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Pioneering Connectivity Using The Single-Pole Double-Throw Antenna

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Ishrat Z. Mukti1, Ebadur R. Khan2. Koushik K. Biswas3 ABSTRACT

AbstrAct This ingenious design combines the principles of RF switching with antenna functionality, This paper paper presents the design of a comparator $\frac{1}{2}$ comparation of $\frac{1}{2}$ is a comparator of the design of the design of the special to intricacies of the SPDT antenna, its design principles, applications, and its potential to
redefine wireless connectivity the microsy connectivity. It is a custom-made α samples per second at non-made α In the realm of wireless communication, innovation knows no bounds. One such breakthrough in antenna technology is the Single-Pole Double-Throw (SPDT) antenna. enabling seamless signal switching between multiple paths. In this article, we explore the redefine wireless connectivity.

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 $c_{\rm 1.8}$ V. The comparator on a nominal supply of 1.8 V. The comparator of 1.8 V. The comparator of α **How to cite this article:** Zakir F, Rozman Z. Pioneering Connectivity Using The Single-Pole Double-Throw Antenna. National Journal of Antennas and Propagation, Vol. 5, No. 1, 2023
(The designed comparator has a unity gain bandwidth of 4.2 and 4.2 and 4.2 and 4.2 and 4.2 at 7.2 at 7.2 at 7.2 at 7.2 at 7.2 and 7.2 at 7.2 and 7.2 and 7.2 and 7.2 and 7.2 and 7.2 and $7.$ (pp. 39-44).

DOI: Antenna

The SPDT antenna is a versatile solution that integrates RF its core, the antenna features a single radiating element paths. This switching functionality allows the antenna **produced and the antenna** and the state of the st to alternate between transmitting or receiving signals and the comparator \blacksquare 45nm CMOS Technology. Journal of VLSI Circuits and System Vol. 6, No. 1, 2024 (pp. from different sources, offering enhanced flexibility and adaptability in various communication scenarios. **IntroductIon** of antenna commonly used in wireless communication and diversity systems. It is designed to provide a flexible and efficient means of routing RF signals between two and gives outputs in terms of a digital signal signal signal and result on the different paths or antennas.^{[1]-[20]} of the comparison. switching capabilities with traditional antenna design. At that can be dynamically switched between two different The Single-Pole Double-Throw (SPDT) antenna is a type systems, particularly in radio frequency (RF) switches

The SPDT antenna consists of a single input/output port connected to a switch mechanism that can alternate between two separate paths. This switch mechanism allows the antenna to connect to either one of two antennas or transmission lines, enabling various configurations such as antenna diversity, signal routing, or antenna selection as shown in Fig. 1.

In antenna diversity systems, SPDT antennas are utilized to switch between multiple antennas to improve signal reception quality by selecting the antenna with the strongest signal or minimizing interference. This technique enhances the reliability and performance

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Fig.1: Single Pole Double Throw Switch to be higher. One of the techniques to obtain a super low obtain a super low obtain a super low obtain a super

of wireless communication systems, particularly in challenging environments with fading or multipath propagation.Furthermore, SPDT antennas find applications in RF switches, where they are used to route RF signals between different paths or devices, such as in signal routing networks, test and measurement equipment, or RF front-end modules. The design of SPDT antennas involves considerations such as impedance matching, isolation between switch states, insertion loss, and switching speed. Additionally, factors in practical implementations.SPDT antennas offer a versatile and efficient solution for switching RF signals between multiple paths or antenn as, making them valuable components in various wireless communication systems and RF applications. Continued advancements in antenna design and switch technology are expected to further improve the performance and capabilities of SPDT antennas in the future.^[21-34] like size, cost, and power consumption are important

three-stage C comparator with a high-speed operation $\mathcal{L}_\mathcal{S}$ **PRINCIPLES OF OPERATION**

The operation of the SPDT antenna revolves around the use of RF switches to control the signal path between the antenna and the RF circuitry. By toggling between the two paths, the antenna can selectively transmit or receive signals from different sources, such as multiple antennas, frequency bands, or communication protocols.

