Marine Radar Scanner Technologies

**Summary:**

The Customer is seeking to offer a range of radar products to the marine market and are seeking new and existing technologies to provide, firstly, target detection capability and, secondly, collision avoidance capability to boaters.

The Customer is interested in both Radar X-Band Transmit sources (such as magnetrons and solid state sources) as well as actual scanners themselves. A complete microwave package solution consisting of Magnetron, RF Limiter, and Local Oscillator with Magic-T or ferrite circulator approach can be considered.

The Customer is also interested in potential licensing agreements to manufacture the scanners/sources himself in his Country of preference.

**Problem Background:**

There is limited commercial magnetron sources and magnetron-based radar scanner suppliers worldwide (Toshiba, JRC, and EEV being the largest magnetron OEM suppliers who sell to Furuno, Ray Marine, and other radar scanner makers).

Existing magnetron based marine radars are expensive which prevents boater adoption in high volume numbers. The present magnetron cost typically is 30-40% of the total cost of the 1.5 – 2KW dome scanners. The total RF microwave package costs are 50-60% of the total radar cost.

Recreational boaters require lower cost conventional radar for 16 to 48 mile detection (using 1.5 - 6kW magnetrons), with competitive performance, quality, and features. Larger sport fish vessels require 10 to 25KW Magnetrons for radar range performance to 96nm. We need to support an entire range of 1.5 to 25KW magnetrons.

In addition, boaters with smaller boats do not utilize conventional radar due to limited installation options (issues are scanner size and Tx emissions which restricts mounting location).

Low power radar does not exist that addresses minimum needs (sub-16 mile radar for lower cost than conventional radar). This solid state Tx approach is currently available only in avionics and military radars.
**Specific Technical Needs:**

The Customer is searching for two radar technologies applicable to the marine industry as well as scanners themselves. The technical characteristics, such as Noise Figure, the number of Receiver Bandwidth Filter switches, Log or Linear receiver, and overall 1 sq meter target detection performance are negotiable based upon availability and pricing.

Tooling and/or proven designs for dome and open array scanners are beneficial.

The Scanners must have internal power supplies that operate from 10.2 to 41.6 Vdc (12 – 36Vdc vessel DC input bus). Output voltages from each internal scanner power supply are specific to the individual scanner.

The scanners have a serial communication port that controls the complete operation including auto tuning through the scanner PCU. The digital communication protocol format must be available, since it is normally a custom protocol. It is not required to have actual display video data as an output over the communication port. A raw analog radar receiver signal that goes from 0 to –2Vdc is acceptable.

Required environmental and emission performance of the scanners is that of an Open Saltwater application for global sales.

**Desired Family of Scanners**

1. 1.5 KW Dome with ~12-18” diameter; 5-7 degrees antenna horizontal beam width
2. 2KW Dome with ~18 – 20” diameter; 4.5-6 degrees antenna horizontal beam width
3. 4KW Dome with ~20 - 24” diameter; 4-5 degrees antenna horizontal beam width
4. 4KW 3’ Open with 2-3 degree or less antenna beam width
5. 6KW 4’ Open with 1.8 degree or less antenna beam width
6. 10KW 5’ Open with 1.6 degree or less antenna beam width
7. 12KW 5’ Open with 1.6 degree or less antenna beam width
8. 25KW 6’ Open with 1 degree or less antenna beam width

**Scanner Environmental and Emission Considerations**

1. Ambient Temperature: -25°C to 55°C
2. Wind Velocity (relative): 100 knots (we could accept 70 knots for Open Scanners)
3. Waterproofness: IPX6 (IEC60529) ith condensation drain or JIS-7
4. Emissions: Passes FCC and CE approvals. CE emissions needs to meet:
   b. EN60945:1997
   c. IEC 60936-1 Annex D
   d. ITU-R M1177 (S3 of radio Regulations & SM.1539 & SM.1541 emissions)
   e. Compass safe Distance – BR100 & ISO R/694
Typical Scanner Specification

2KW 18" DOME

1) Outside dimensions:       approx. height 227mm x diameter 450mm (1.5ft)
2) Mass:                     approx. 5kg
3) Plane of polarization:    Horizontal polarization
4) Beam width:               Horizontal beam width 5.2 degrees
                              Vertical beam width 30 degrees
                              Side lobe level -21dB max.

