Advice for Modulator Designers for Marine Radar

Modulator designers of marine radars have always adjusted the pulse waveform of the modulator accurately to get the best performance. The pulse waveform of the modulator affects the below factors, which relate with the radar performance:

1. 1st Minor lobe of the spectrum
2. Oscillation stability
3. Magnetron lifetime
4. Unwanted emission level

The mechanism between the above factors and the pulse waveform is described in this technical information.

1. 1st Minor lobe of the spectrum

The 1st minor lobe of the spectrum has to be smaller than the main lobe, [N1]since it causes the tuning error of the echo signal from the target. In general, the level difference between the 1st minor lobe and the main lobe is required from –6 dBc to –13 dBc. This level of the 1st minor lobe is dependent on the flatness of the anode voltage waveform, since the magnetron frequency varies according to the anode current, which varies according to the anode voltage. It's called the "Current Pushing Effect". Fig.1 is the magnetron performance chart. The small variation of the anode voltage creates a large variation of the anode current. Therefore, the flatness of the anode voltage is the key point to get a good 1st minor lobe.

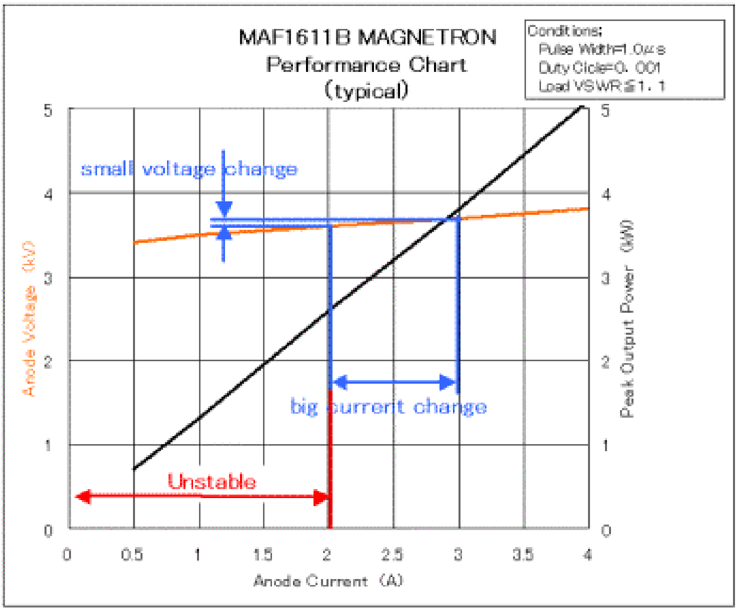

Fig. 1 performance chart

In addition, the anode current has to be more than the specified minimum level during the period of the required pulse width, and the too slow pulse rising edge and the sag of the anode

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current has to be controlled smaller than the specified level.

Fig.2 shows the anode current lower than the specified level at the rising edge of the anode current. Fig.3 shows the sag lower than the specified level.

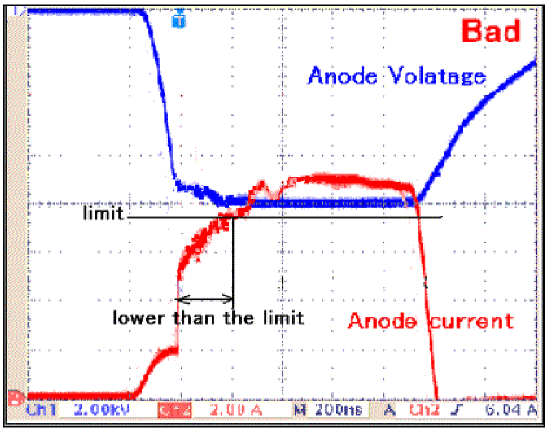

Fig.2 Example of the bad anode current 1

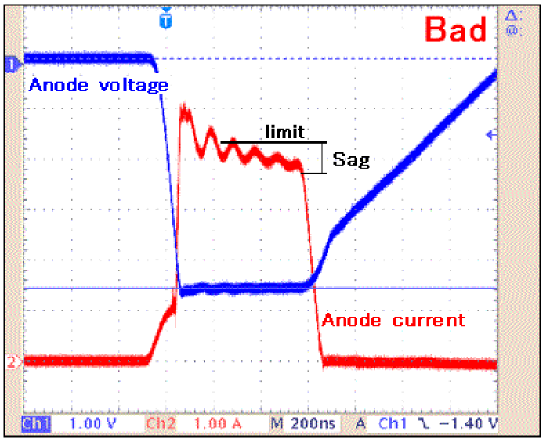

Fig.3 Example of the bad anode current 2

2. Oscillation stability

The example of the bad anode current of Fig.3 causes not only the level of the 1st minor lobe, but also the oscillation stability. There are some theoretical oscillation modes for the magnetrons. Normally, the magnetron oscillates the fundamental mode (Pi-mode) under the specified condition, but it oscillates the other mode under the unspecified [N2]condition.

