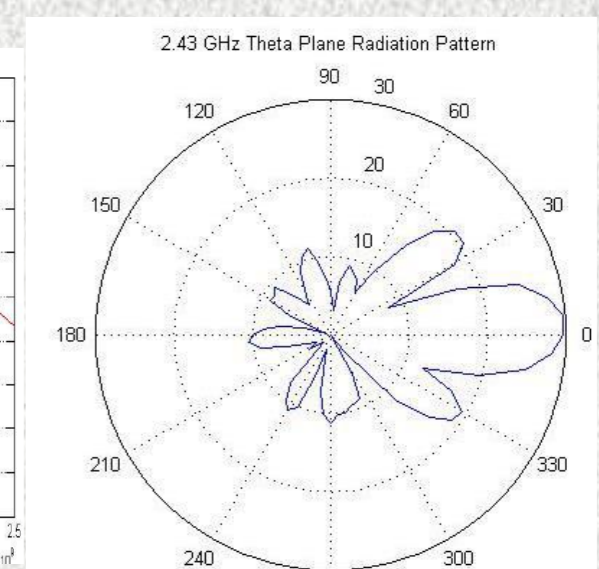
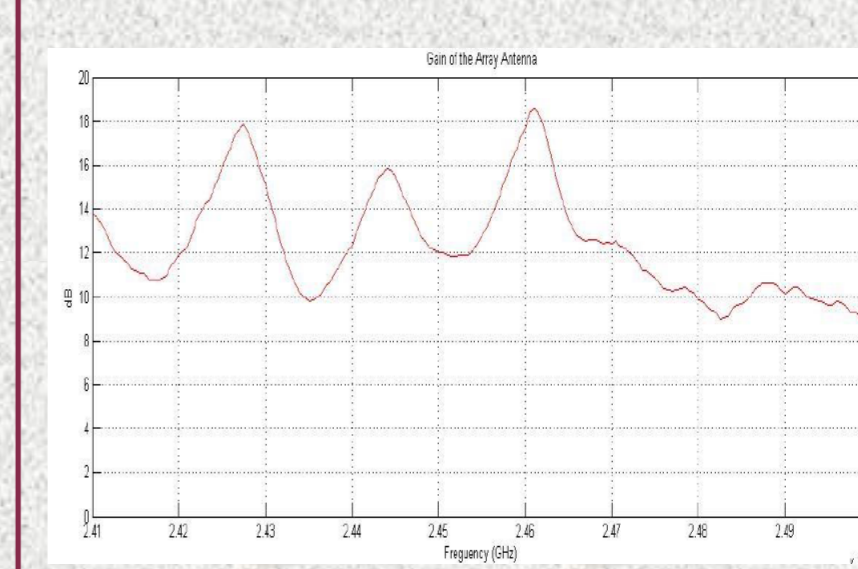


