

# Lightweight Display-to-device Communication Using Electromagnetic Radiation and FM Radio

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AND TECHNOLOGY

# Display-to-device Communication: Demand

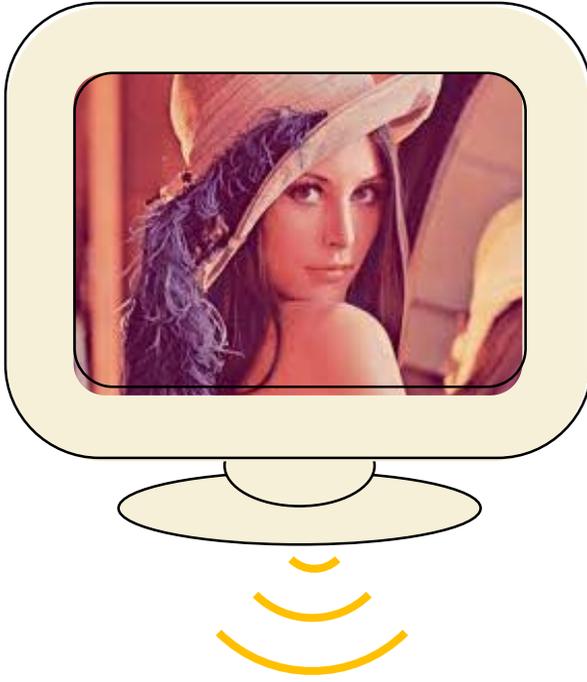
- Using devices to retrieve information from displays is helpful



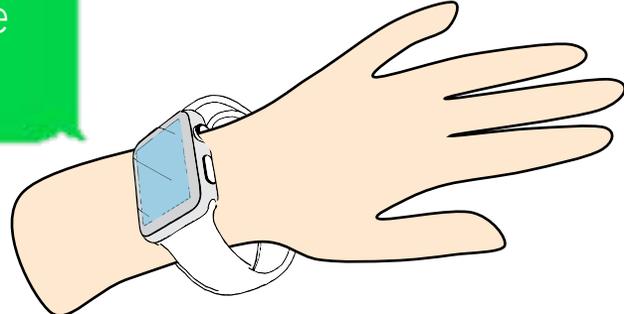
# Display-to-device Communication: Solution

- Current Method
  - Visible light channel, e.g. QR Code
- Limitations
  - Cumbersome Process
    - Take out phone, open camera, aim at the target, adjust the brightness, keep for a while, connect to the Internet...
  - Dependency on Cameras
    - Many devices do not have cameras, e.g. wrist band, smart watches, etc.



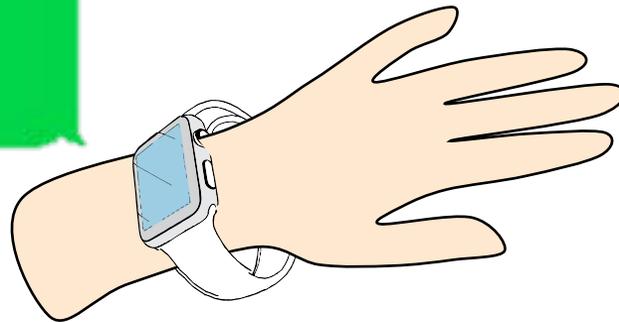


Message:  
"This is a figure  
about Lenna"



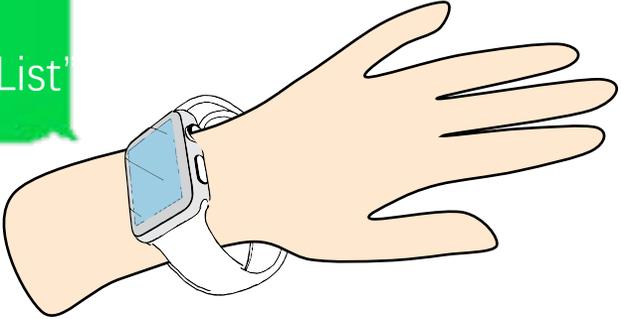


Message:  
"Coupon from  
McDonalds"





Message:  
"The Movie is  
Added to Play List"





Ubuntu Desktop

5:14 PM

- Dash
- Home Folder
- Firefox
- Files
- LibreOffice Writer
- LibreOffice Calc
- LibreOffice Impress
- LibreOffice Draw
- LibreOffice Base
- LibreOffice Math
- LibreOffice Remote
- LibreOffice Start Center
- LibreOffice Help
- LibreOffice Online
- LibreOffice Writer (New)
- LibreOffice Calc (New)
- LibreOffice Impress (New)
- LibreOffice Draw (New)
- LibreOffice Base (New)
- LibreOffice Math (New)
- LibreOffice Remote (New)
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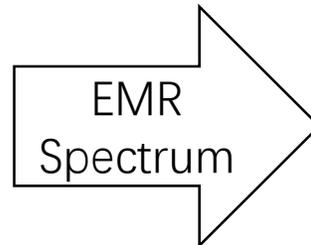
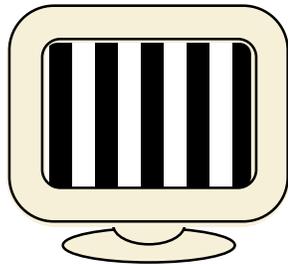


