Paralyzing Drones via EMI Signal Injection on Sensory Communication Channels

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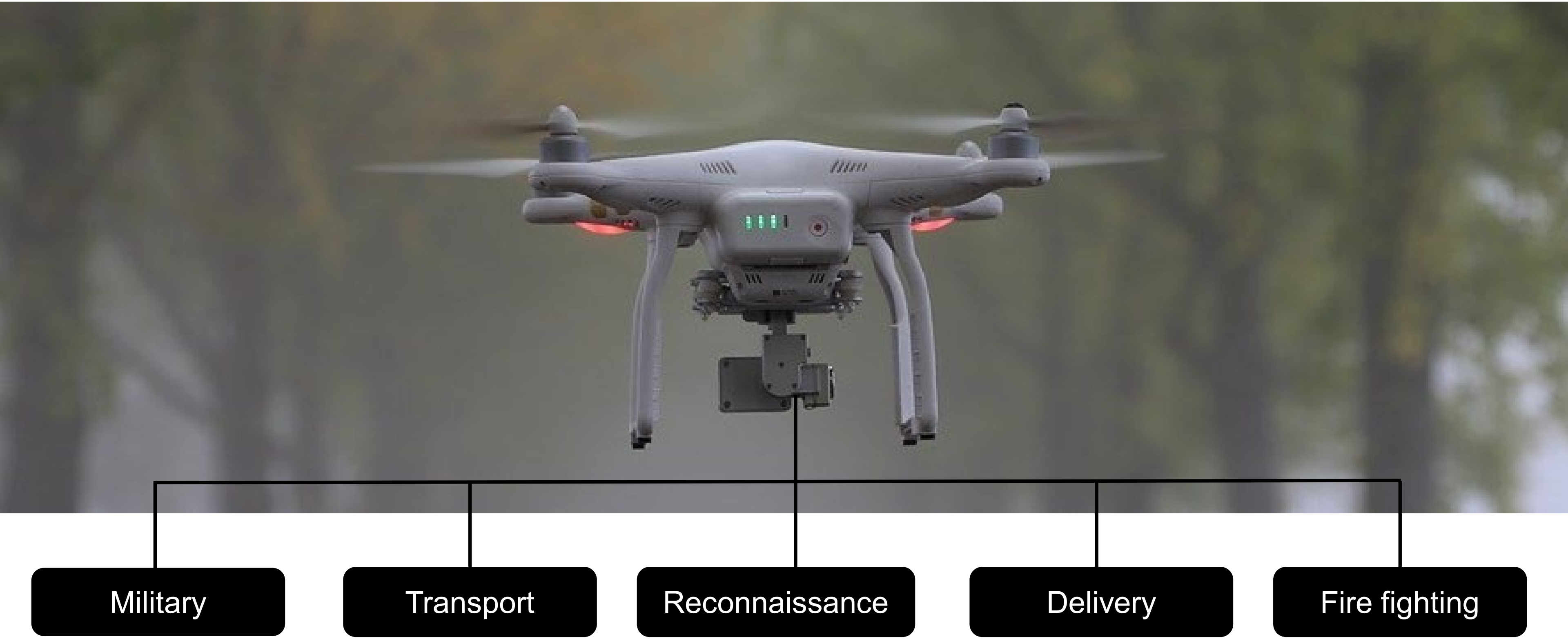
Drone



Military

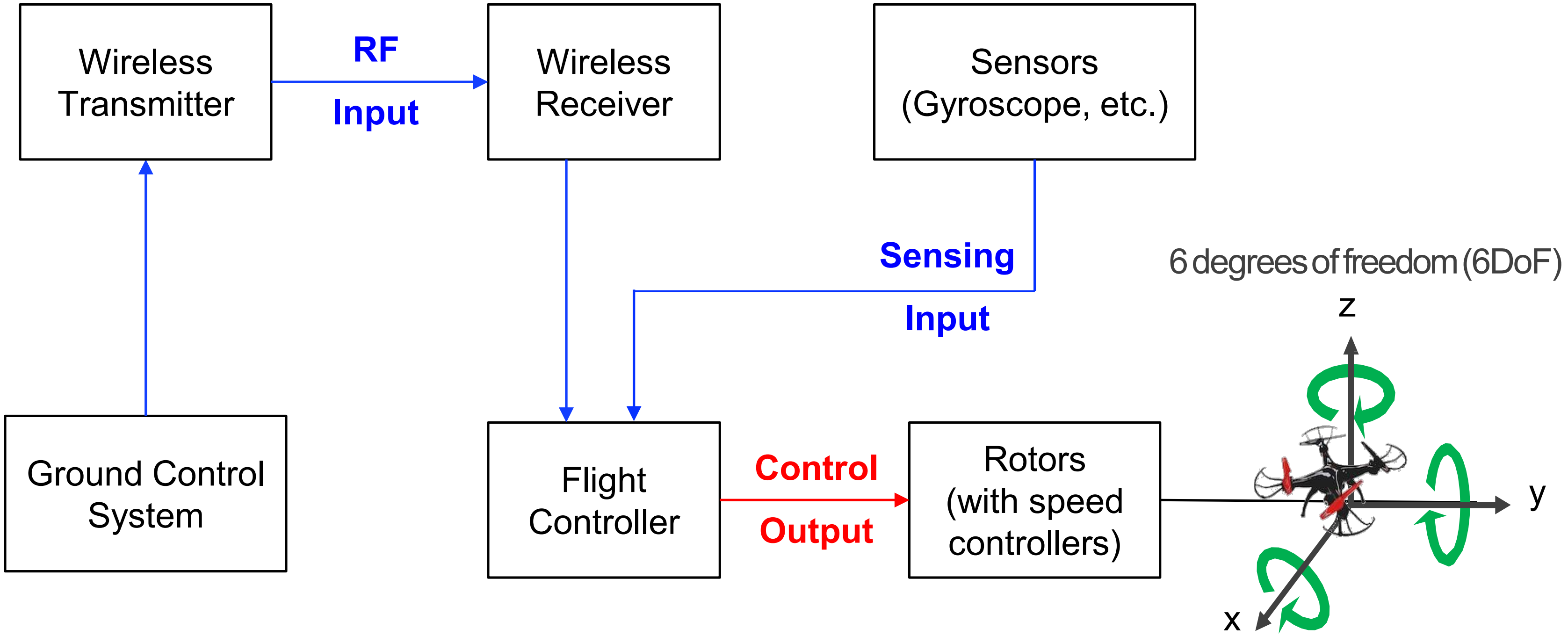
Transport

Reconnaissance

Delivery

Fire fighting

Drone system



Wireless Transmitter

RF

Input

Wireless Receiver

Sensors (Gyroscope, etc.)

