MMIC Design and Technology

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Sharif University of Technology

Class Intro

- MMIC
  - Monolithic Microwave Integrated Circuit

- MMIC Design and Technology
- Project based class
- Hands on Collaborative Engineering

Course Objective

- Design a MMIC chipset for a microwave transceiver.
- Learn about MMIC devices, components, and their design and fabrication
- Learn MMIC CAD Techniques
- Utilize RF system design skills
- Experience Collaborative Engineering

Syllabus

Review of Field & Wave, Microwave
Passive Microwave Devices
Active III-V Devices
Amplifier Design
Oscillator Design
Mixers and Non-Linear Circuits
Switches, Attenuators and Phase Shifters
CAD Software
Layout Techniques
Simulation and Verification

Grading

- Midterm 5/2/1387 20%
- Final 3/4/1387 30%
- Project 15/4/1387 40%
  - Home Works 5 %
  - Design Requirement Report 5 %
  - Schematic Design Report 5 %
  - Simulation Report 5 %
  - Layout Review Report 5 %
  - Post Layout Simulations 5 %
  - Final Report 10 %
- Presentations 10 %

Text

- Microwave Solid State Circuit Design

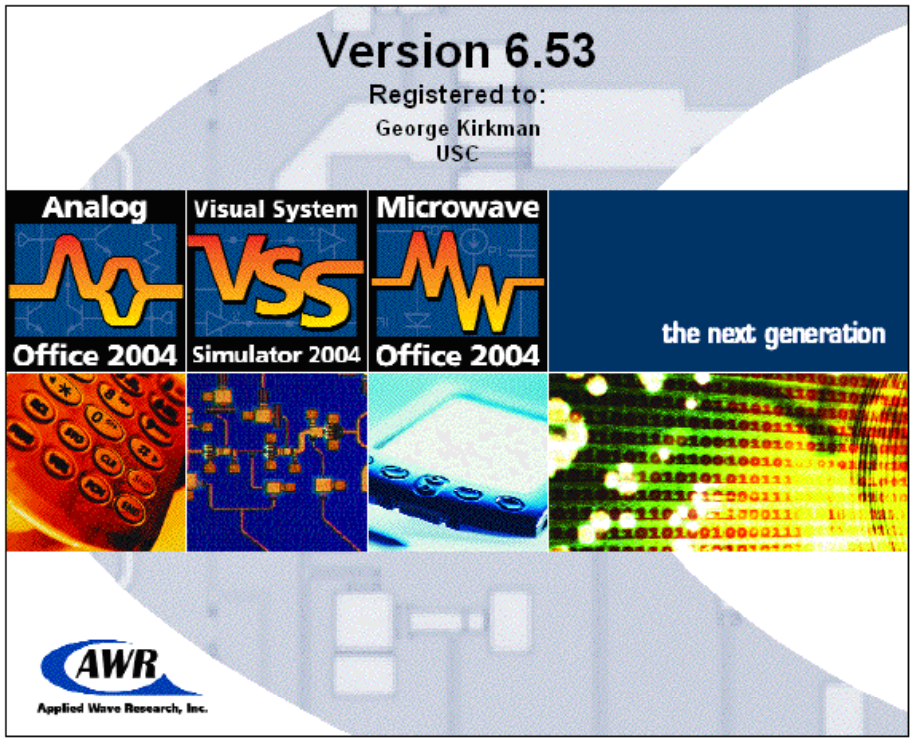
  Second Edition

  Inder Bahl and Parkash Bharita

  2003 Wiley-Intersience

Website : ee.sharif.edu/~mmic

Software



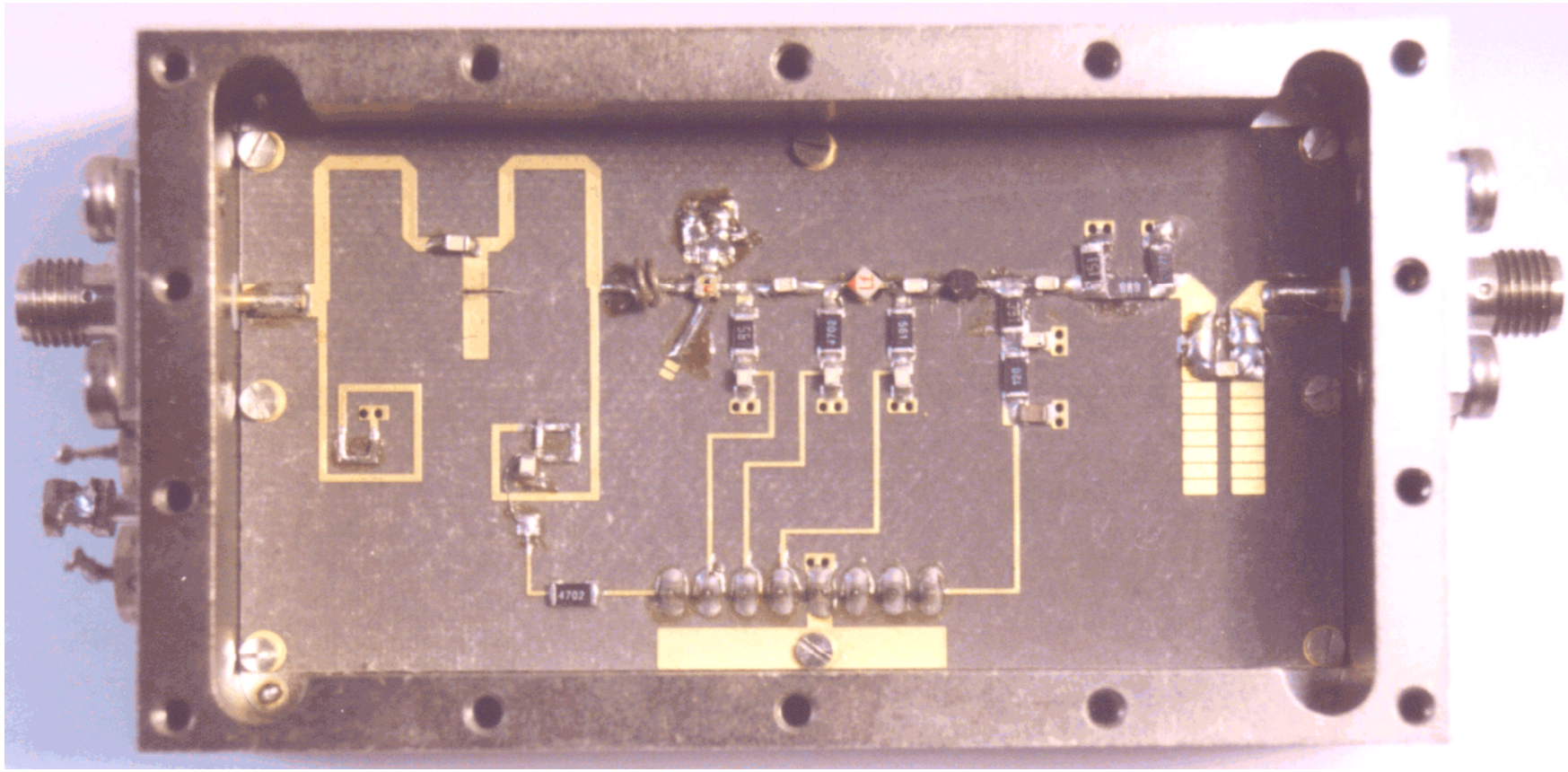
www.appwave.com

- Microwave Office by Applied Wave Research will be the primary design software used
- Microwave Office will be available on a server during second part of the course
- Agilent ADS may be available as an alternate

Helpful Prerequisite Knowledge

- Electromagnetics
- Field and Wave
- RFIC
- Familiarity with RF Systems
- Microwave Measurements
- Microwave Devices and components
- Microwave Circuits

MHIC



Letcture 1 Overview

MMIC

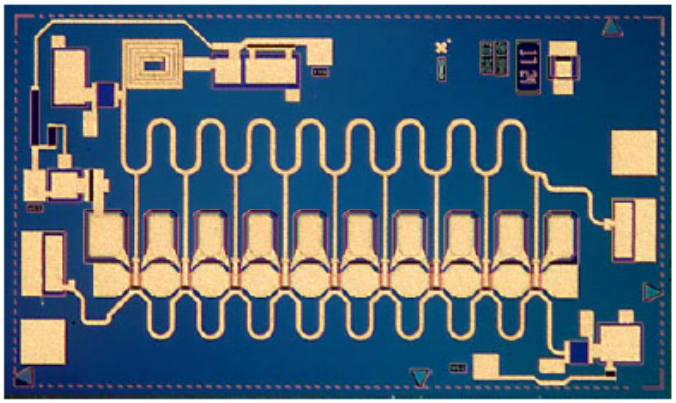
TriQuint SEMICONDUCTOR

Product Data Sheet

2-20 GHz Wideband AGC Amplifier

TGA1342-SCC

May 28, 2004



Chip Dimensions: 3.4 x 2.0 x 0.1 mm

Key Features and Performance

- 0.5 um MESFET Technology
- 9 dB Nominal Gain
- 3.5 dB NF Typical Midband
- 17.5 dBm Nominal Pout @ P1dB
- Bias 5-8V @ 60 mA
- Dimensions 3.4 x 2.0 x 0.1 mm