# Idea 1: EMR from Display Interface

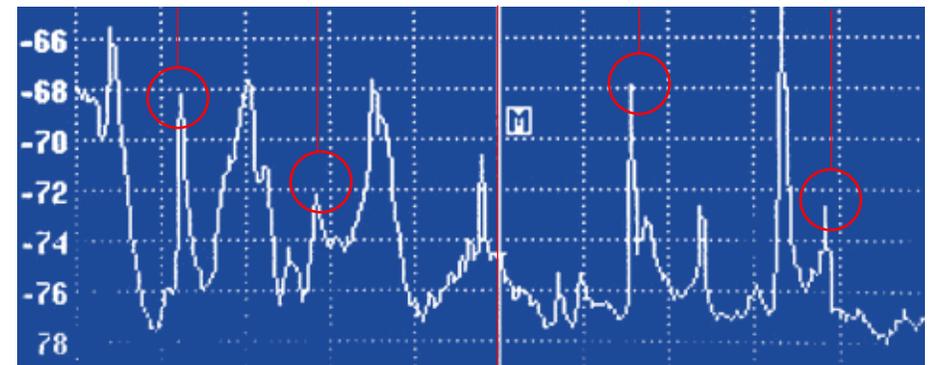
- Display interface has ElectroMagnetic Radiation (EMR) leakage



Displaying Strip Lines

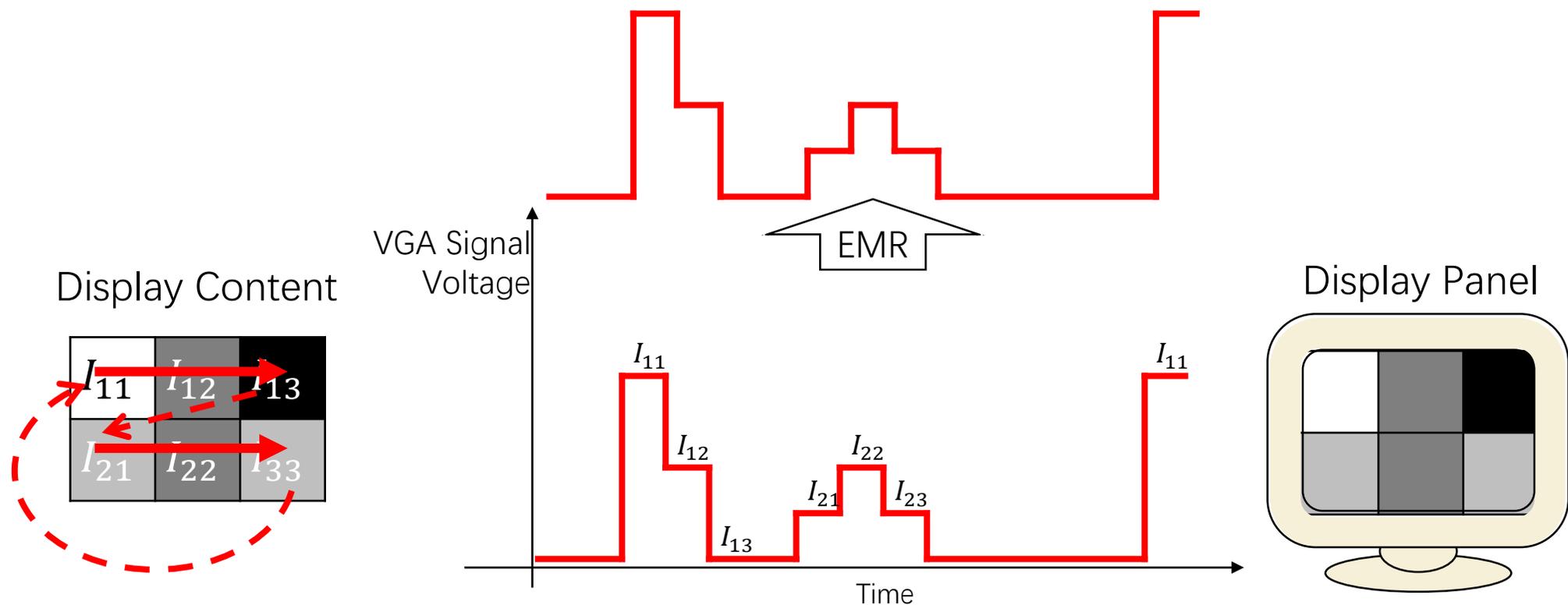


26.5MHz 79.5MHz 106MHz 132.5MHz 185.5MHz



# Idea 1: EMR from Display Interface

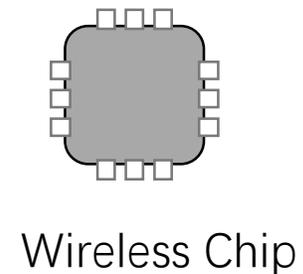
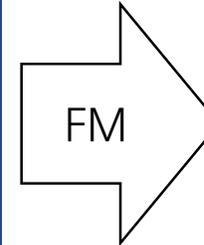
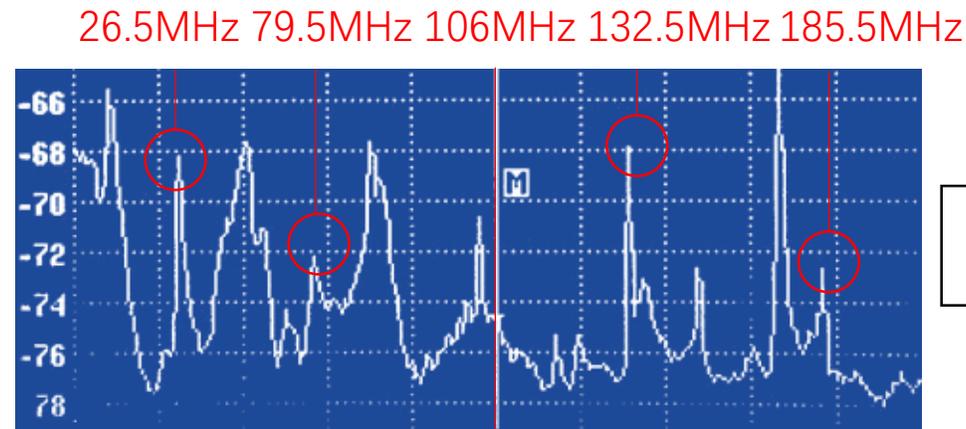
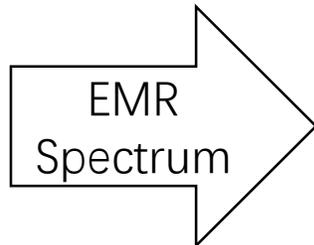
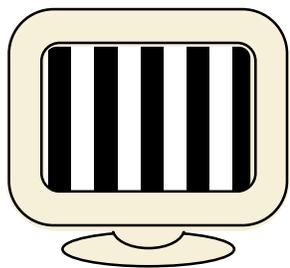
- Display interface has ElectroMagnetic Radiation (EMR) leakage
- EMR from VGA display interface is highly correlated with the display contents