Sensing

Input

Ground Control System

Flight Controller

Control

Output

Rotors (with speed controllers)

6 degrees of freedom (6DoF)

Drone Neutralization Technologies

Type	Technology	Strength	Weakness	Response Time
Physical	Machine Gun,	Cost	Accuracy, Collateral damage	≈ 0
	Net, Colliding Drone	Cost	Accuracy, Reload	<10 sec
	Sound	Swarm attack	Distance, Power, Bypass, Aiming	<10 sec
	High-power laser	Accuracy, Distance	Response time, Cost, Swarm	>10 sec
Electro-magnetic	RF jamming	Cost, Distance	Collateral damage, Response time, Bypass	>10 sec
	GNSS jamming	Cost, Distance	Collateral damage, Response time, Bypass	>10 sec
	High-power EM	Swarm, Distance	Cost, Collateral damage	≈ 0
	Targeted EM	Power, Swarm, Distance	Cost	≈ 0
Hijacking	GNSS spoofing	Hijacking, Distance	Collateral damage, Response time	<10 sec
	Software hijacking	Cost	Need vulnerability	

Previous Work: Rocking Drone [Usenix'15]

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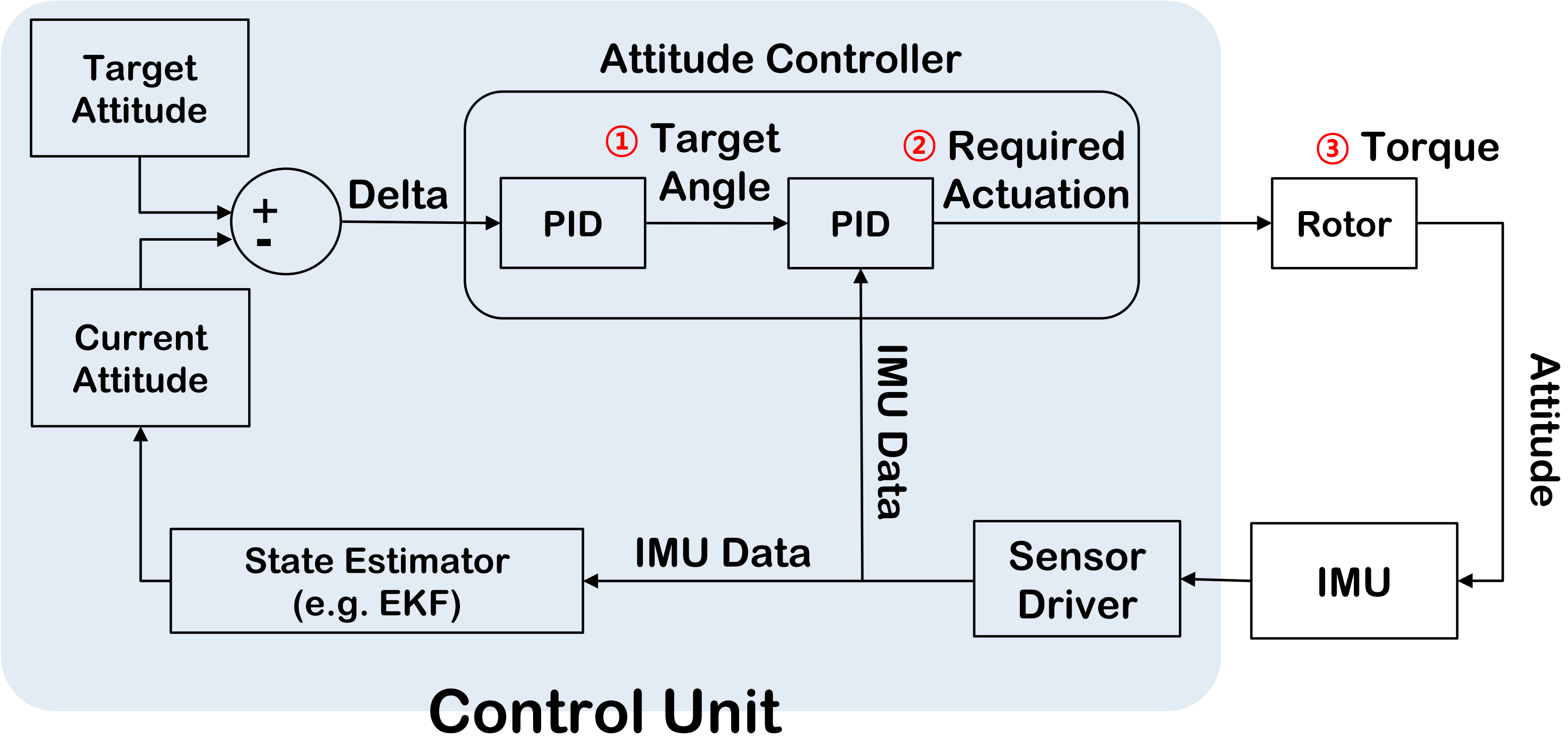
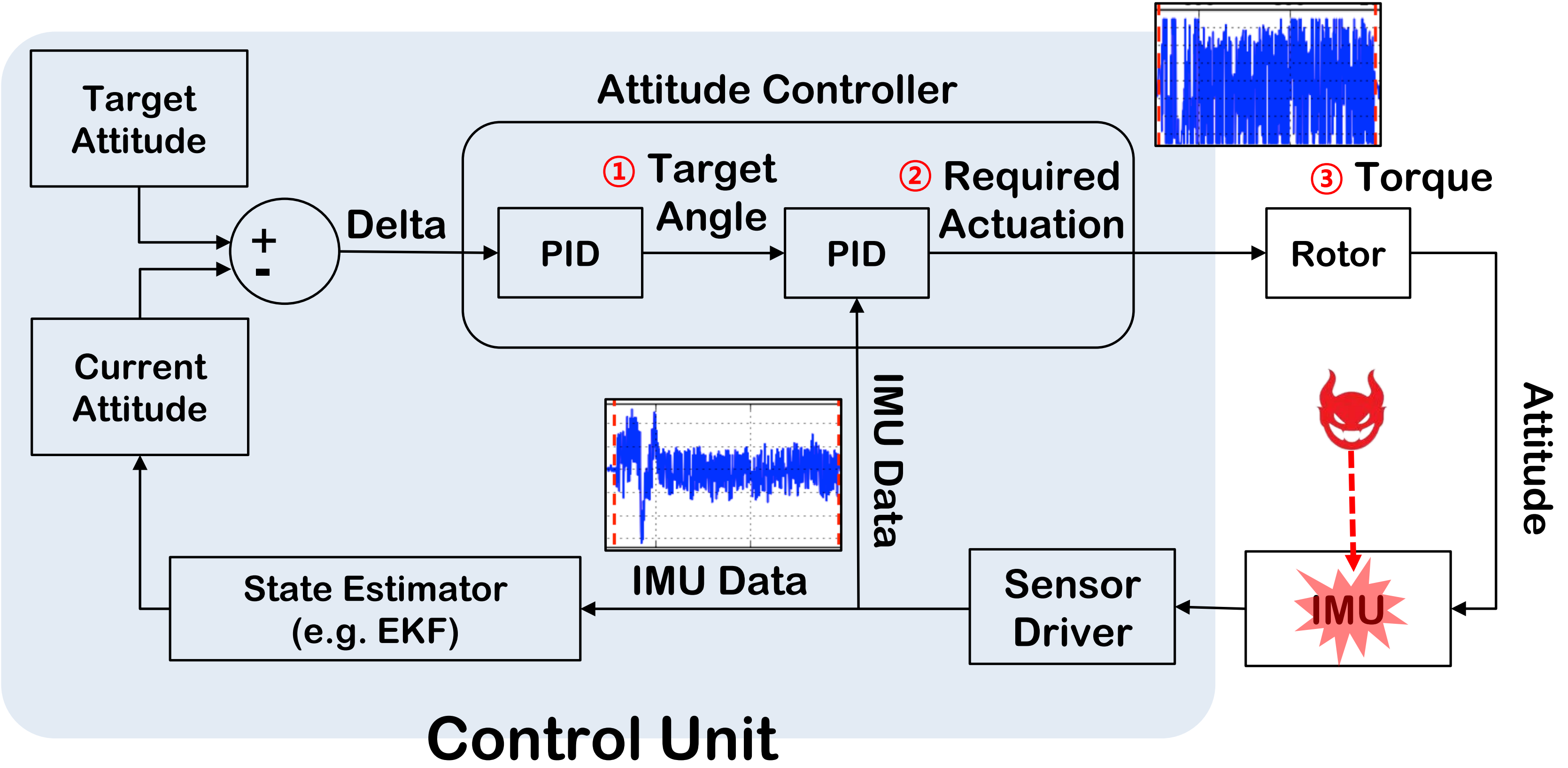
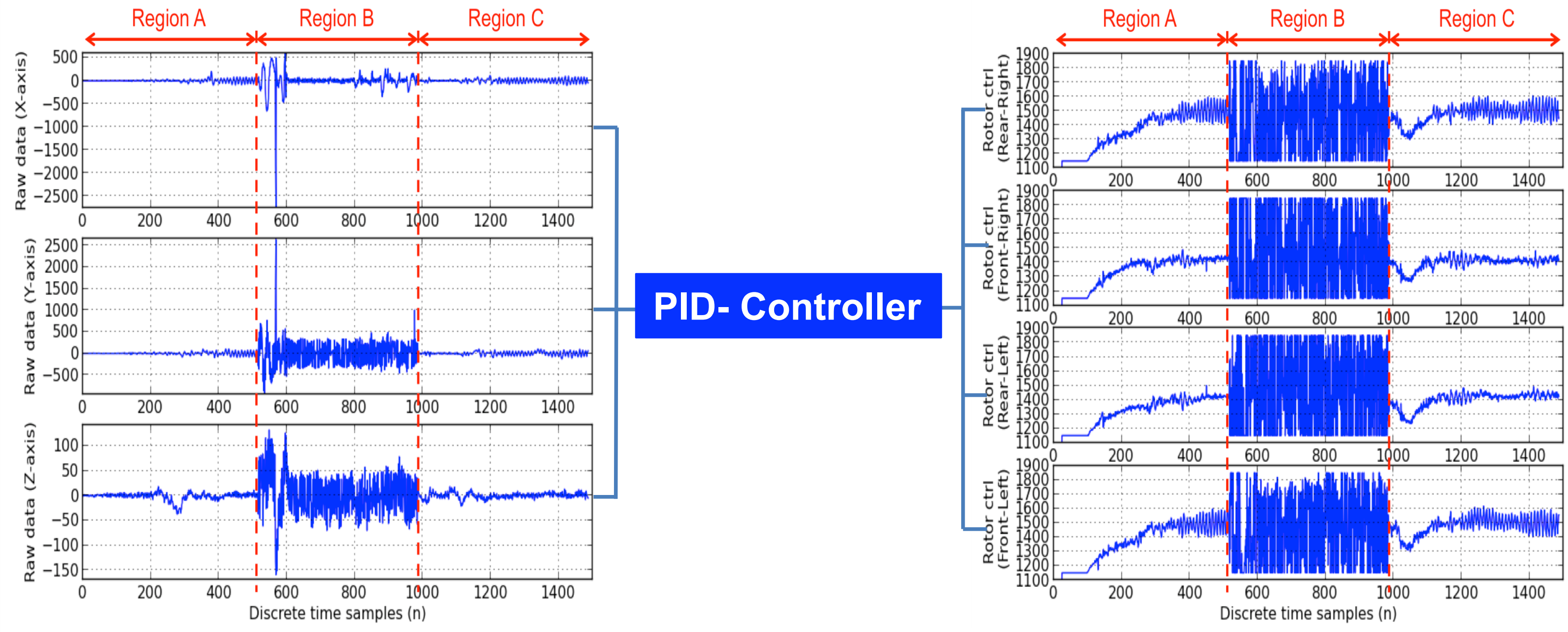
How Drone Control Works



