Non-linear Junction Detector

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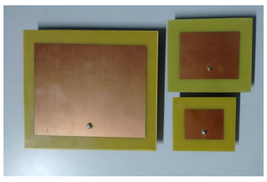
Introduction

- A non-linear junction detector, or an NLJD is a counter-surveillance tool commonly used for detecting hidden transmitters or other electronic items. Its working principle is based on the detection of harmonic frequencies which are generated by any non-linear junction when illuminated by RF radiations.
- Since all electronics invariable contain such junctions nowadays, an NLJD is correspondingly capable of detecting almost any unshielded electronic device containing semiconductors, immaterial of whether it is on or off.
- Rust, corrosion, other metal joints are also non-linear junctions and can give false positives. But it is possible to distinguish them from p-n junctions by comparing relative strength of 2nd and 3rd harmonics.

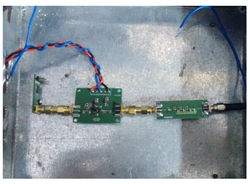
Uses

- In the naxalite affected regions of the country, the naxals regularly plant remote controlled bombs under the roads there. Detecting these is crucial for the CRPF jawaans operating there.
- These detectors are used for providing location secure from covert listening devices in different organizations.
- Some specific models of NLJD are also used by the police in search for weapons during events involving great masses of people.

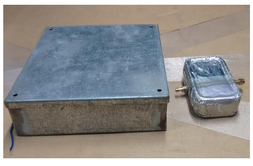
System Subparts



Antennas



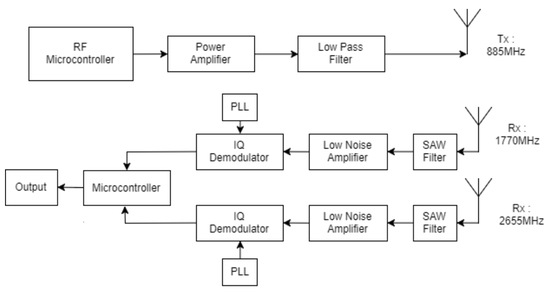
Transmission Chain



Shielding

Receiver Chain

Block Diagram



Current Scenario

NLJDs are currently imported from countries like Germany. They however prove to be very expensive (around Rs.12 lakh per piece). Moreover the spare parts aren't easily available in the country and the foreign companies charge hefty amounts for them.
Thus there is need for indigenization of this device. Indigenization will also allow us to customize the product according to the needs of our forces..

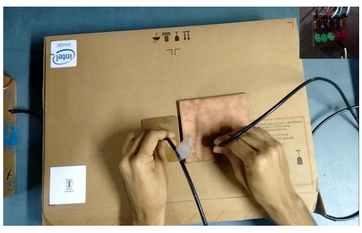
Target Specifications

- Operating Frequency : TX – 885 MHz | RX – 1770MHz , 2655 MHz
- Sensitivity : -130dBm or better for both harmonics
- Transmit Power : 30dBm
- Antenna type : Microstrip patch antennas for both Tx, Rx

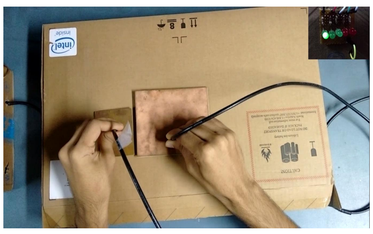
Work done

- Pulsed frequency generation using RF microcontroller
- Power amplifier to increase the final output power to close to 0.5W
- Designed low pass and band pass filters in order to remove unwanted signals in the transmitter and receiver chains
- Designed microstrip antennas at 885MHz, 1770MHz and 2678 Mhz
- Low noise amplifier at the receiver side to amplify the harmonics
- Downconversion of received signals using an IQ demodulator
- Final signal confirmation and indication using microcontroller and LEDs
- Proof of concept demonstration of the technology and ability to detect false positives resulting due to presence of rust or metal junctions

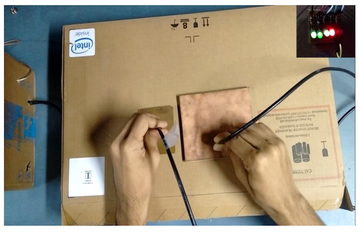
Searching for hidden electronics - trial



When the antennas are away from the hidden device no LEDs are on

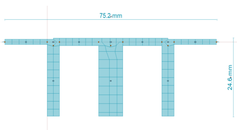


As we move the antenna towards the hidden device, some of the LEDs turn on

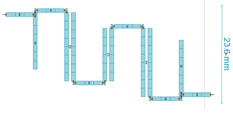


When the antennas are closest to the hidden device most of the LEDs turn on

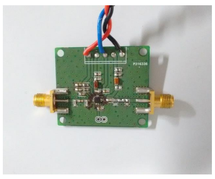
Components currently being developed



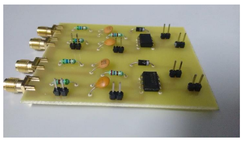
Layout of Stub filter



Hairpin Microstrip Filter



Power Amplifier



Log amplifiers & precision rectifiers

Challenges

Major challenges in the development of the technology

- The harmonic signals are very weak (less than a femto-watt) which requires our systems to have high gain while keeping low noise figures
- The transmit signal itself has significant harmonic components that may screen the harmonics generated by the concealed electronics
- Filters, PA and LNA radiate a significant amount of harmonics interfering with the harmonics generated by the concealed electronics
- Filtering the harmonics generated by the power amplifier which gets very severe at the higher output power levels

Current focus and Future work

- Generating signal at desired frequency with low harmonic content
- Improving the sensitivity of the receiver chain to -140dBm
- Increasing the out of band suppression achieved by the filters
- Reducing the amount of signal radiated out by the filters
- Designing a single multi band antenna for both Rx and Tx
- Use techniques like coherent integration and FFT after downconversion
- Battery and power management of the system