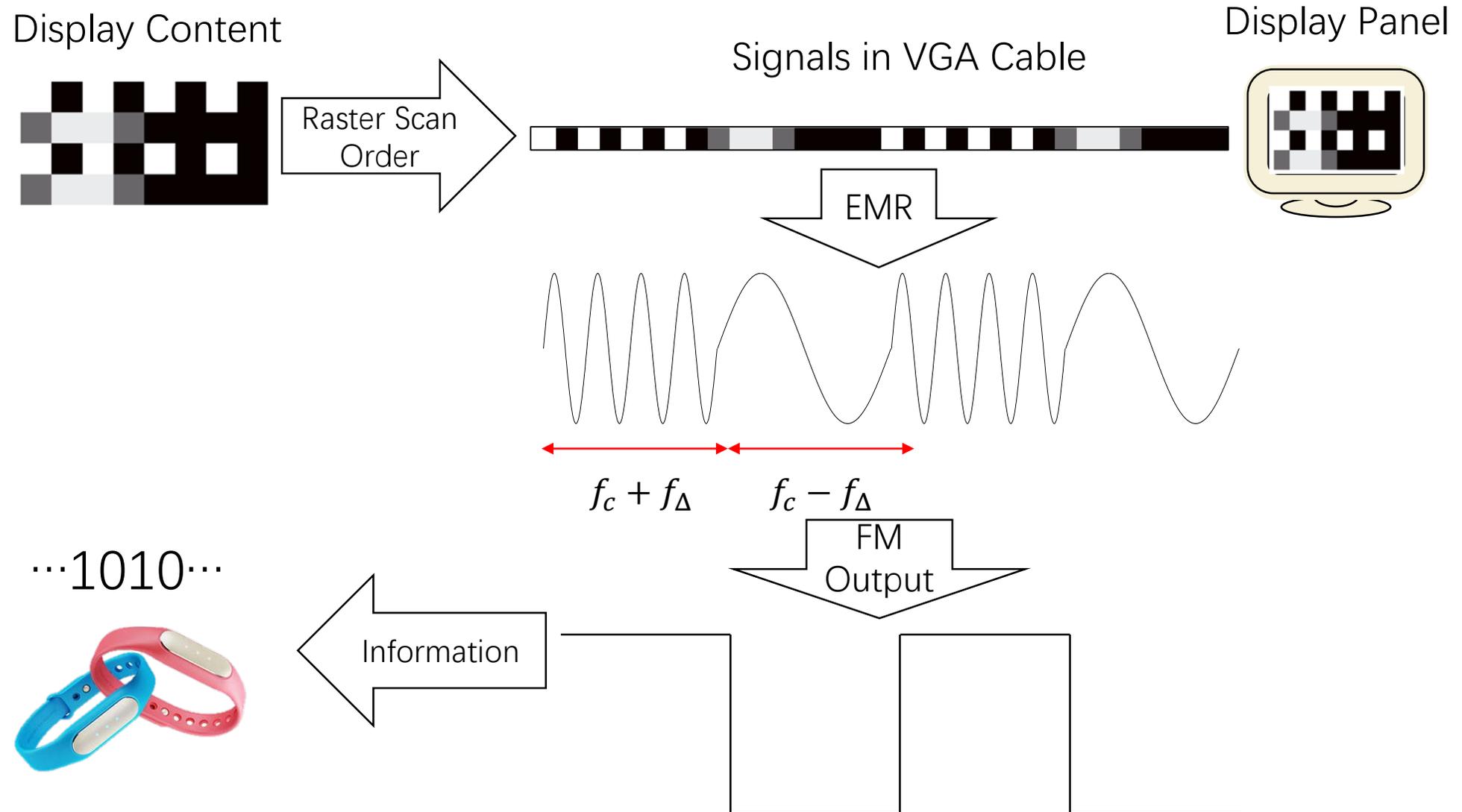
# Idea 2: Receiving EMR with FM Radio

- Modulate the **EMR** signal to transmit information
  - Through dedicated display content
- Use **FM** radio to receive
  - FM radio is widely integrated in wireless chip