How Rocking Drone Control Works



Rocking Drone Attack Results



PID- Controller

Raw data samples of the gyroscope

Rotor control data samples

Paralyzing Drones with EMI Attack

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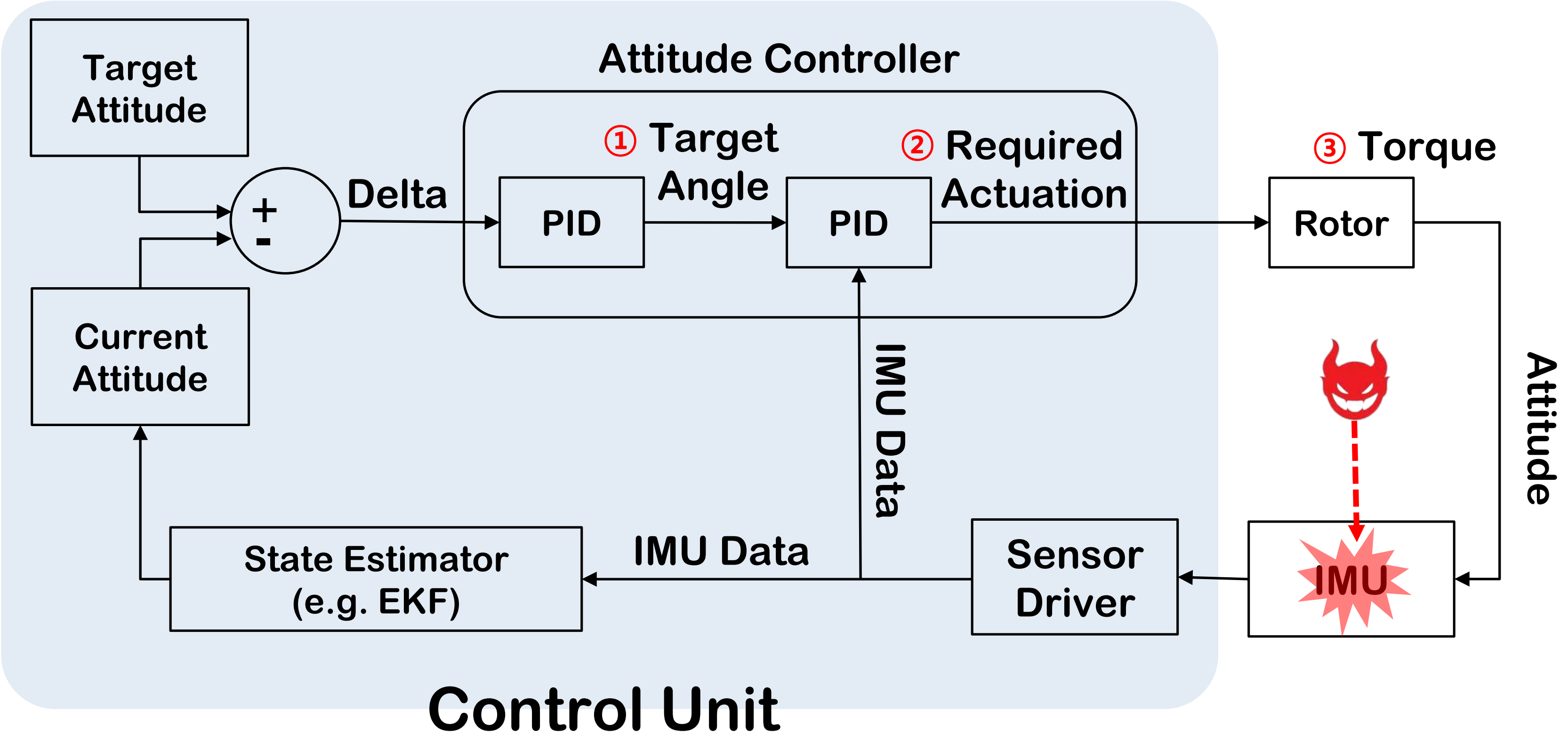
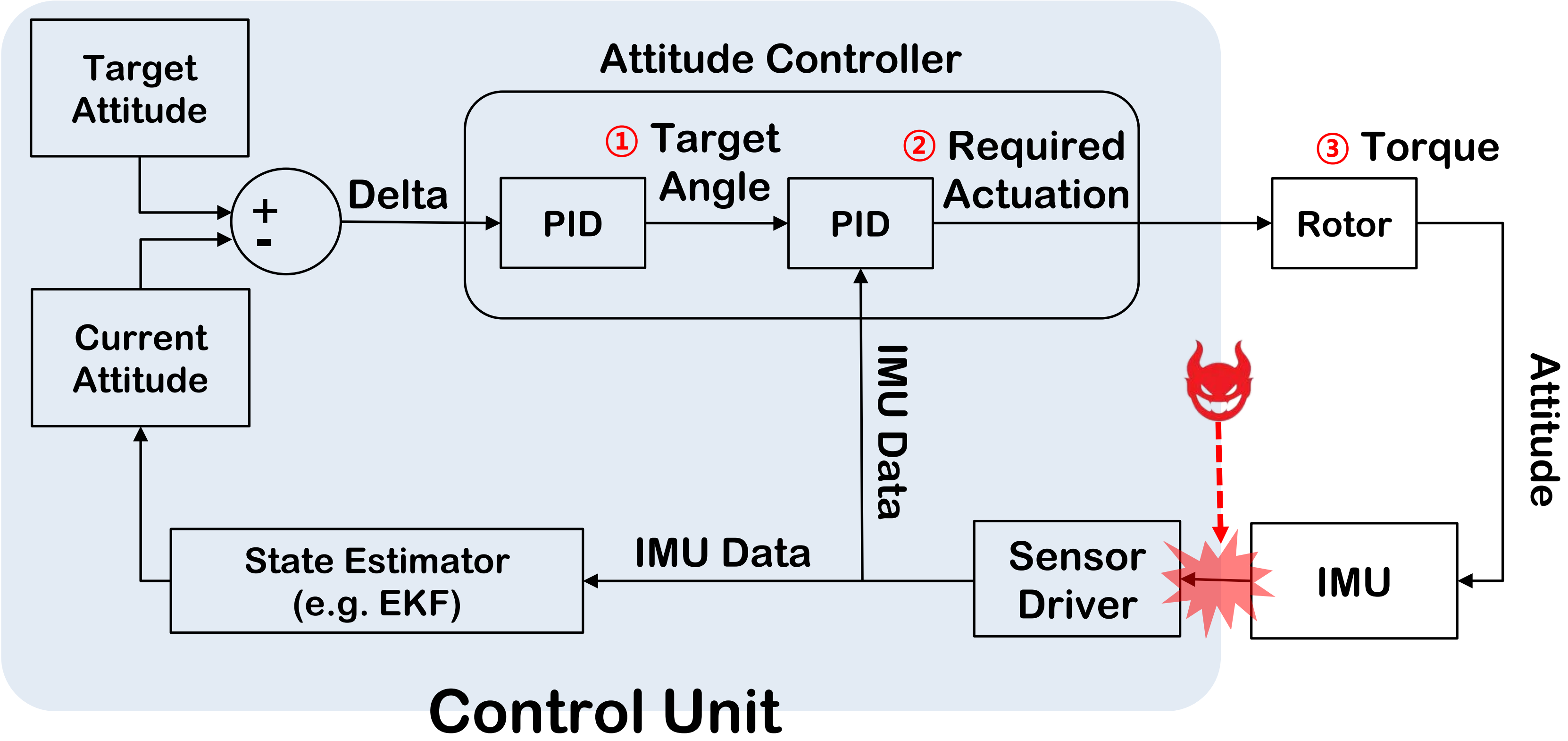
Rocking Drone: Control System Perspective



