# A Low Power Integrated UWB Transceiver with Solar Energy Harvesting for Wireless Image Sensor Networks

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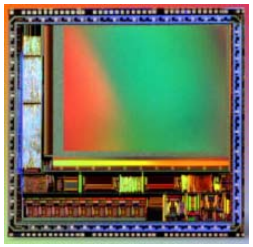
# Introduction

**CMOS imager**



**Sensor node**

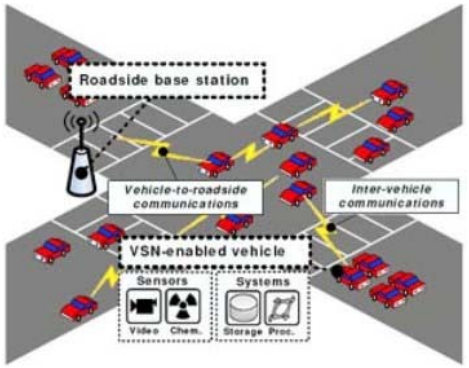
**100 Mbps (@ VGA, 30 fps, 10-b)**

**Power consumption: < 100 mW**

***Need low-power integrated transceiver***
***→ low-power, short-range transceiver***
***→ UWB***

**Environment monitoring**

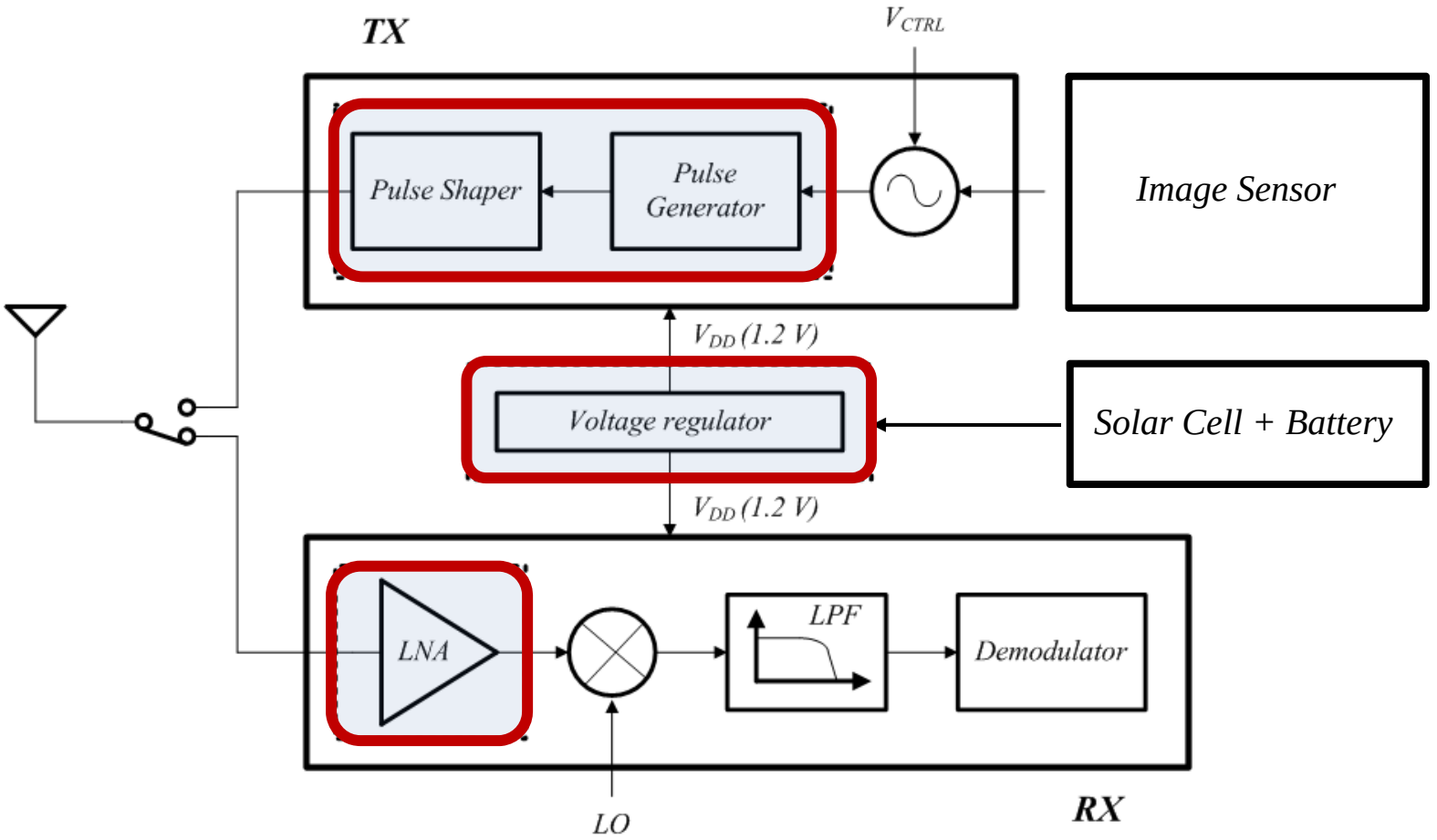
**Traffic management**




**Military surveillance**

# Block Diagram Circuit Description

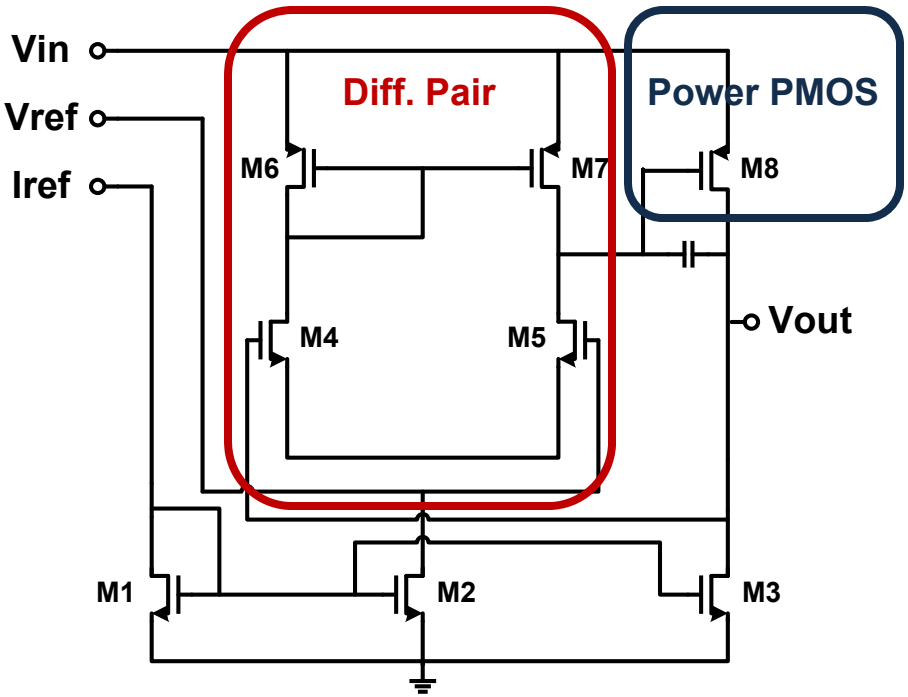
