To: MBR Users / National Frequency Authorities

Date: 2016-06-03

Subject: **MBR Technical Description**

Maritime Broadband Radio

1. Background

Kongsberg Seatex AS, a major manufacturer of marine electronics in Norway, has developed a new radio for maritime use named Maritime Broadband Radio (MBR). This radio is primarily used in maritime coordinated operations and similar scenarios. The radio operates in the 5 GHz band and offers high speed reliable data transfer between vessels and structures at sea, mainly in connection with offshore operations where high speed data and video communication can be used for increased safety and efficiency.

Typical MBR applications can be:

- Coordinated offshore operations
- Offshore exploration, drilling operations
- Offshore exploration, seismic operations
- Seabed mapping, hydrographic operations
- Coast-guard activities (inspections, anti-pollution, distress etc)
- Generic IP-data transfer between vessels

Kongsberg Seatex has been operating the MBR system on an experimental license in the Gulf of Mexico since June 2011. The call sign for the license has been WF2XTF up to May 2013, and WG2XTC since May 2013. In addition to this, the MBR system has been extensively tested and operated in Norway from 2011 and up to the present date. The MBR has a Norwegian national license on four frequencies which are valid until 2021. So far no instances of interference to or from the MBR system have been reported.

2. MBR Specifications

The MBR system is based on radio transceivers operating in the 5 GHz band, and so far the following center frequencies have been used:

- 5180 MHz
- 5230 MHz
- 5862 MHz
- 5890 MHz

The channel bandwidth is 20 MHz (±10 MHz with respect to the center frequency).

In order to get a standard frequency allocation for MBR, CEPT is now considering to make 5862 and 5890 MHz standard frequencies for MBR.

A main feature of the MBR system is an integrated antenna array with steerable antenna lobes. The antenna system consists of up to 60 antenna elements, each one with its own power amplifier which can be controlled in amplitude and phase. The antenna radiation diagram can therefore be tailored to the optimum diagram in real-time. Normally, all antenna elements will be driven in phase and amplitude, thereby obtaining a high antenna gain and a very narrow antenna lobe. The antennas can hence direct the main antenna lobe in the optimal direction for communication. The communication system may consist of multiple nodes and the adaptive antenna arrays use beamforming to establish multi-point network functionality. The antennas have steerable fan shaped lobes that can be steered 360° around the horizon.

The system is digital and may be used for voice, video and generic IP-traffic. Data rates will typically be in the order of 1 to 15 Mbps. The communication content will typically be different kinds of operational data, navigational data, administrative data, update of chart data, and live video from cameras, etc.

The system operates in duplex mode on a single frequency.

The modulation type GMSK gives high tolerance to clipping/saturation, and gives optimum spectral efficiency and power amplifier efficiency because of the large number of radios in the phased array antenna system. The MBR system uses a phase coherent modulated code-word as a start for each data frame. The code-word that indicates the start of each data frame is used for exact time and phase synchronization.

The MBR units in a network negotiate a common time reference and have no need for a base station to operate. The MBR system is hence able to combine both highly efficient disciplined TDMA transmissions with guaranteed latency and contention based ad-hoc networking.

Whitening of the modulation data and forward error correction are applied as a part of the physical layer.

The MBR wireless communication system is based on electronically steerable antenna beams implemented by phased array digital signal processing beamforming. The antenna system consists of up to 60 antenna elements that provides a high gain on both the transmitter and receiver system.

When communication is established, the transmitting antenna and the reception antenna are both aligned towards each other by software controlled antenna lobes. The transmission therefore takes place within a relatively small closed volume. The major part of the e.i.r.p. will be in the direct line between the transmitting and receiving antenna. The use of beamforming permits the production of shaped and dynamically steerable beams in several directions, thereby enabling the desired system performance objectives to be maintained as the vessels move relative to each other and, at the same time, minimizing interference for other co-frequency systems. The tailored radiation patterns can be optimized to reduce interference and to allow operation at lower transmit powers than would otherwise be necessary if more conventional fixed antennas were deployed.

The available transmission output power in the narrow antenna lobe (e.i.r.p.) of the MBR system is designed to be high in order to achieve a long communication range with sufficient link margin. The high peak power is achieved by coherent beamforming of a large number of antenna elements where each individual element has a low radiated power. In the far-field the phasing of the antennas form a narrow beam that focuses the energy and leads to a high e.i.r.p. in the direction of interest. Using a large number of antenna elements will provide low field intensity in the near-field area and an equivalent high power emission in the far-field.