Displaying Strip Lines



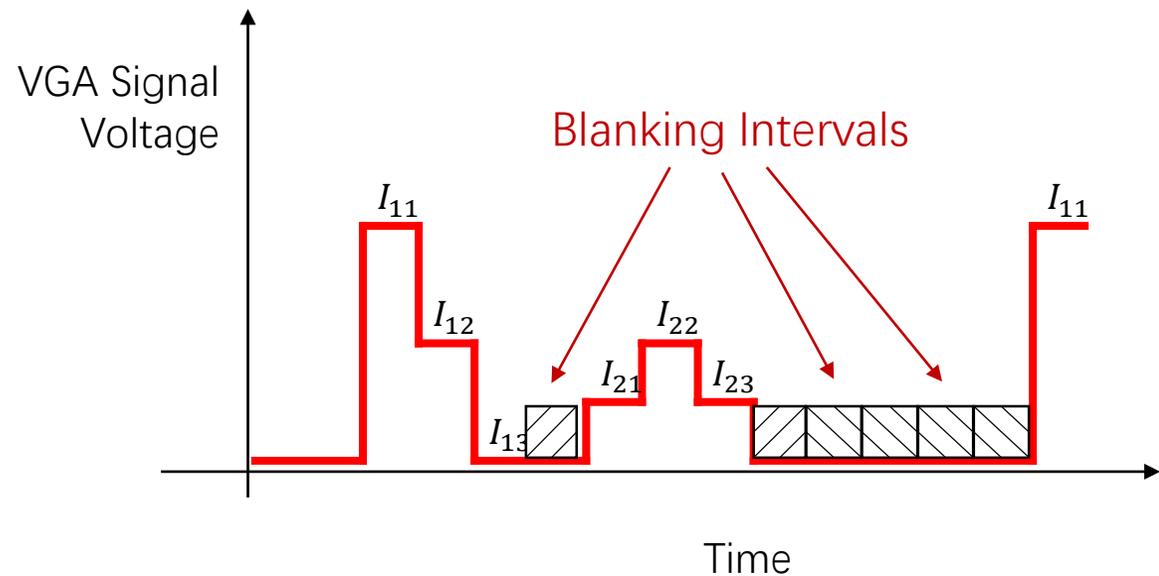
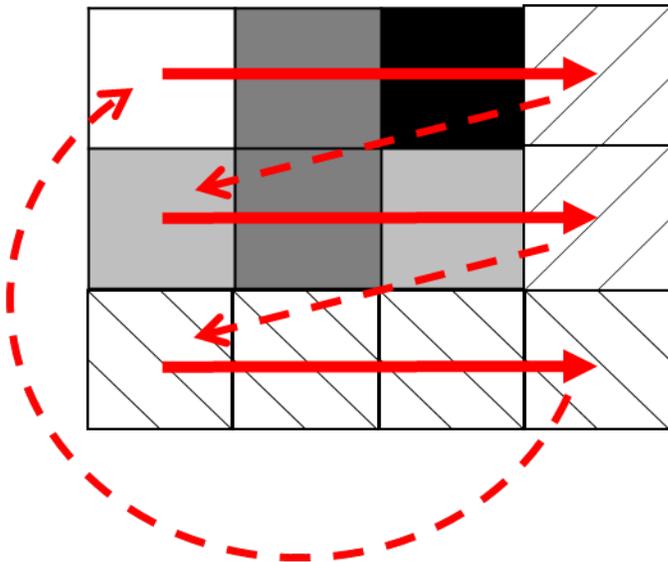
# Design: Modulating Frequency of Display EMR