Primary Applications

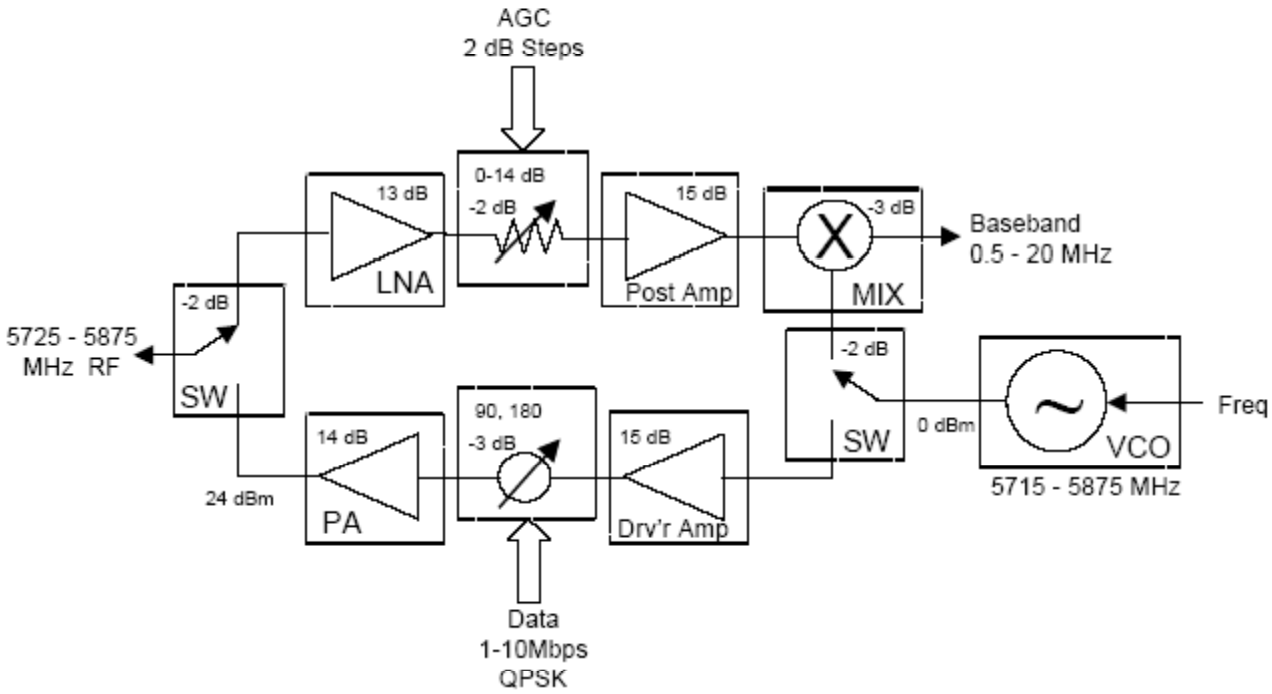
- Wideband Gain Block / LN Amplifier
- X-Ku Point to Point Radio
- IF & LO Buffer Applications

MMIC or MHIC

Table 1.1 Advantages and disadvantages of MMICs

MMICs	*Hybrid MICs*
Cheap in large quantities; especially economical for complex circuits	Simple circuits can be cheaper; automatic assembly is possible
Very good reproducibility	Poor reproducibility due to device placement and bond-wires
Small and light	Compact multilayer substrates with embedded passives now available
Reliable	Hybrids are mostly 'glued' together and so reliability suffers
Less parasitics – more bandwidth and higher frequencies	The best transistors are always available for LNAs and PAs
Space is at a premium; the circuit must be made as small as possible	Substrate is cheap, which allows microstrip to be used abundantly
Very limited choice of component	A vast selection of devices and components is available
Long turn around time (3 months)	Can be very fast (1 week), making multiple iterations possible
Very expensive to start up	Very little capital equipment is required

