Modulator Technology

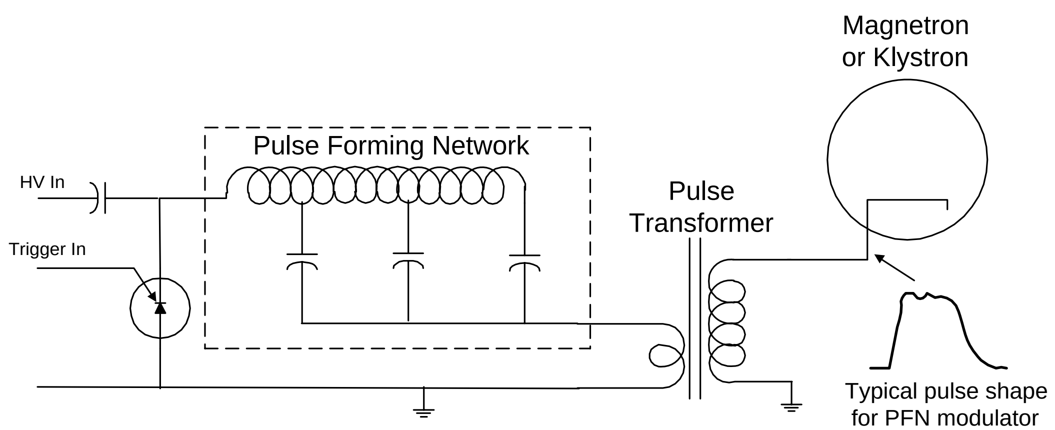
The modulator is a critical element in a weather radar. The modulator controls the accuracy and consistency of the pulses the radar transmits. The accuracy and consistency of the pulses ultimately determines the accuracy of the data the radar produces. No amount of technology can produce accurate data from pulses that are inconsistent or inaccurate.

Essentially all modern radar modulators are solid state. Solid state technology has significantly improved the reliability of modulators. However, there are still important differences between different modulator technologies.

Modulator Technologies

Pulse Forming Network (PFN) Disadvantages

- Widely used since the 1940's
- Simple
- Solid state PFN is adaptation of the old thyratron tube type modulators
- Pulse width is determined by PFN components
- Components must be changed to change pulse width
- Pulse shape determined by PFN components
- Pulse shape has ripples, no known technology to correct ripples
- Ripples affect magnetron operation (frequency/phase and power), particularly the Doppler velocity and dual polarity accuracy
- Long pulses (high average power) are difficult if not impossible with PFN's



Simplified Diagram Of A Solid State PFN Modulator

Both the power output and the frequency output of a magnetron are affected by the ripples in the pulse that a PFN modulator produces. While these changes a relatively small in a well designed radar, they establish an accuracy limit that no amount of other technology can overcome.

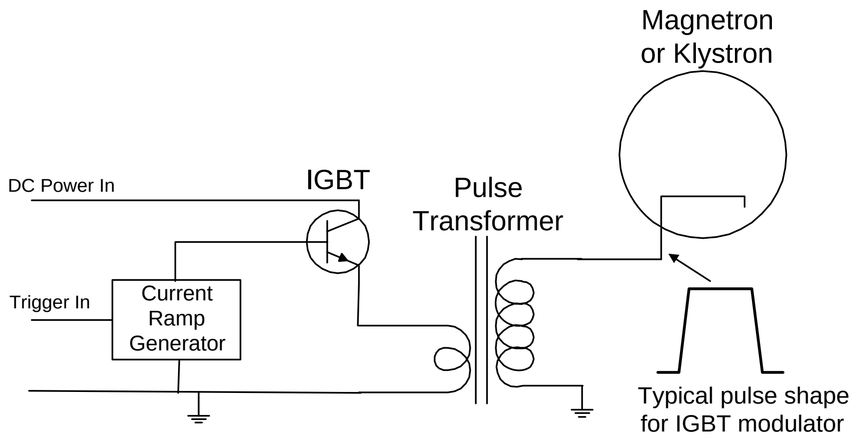
The fundamental concept of a PFN is to relate the time constants of the inductors and capacitors in the PFN to the radar's pulse rate and pulse width. This limits the operation of the radar, and is the basic reason why most weather radar have a reflectivity mode and a velocity mode, i.e., a different set of components is required for each mode.

Doing dual rate pulsing, such as velocity unfolding, causes even more of a compromise in the PFN operation. In this mode even more compromises are required between the PFN component selection and the pulse width and pulse rate.

One of the major effects of this is to limit the radar's ability to do effective velocity based clutter filtering. Velocity based clutter filtering eliminates reflections that have zero velocity. Changes in the modulator pulse introduce velocity errors, thus, reflections from stationary objects can have non-zero velocity and will not removed by the zero velocity filter.

REI Insulated Gate Bipolar Transistor (IGBT)

- Pulse width, amplitude and shape controlled electronically
- Modern, advanced technology, enabled by insulated gate bipolar solid state devices
- Simple
- Electronic control of pulses permits flexibility in radar operation
- Pulses are consistent and accurate, improves accuracy of radar data
- Pulse length limited only by component duty cycle.