The MBR system optimizes the link budget under different conditions and uses adaptive power control to regulate the output power to the minimum necessary for the communications. The link margin is measured and exchanged in real-time and the sender will then know how much output power is needed for maintaining link with an acceptable margin.

The MBR unit is one enclosed part containing the TX/RX antennas, the RF units, the CPU and a Ethernet interface and is mounted outside above deck at a suitable location for the operational radiation area.

The user equipment, normally some sort of PC or network equipment placed inside in a vessel, is connected to the MBR with a standard Ethernet connection.

A schematic block diagram of a MBR unit is indicated in **Figure 1**.

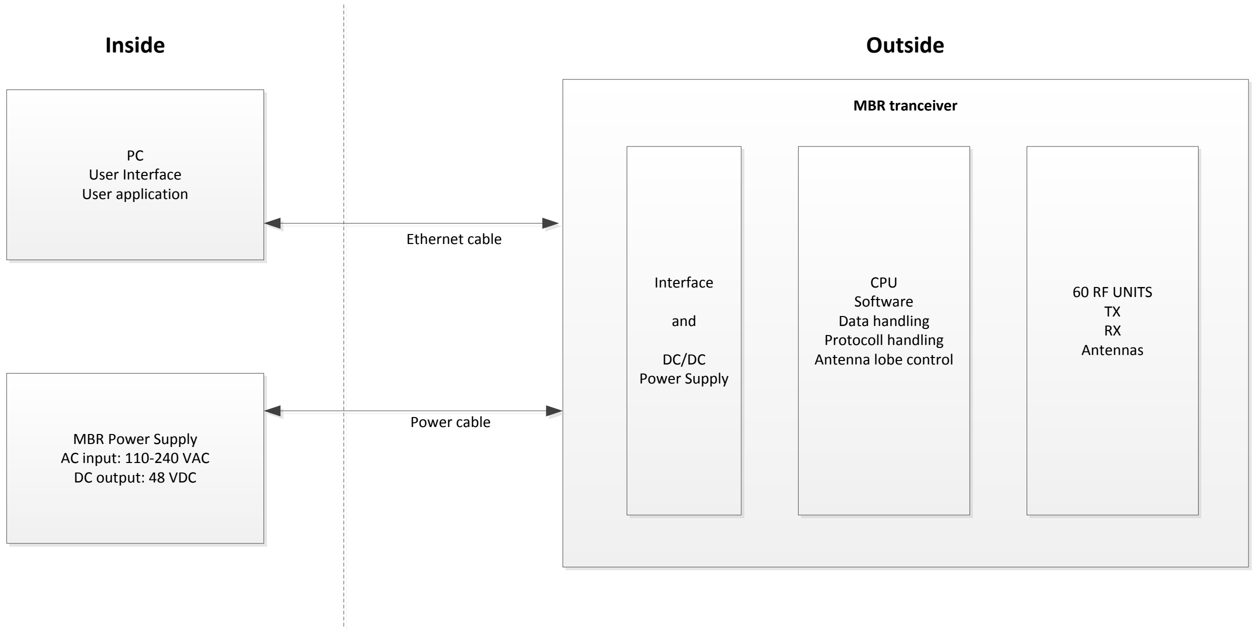

Figure 1: Schematic block diagram of the MBR unit

The MBR unit consists of 60 individual transmitters and 60 individual receivers that are controlled by multiple CPUs. Each transmitter/receiver is connected to an individual antenna.

Figure 2: MBR main board / MBR front side with antennas / MBR unit assembled

The MBR antenna has high gain and directivity by electronically combining each individual antenna and the total antenna gain is 24 dBi for MBR 189, and 21 dBi for MBR 179.

The antenna has steerable fan shaped beams that can be steered spatially within operational freedom of the antenna. For the MBR 179 the beam can be steered 360° around the horizon, and for MBR 189 the beam can be steered ± 50° horizontally and ± 50° vertically. The - 3 dB width of the beam is less than 10° and the - 10 dB width is less than 16°.