Transceiver Example

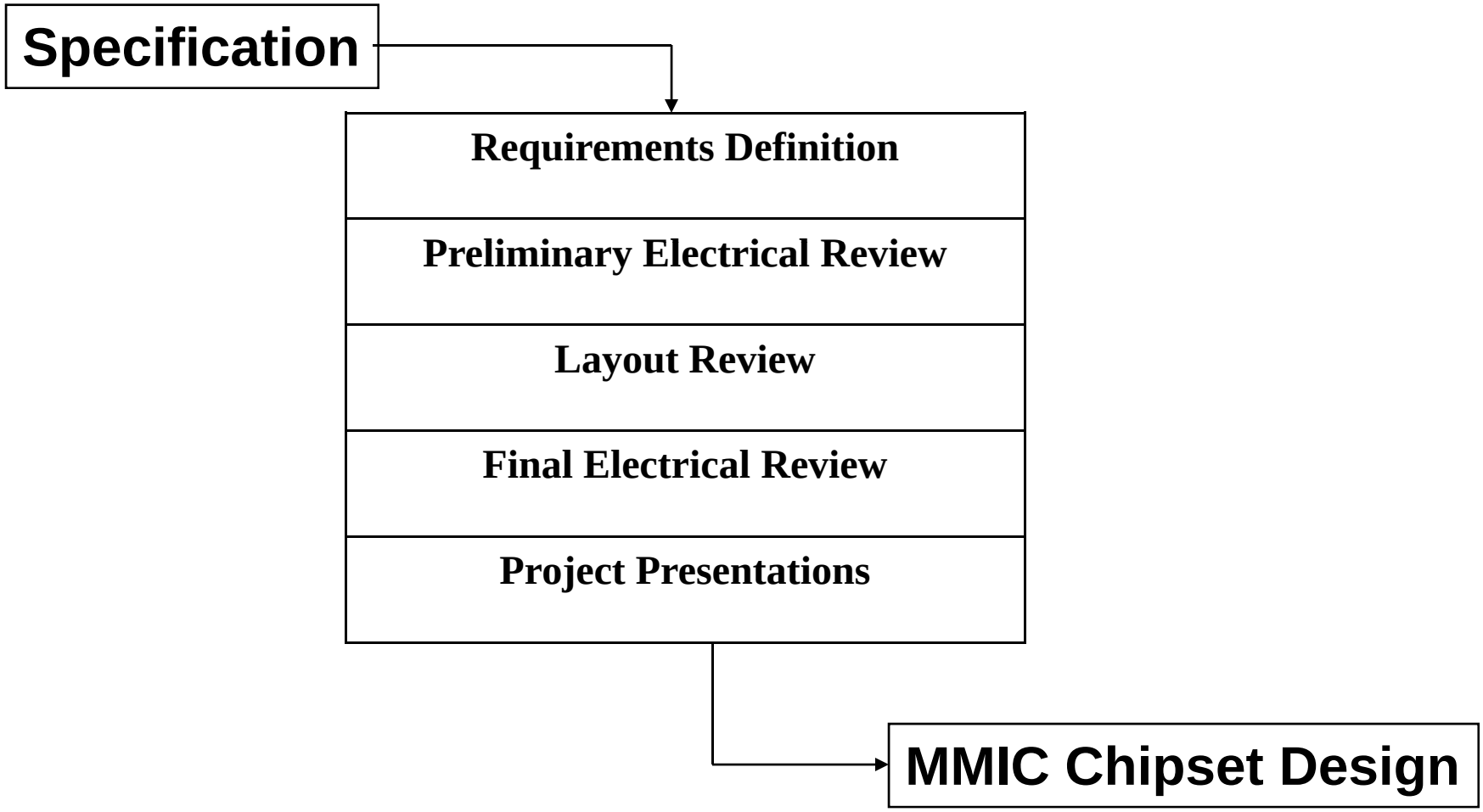


Yield

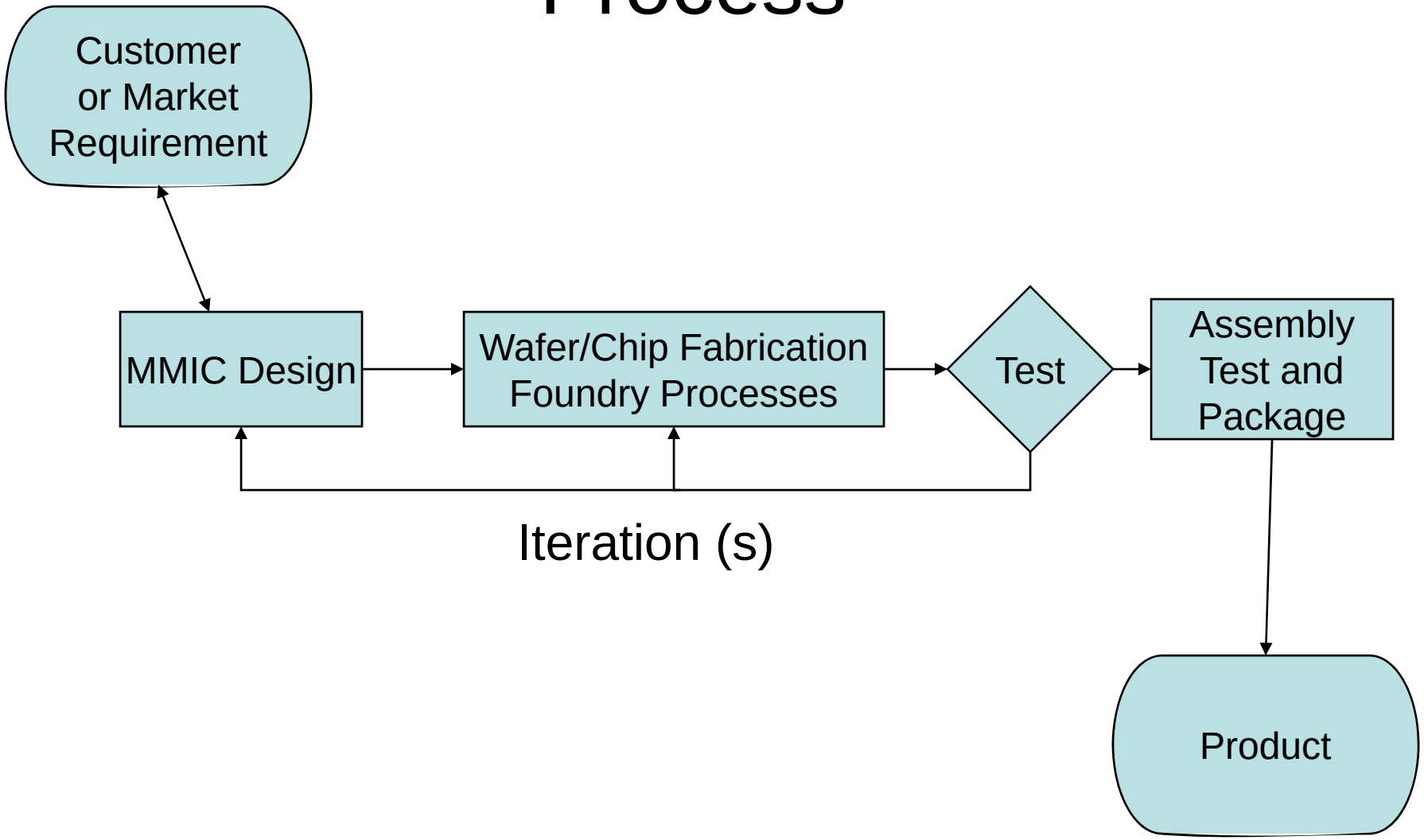
Table 1.2 Chip cost against size

Chip size (mm^2)	Typical yield (%)	Working circuits per 6" wafer	Bare chip cost ($) at $5k per wafer
1 × 1	80	12800	0.4
2 × 2	70	2800	1.8
5 × 5	45	288	17
7 × 7	30	98	51
10 × 10	20	32	156

Engineering Development Process



MMIC Product Develpoment Process



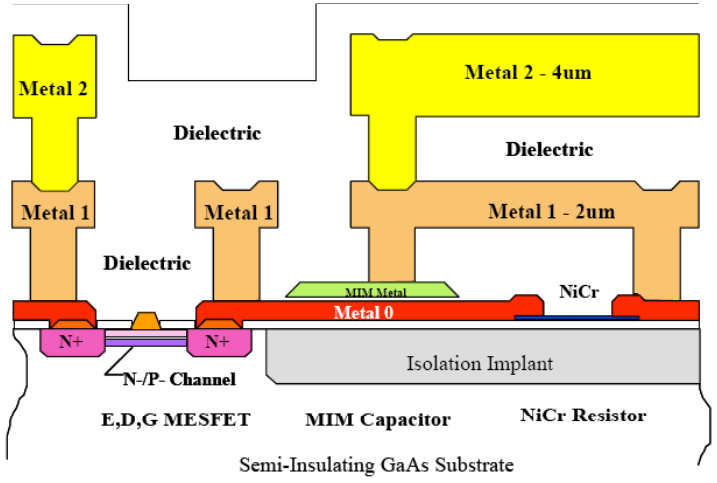
MMIC Production Process

Production Process

TriQuint SEMICONDUCTOR

TQTRx

GaAs MESFET Foundry Service