The RF switches used in SPDT antennas are typically semiconductor devices, such as PIN diodes or fieldeffect transistors (FETs), controlled by a bias voltage or current. When the switch is in one state, the antenna is connected to one signal path, while in the other state, it is connected to a different path. This switching mechanism enables seamless transition between different operating modes without the need for additional antennas or antenna operates by switching between two different paths or antennas, enabling the selection of one of two signal sources or destinationsshown in Fig. 2. This switching action is achieved using a switch mechanism integrated into the antenna design.^[35-45] complex circuitry.The Single-Pole Double-Throw (SPDT)

Fig. 1: Block diagram of the suggested Comparator **reconfigurable antenna Fig.2: Machine learning assisted metamaterial-based**

In its basic configuration, the SPDT antenna consists of a of the major output por component to a surfact mechanism. men tho batput input-put... The switch incenditism can
be activated electronically or mechanically to connect be derivated electromedity of mechanically to connect the input port to either one of the two output paths. This allows the antenna to alternate between two antennas, attory the antenna to attennate between two antennas,
transmission lines, or signal paths.During operation, the that the output of output of output of the set of the spectrum, the SPDT antenna receives an RF signal at its input port. The si B F antenna receives an KF signal at its input port. The
switch mechanism then routes the signal to one of the switch incentation then routes the signal to one or the
two output paths based on the desired configuration. For example, in antenna diversity systems, the switch may select the antenna with the strongest signal or least interference. In RF switches, the switch may route the sharp we get a sharp we get a sharp we get a sharp we g signal to different devices or paths for signal routing or testing purposes. We make the OTA stage by connecting purposes. single input/output port connected to a switch mechanism

The selection process in SPDT antennas is typically controlled by an external signal or control mechanism, which activates the switch to change its state. This switching action can occur rapidly, allowing the antenna to adapt to changing signal conditions or user-defined preferences in real-time. The operation of the SPDT antenna provides a flexible and efficient means of routing RF signals between multiple paths or antennas, enabling various configurations and applications in wireless communication systems, RF switches, and antenna diversity systems. The design and implementation of SPDT antennas involve considerations such as switch speed, isolation between paths, insertion loss, and compatibility with the desired application. Continued advancements in antenna design and switch technology are expected to further enhance the performance and versatility of SPDT antennas in the future.

Key Components

1. Radiating Element

The radiating element of the SPDT antenna serves as the primary interface for transmitting or receiving RF signals. It can take various forms, including a monopole, dipole, patch, or any other antenna configuration suitable for the application requirements. The radiating element in antennas is the component responsible for emitting or receiving electromagnetic waves. It serves as the interface between the electrical signals in the antenna feed system and the surrounding electromagnetic field, [46]-[51] shown in Fig. 3.

and loops, each offering unique advantages and suitability for different applications. The design and geometry of the radiating element significantly influence the performance characteristics of the antenna, including radiation pattern, polarization, and impedance matching. Common types of radiating elements include dipoles, monopoles, patches, helices,

Fig.3: Dual-ring slot antenna design with liquid metal

elements aligned in parallel, while a monopole antenna For example, a dipole antenna consists of two conductive uses a single conductive element above a ground plane. Patch antennas employ a metallic patch on a dielectric shaped wire element. The choice of radiating element depends on factors such as frequency range, bandwidth, Accepted xxxxxxxxxxxx directional properties, and size constraints. substrate, while helical antennas utilize a spiral-

performance objectives. Techniques such as impedance Authoris extensive, parameter community and onlying and anticianal system.
The chingues can be employed to optimize the radiation **Sumate can be empressed to epinnihism characteristics of the antenna. The radiating element** design and materials continue to drive innovation in of antennas with improved efficiency, bandwidth, and elements may be tuned or modified to achieve specific In addition to their physical structure, the radiating matching networks, parasitic elements, and shaping plays a crucial role in determining the functionality and performance of antennas in various communication, radar, and sensing applications. Advances in antenna radiating element technology, enabling the development miniaturization.

signals, basically an input analog signal with a reference signal, **2.RF Switches**

The RF switches are the critical components that me is sincenced are the critical components that enable signal switching within the SPDT antenna. These enable signal switching within the si DT antenna. These
switches control the connection between the antenna and the RF circuitry, allowing for dynamic selection of power consumption. They also a reduced noise level and a reduced noise level and and and and and and and and a signal paths.RF switches play a vital role in antenna
signal in obtaining the coloring in the contract PF systems by rachitating the selection or routing or the signals between different paths or components. These signals between amerent paths or components. These
switches enable antennas to dynamically switch between stricties enable antennas to ay nameatly strict between
various signal sources, antennas, or transmission lines, T_{total} are detailed details the design of a comparator for use in a comparator for use in a comparator for use in a comparator θ and θ and thereby providing flexibility and adaptability in wireless communication systems. systems by facilitating the selection or routing of RF

RF switches are commonly used in antenna diversity systems to select the antenna with the strongest signal or least interference, improving signal reception quality