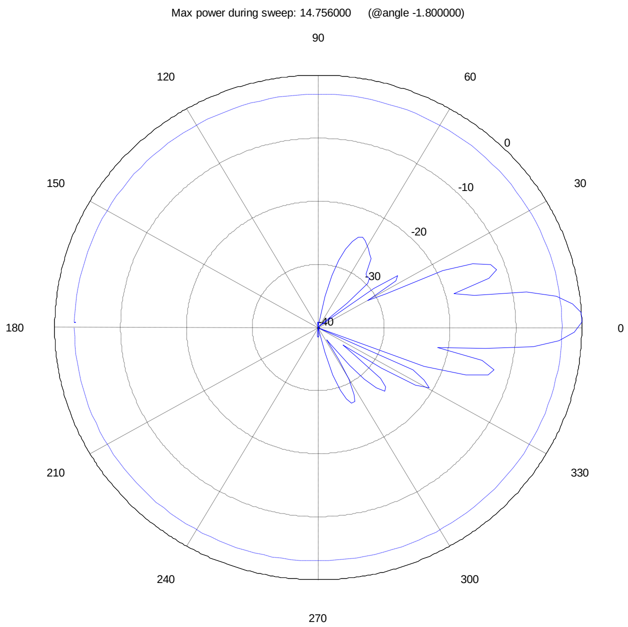

Figure 3: Nominal radiation pattern in the vertical and horizontal plane (cone shaped) of the steerable antenna beam in a given direction

The MBR has a functionality for power reduction, Adaptive Power Control (APC), and will reduce the output power to an acceptable signal margin at the receiver. Each transmitted package contains information on the transmitted power level. The receiver measures the received signal strength, calculates the quality of the link and indicates suitable power reduction. The output power may be reduced up to 25 dB.

The bandwidth of a MBR channel is 20 MHz. The transmitter emitted power density outside the band fc ± 50 MHz is < -31 dBm/MHz.

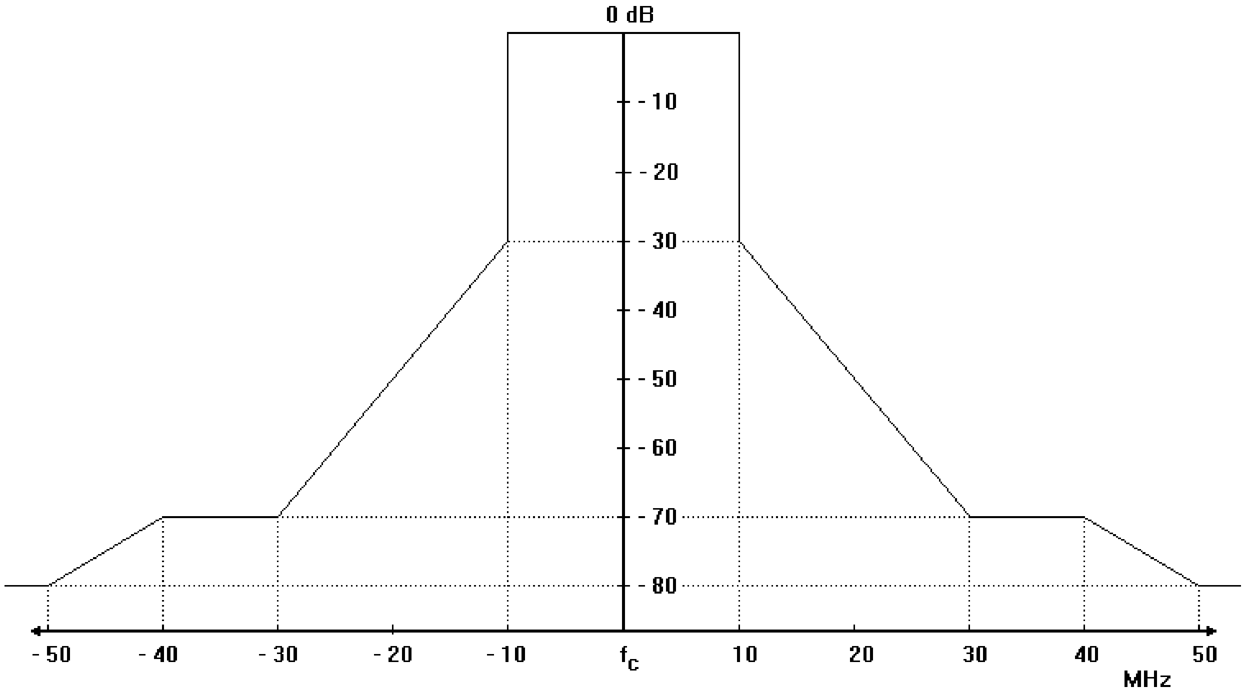

Figure 4: Transmitter output power spectrum mask

The MBR link operates satisfactorily when the received BER is less than 10^{-5}.