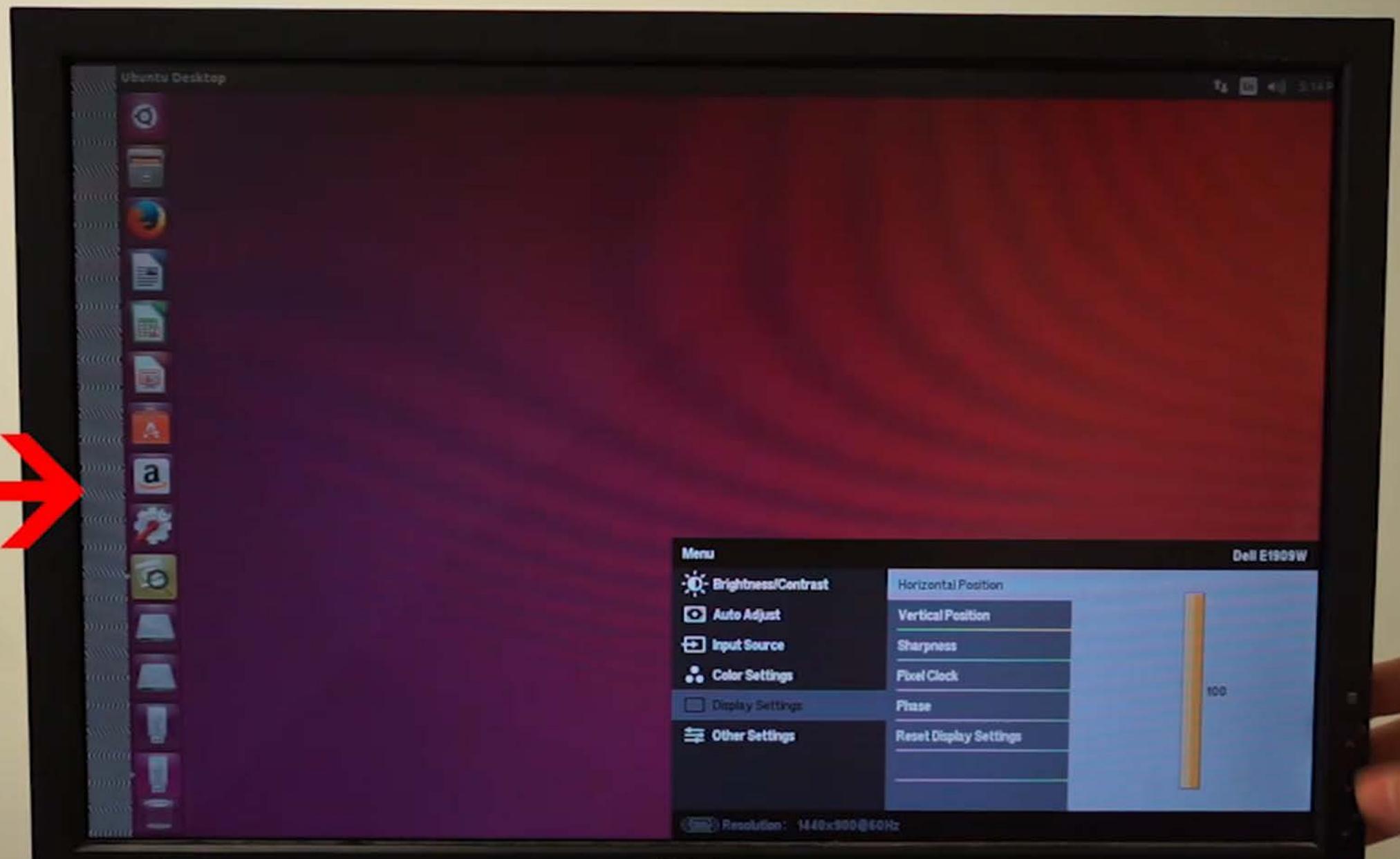




# Be Invisible

- Fact: display protocols contain invisible periods – **the Blanking Intervals** after each line and each frame
- Solution: modulating EMR signals only in **the Blanking Intervals**



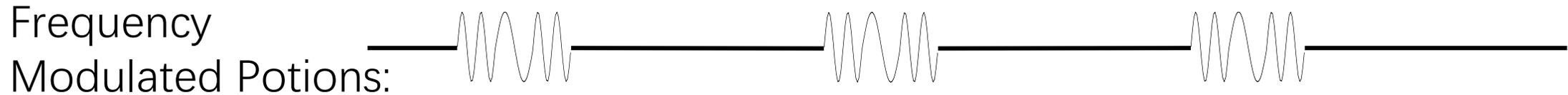
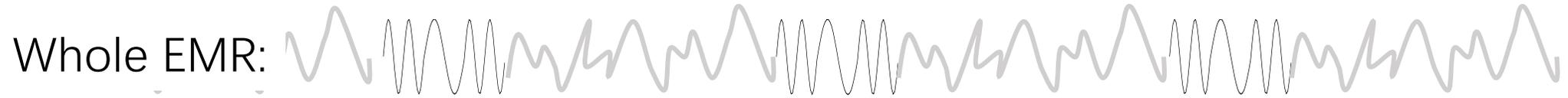