Paralyzing Drone: Control System Perspective



Q1. Distorting Communication Channel?

Disrupting
Original Signal

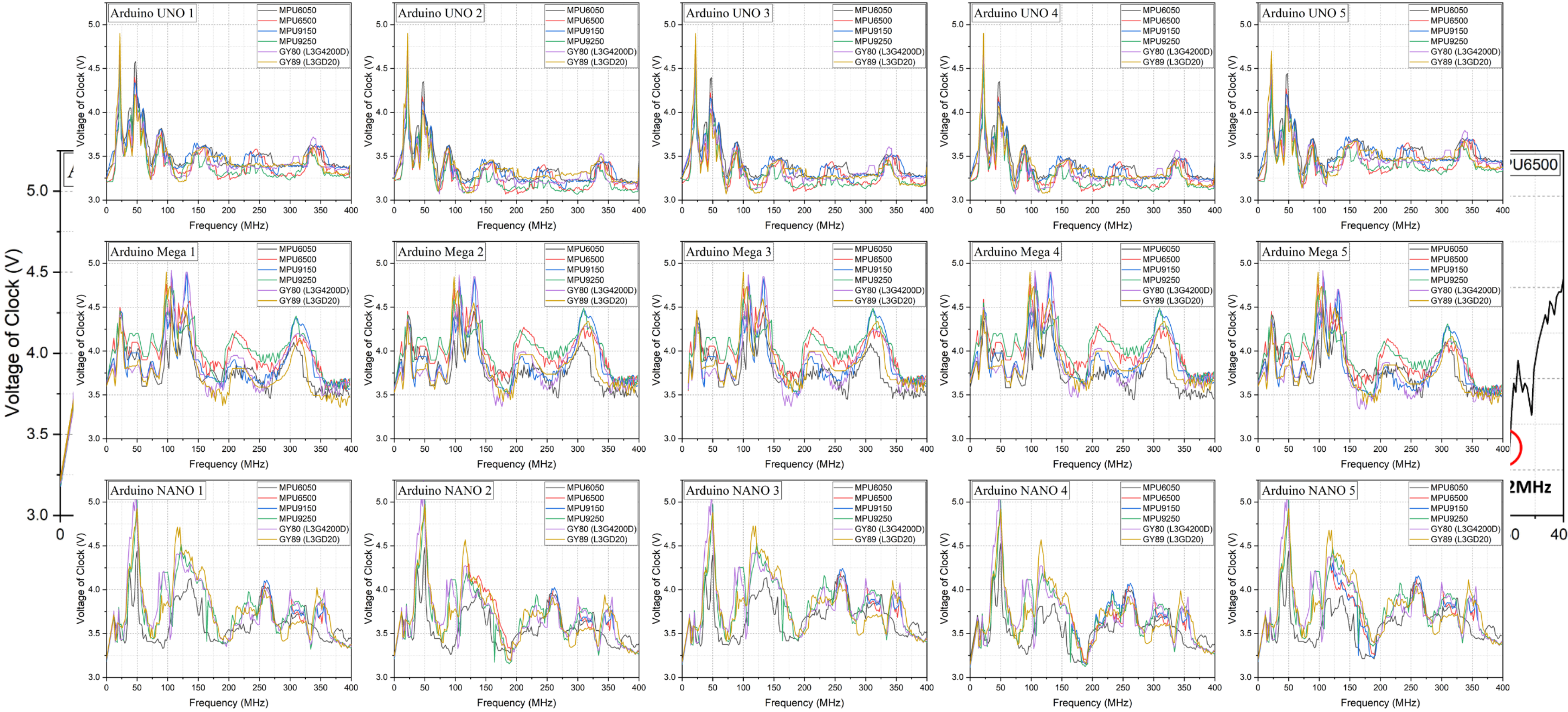
Q2. Remote disturbance possible?