The maximum usable receiver sensitivity of the MBR at the demodulator is -83 dBm. With an antenna gain of 24 dBi in the main lobe, the sensitivity at the antenna input is -107 dBm, corresponding to a field strength of 9 dBµV/m.

For nominal data bit rates, the co-channel rejection ratio between a wanted and an unwanted signal, is 6 dB. The adjacent co-channel rejection ratio for an interfering MBR signal is 13 dB. The adjacent channel selectivity of the receiver, where the adjacent channel is the other MBR channel, is 45 dB.

3. RF Signal Characteristics

The MBR can operate on the frequencies 5862 MHz and 5890 MHz with e.i.r.p. less than 30 dBW. The channel bandwidth is 20 MHz.

Table 1: MBR parameters

Parameter	MBR 189	MBR 179
Carrier frequency	5862 MHz and 5890 MHz	5862 MHz and 5890 MHz
Channel bandwidth	20 MHz	20 MHz
Maximum output power from all transmitters	36 dBm	36 dBm
Antenna gain	6 dBi	3 dBi
Gain from beamforming	18 dB	18 dB
Maximum e.i.r.p	30 dBW	27 dBW
Maximum transmitter power density	- 65,0 dBW/Hz	- 65,0 dBW/Hz
Maximum radiated power density (e.i.r.p.)	- 41,0 dBW/Hz	- 41,0 dBW/Hz
Maximum radiated power density (e.i.r.p.)	49,0 dBm/MHz	49,0 dBm/MHz
Receiver sensitivity at modulator	- 83 dBm	- 83 dBm
Receiver sensitivity at antenna input	-107 dBm (9 dBµV/m)	-107 dBm (9 dBµV/m)

Note: Due to the digital modulation, the power density is quite constant over the occupied bandwidth and the maximum radiated power density from the MBR transmitter within the working channel is -41 dBW/Hz = 49 dBm/MHz.

4. Installation

On vessels, the MBR is generally installed at heights below 30 meters, and generally under 60 meters on platforms.

Figure 6: Example of MBR installations on board a vessel

5. ETSI / CEPT Standardisation Process

ETSI has undertaken to develop an international product standard for the Maritime Broadband Radio. This work is currently ongoing in TC ERM TG26.

It is proposed to standardize two frequency channels in the upper 5 GHz band for this purpose. The center frequencies are 5862 and 5890 GHz and the bandwidth of each channel is 20 MHz.

The frequency issue is discussed in CEPT WGFM/ WGSE/ SE 19 which is also discussing interference and sharing issues for MBR.

Two documents have so far been prepared and are work items in the relevant working groups. The product standard is estimated to be finished in 2016.

6. Current Licenses

Kongsberg Seatex AS has obtained licenses for use of MBR in the following areas:

1. Norwegian license for Norwegian vessels, valid until 2021.
2. Norwegian experimental license for MBR between land stations, vessels and airplanes.
3. FCC license for operating from Pelican Island, Texas in the Gulf of Mexico.
4. Canadian experimental license for testing from one land station to a vessel.
5. Licence in the Panama canal
6. Experimental license in the Netherlands
7. Temporary use license in UK (central London and near Southampton)

Applications for test and demo licenses in more countries will be prepared in the near future.

7. Conformity Declaration

KONGSBERG

DECLARATION OF CONFORMITY

(according to ISO/IEC 17050-1)

Manufacturer's name: **Kongsberg Seatex AS**

Manufacturer's address: **Pirsenteret, N-7462 Trondheim, Norway**

declares that the product:

Product name: **Marine Broadband Radio, MBR**

Model numbers: **MBR 179 and MBR 189**

Product options **MBR Power Supply**

is in conformity with the **R&TTE directive 1995/5/EC** which also implies conformity with applicable EMC and safety regulations. Relevant sections of the following product standard have been used for product testing:

Radio: **ETSI EN 301 893 V1.7.1**

Test reference
Test Report Radio: 264318-03, issued by Nemko AS

Notified Body report reference
Report: NBO 0470-RTTE-151201, issued by Nemko AS

Supplementary information
R&TTE conformity implies compliance with EMC and safety regulations and the following standards have been used for assessment:

EMC: **EN 60945 (2002);**

Electrical safety: **EN/IEC 61010-1 (2010)**

Report references:
EMC: Report E14212.00, issued by Nemko
Safety: Report KSX-2014-5-MBR, issued by Kongsberg Seatex AS

The product was tested in its normal configuration.

Date and signature
2015-04-07

Arne Rinnan

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