DELL

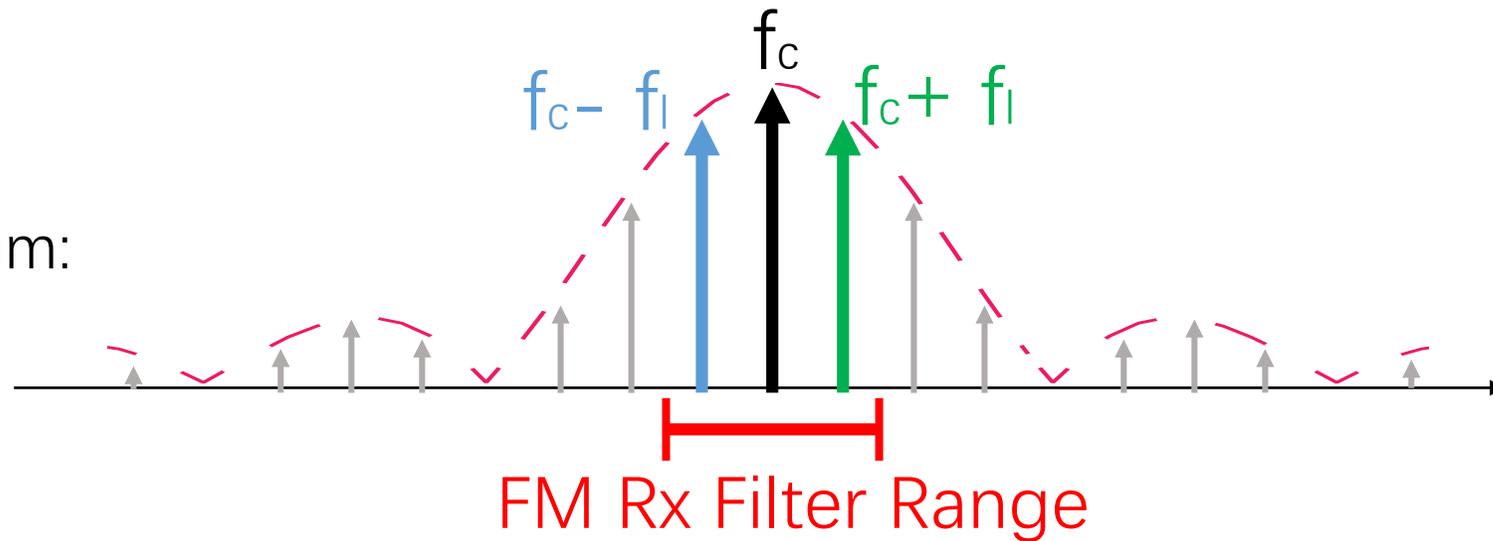
Resolution: 1440x900@60Hz

Dell E1909W

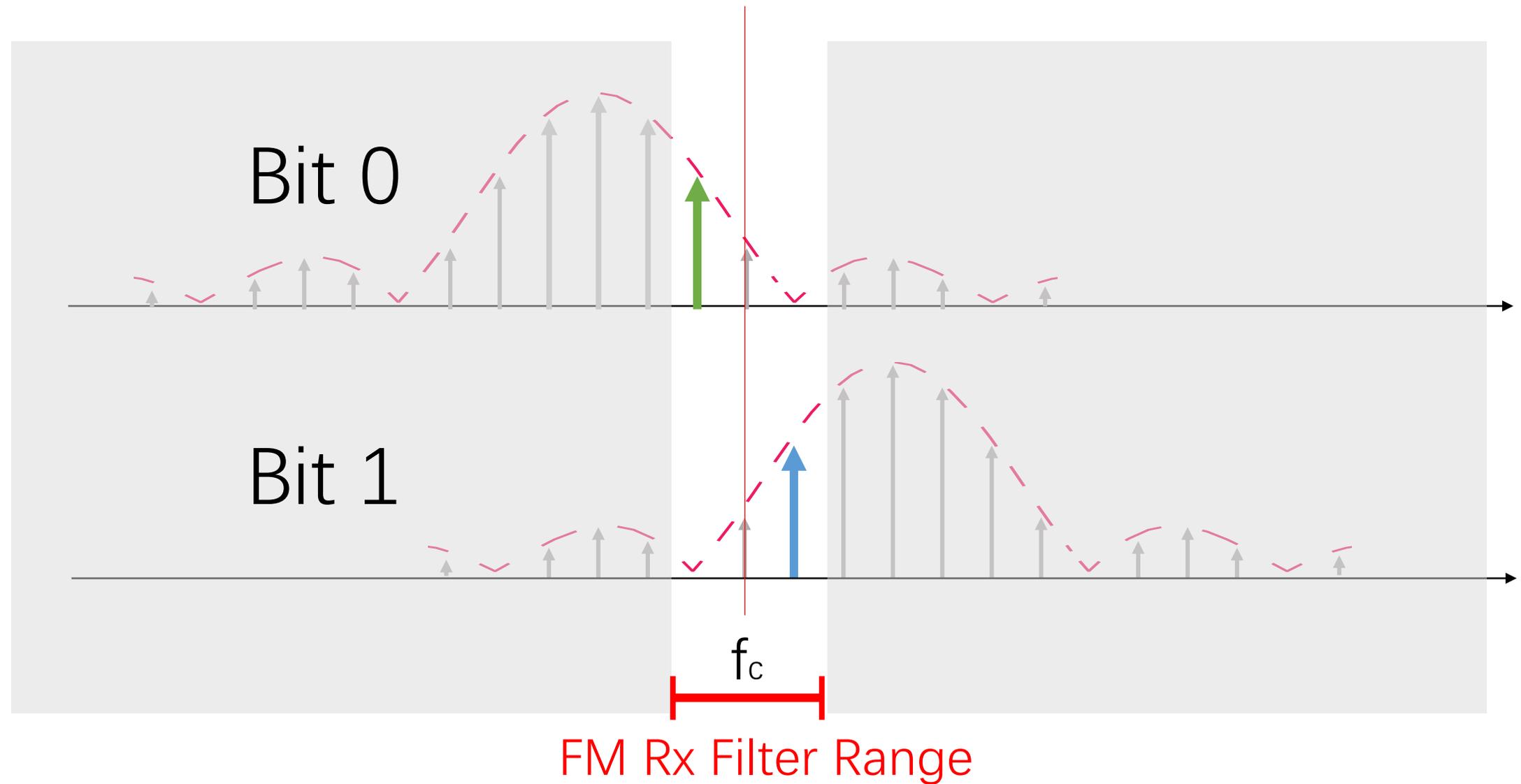
# Windowing Interference



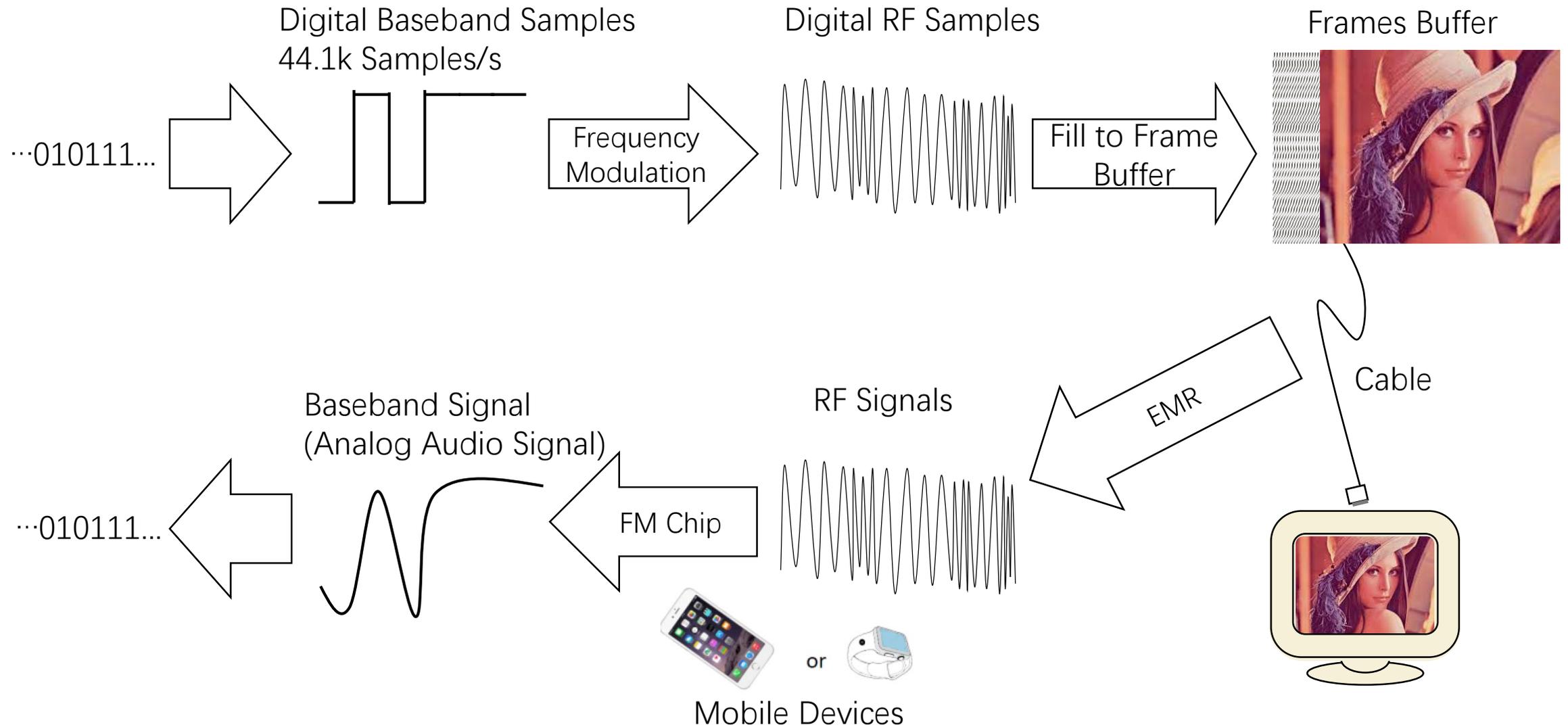