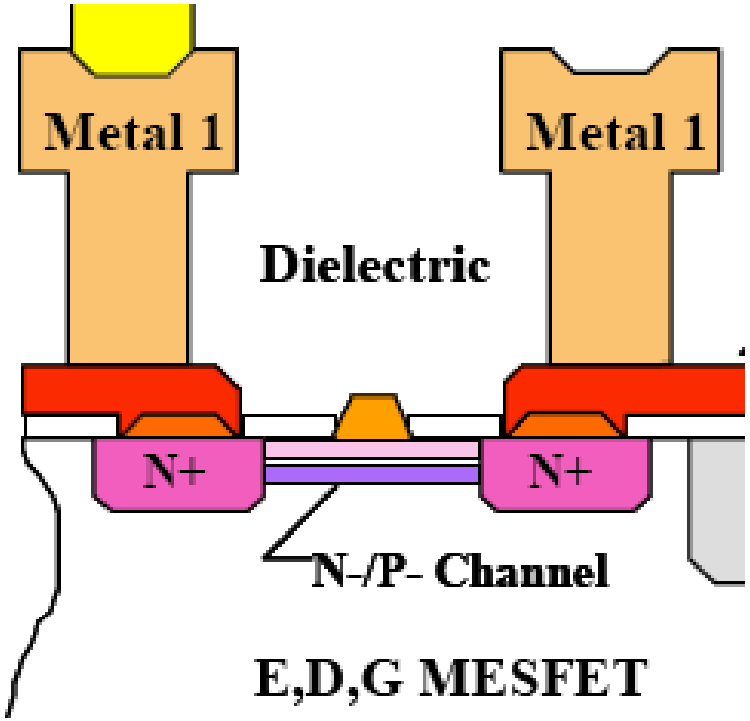


TQTRx Process Cross-Section

Features

- 0.6 µm Gate Length MESFET Process
- 4 Active Devices:
  - Power & Gain D-FETs
  - E-FET
  - Schottky-Barrier Diodes
- High Density Interconnects:
  - 2 Global and 1 local
  - 6 µm total thickness
- High-Q Passives
- Bulk & Thin Film Resistors
- High Value Capacitors
- Dielectric Encapsulated Metals
- Planarized Surface; simplified plastic packaging
- Substrate Vias Available
- Volume Production Process
- Validated Models and Design Support

Active devices



- See also Figure 2.27 of text.