## Proposed UWB transceiver architecture



# LDO Voltage Regulator Circuit Description

## Features

- To regulate voltage from solar cell and provide stable 1.2V supply voltage
- Low Drop-Out Design by using PMOS in output stage
- Unity gain feedback Amplifier in small signal aspect

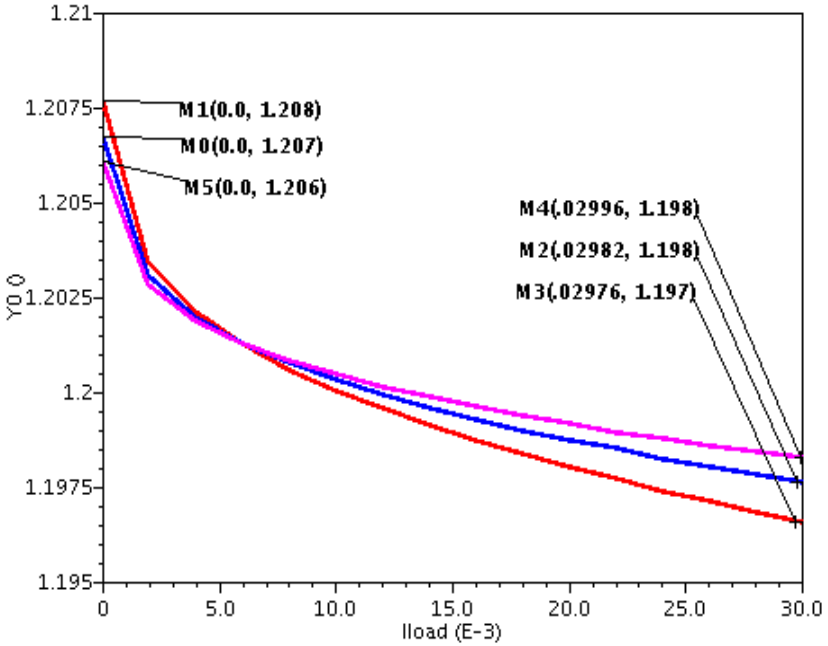


# LDO Voltage Regulator Simulation Results

## Key performance

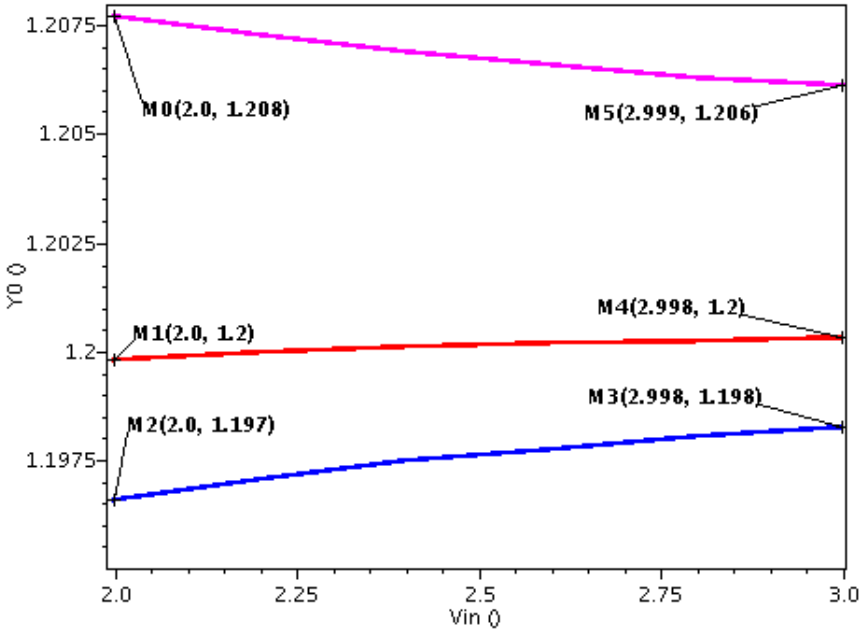
- $V_{in}$ = 2 ~ 3V ; $V_{out}$ = 1.2V
- $I_{load}$ = 0 ~ 30mA
- **Load regulation = 0.304mV/mA**

