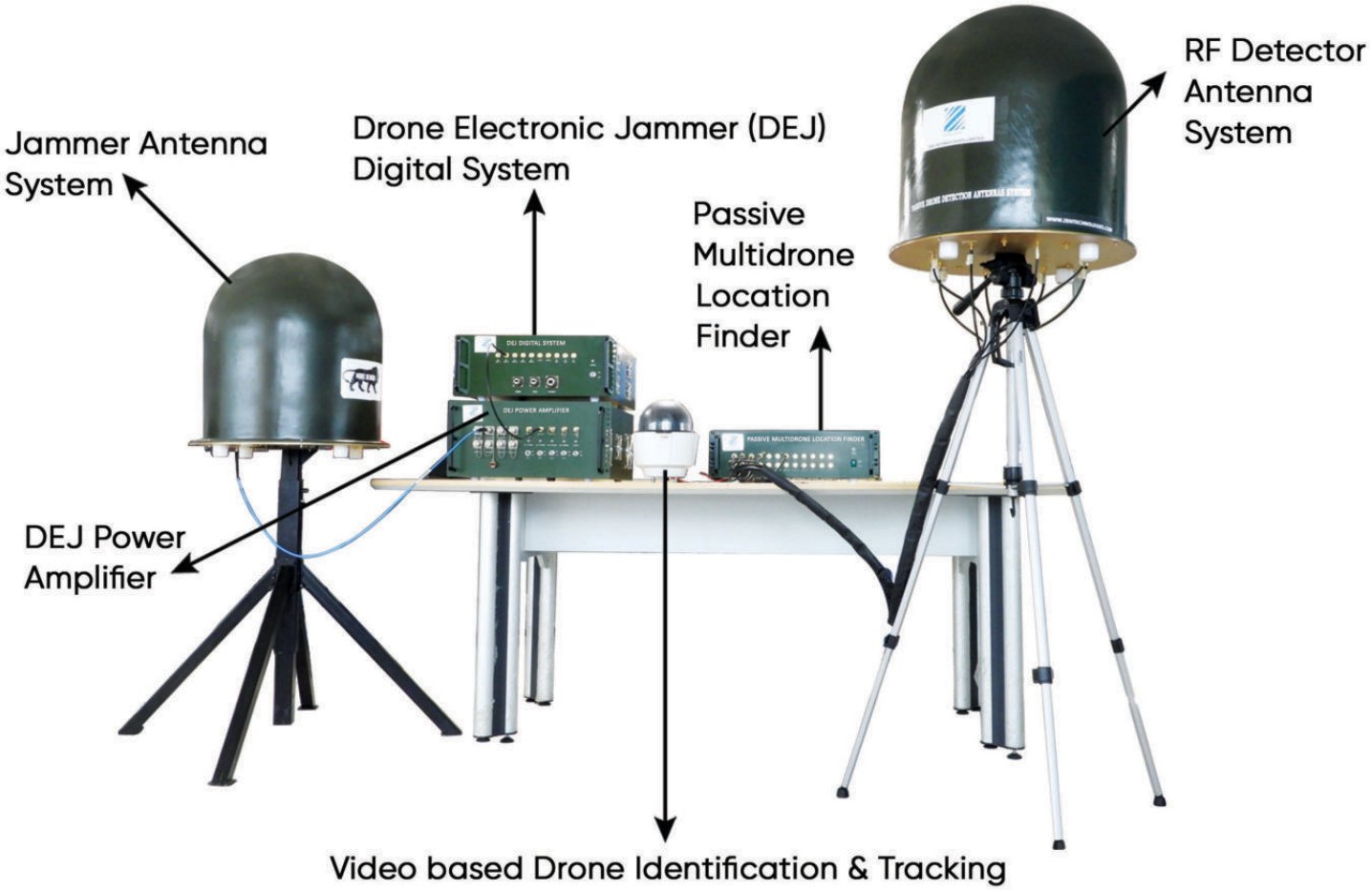
ZEN ANTI-DRONE SYSTEM



Zen Anti-Drone System is a Multi-Layer Multi Sensor Architecture aimed at providing comprehensive security against drone attacks. Modules of Multi Sensor setup include:

- RF Based Drone Detector (RFDD)
- Video based Drone Identification & Tracking (VDIT)
- Data Fusion and Command Center (DFCC)
- Drone RF Jammer (DRFJ)

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RF Based Drone Detector (RFDD):

RFDD detects the drone using Radio Frequency (RF) communication between drone and Ground Control Centre (GCC). This System is on continuous search mode on wide band of frequencies that typically used by Drone and its GCC. Whenever a frequency of interest is identified, the system locks and monitors the signal. Based on the identified signal, system estimates the direction of Drone and its GCC. An array of receive antenna is used for estimation of direction of signal.