Experiments With
EM Injection

Q3. Remote injection possible for drone?

EM injection experiment
On hovering Drone

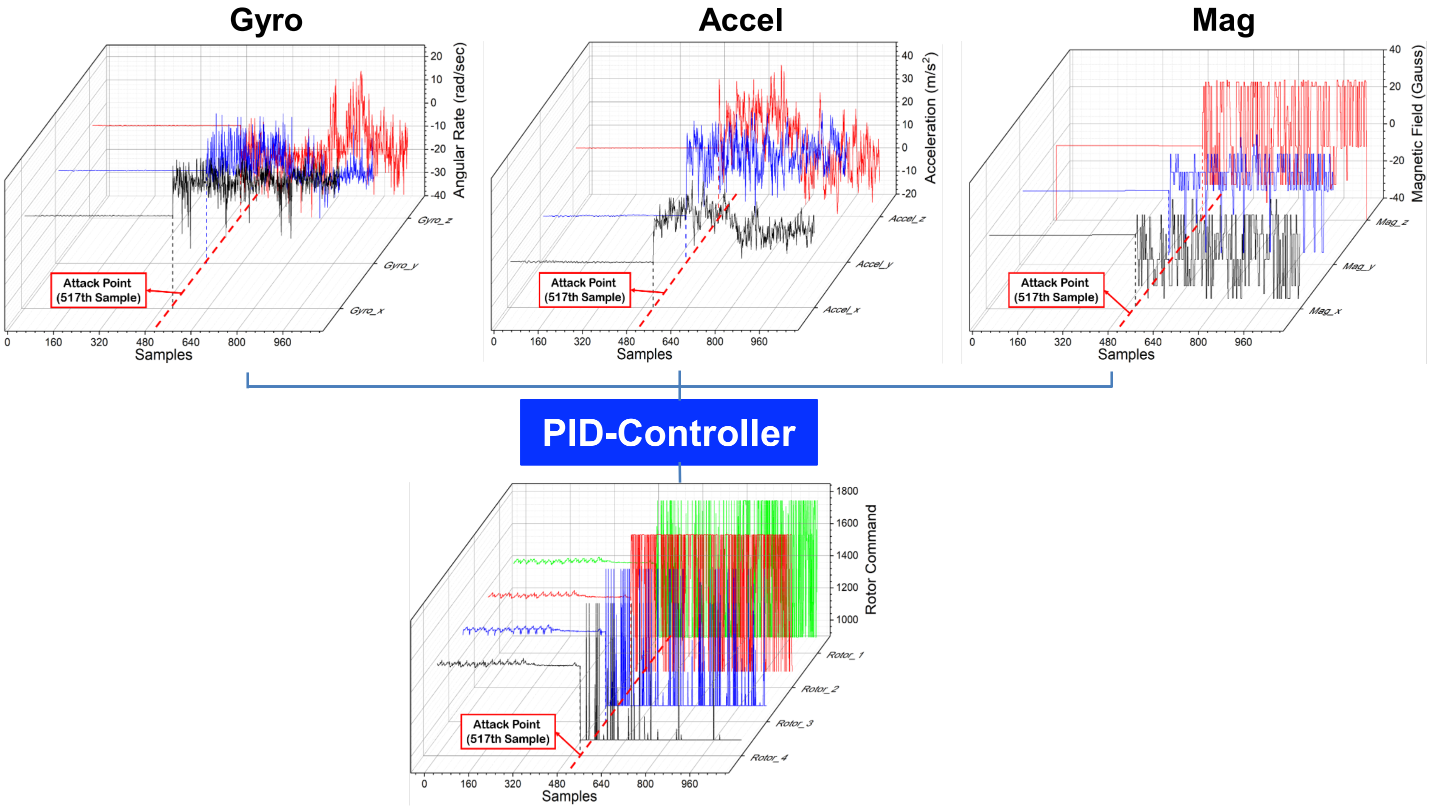
Q4. Attack Frequency?



Q4. Attack Frequency?