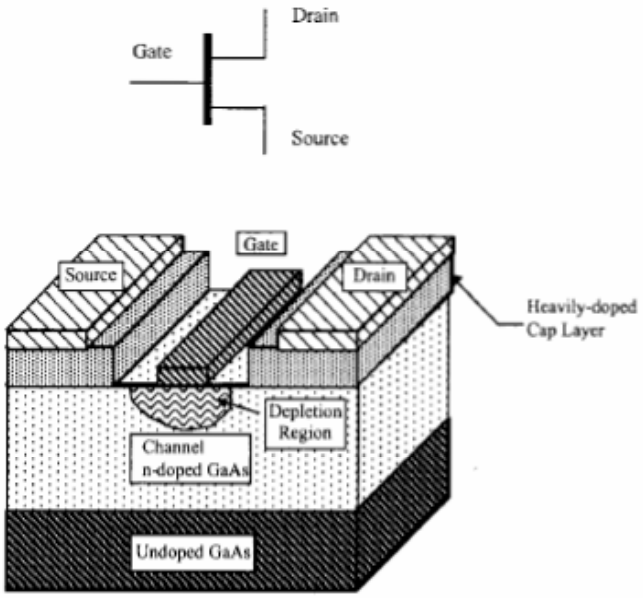
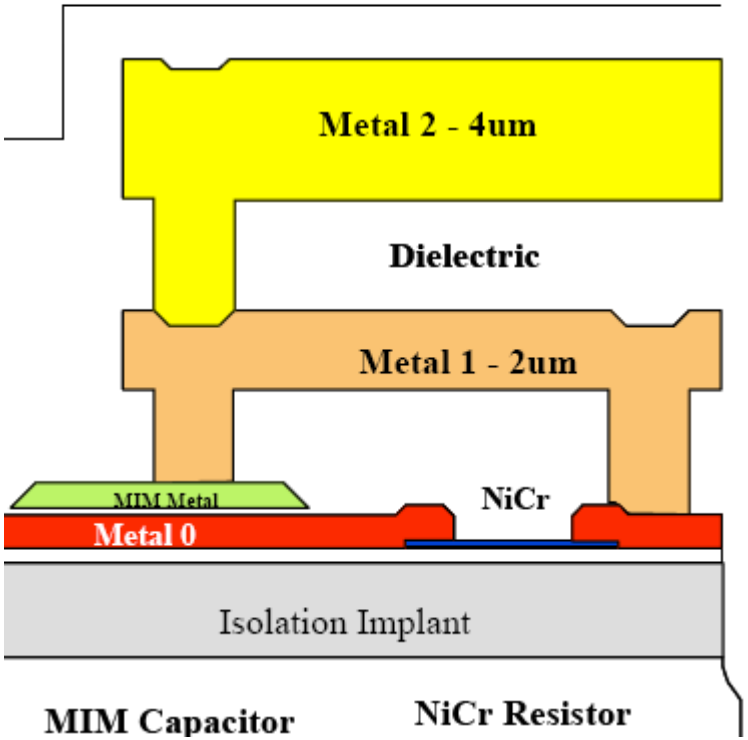


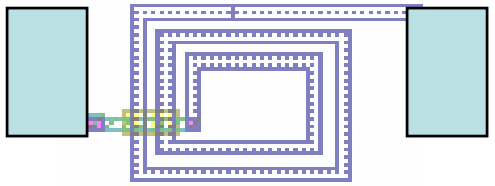
Figure 2.27 Cross-section of a MESFET device