5) Antenna rotation:         Approx. 32 rpm
6) Transmission output:      2kW
7) Transmission frequency:   9445±30MHz
8) Transmission tube:        Magnetron
9) Transmission pulse length/PRF
   0.125nm  0.08µs/2250Hz
   0.25nm  0.08µs/2250Hz
   0.5nm   0.08µs/2250Hz
   0.75nm  0.08µs/2250Hz
   1.5nm   0.3µs/1200Hz
   3nm    0.8 µs/600Hz
   6nm    0.8 µs/600Hz
   12nm   0.8 µs/600Hz
   24nm   0.8 µs/600Hz

10) Duplexer:                T-junction with diode Limiter
11) Mixer:                   MIC front end
12) Intermediate frequency amplifier:Intermediate frequency 60MHz
    Band width   10MHz (0.08 µs)
                 3MHz (0.3 µs, 0.8 µs)
13) Overall noise figure: 7dB (average)
14) Timed TX mode: TX time 10, 20, 30, all rotation
ST-BY time 3, 5, 10, 15 minutes

** An Integrated X-Band package consists of Magnetron, Magic-T junction, RF Limiter, and tracking Local Oscillator/Mixer with 60Mhz video outputs to a Log or Linear IF Receiver.
** Photo of a typical Marine Radar RF microwave structure inside a scanner.

**Conventional Radar Magnetron Sources**

1. Tooling or proven designs for sources must be available.
2. Magnetrons must be made of such materials to be approved by Countries worldwide.
3. X- Band Magnetron must have negative temperature tracking on frequency drift, such that the local oscillator design “naturally” tracks. This minimizes the problems associated with Auto Tuning.
4. Typical Magnetron Specifications we need are shown on the next page.
Typical Magnetron Specification of a 4KW Unit

**X-Band Magnetron**

MSF1421B is designed for the magnetron of x-band radar system. The frequency range is fixed <9380-9440MHz> and the peak output power is 4kW.

--- MAXIMUM RATINGS ---

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak anode current</td>
<td>2.0</td>
<td>4.0</td>
<td>A</td>
</tr>
<tr>
<td>Peak anode power input</td>
<td>-</td>
<td>30</td>
<td>kW</td>
</tr>
<tr>
<td>Duty cycle</td>
<td>-</td>
<td>0.001</td>
<td>-</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>0.05</td>
<td>1.0</td>
<td>μs</td>
</tr>
<tr>
<td>Rate of rise of voltage pulse</td>
<td>-</td>
<td>70</td>
<td>kV/μs</td>
</tr>
<tr>
<td>Anode temperature</td>
<td>-</td>
<td>100</td>
<td>°C</td>
</tr>
<tr>
<td>V.S.W.R at the output coupler</td>
<td>-</td>
<td>1.5:1</td>
<td>-</td>
</tr>
</tbody>
</table>

--- ELECTRICAL ---

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Typical</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heater voltage (Note 1)</td>
<td>5.7</td>
<td>6.3</td>
<td>6.9</td>
<td>V</td>
</tr>
<tr>
<td>Preheat time</td>
<td>60</td>
<td>-</td>
<td>-</td>
<td>S</td>
</tr>
<tr>
<td>Peak anode voltage (Note 2)</td>
<td>3.4</td>
<td>3.6</td>
<td>3.8</td>
<td>kV</td>
</tr>
<tr>
<td>Peak output power (Note 2)</td>
<td>3.6</td>
<td>4.0</td>
<td>-</td>
<td>kW</td>
</tr>
<tr>
<td>Frequency (Note 2)</td>
<td>9380</td>
<td>9410</td>
<td>9440</td>
<td>MHz</td>
</tr>
</tbody>
</table>

Note 1: Measured with heater voltage of 6.3V and no anode input power, the heater current limits are 0.5A minimum, 0.6A maximum. No reduction of heater voltage is required.

Note 2: Measured at peak anode current 3.0A
Solid-State Radar Sources

1. Our X-Band .5 - 1W source requires a continuous operation design with a center frequency that can be phase locked at 9400Mhz and frequency modulated (chirped) around +/-100Mhz with commercially available parts.
2. These sources will go inside of a scanner, so the marine environmental specs are same as a magnetron.
3. Phase Noise specifications are not available at this point in time.
4. See additional attached .pdf file shows a X-Band 1W solid-state MESFET amplifier working at ~60% high efficiency. Russian components like this will be of great interest.
5. Attached is a file for a 10W X-Band component used in SPACE RADAR applications. Maybe Russian Companies wish to go commercial for a “very scaled-down” version type of GaAs HBT part.