  @ 2.5V nominal supply voltage




- **Line regulation = 0.517mV/V**

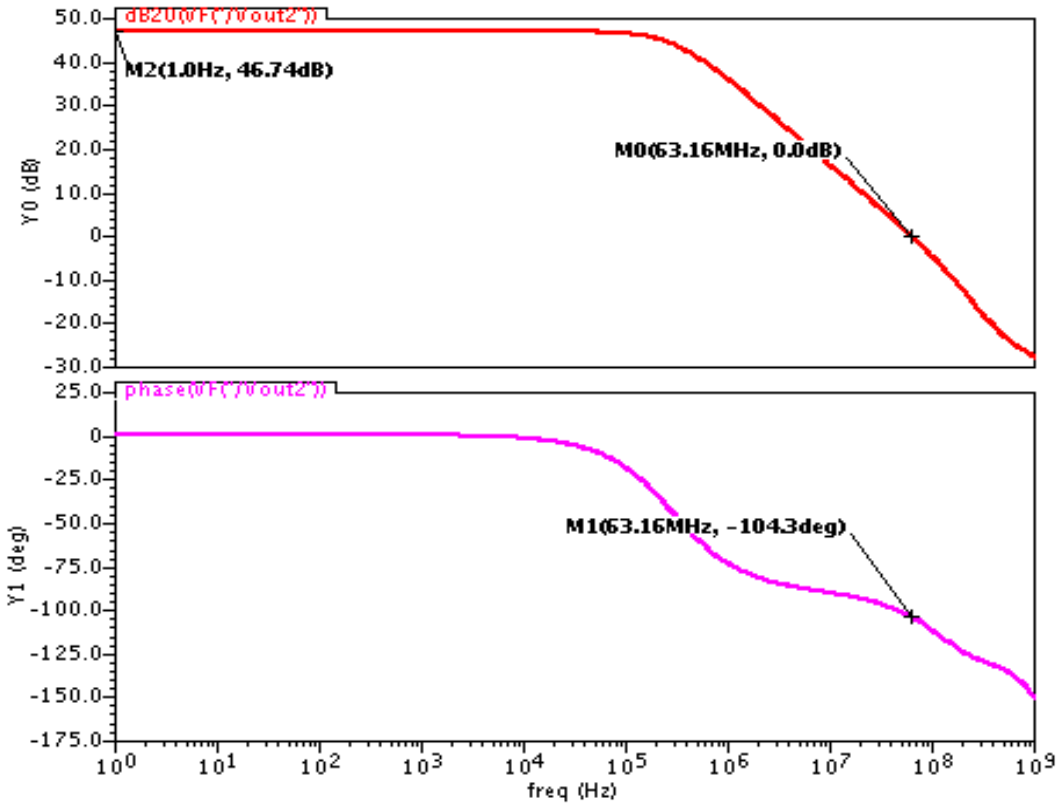
  @ 11mA nominal load current



# LDO Voltage Regulator Simulation Results

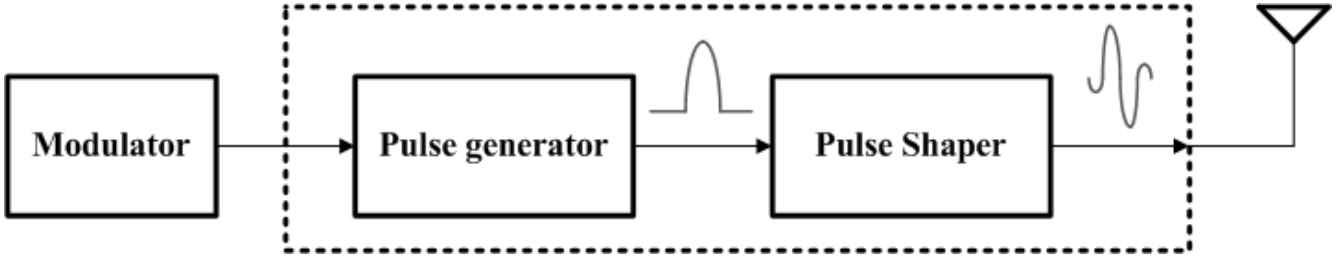
## Frequency response

- Open loop gain= 46.74 dB
- Phase margin= 76°

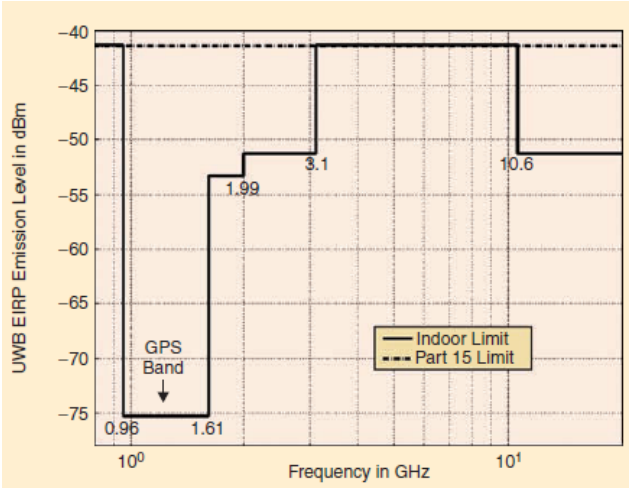