Frequency Covered:

- **Model RFDD01:** As per below given Centre frequency and bandwidths.
  433.92 MHz (1.74 MHz bandwidth)
  915 MHz (26 MHz bandwidth)
  2.45 GHz (100 MHz bandwidth)
  5.8 GHz (150 MHz bandwidth)
- **Model RFDD02:** 400MHz to 6GHz
- **Model RFDD03:** 20 MHz to 6GHz

Instantaneous Bandwidth:
25 MHz(extendable to 40 MHz)

Frequency Scan Speed:
Fast mode: 20 GHz/ sec
Slow mode: 1 GHz /sec

Frequency Resolution:
25 KHz / 50 KHz

Detection Sensitivity:
-110 dBm at 0 dB SNR

Detection Range: 10 meters to 3 Km for commercial and military drones

Response Time: <0.1 sec

Detection of frequency hopping signals:
Up to 2000 hops per second

Angle Coverage:
Azimuth 0 to 360 degrees
Elevation 0 to +70 degrees

Angular Accuracy (Azimuth): Up to 3˚ (RMS)

Tracking Accuracy (Azimuth): Up to 2˚ (RMS)

Maximum Input Level: +10dBm

Types of Signals:
RF signal emissions of types used by remote controls and telemetry (video) signals. Even non-standard waveforms such as military SDRs (Software Define Radio) falling in the frequency range are detectable

Temperature:
Operational temperature: -10 to +45
Storage temperature: -20 to +55

Video based Drone Identification & Tracking (VDIT):

The day and night camera sensors are mounted on an automatic servo-based positioning system. This system receives commands for position from RFDD. Once positioned in the direction of interest, captures video and images of the drone. VDIT is capable of capturing and tracking video up to a range of 3 Km. Video feeds are given to software module and video processing algorithms in the the software automatically confirm the presence of a drone and imitate tracking.

Feature	Specification
Camera Type	Day Camera
Sensor Size	1/2.8", Full HD CMOS
Resolution	2MP, 1080p
Detection Range	Up to 3km
Continuous Zoom Optics	Up to 2000mm with 0.13 HFOV
Pan	0 to 360 (Continuous Rotate)
Tilt	-20 to 70
Pan and Tilt Speed	Configurable from 0.01 to 60 /sec
Environmental Rating	IP66
Operating Temperature	-20 C to +55 C
Operating Humidity	≤ 90%
Other Features	Detection and classification of drone make and model. Eg: DJI Phantom 4 Pro

Radar Detection:

Detection of autonomous drones (flying without a link between drone and operator) using RFDD, is not possible. RADAR provides the best choice to detect such threats. An X band 2D/3D RADAR detects the drones as per the RADAR detection range specifications and provides precise data for target coordinates both in Azimuth and elevation. The feed from the RADAR is integrated to the data fusion centre for effective detection and monitoring of the threats.

Hard Kill Interface:

Zen Anti-Drone System is offered with integration of Hard Kill options. Standard Air Defence Guns interface and a Net based drone catcher are the two options available. Gun interface can feed coordinates to the gun and align it to the target ingress direction to destroy it physically. Regulatory permissions required to use such solutions shall be obtained by the users.

In order to capture the drone and land it at a safe place, net-based drone capture option can be employed. For this, a dedicated drone with a hanging net could be launched to capture the rogue drone. This option is suitable for small rogue drones carrying potentially damaging explosives.

Data Fusion and Command Centre:

This module integrates the data from RFDD and VDIT. Detection and classification algorithms based on RF data as well as visual data are built into this system. An integrated display system enables the display of the threat situation. This display system integrates the Map with zones of threat. Provision to define the area of monitor, zone of threat, zone of identification of threat etc is given in the console. Spectrum and waterfall screens are also part of the software, which provide the complete picture of the detected emissions.

- The circle marked in blue depicts maximum detection range of the system
- The black marking on the map is vulnerable area
- And the red color marking is for the protection zone

