

## LightAntenna: Characterizing the limits of fluorescent lamp-induced electromagnetic interference

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Medical







Medical



Household







Medical



Household



Industry







Medical



#### Household



Industry



Meeting rooms







Medical



Household



Meeting rooms



Industry



USD 6.5 Billion in 2023 and USD 7.15 Billion by 2030







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Fluorescent lamp (FL) plays an indispensable role in the IoT world









Quora	Microsoft Surface Home Forums - What's new - Members -
Why does bright fluorescent light affect iPhone touch screens?	Forums
All related (1) V Sort Recommended V	Home Forums Microsoft Surface Forum Microsoft Surface Pro 3
C Leslie Norwood ×	Solved Touchscreen interference issue, CONFIRMEDWEIRD!
It is due to the high-output of EMI produced by the fluorescent lights.	& dankgus · ③ Apr 10, 2015
iPhone	Surface laptop











~?
2.

Microsoft Surface Forums Home Forums What's new Members -							
Home Forums Microsoft Surface Forum Microsoft Surface Pro 3							
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Surface laptop							









# □ The underlying principle of the FL-induced EMI







### Motivation

# □ The underlying principle of the FL-induced EMI

# The impact of the FL-induced EMI on sensors































































**C1** • **Underlying principle:** Why can the FL be utilized as an antenna?







• Underlying principle: Why can the FL be utilized as an antenna?

### **C2** • Antenna performance: What is the FL's antenna performance?





Principle of FL-induced EMI







#### Principle of FL-induced EMI









Principle of FL-induced EMI



Incandescent lamp





#### Principle of FL-induced EMI



220V/50Hz

Incandescent lamp

LED





#### Principle of FL-induced EMI



Incandescent lamp



LED



Ballast of FL





#### Principle of FL-induced EMI







Principle of FL-induced EMI



The FL cannot be **replaced** by other lamps The EMI mainly comes from the **tube** of the FL, rather than the power source or ballast





## The EMI performance

• 2. The EMI Performance of the Fluorescent Lamps







## The EMI performance

• 2. The EMI Performance of the Fluorescent Lamps





The intentional EMI frequency response

The FL-induced EMI has a stable frequency response in the band range of EMI attacks





## Attack design

### Step1: Control the FL to generate EMI.

- How to inject signals into power line?
- Whether the signal can be transmitted to the lamp?

### Step2: Utilize the FL-induced EMI to manipulate IoT devices.

- How to modulate EMI signals?
- Whether the EMI can achieve controllable attack?





























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#### • 1. Sensor manipulation attack







#### • 1. Sensor manipulation attack



#### LightAntenna Evaluation Setup

Victim device

Sensor	Sensor	Output	Measurement Attack parameters Output					
type	model	type	span	Freq.(MHz)	Pow.(W)	Original	Deviation	Rate
Temperature	PT100	Analog	0~50 °C	966	10	26.5 °C	-11 °C	-41.5%
Temperature	DS18B20	Analog	-55~+125 °C	876	10	26.5 °C	+9 °C	+34.0%
Humidity	DHT11	Analog	20%~90%	779	10	61%	+17%	+27.9%
Sound	/	0/1	/	627	10	0	1	+100.0%
Light	LM393	0/1	/	677	10	0	1	+100.00%
Light(Ultraviolet)	S12SD	Analog	0~11	724	10	2	+4.5	+225.0%
Light(Infrared)	HC-SR501	0/1	/	1322	10	0	1	+100.0%
Current	ACS712	Analog	0~5 A	1280	10	5 A	+8.2 A	+164.0%





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### **Evaluation**

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#### 2. Voice injection attack







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• 2. Voice injection attack

#### Comparison with GhostTalk







2. Voice injection attack

#### **Comparison with GhostTalk**



#### **Recognition rate on 50 sentence (384 words)**







2. Voice injection attack

#### **Comparison with GhostTalk**



#### **Recognition rate on 50 sentence (384 words)**







#### • 3. Comparison with conventional antennas



The 8 metal antennas and tested fluorescent lamp.

Comparison of EMI intensity



Comparison of attack distance (Make the temperature sensor deviate over 5 °C)





#### • 3. Comparison with conventional antennas



The 8 metal antennas and tested fluorescent lamp.

Comparison of EMI intensity

150

100

200

Distance (cm)

A1: UWB Antenna

A2: Magnetic Field Probe

A3: Rubber Rod Antenna

A4: Suction Cup Antenna

A5: Directional Antenna 1

A6: Directional Antenna 2 A7: Directional Antenna 3

A8: Yagi Antenna A9: LightAntenna

250

300

350



Comparison of attack distance (Make the temperature sensor deviate over 5 °C)





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#### • 4. Impact of grid branches



The experiment setup of the impact of power branches.





### • 4. Impact of grid branches



The experiment setup of the impact of power branches.



#### Same phase

Main switch, air switch, and leakage protector

#### Isolation transformer





#### • 5. Impact of loads







Charging Laptop



Speaker



Multiple lamps

The experiment setup of the impact of loads.





### • 5. Impact of loads



Multiple lamps

The experiment setup of the impact of loads.



Loads on the same branch

The result of the impact of different loads





#### Portable attack device











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## Conclusion

- 1. We systematically analyze the underlying principle of how fluorescent lamps generate EMI and how to control them.
- 2. We design and evaluate the *LightAntenna* attack on eight different sensor modules and a microphone, and evaluate potential impact factors.
- 3. We discuss the potential countermeasures of LightAntenna and design a portable attack device.





### **Questions & Answer**





Demo website: https://tinyurl.com/LightAntenna





### Thanks Q&A