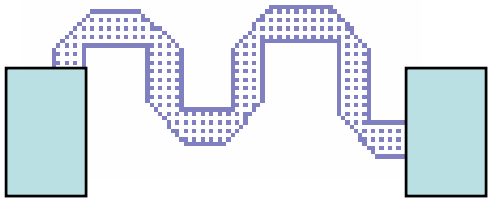
Passives

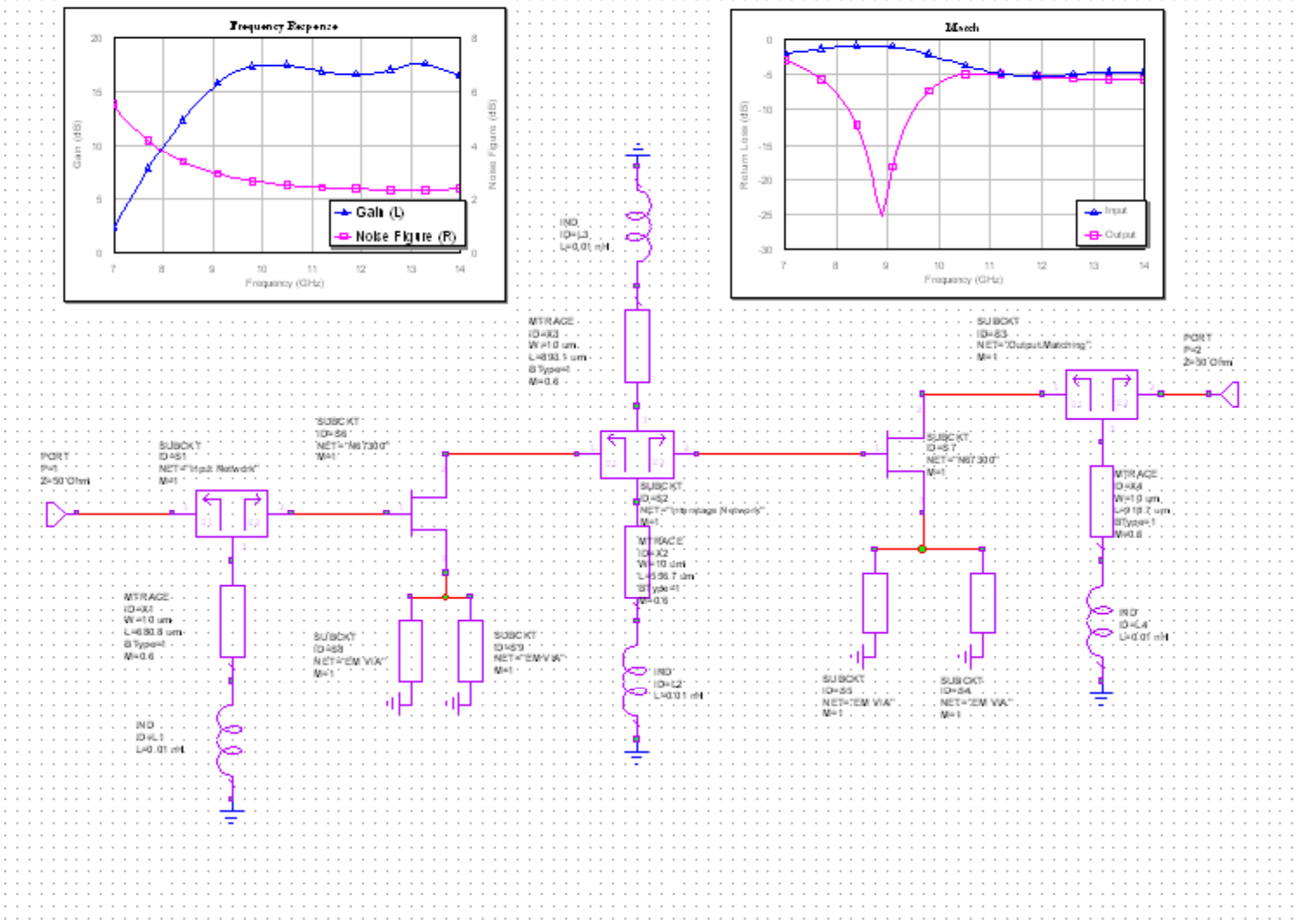

Metal 2 - 4um
Dielectric
Metal 1 - 2um
MIM Metal
NiCr
Metal 0
Isolation Implant
MIM Capacitor
NiCr Resistor

Interconnects

- Interconnects are transmission lines
- Geometry is important
- May require Electromagnetic Solution







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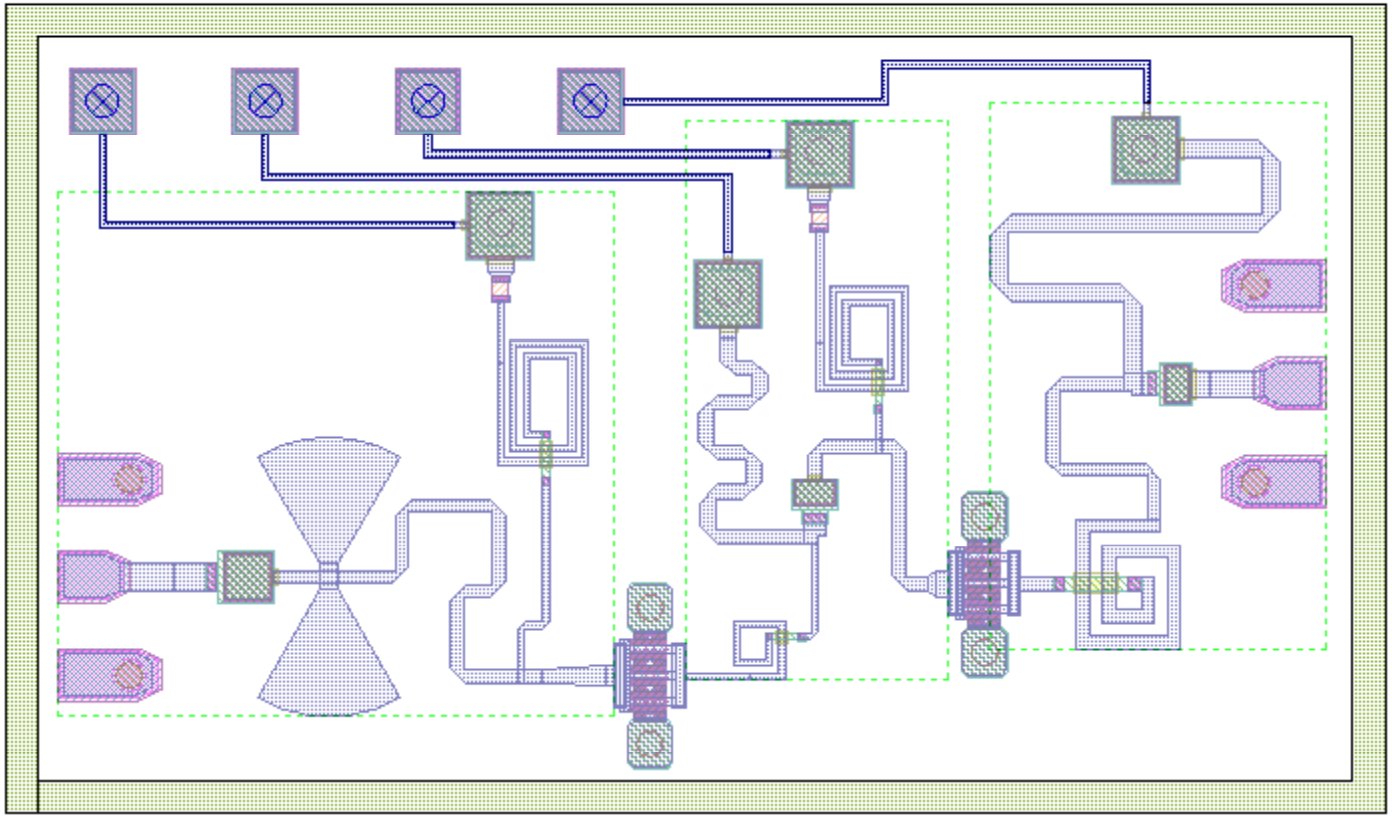