# UWB Pulse Generator Circuit Description

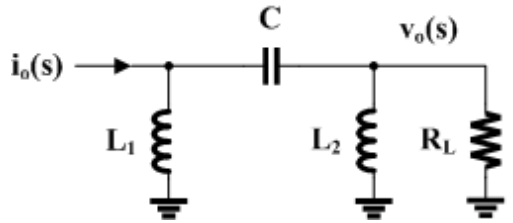
- **UWB pulse-based transmitter system**




- **UWB spectral mask (defined by FCC)**




- **3rd order Gaussian pulse shaping**

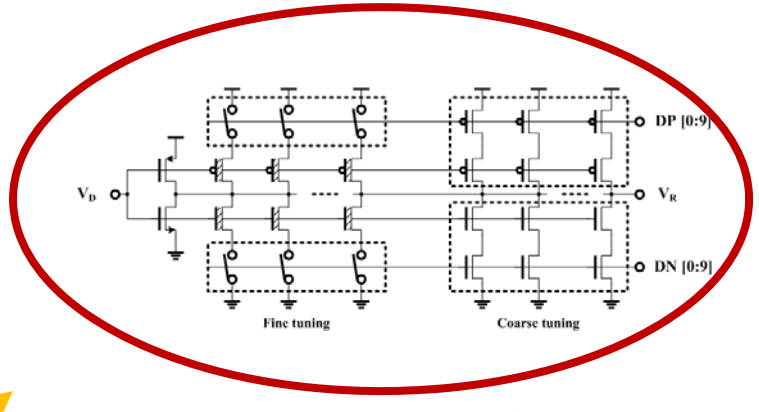


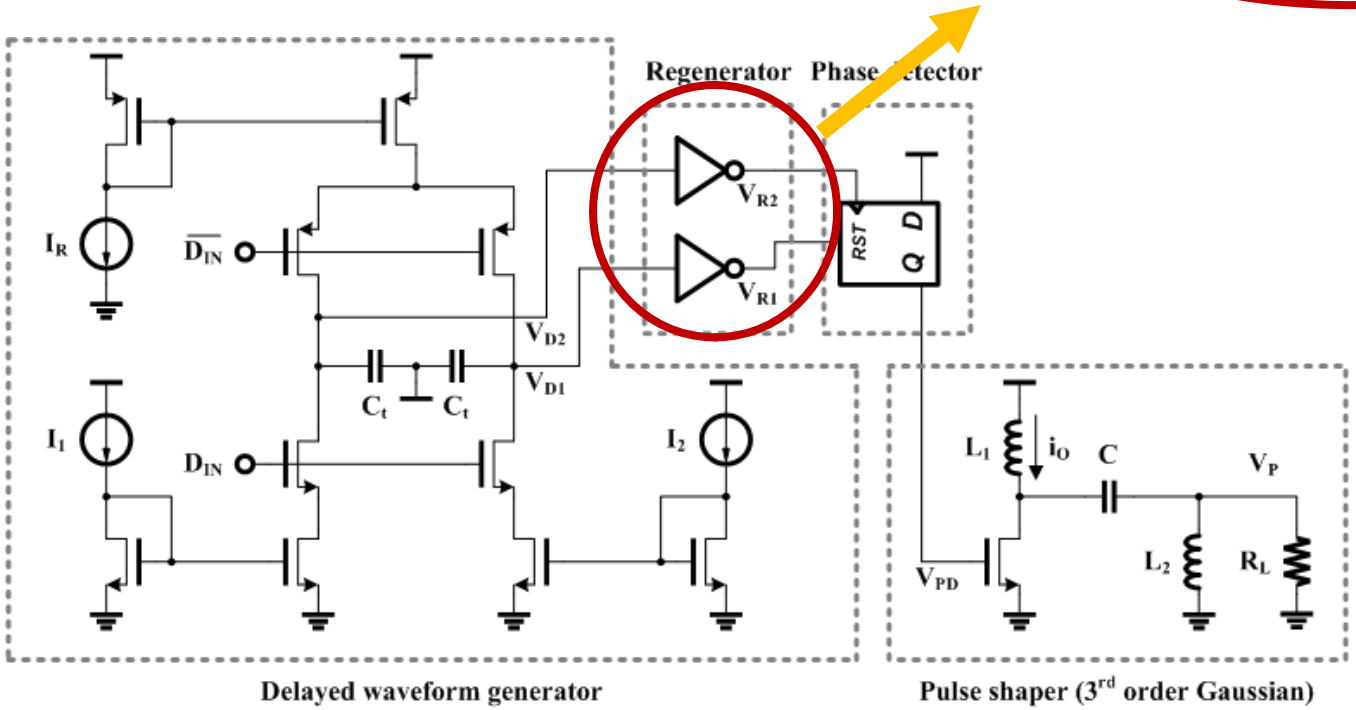

$$T(s) = \frac{v_o(s)}{i_o(s)} = \left\{ \left( R_L \parallel sL_2 \right) + \frac{1}{sC} \right\} \parallel sL_1$$