Targeted EMI injection Experiment

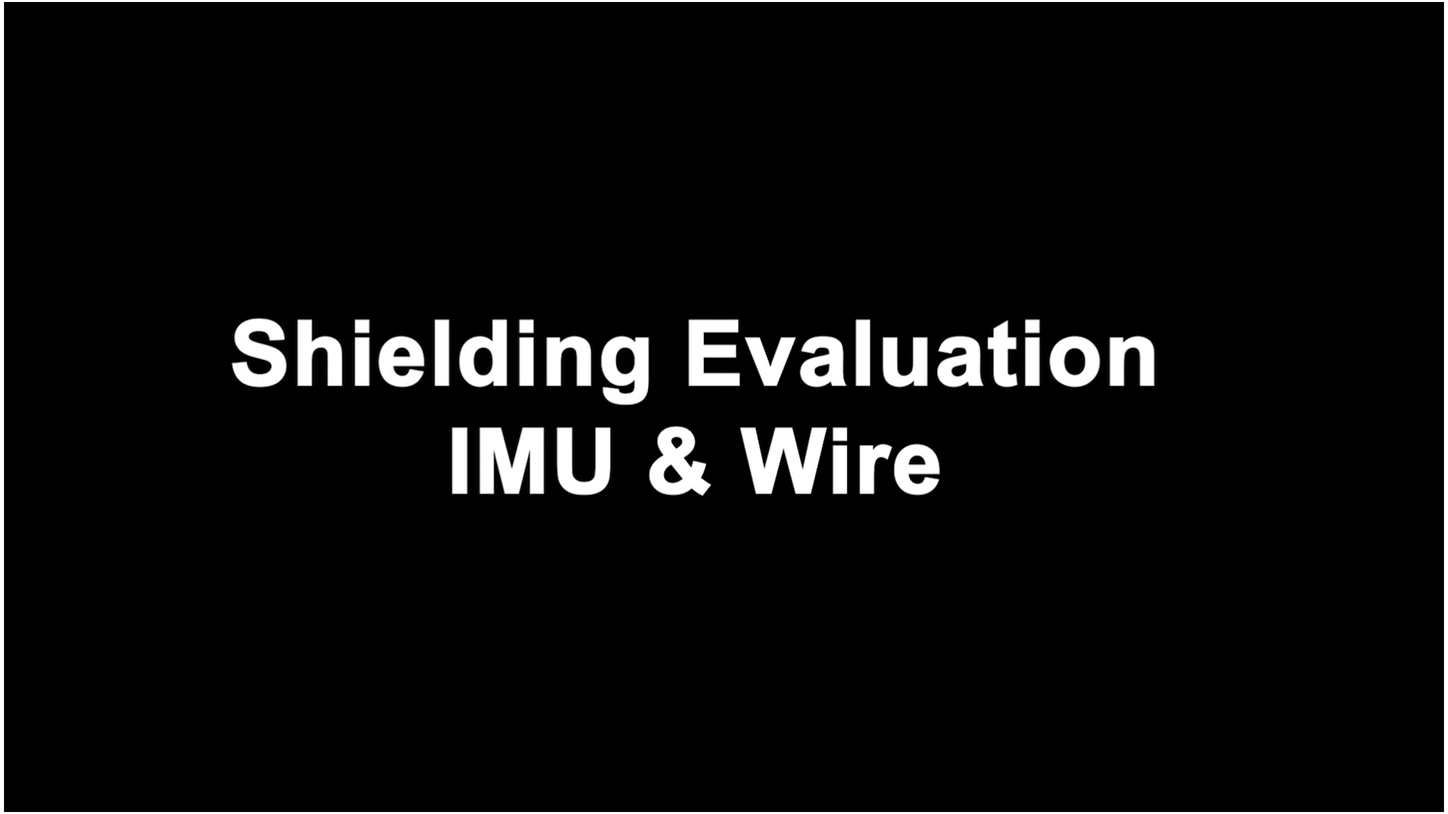
Q5. Response time?



Attack Point (517th Sample)

PID-Controller

Q6. Countermeasure?



Shielding Evaluation
IMU & Wire

Q6. Countermeasure?

- ❖ Existing Circuit level Detect and Mitigation
  - – Time Offset Approach
  - – Dummy Circuits Apporach
- ❖ Detection & Recovery
  - – Detect the impact of EMI
  - – Recover or Replace the impact of EMI
- ❖ Shielding [Most Effective]
  - – Block the injection rather than the impact of EMI

Conclusion

- Advantages of Paralyzing Drones
  - The attack frequency is determined by the main board ➔ Swarming
  - Very narrow frequency ➔ lesser collateral damage, lesser power
  - Within a single sampling time ➔ no time for detect and recovery

- Future work (commercialize)
  - Analysis of countermeasures
  - Analysis with more drones
  - Analysis for more efficient and effective EMI injection

Thank you!

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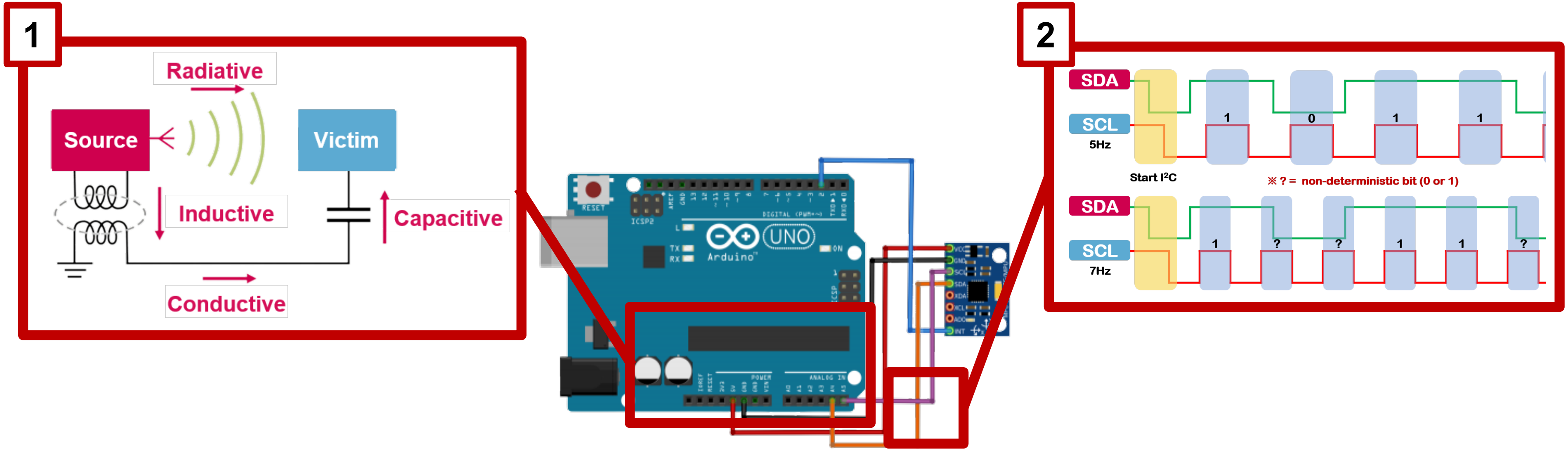
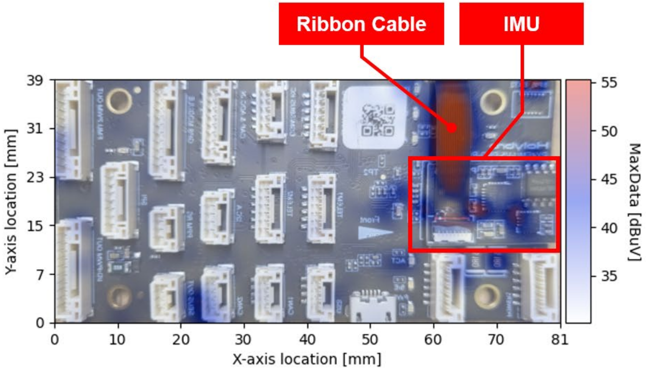
https://sites.google.com/view/paralyzing-drones-via-emi