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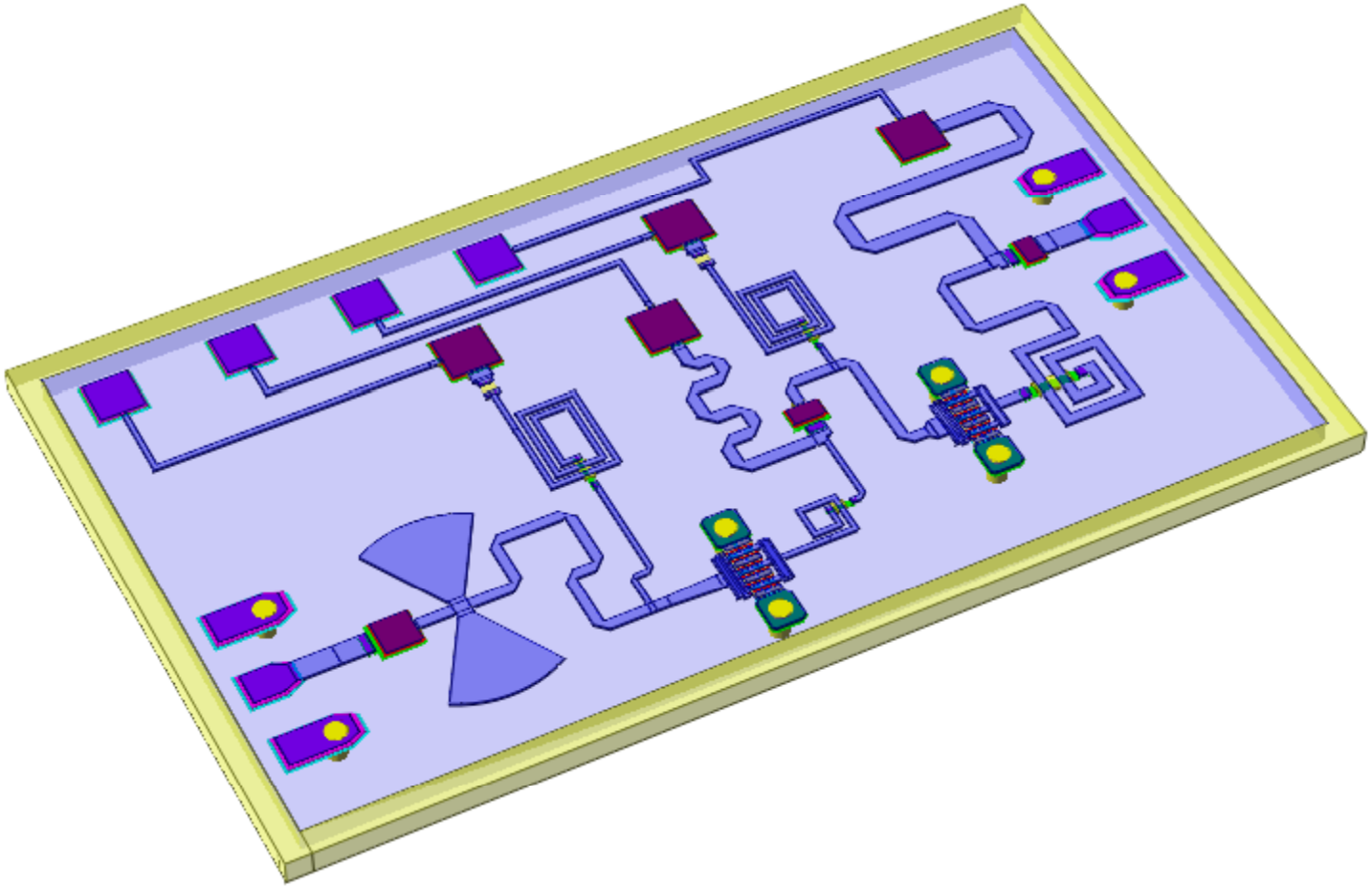

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