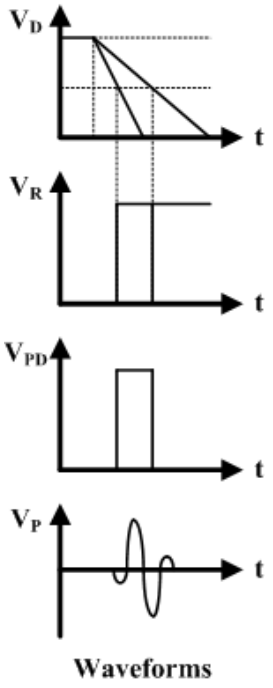
$$= s^3 (L_1 L_2 C)$$

# UWB Pulse Generator Circuit Description

- Delayed waveform generation
- Phase detection
- Pulse shaping



# UWB Pulse Generator Simulation Results

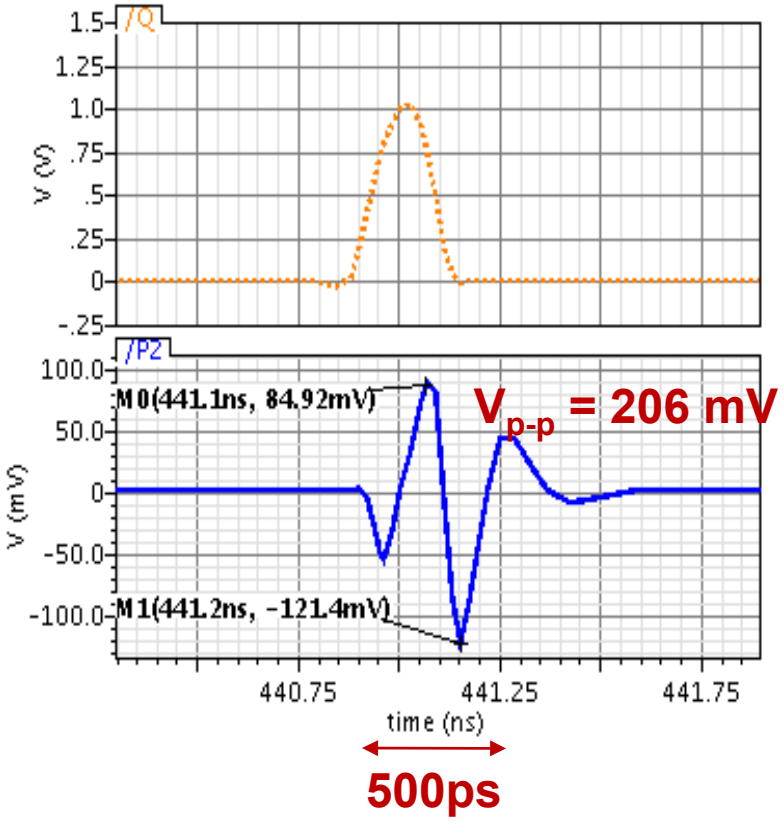
## Key performance

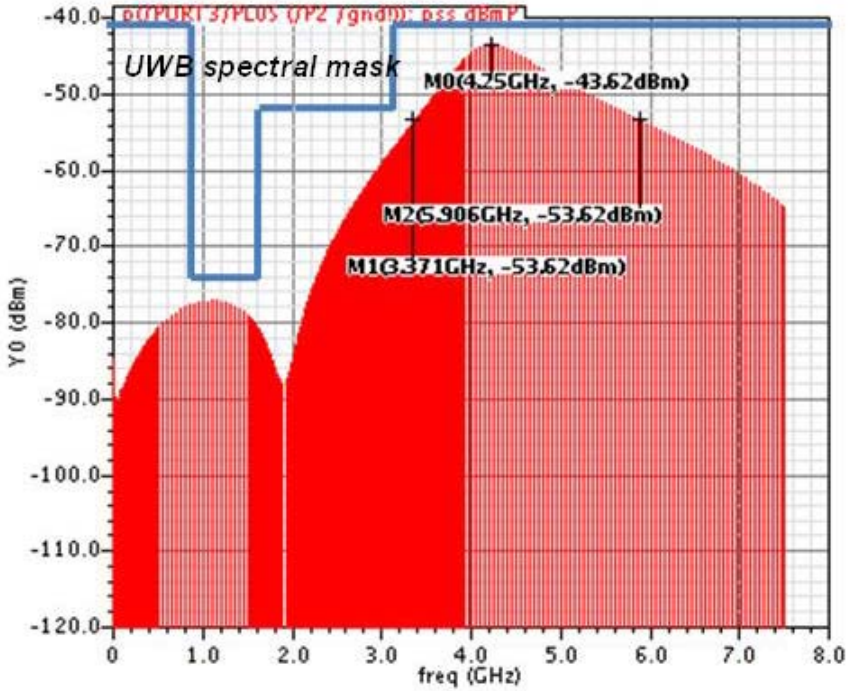
- **Pulse output (transient)**

  **$V_{p-p}$ = 206 mV**

- **Power spectral density**

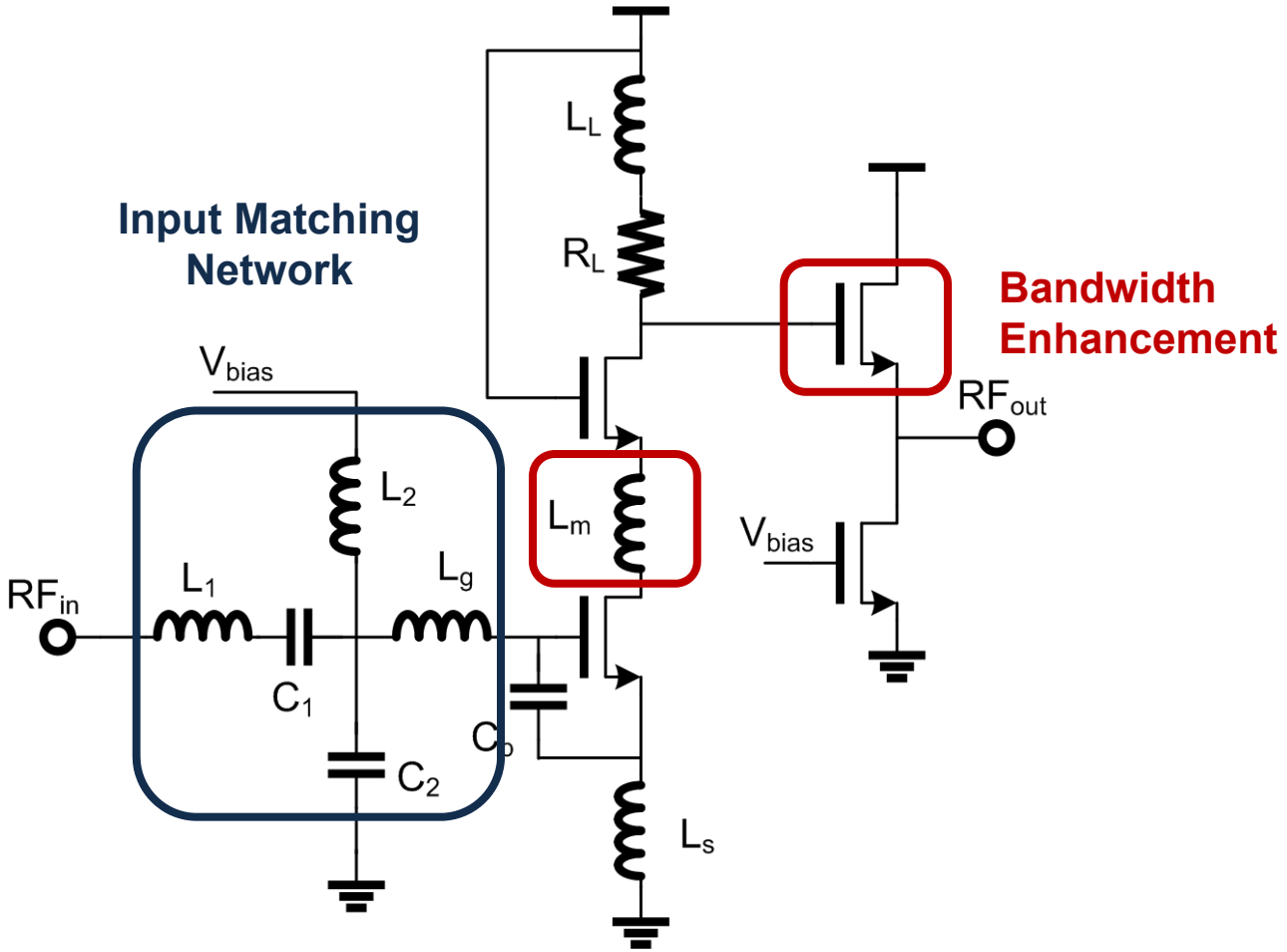
  **Bandwidth (10dB) = 3.37~ 5.9 GHz**



# Wideband LNA Circuit Description

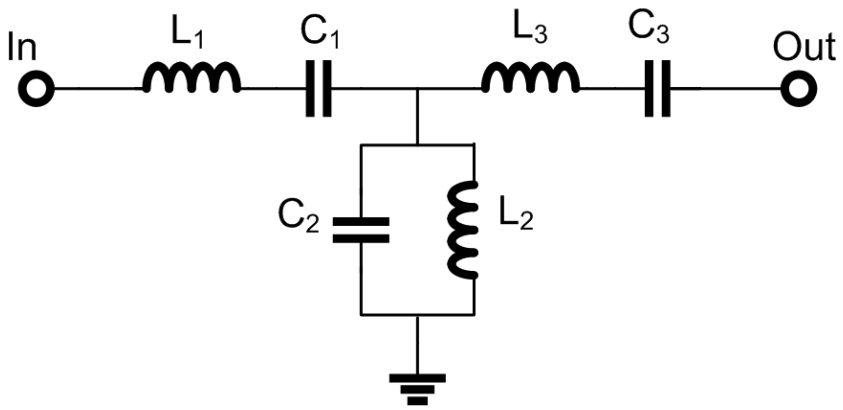
## Proposed LNA architecture



# Wideband LNA Circuit Description

## Input matching

- 3rd order Chebyshev filter for broadband matching