How is this Working

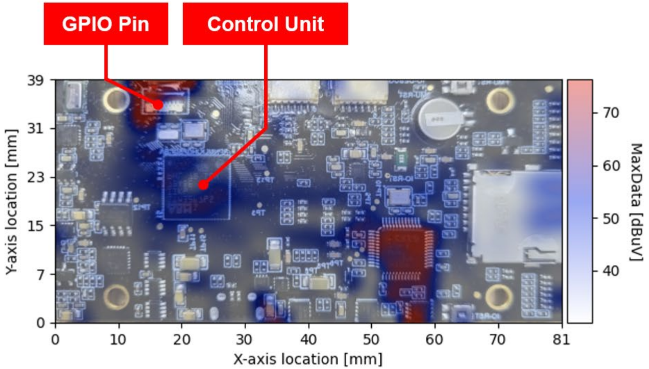
1. Back door EMI coupling(Radiative) on Control unit
2. Signal distortion in the digital signal of the communication channels between the IMU and control unit.



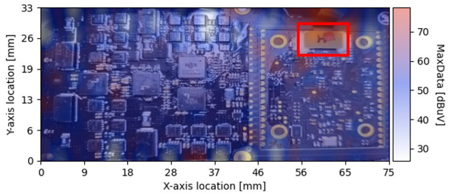
POE (Point of Entry)


Ribbon Cable

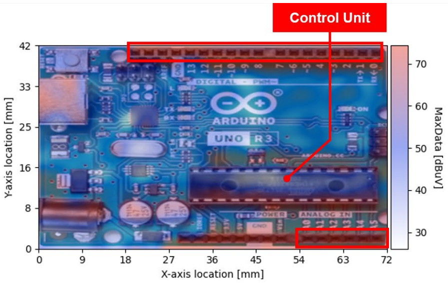
IMU


GPIO Pin

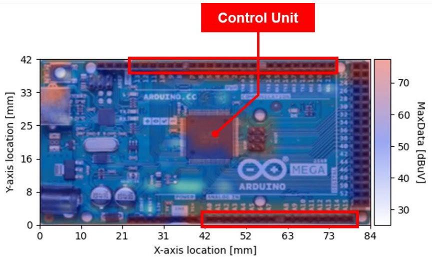
Control Unit



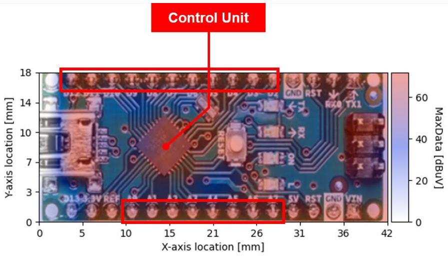
DJI Mavic Pro


Control Unit

Arduino UNO

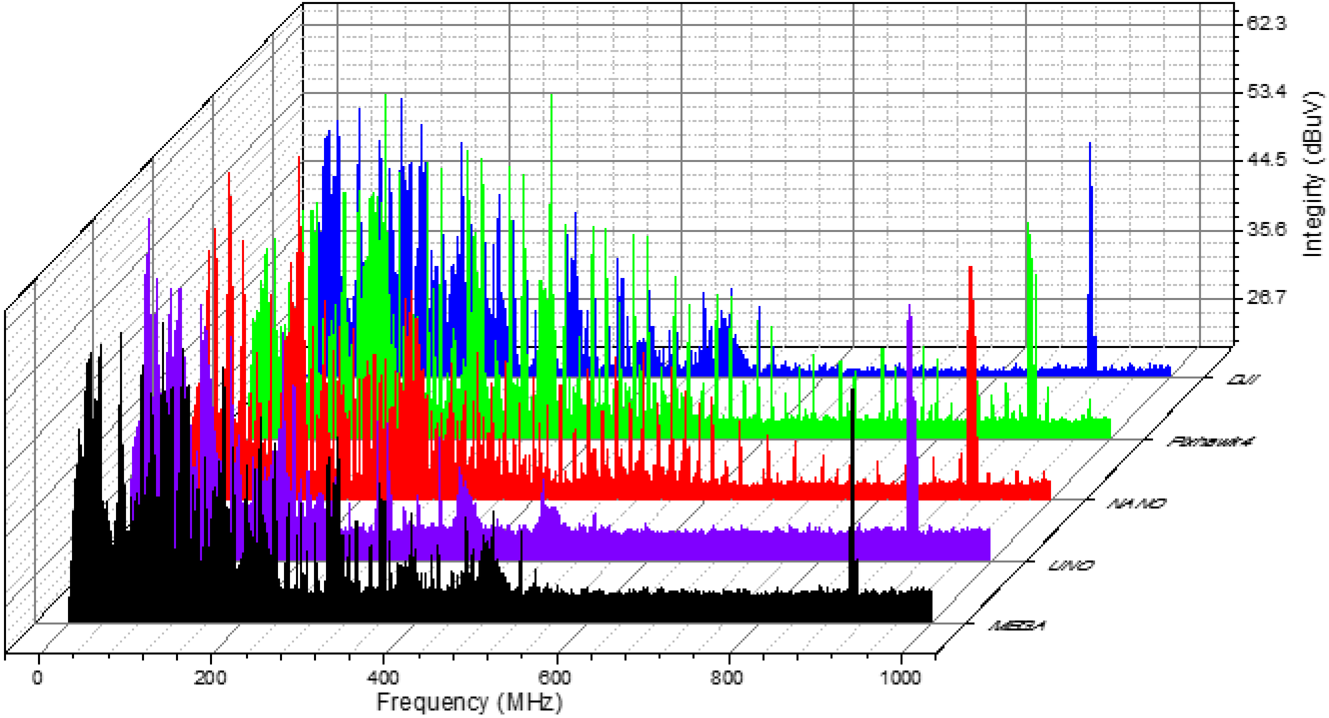

Control Unit

Arduino Mega


Control Unit

Arduino NANO

POE (Point of Entry)



Experiment Setup