Radiation Pattern and Gain

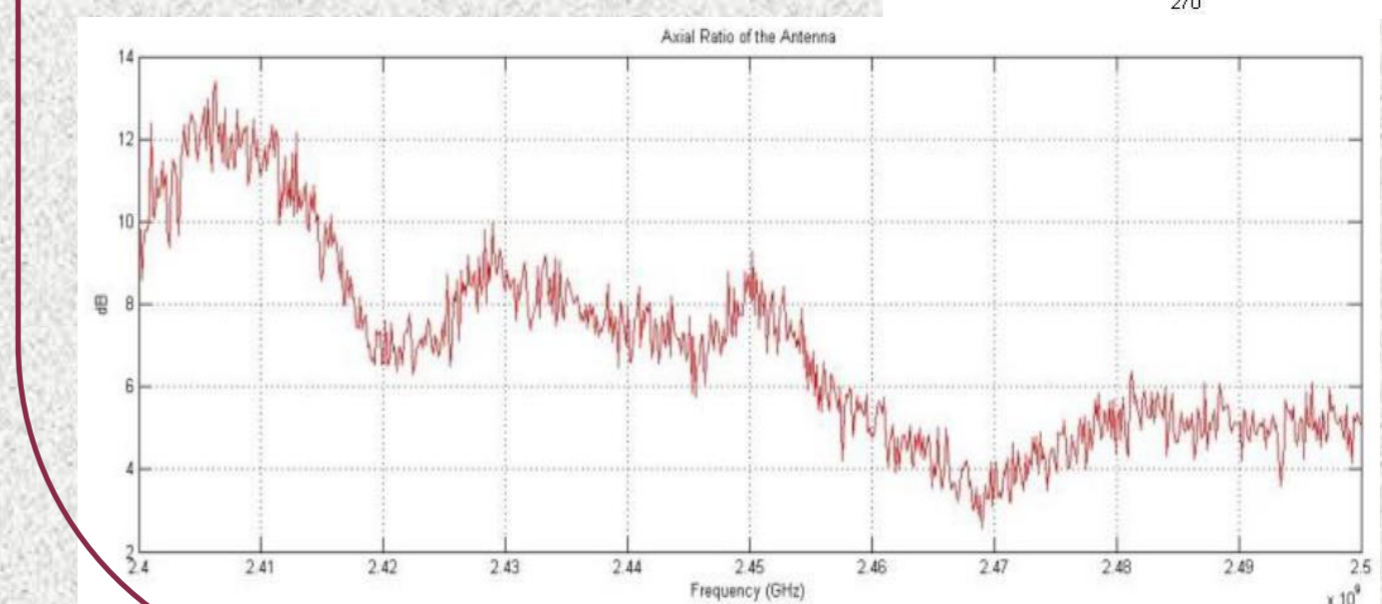


Return Loss

S11 parameter of the produced antenna is under -10 dB. Return loss of the antenna is lower than 10% along the ISM Band as expected.

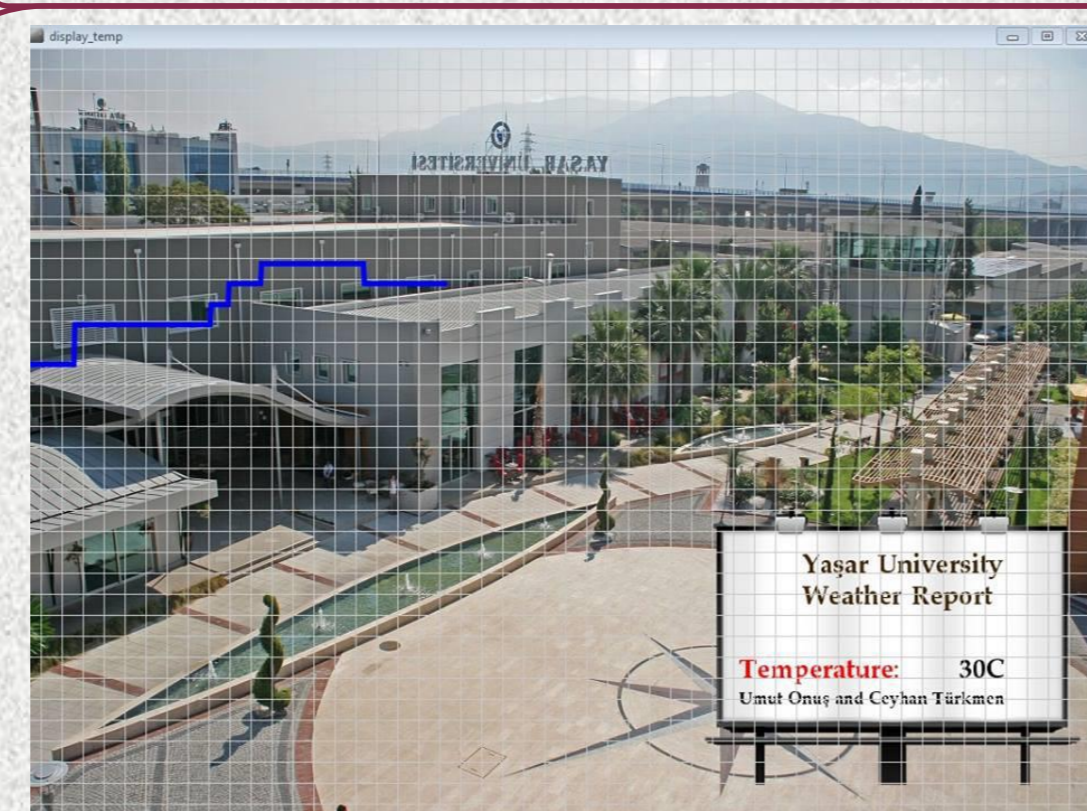


Produced antenna array has 13 – 15 dB gain and 20° beamwidth



The axial ratio of the antenna is nearly 5-8 dB

TELEMETRY SYSTEM, TEST and RESULTS



Up to 45 meters data flow is perfect. At the distance between 45 and 65 meters, communication is performed without any distortion but response time of the system is slightly increased. Despite distortions started after 65 meters, data can be sent up to 100 meters away. A simple oven system can be remotely monitored and controlled from 65-80 meters away.

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