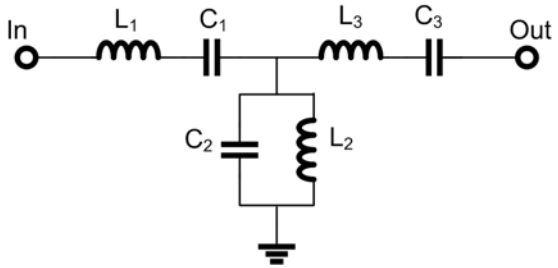

- For ground output

$$Z_{IN} = \frac{\left(s^2LC+1\right)\left[\left(s^2LC+1\right)^2 + s^2LC\dfrac{C_1+C_3}{C_2}\right]}{sC_1\left[\left(s^2LC+1\right)^2 + s^2LC\dfrac{C_3}{C_2}\right]}$$

# Wideband LNA Circuit Description

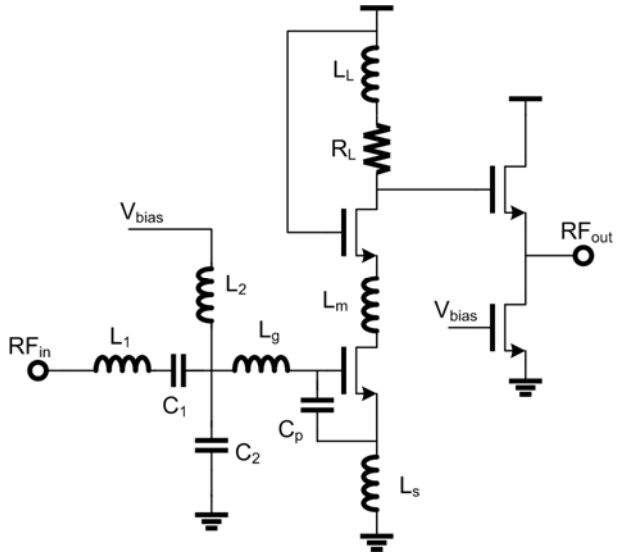
## Gain

- **Tradeoff**
  - **Large $C_1$+$C_3$ : More matching bandwidth**
  - **Small $C_3$ : Less gain loss @ high frequency**




**Chebyshev filter**

- **Bandwidth enhancement**
  - **$L_m$ cancels inter-cascode node capacitance**
  - **Buffer reduces $C_{out}$ of gain stage**