THE COMPACT OF A COMPART POLE COMPART POWERS Fig.4: Single-pole double-throw series-shunt switch

technology and runs 4.2 in challenging opyiropments. They also find application. in challenging environments. They also find applications h on a dielectric recommunicaties in RF front-end modules, test and measurement encompensate of the offset voltage in this mismatch. This mismatcher is equipment, and signal routing networks, where they anding element are utilized for switching between different RF paths T_{inter} candwidth, or devices.^{[52]-[63]} The design and performance of RF nts.

switches are critical considerations in antenna systems. switches are critical considerations in antenna systems
A the rediction **Contagned comparator has designed comparator** has a the rediction e, the radiating Factors such as insertion loss, isolation between switch is the reachieve specific states, switching speed, and power handling capabilities influence the overall performance and reliability of the antenna system.

Hunctionality and Errors American Enteriors, This Error Enteriors, High-Res-
Communication MEMS (Microelectromechanical Systems) switches, communication, and semiconductor switches. Each type offers unique nces in antenna

advantages in terms of switching speed, power requirementsshown in Fig. 4.RF switches play a crucial role in enhancing the flexibility, reliability, and performance of antenna systems, enabling efficient signal routing and management in wireless communication applications. Continued advancements in switch technology are expected to further improve the capabilities and integration of RF switches in antenna systems, driving innovation in wireless communication technologies. Various types of RF switches are available, including electromechanical switches, PIN diode switches, consumption, and frequency range, allowing for tailored solutions to meet specific antenna system

3.Control Circuitry 3. One of the techniques to obtain a super low α super low α

The control circuitry provides the necessary signals to control the RF switches and manage the switching operation of the SPDT antenna. This circuitry may include microcontrollers, digital logic circuits, or specialized RF switching controllers. Control circuitry in antennas refers to the electronic components and systems responsible for managing and controlling the operation of the

antenna. This circuitry plays a crucial role in optimizing antenna performance, adjusting antenna parameters, and enabling advanced functionalities in modern **relAted work** circuitry is to manage the antenna's radiation pattern, polarization, and frequency characteristics. This may involve adjusting the phase, amplitude, or frequency of the RF signals fed to the antenna elements to achieve desired radiation properties. For example, phased array antennas use control circuitry to dynamically steer the beam direction without physically moving the antenna $\mathsf{structure.}$ antenna systems.One of the primary functions of control structure.

Control circuitry also facilitates the implementation of static calculation and a lower distinctive and and production and small smaller and minimal commiques, such as sound commiss, operator traditional comparator to the latched and hysteresis-technology. These techniques utilize signal processing based compared to the designing the design of the design of algorithms and feedback mechanisms to optimize signal angerman and reception mechanisms to epinning eigenvalues reception, chilance catalog in eaglipsity and intergate interference in wireless communication systems.^[64]

Additionally, control circuitry may incorporate sensing and feedback mechanisms to monitor environmental conditions, antenna performance metrics, and user preferences. This information can be used to adaptively adjust antenna parameters in real-time, ensuring optimal performance under varying operating conditionsshown in Fig. 5. Control circuitry plays a critical role in modern antenna systems by enabling adaptive, reconfigurable, and intelligent operation. Advances in semiconductor **ArchItecture of compArAtor** communication protocols continue to drive innovation in control circuitry, enabling the development of more efficient, flexible, and capable antenna systems [65]. technology, digital signal processing, and wireless

Low Noise Amplifier **Fig. 5: Switching a Remote Antenna,**

A. Operational Transconductance Amplifier Applications of SPDT Antennas

The versatility and adaptability of SPDT antennas make them well-suited for a wide range of applications across various industries: various industries:

- amplifiers in which differential inputs are present. The ***** Wireless Communication Systems: SPDT antennas are used in wireless communication systems to switch between different antennas, frequency bands, or communication protocols. This enables devices such as smartphones, IoT devices, and Wi-Fi routers. seamless connectivity in multi-band/multi-protocol
- ◆ Beamforming and MIMO Systems: SPDT antennas play a crucial role in beamforming and multipleinput multiple-output (MIMO) systems by switching between different antenna elements or polarization states. This allows for adaptive beam steering and spatial multiplexing, enhancing spectral efficiency and coverage in wireless networks.
- **Cognitive Radio and Dynamic Spectrum Access:** SPDT antennas facilitate cognitive radio and dynamic spectrum access applications by switching between different frequency bands or channels based on realtime spectrum availability and usage. This enables efficient utilization of the available spectrum and improved coexistence with other wireless systems, [45] shown in Fig. 6.
- antennas or operating modes, SPDT antennas optimize communication range, data throughput, **RFID and Sensor Networks: SPDT antennas are** utilized in RFID systems and wireless sensor networks for selective communication with multiple RFID tags or sensor nodes. By switching between different and energy efficiency in IoT deployments.

