Low-cost vector network analyzer – VNA for measuring the antenna of IoT devices

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The project presents a device that analyzes qualities of the antenna in IoT devices by using the low cost embedded modules. It's used for developing wireless communication devices. The low cost VNA based on the principle of comparison between transmitted wave and reflected wave on the antenna to compute the reflected factor and appreciate qualities of the antenna.

I. INTRODUCTION

Nowadays, the IoT field is developing significantly, so the quality requirements of IoT devices is not only about the stable operation of itself but also a good ability in communicating with other IoT devices. Therefore, the demand of analyzing qualities of the antenna is more necessary. However, the solutions, as well as devices that analyze the quality of the antenna, are still not popular and expensive.

To measuring the quality of antenna, the RF loss that is created by antenna will be analyzed. There are some machines/devices can do this task such as:

- Voltage Standing Wave Ratio Meter (SWR Meter or VSWR Meter)
- Scalar Network Analyzer (SNA)
- Vector Network Analyzer (VNA)

	Cost	**Size**	**Frequency**
SWR Meter	Low	Small	< 600 MHz
SNA	Low	Large	High
Normal VNA	High	Large	High
Soc VNA	Still in research	Small	4GHz–32GHz

After reviewing these solutions as well as devices, our team decides to make a device having all advantages above and get rid of all disadvantages:

- Cost: Low (Under 100$)
- Size: Small
- Frequency: ISM band such as 433 MHz band, 900 MHz band, 2.4 GHz band
- Intuitive and easy to use

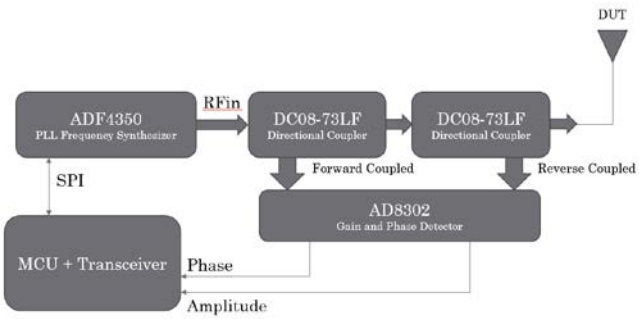
II. TARGET, CONTENT AND PLAN

A. *Target*

Research and fabricate a device that analyzes qualities of the antenna in IoT devices with the low cost, lightweight and meet the frequency band requirements. The device contains following modules:

- PLL Frequency Synthesizer
- Directional Couplers
- Gain and Phase Detector
- MCU + Transceiver

Block diagram:



B. *Content and plan*

- Content 1: Review solutions as well as devices
- Content 2: Design schematic and block diagram
- Content 3: Programming libraries for the MCU to communicate with other modules, layout PCB
- Content 4: Connecting modules

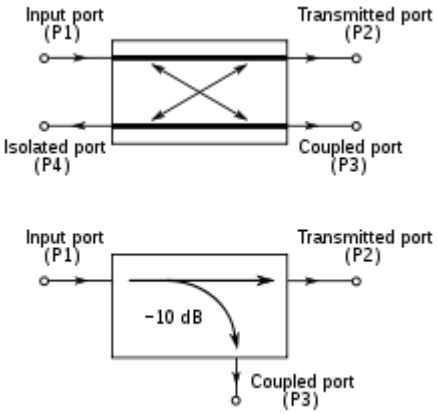
III. MODULE DESCRIPTION AND PRINCIPLES

A. PLL Frequency Synthesizer

To generate radio waves at a specific frequency, we chose a PLL Frequency Synthesizer IC - ADF4351 from Analog Devices company. IC ADF4351 is a Wideband Synthesizer with Integrated VCO which can generate waves from 35MHz to 4400MHz.

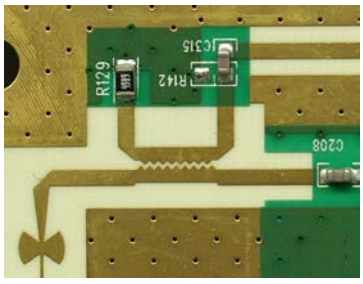
In our current prototype of VNA device, we use EVAL-ADF4351 board. This board is designed to allow the user to evaluate the performance of the ADF4351 frequency synthesizer for phase-locked loops (PLLs). It contains the ADF4351 integrated synthesizer and VCO, SMA connectors for the output signal, power supplies, a reference oscillator, and a USB connector. There is also a loop filter (35 kHz) on board. The price of EVAL-ADF4351 board is about 30USD from Chineses suppilers, quite low to make a low-cost device.

B. Directional Couplers



Two symbols used for directional couplers[1]

- Directional couplers are most frequently constructed from two coupled transmission lines set close enough together such that energy passing through one is coupled to the other.
- The main line is the section between ports 1 and 2 and the coupled line is the section between ports 3 and 4. Any port can be the input



Microstrip Sawtooth Directional Coupler[1]

- We use the IC DC08-73 Directional Coupler 0.3–2.7 GHz for our device because it has many advantages:
  - Low cost
  - Low profile
  - Small SOT-6 package ●
  - Available on tape and reel
  - Available lead (Pb)-free and RoHS-compliant MSL-1 @ 260 °C per JEDEC J-STD-020
- The coupler will take out the feedback signal from the antenna and then transmit it to the AD to compare with the transmitted signal (orginal signal).

C. Gain and Phase Detector

To analyze the difference between source waves from PLL Frequency Synthesizer module and reverse waves from the antenna under test, we use another IC from Analog Devices company - AD8302.

The AD8302 is a fully integrated RF IC for measuring amplitude and the phase between two independent input signals. The device can be used from low frequencies up to 2.7 GHz.

The AD8302 integrates two closely matched wideband logarithmic amplifiers, a wideband linear multiplier/phase detector, precision 1.8V reference, and analog output scaling circuits.

The applied input signal can range from -60 dBm to 0 dBm (ref 50 Ω), which corresponds to a 60 dB dynamic range.

Its price from Chineses suppliers is about 10USD for EVAL-board and 1USD for an IC.

D. Microcontroller and Transceiver

Currently, our VNA device can work dependently and show the measuring result on its LCD or on Android phone via Bluetooth connection.

For the Bluetooth connection between our VNA device and Android phone, we use Bluetooth module HC-05. Module HC-05 use Bluetooth 2.0 technology with very simple AT-commands interface to control via UART protocol.

For the MCU, we choose Tiva Connected Launchpad with ARM Cortex-M4F-Based MCU TM4C1294. The main reason is that Tiva Connected Launchpad supports Ethernet can expand in future development. Besides, Tiva Connected Launchpad supports many connection interfaces such as UART, SPI, I2C,...

ACKNOWLEDGMENT AND DIFFICULTIES

Some modules don’t work stably

DEVELOPMENT

REFERENCES

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[1] https://en.wikipedia.org/wiki/Power_dividers_and_directional_couplers (*references*)

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