EMR Spectrum:



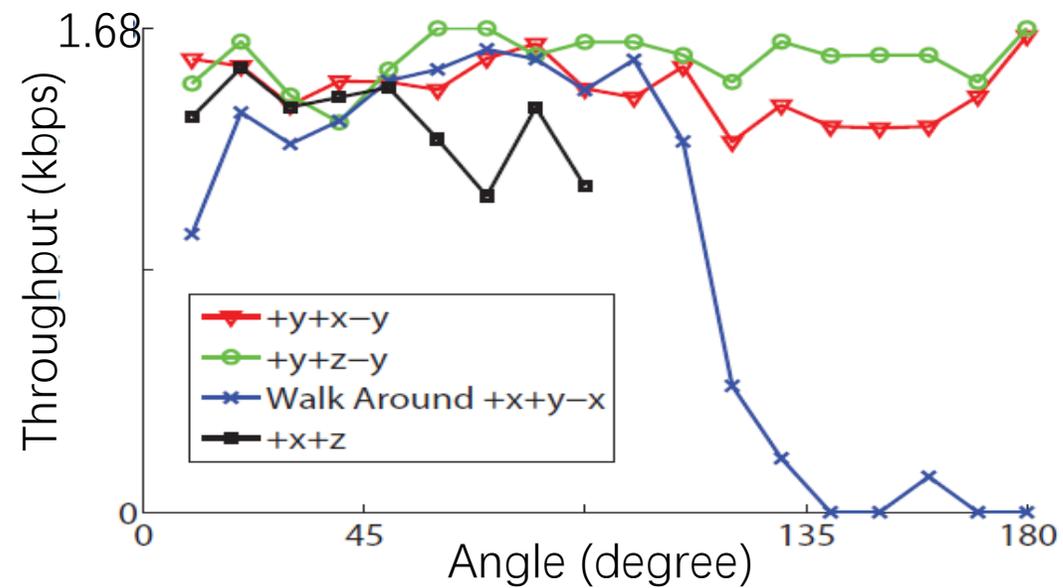
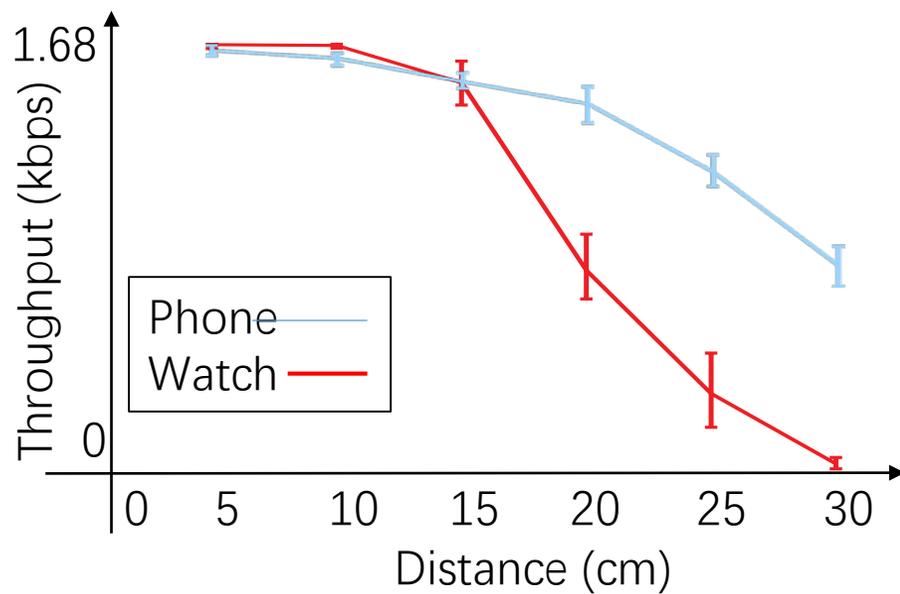
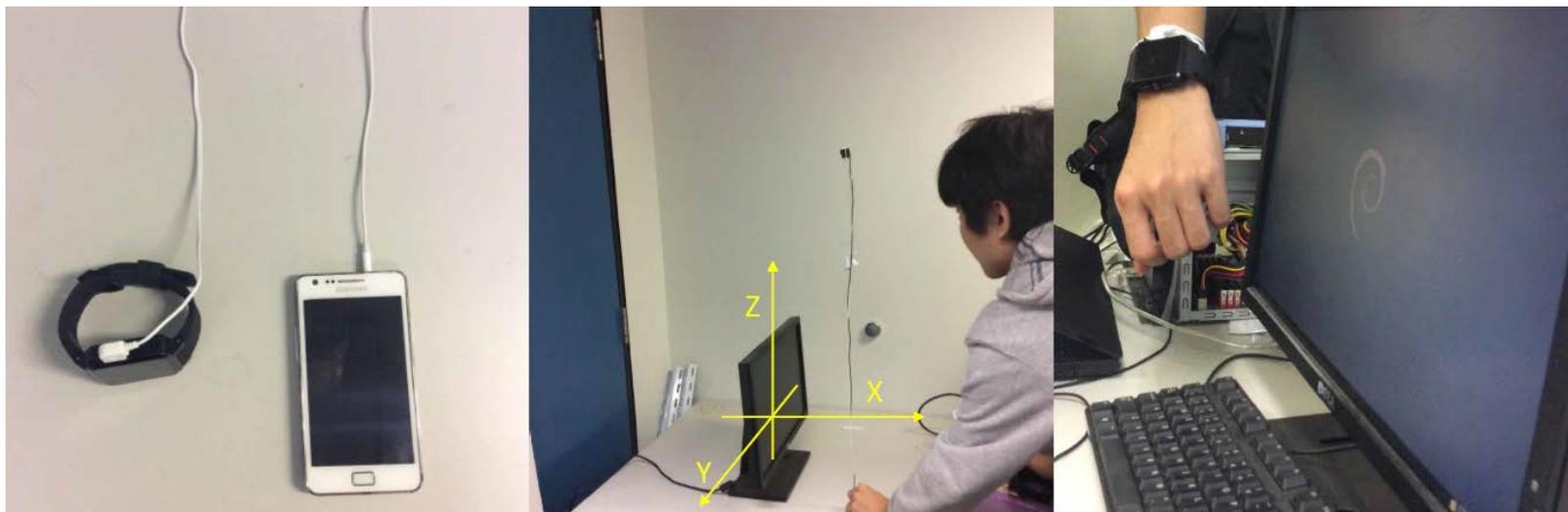
# Frequency Over Shift Keying