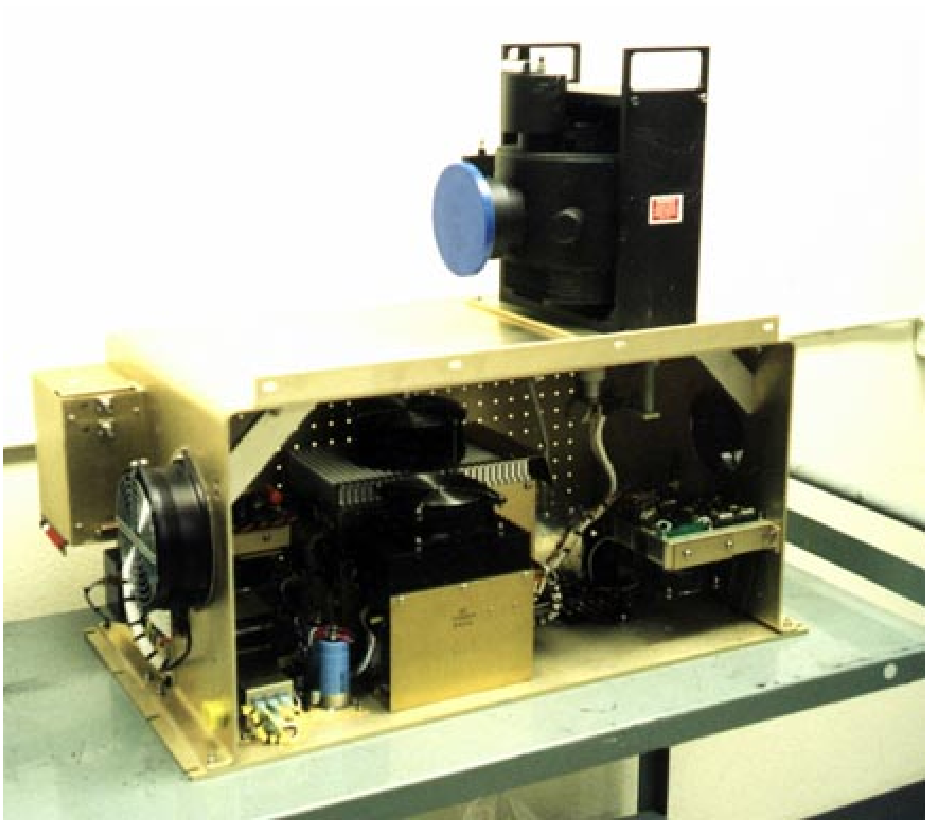


Simplified Diagram Of A Solid State IGBT Modulator

IGBT modulators control the width, amplitude and shape of the pulse electronically. This provides flexibility in operating the radar, and it also improves the accuracy of the radar, because pulses have few ripples and inconsistencies. In practice, the maximum current IGBT's can handle is on the order of a few hundred amps, thus the maximum pulse width is typically limited to something in the range of 6 or 7 microseconds.

With an IGBT modulator, a well designed magnetron radar can produce data that approaches the accuracy of a fully coherent Klystron radar. This improvement in accuracy provides more effective velocity based clutter filtering, and is required for more advanced radar technologies such as dual polarity.

The end result is that a magnetron radar with an IGBT modulator is ready for 21st century technologies/applications, and will not be restricted by the limitations imposed by 1940's PFN technology.



1MW Radtec Transmitter Including High Voltage Power Supply And IGBT Solid State Modulator

REI Solid State DC Switch Modulator

The Radtec Solid State DC Switch modulator is the only modulator in the industry which is capable of taking full advantage of a Klystron's ability to produce wide pulses with a high duty cycle. This increases the radar's sensitivity.

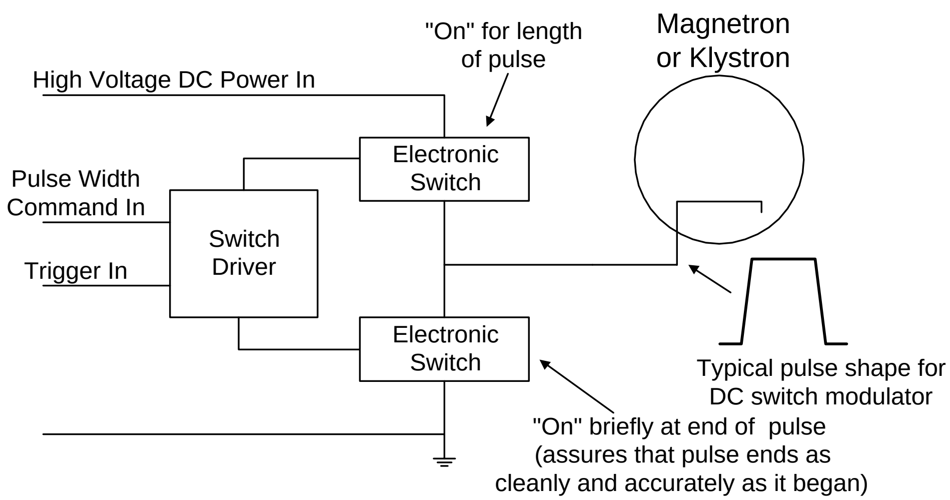
The REI Solid State DC Switch Modulator has the following advantages:

- Pulse width and rate independent of modulator component values
- Can produce pulses of very large width if required
- Pulse width and rate are electronically controlled
- Can produce complex sequences of pulses with varying rate and width
- Well suited to Klystron radars to take advantage of Klystron's high duty cycle

The DC switch modulator simply turns the high voltage DC power to the transmitter tube on and off at the rate specified by the pulse rate and pulse width. This is done with solid state electronic switching elements configured to operate at the high voltages and high currents required by magnetron and Klystron tubes.

In a DC switch modulator, there are no pulse forming networks, or time sensitive capacitors or inductors. The length and rate of the pulses are independent of any component values in the modulator.

The end result is that pulses can begin and end at any time, limited only by the duty cycle of the components involved. Thus, a DC switch modulator can easily do complex pulse sequences with staggered pulse rates and multiple pulse widths that would be impossible with any other type of modulator.



Simplified Diagram Of A DC Switch Modulator

The following photograph shows the Radtec solid state DC switch modulator in a test fixture. The high voltage electronic switch modules are visible on the right side of the modulator.

Radtec DC Switch Modulator