Fig.4 shows the mode jumping. This instability of oscillation is caused by the quick rising (Unspecified rate of rising voltage) edge of the anode voltage, or the overshooting (Unspecified anode current) at the anode current rising edge.Therefore applying the correct anode voltage is the key point to achieve oscillation stability.

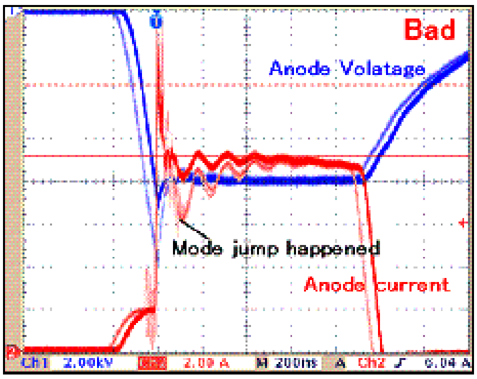

Fig.4 Example of the instability of oscillation

3. Magnetron lifetime

The overshooting (Unspecified anode current) of the anode current and the mode jumping described in “2. Oscillation stability” causes the damage of the cathode to shorten the magnetron lifetime. Fig.5 shows the overshooting of the anode current. Therefore the adjustment of the modulator (especially output reactance) to avoid the above conditions are the key points to get the best magnetron lifetime.

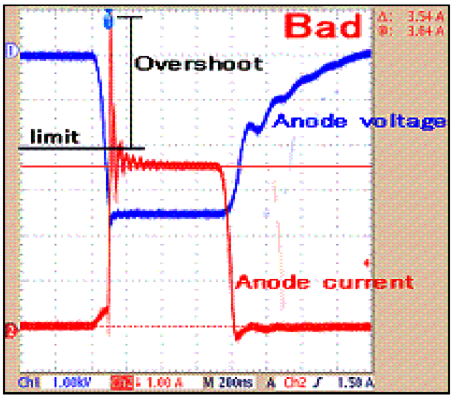

Fig.5 Example of the overshooting of the anode current

4. Unwanted emission

The rising edge of the anode voltage or current is the focal point, since the unwanted emissions in Fig. 6 are normally created at this area. Fig.7 shows the magnetron transient impedance in pulse duration. The impedance of the magnetron is transiently changed at the pulse rising edge, from high impedance to normal oscillating impedance. The fundamental pi mode oscillation is not built up rapidly, if the transient impedance is mismatched.

Therefore the transient impedance matching between the modulator and magnetron is the key point to suppress unwanted emissions.

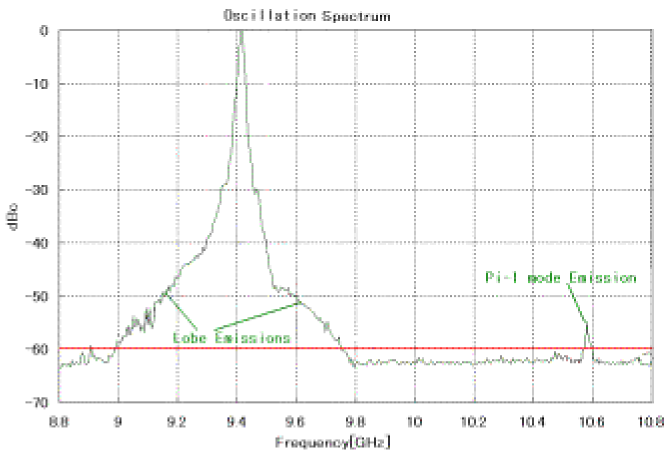

Fig.6 Example of Unwanted emissions

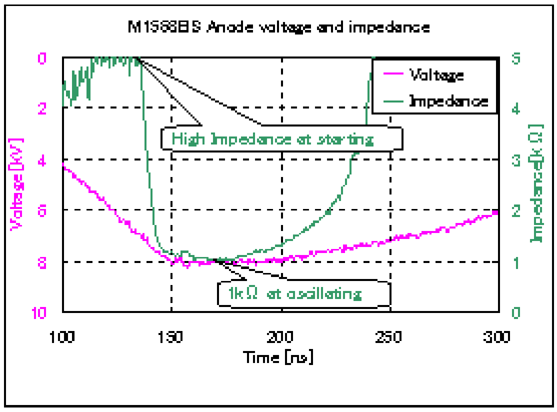

Fig.7 Example of Transient impedance

We hope this information will be useful for radar modulator designers.

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