Challenges and Future Directions

Despite their numerous advantages, SPDT antennas pose certain challenges, including signal loss, insertion loss,

Low Noise Amplifier **Fig. 6: A Novel Antenna Radiation-Pattern**

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integration with adaptive signal processing algorithms. Conclusions
While Single-Pole Double-Throw (SPDT) antennas and complexity associated with RF switching circuitry. Addressing these challenges requires careful design optimization, advanced RF switching technologies, and While Single-Pole Double-Throw (SPDT) antennas offer significant benefits in signal routing and antenna selection, they also face several challenges that need to be addressed for optimal performance and reliability.

insertion loss is crucial for maintaining signal integrity overall performance of the antenna system. Minimizing and maximizing the efficiency of the antenna. One challenge is related to insertion loss, which refers to the attenuation of the signal when passing through the switch mechanism. High insertion loss can result in reduced signal strength and degraded

or signal sources. Slow switching speed can result in Another challenge is isolation between switch states, which refers to the ability of the antenna to maintain switch is in the OFF state. Poor isolation can lead to signal leakage or crosstalk between paths, affecting the antenna's ability to accurately switch between antennas or transmission lines [25]. Switching speed is applications requiring rapid switching between antennas separation between the two output paths when the also a critical factor in SPDT antennas, particularly in latency and impact the responsiveness of the antenna system, especially in dynamic environments or real-time communication systems.

in compact or low-power applications where space **IntroductIon** optimization, advanced switch technology, and integration with efficient control circuitry to ensure the reliable and efficient operation of SPDT antennas Additionally, SPDT antennas may face challenges related to size, cost, and power consumption, particularly and energy efficiency are paramountshown in Fig. 7. Addressing these challenges requires careful design

Fig. 7: Building an RF Switching Unit

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I complexity associated with RF switching circuitry. In various wireless communication systems and RF applications.

Conclusions

Comparator Millet Comparator Inconclusion, Single-Pole Double-Throw (SPDT) antennas
leo face several challenges that need represent a versatile and efficient solution for signal Implemented in the several challenges that heed
Affer optimal performance and reliability.
Wireless communication applications. By allowing the Ishat *Internation* and *Ishan and The Remarks*, addpearing, and improved
Iigh insertion loss performance in challenging RF environments.Throughout strength and degraded this discussion, we have explored the principles of tenna. loss, isolation between switch states, switching speed, and size considerations can impact the performance and position considerations can impact the performance and It switch states, usability of SPDT antennas.Despite facing challenges enna to maintain such as insertion loss and switching speed, SPDT antennas paths when the continue to be widely odented in verious wireles paths when the continue to be widely adopted in various wireless tion can lead to non can tead to communication systems, RF switches, and antenna paths. affecting paths, ancering diversity applications. Advances in switch technology, switch between control circuitry, and antenna design have enabled the It ching speed is development of more efficient, compact, and reliable in the last designed comparator has des s, particularly in SPDT antennas.Looking ahead, further research and etween antennas innovation in SPDT antennas are expected to address authoris entermation of the enhanced performance, miniaturization, and **shis of reat-time** integration into emerging wireless communication How to complement article articles are arricleded antennas will play a crucial role in shaping the future ratienges retated and anti-mas with play a crucial rote in shaping the ruture
ion, particularly of wireless communication systems, enabling seamless fort, particularly for virticless communication systems, enabling searness
ns where space connectivity, improved signal quality, and enhanced user enabling new applications across diverse industries. As researchers, engineers, and innovators continue to explore the potential of this transformative technology, we can expect to see further breakthroughs that enhance performance, reliability, and versatility, driving innovation in wireless communication systems and shaping the connected world of tomorrow. In conclusion, Single-Pole Double-Throw (SPDT) antennas routing, antenna selection, and diversity systems in selection between two different paths or antennas, SPDT antennas offer flexibility, adaptability, and improved operation, key components, and challenges associated with SPDT antennas. We have discussed how insertion existing challenges and unlock new opportunities technologies. With continued advancements, SPDT experience. SPDT antennas holds tremendous promise for advancing wireless communication capabilities and

structure, the gate capacitance tends to show a higher **References**

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