TUNABLE TRUE-TIME-DELAY ELEMENT USING A VARIABLE-ORDER ALL-PASS FILTER

IITM Technology Available for Licensing

Problem Statement

- Existing true time delay elements have limited tunability and delay-bandwidth product, hindering their effectiveness in wideband signal processing applications.
- There is a demand for a compact and widely tunable true time delay element that can maintain a large, flat group delay over a wide bandwidth, especially in beamforming and continuous-time equalizer systems.

Technology Category/ Market

Category – Electrical Engineering, Circuit Diagnostics
Applications –Electronic System & Design Manufacturing, ICT, Automotive
Industry – IT Hardware, Test Equipment, Wireless
Market - Electronic Design Automation Market was valued at USD 12.9 billion in 2022 and is estimated to register **a CAGR of over 10%** between 2023 and 2032.

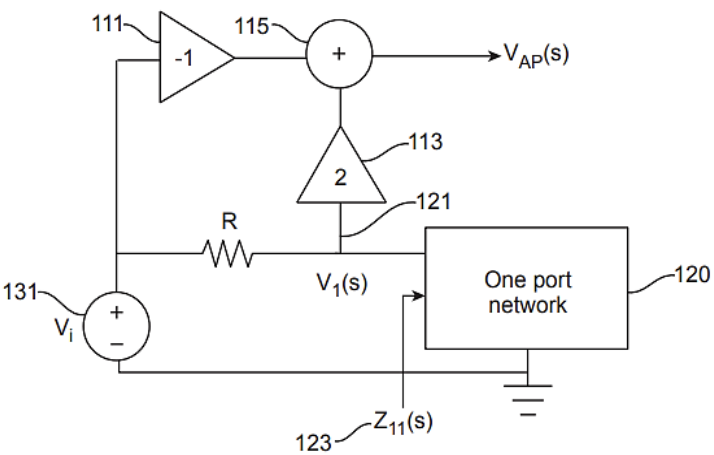

FIG. 1: Illustration of an all-pass filter, providing a fundamental understanding of the filter architecture.

Technology

Tunable True Time Delay Element:
Introduces widely tunable delays over wideband signals, crucial for applications like beamforming and continuous-time equalizers.

All-Pass Filter Architecture:
Utilizes a weighted sum of input voltages and one-port networks to achieve tunable delays.

Variable LC Ladder Circuits:
Allows for precise control over delay order by adjusting the number of stages, enhancing flexibility in delay adjustment.

Lossless and Lossy Transmission Lines:
Offers options for adjustable delay by varying length, with lossy lines providing additional control over delay characteristics.

Integrated Circuit Implementation:
Incorporates operational transconductance amplifiers (OTAs) and digital logic for order selection and capacitance programming, facilitating integration into signal processing systems.

Intellectual Property

- **IITM IDF Ref. 1455**
- **IN 511139 (Patent Granted)**

Research Lab

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Key Features / Value Proposition

- Widely **tunable true time** delay element utilizing all-pass filter architecture and **variable LC ladder circuits for precise delay control.**
- **Integration of operational trans conductance amplifiers (OTAs)** and digital logic enables compact implementation with enhanced tunability, catering to diverse wideband signal processing needs.
- This invention **offers a compact, highly tunable solution** for **achieving precise delays** over **wideband signals**, enhancing performance in applications such as **beamforming and continuous-time equalizers.**

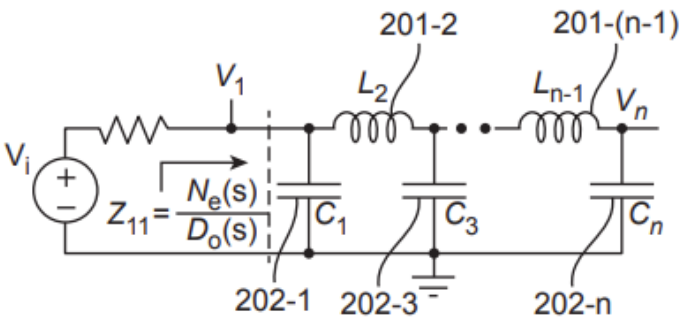

FIG. 2: Representation of an odd-order capacitor first LC ladder, crucial for understanding the variable LC ladder circuits used in the invention.

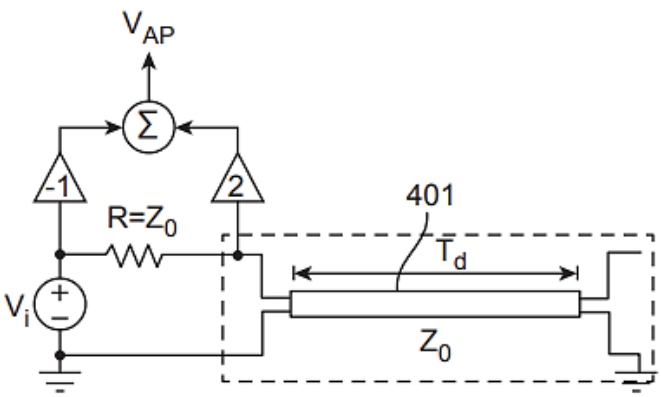

FIG. 3: Illustration of an all-pass filter with a lossless LC ladder as one port network, demonstrating one of the key components of the tunable delay element.

Image

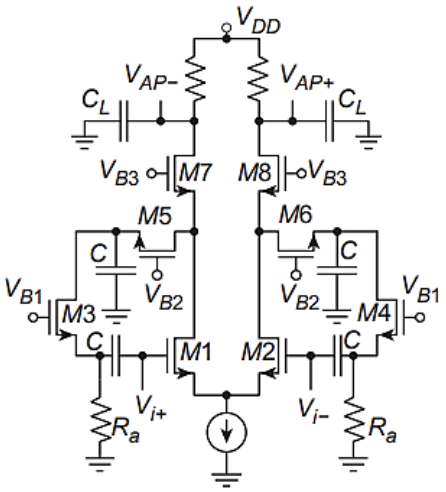

FIG. 4 Diagram of an active second-order all-pass delay cell, essential for comprehending the active circuitry used in achieving tunable delays.

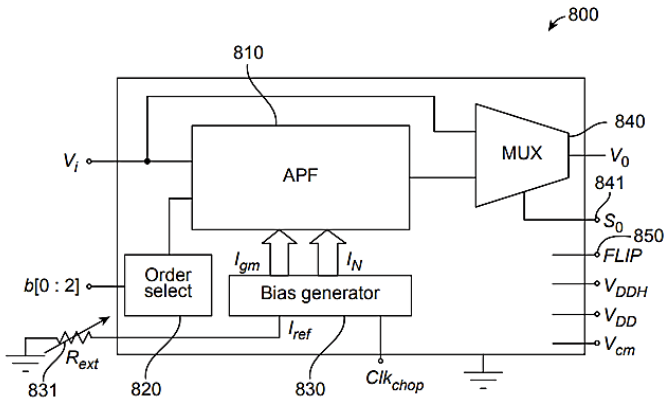

FIG. 5 Block diagram of the integrated circuit chip providing widely tunable delay over a wideband signal, offering insight into the practical implementation of the invention.

TRL (Technology Readiness Level)

TRL- 4, Technology Validated in lab

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