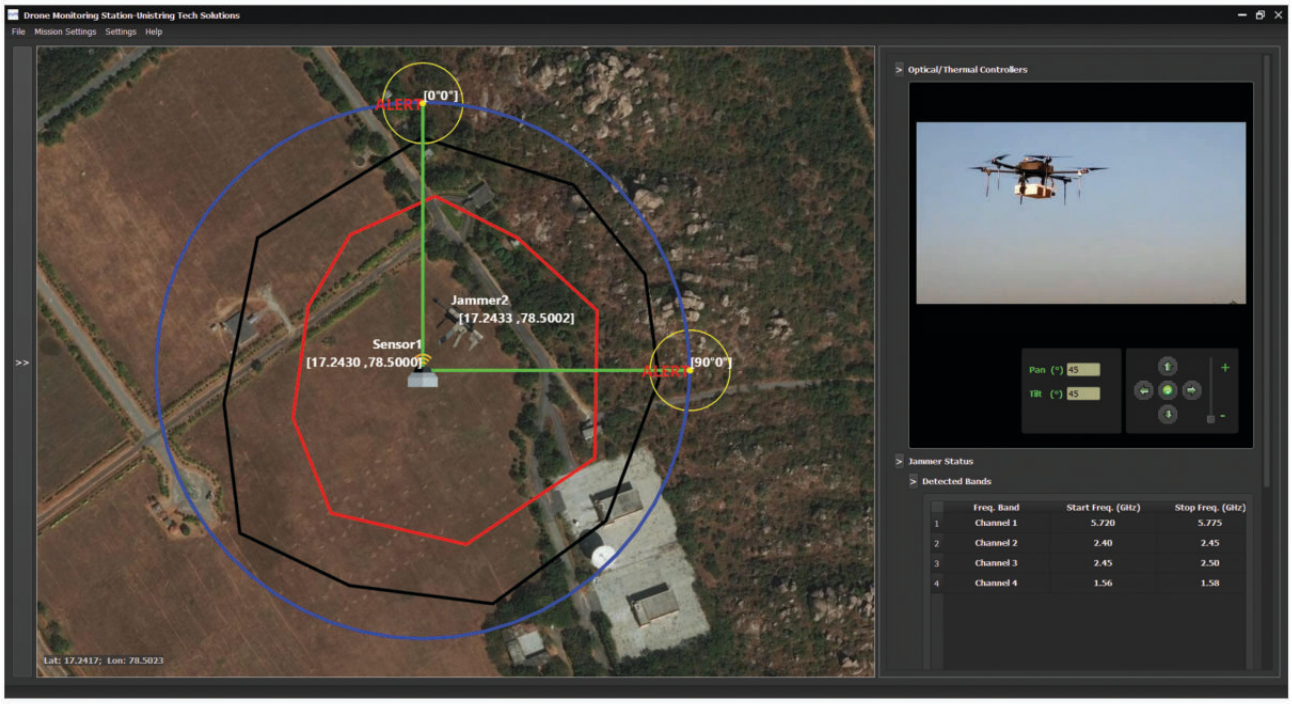

Figure 1: GUI display of Data fusion software

The system starts tracking a drone on entering into the detection zone. Drone's trajectory is marked with yellow. On the right top corner there is a window to provide a live video feed from VDIT. Also, at the right bottom corner a drone jamming sub system status display is provided. This display enables to set start and stop frequency manually to control jammer output frequencies.

Drone RF Jammer:

Drone RF Jammer (DRFJ) is capable to disable the link between GCC and Drone by jamming simultaneously ISM bands, GNSS signals, mobile signal and any other intercepted frequencies. The frequencies detected by RFDD are automatically taken and jamming waveforms are generated and radiated using the directional antennas. The system also supports user configured frequency to carry out the jamming action. A provision to manually feed the jammer frequencies is also given.

Description	Value
Architecture	Software based selection among • Directional antenna with servo control • Omni antenna for 360 degree jamming
Jammer Range	**Model DRFJ01:** Up to 1 Kilometers directional jamming and up to 0.5 Km Omni jamming **Model DRFJ02:** Up to 3 Kilometers directional jamming and up to 1.5 Km Omni jamming (higher range models available)
Angle Coverage	360 degrees azimuth and 70* degrees Elevation *can be adjustable based on the installation for lower elevation angles coverage
Communication Frequency Bands	All ISM, Navigation bands *Wide band system can be provided covering all frequency bands.
ISM Frequency Bands	433.92 MHz (1.74 MHz bandwidth) 915 MHz (26 MHz bandwidth) 2.45 GHz (100 MHz bandwidth) 5.8 GHz (150 MHz bandwidth)
Navigational Frequency Bands	**GPS:** L1-1575.42 MHz L2-1227.60 MHz L5-1176.45 MHz **GLONASS:** L1-1598.0625 MHz to 1605.375 ± 0.511 MHz L2-1242.9375 to 1248.625 MHz± 0.511 MHz L3-1201 MHz **GALILEO:** E1- 1575.42 MHz E6- 1278.75 MHz E5-1191.795 MHz **BEDOIU:** B1: 1561.098 MHz B1-2: 1589.742 MHz B2-1207.14 MHz B3-1268.52 MHz

*Note: All product specifications are subject to change without notice to improve reliability, function, design or otherwise.

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