# Put Together

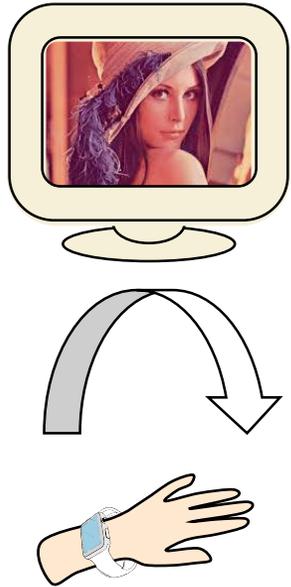


# Results

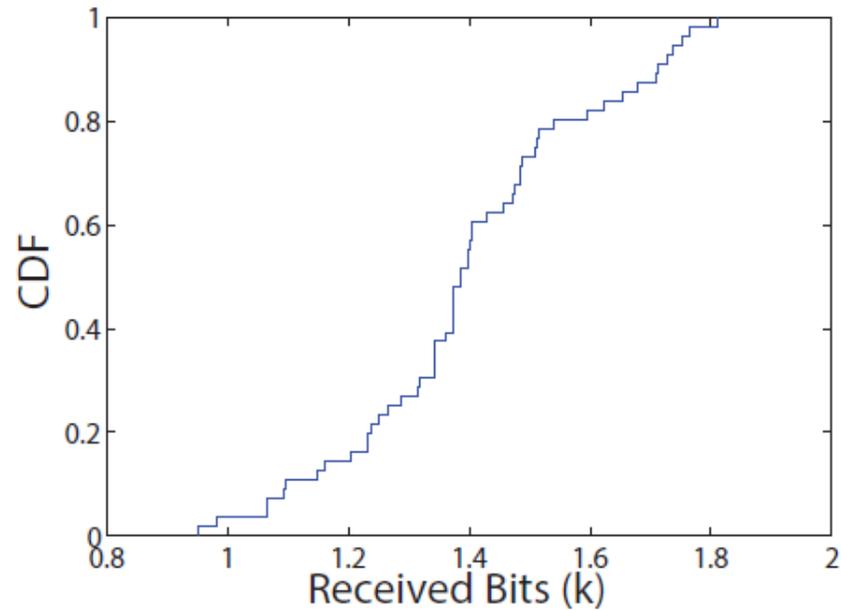


# Results

- One Action Information



The Fetch Action



$\approx$



QR Code (57\*57)



# Limitation & Conclusion

- Limitation of current work
  - Communication Distance
    - Limited by interference of harmonics
  - Based on VGA Protocol
    - Cannot be directly extended DVI, HDMI, DisplayPort, etc.
  - Antenna Size
- Conclusion
  - EMR signals from displays have the potential to convey information
    - FM radio is a feasible way for common mobile devices to receive
  - Modulating signals in the Blanking Period to hide communication

# Q&A

Thank You !