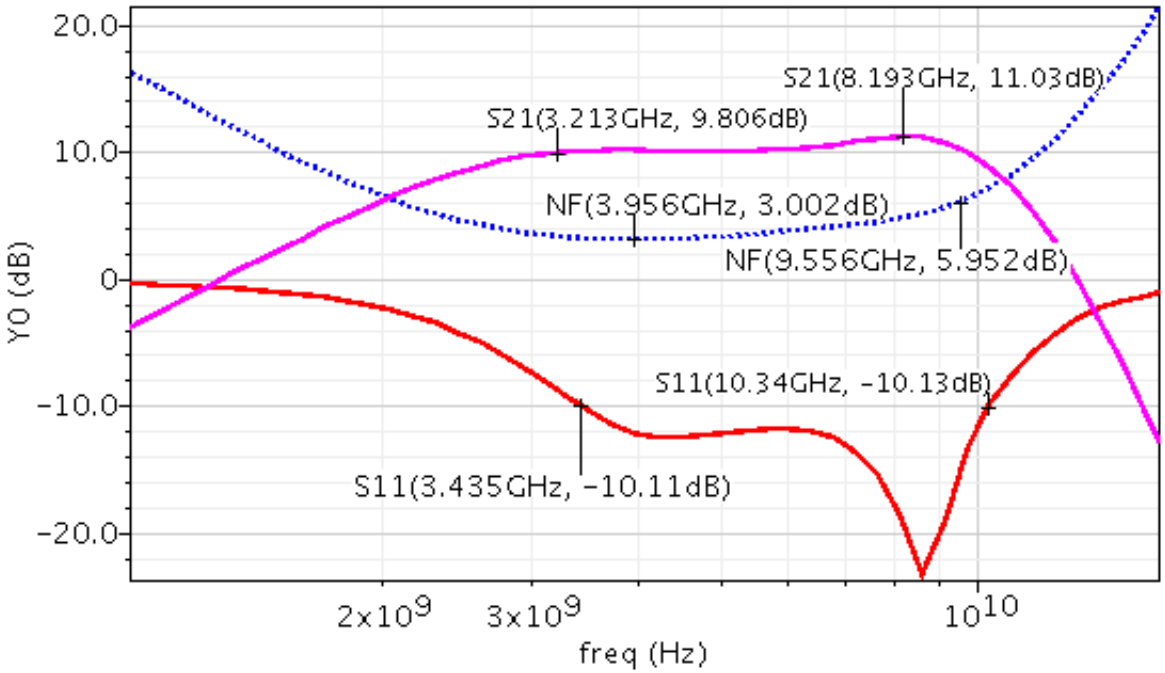



**Proposed LNA**

# Wideband LNA Simulation Results

## Key performance

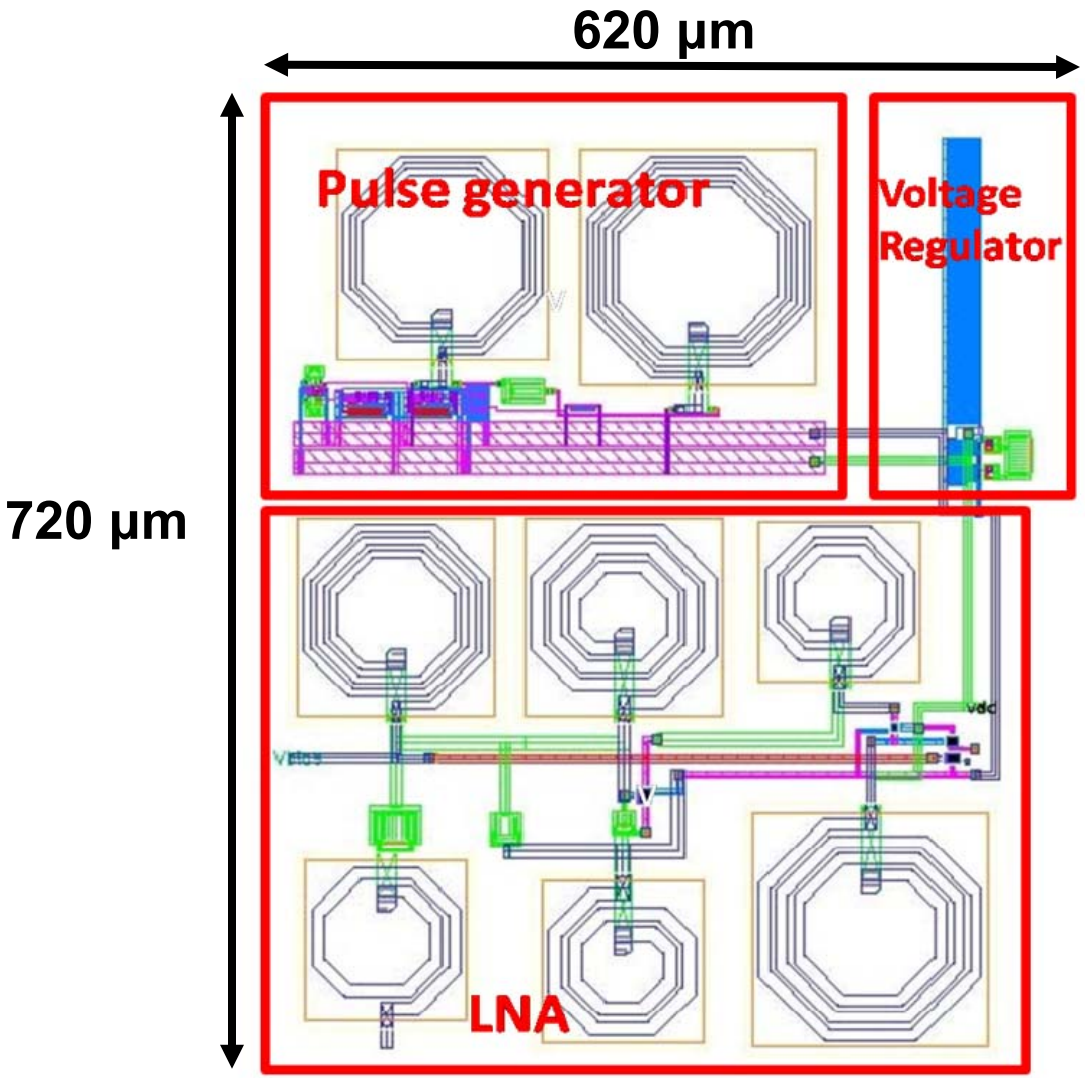
- $S_{21}$ > 9.8dB @ 3.5GHz ~ 9.7GHz
- $S_{11}$ < -10dB @ 3.4GHz ~ 10.3GHz
- 3dB Bandwidth @ 3.2GHz ~ 10.6GHz



# Summary of Specification Conclusion

| | Parameter | RESULTS |
|---|---|---|
| **LDO Voltage Regulator** | **Line Regulation** | **0.517mV/V** |
| | **Load Regulation** | **0.304mV/mA** |
| | Output voltage | 300mV-1.2V |
| | Maximum Load current | 30mA |
| | Power Consumption | 1.22mW ( No Load )<br>76.2mW (Full load) |
| **Pulse Generator** | **Pulse amplitude** | **208 mV** |
| | **Pulse duration** | **500 ps** |
| | Bandwidth (10 dB) | 3.37 / 5.9 GHz |
| | Power Consumption | 249.6 μW |
| **LNA** | **$S_{11}$** | **-10 dB (3.4-10.3GHz)** |
| | **$S_{21}$** | **9.8 dB (3.5-9.7GHz)** |
| | **3dB bandwidth** | **3.2-10.6GHz** |
| | NF | < 6 dB (3.2-9.6GHz) |
| | Power Consumption | 8.4 mW |

# Layout View Conclusion



# Q & A

THANK YOU !