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| **U.S. Radiocommunications Sector**  **Fact Sheet** | |
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| Document Title: New SSTX weather radars and current WAS/RLAN in the 5 GHz band. | |
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| Purpose/Objective: To provide relevant information and facilitate the discussions regarding the new SSTX weather radars and WAS/RLAN in the 5 GHz band | |
| **Abstract:**  The recent meeting of Working Party 5B (14-24 May 2024) discussed new solid-state transmitter (SSTX) pulse characteristics for weather radars and wireless access systems (WAS)/radio local area networks (RLAN) dynamic frequency selection (DFS) in the 5 GHz band, and agreed to have a joint-meeting of WG 5B-1 with the relevant WG within Working Party 5A. This contribution intends to provide relevant information to facilitate the discussions at the upcoming joint meeting of the WP 5B and WP 5A. | |
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**Pulse Characteristics of SSTX Weather Radars in the 5 GHz band**

**Background**

Solid-state transmitters (SSTX) are a major technological positive change in improving weather radar systems. The flexibility, reliability, and operating costs offered by SSTX make them an attractive alternative to conventional tube-based transmitters (e.g., klystron, magnetron, traveling wave tube). As a result, SSTX are expected to become more commonplace as the solution becomes the preferred and sometimes the only feasible solution for weather radars.

Pulse characteristics differ between legacy tube-based transmitters and SSTX-based weather radar systems. If this difference is significant enough, it could lead to a reduction of the effectiveness of Radio Local Area Network (RLAN) devices to detect weather radar signals and employ Dynamic Frequency Selection (DFS). It is important for future DFS-enabled systems to detect and avoid interfering with modern radar systems that do not share legacy pulse characteristics.

**Pulse Characteristics of Solid-State Transmitters**

Many parameters associated with radar transmissions are consistent with both tube-based and solid-state transmitters, including operating frequency, pulse repetition frequency (PRF), and average power. While these parameters may be radar- or application-dependent, they are determined primarily by desired observational characteristics, not system architecture. The remainder of this section will focus on the notable differences in pulse characteristics of SSTX.

In contrast to the high-power tube-based transmitters, solid state radar transmitters operate at significantly lower *peak power*–often 10x or even 100x lower. As a result, proportionally longer pulses (resulting in higher duty cycle) become necessary to increase the *average power* of the pulse to match that of the higher peak power tube-based transmitters; otherwise sensitivity and effectiveness of the radar will degrade significantly.

The use of a longer pulse has two undesirable consequences: increased range resolution and increased blind range.

* To address the increased **range resolution**, SSTX typically employs a signal processing technique called pulse compression. Pulse compression allows recovering the native range resolution of a shorter pulse (~1 μs), while extending the pulse length (typically 40-200 μs) to improve sensitivity. Importantly, for detection, the pulse will be modulated in frequency along its duration of the pulse. This modulation is typically 1-6 MHz about the center frequency (depending on the range resolution desired) and may be linearly or nonlinearly modulated.
* A longer pulse also suffers increased **blind range** due to the inability of the radar to receive data while transmitting. The conventional approach to mitigate the blind range is to employ a “fill pulse”, a short (0.1-1.0 μs) non-modulated pulse immediately appended to the end of the long modulated (pulse compressed) pulse. However, its transmit power will be lower, and alternative strategies for blind range mitigation have been demonstrated, so the absence or presence of a fill pulse should not be used as a criterion for detection.



*Figure 1. Exaggerated example of frequency-modulated long pulse followed by a non-modulated fill pulse*

Figure 1, above, illustrates a conceptual solid-state radar waveform showing the characteristics above. In this example, the radar transmits a 40 μs main pulse, which is modulated in frequency, followed immediately by a 1 μs non-modulated fill pulse for blind range mitigation. Typical pulse widths for SSTX radars range from 40-200 μs, with a fill pulse on the order of 1 μs or less. It should be noted that both the center frequency and modulation shown are greatly exaggerated in this example to illustrate the concept. Realistic values for a C-band weather radar (1-6 MHz modulation about a ~5.6 GHz center frequency) would not be visible in print. The modulation shown here is a simple chirp increasing in frequency. The frequency modulation in a real system may alternatively be linearly decreasing, triangular, or nonlinear.

In summary, when contrasted to pulses from a tube-based transmitter radar, SSTX radar pulses will typically be characterized by:

1. Much lower peak power
2. Much longer pulse width
3. Frequency modulated main pulse
4. Often, a short fill pulse trailing the main pulse

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|  | **Magnetron** | **Solid State** |
| *PRF* | 500-3000 Hz | 500-3000 Hz |
| *Peak power* | 50-500 kW | 0.5-5 kW |
| *Pulse width (main pulse)* | 0.25-2 μs | 40-200 μs |
| *Frequency modulation (main pulse)* | None | 1-6 MHz bandwidth |

*Table 1. Typical values for weather radar pulse specifications*

Table 1, above, outlines expected typical values for pulse characteristics of C-band weather radars, showing the contrast between conventional tube-based transmitters such as magnetrons and newer SSTX radars. It should be noted that these are expected typical values and not intended to comprehensively cover all likely SSTX weather radars.