Prepared (also subject responsible if other)		No.		
ERA/RBI/R Per Helmersson		B5KBKRC1311005-2		
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KI/ERA/RBI/R (P Helmersson)		2003-09-16	B	

Exhibit 12 – Cover Sheet

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1 2.1033(c) Circuit Description

1.1 (2) FCC Identifier: B5KBKRC1311005-2

This dTRU (double Tranceiver Radio Unit) consist of two synthesized transmitters (TRX) operating in the frequency band of 869.4 to 893.6 MHz. There are 122 Channels available with a channel spacing of 200 KHz. The transmitter is capable of operation in a TDMA (Time Division Multiple Access) system. For each channel there are 8 time slots available, each containing digital speech or data for GMSK and data for 8-PSK.
The dTRU have a hybrid combiner included which can be used to increase the number of TRX:s per antenna. The combiner can alternatively be used to increase the output power (TCC = Transmitter Coherent Combining) by using the same transmit frequency channel in both TRX:s. This combiner is connected before the cavity band pass filter in the combining system.

1.2 (4) Type of Emission:

GMSK: 254KGXW

8-PSK: 252KG7W

1.3 (5) Frequency range: 869.4 to 893.6 MHz

1.4 (6) Range of Operating Power:

This transmitter is designed to supply a nominal power level of 46 dBm at the antenna connector. The power level can be set at 16 power levels, each with a 2 dB increment. The power levels are labeled P(0) to P(15) where P(0) is the highest power level.
In TCC mode with both TRX:s combined will the combination supply a nominal power level of 49 dBm at the antenna connector. The power level can be set at 16 power levels, each with a 2 dB increment. The power levels are labeled P(0) to P(15) where P(0) is the highest power level.

1.5 (7) Maximum Power Rating:

The maximum power rating with one TRX under environmental and supply voltage variations is equal to 46 dBm plus a power level tolerance of + 1.5 dB. Therefore the maximum output power is 47,5 dBm equal to 56 W at the antenna connector of the radio base station.
The maximum power rating with two TRX.s combined (TCC) under environmental and supply voltage variations is equal to 49 dBm plus a power level tolerance of + 1.5 dB. Therefore the maximum output power with TCC is 50,5 dBm equal to 112 W at the antenna connector of the radio base station.

1.6 (8) Final Amplifier Voltage and Current in normal operation

	P (0)	P (15)
Collector Voltage	26.0 Volt DC	26.0 Volt DC
Collector Current	6.5 Amps DC	0.8 Amps DC

1.7 (10) Frequency Stabilizing Circuit Description

The transmitter in each TRX contains three synthesized oscillators. One PLL gives a 90 MHz signal to the I/Q modulator. The two other generate a 779 to 804 MHz signal to the mixer where the modulated signal is converted to the transmit frequency. Two oscillators are needed in frequency hopping mode, one is retuning while the other is active. All three synthesized oscillators have a reference of 13 MHz, which is mixed down by 2, generated in a central synthesized oscillator (PLL) of 26 MHz in the LTU part of the dTRU. This PLL frequency reference is extracted from the 13 MHz signal on the Y-link, which is generated and distributed, by the DXU (Distribution Switch Unit), to all dTRU:s in the base station.

The frequency reference 13 MHz in the DXU is generated in a voltage controlled oscillator placed in an oven together with and phase-locked to a long-term stable oven heated oscillator. As an option can the oscillator be phase-locked to the incoming PCM-link frequency or an incoming GPS-link frequency.

1.8 (10) Spurious and Harmonic Suppression

Spurious and harmonic suppression is achieved by using two separate band pass filters of ceramic type in the exciter. A filter module at the output works like a band pass filter around the carrier. In addition to these filters, the output signal passes a cavity band pass filter in the combining system.

1.9 (10) Limiting Power

The TRU measures the output power at its output connector via a RF-detector and the detected value is used by the power loop control block to control two variable gain amplifiers between the modulator and the power amplifier.

In TCC (Transmitter Coherent Combining) mode is the output power also measured with a RF detector in the non-output branch of the hybrid combiner in the dTRU. This output power is kept as low as possible, by keeping the TRX:s output power in phase with each other, to get maximum output power at the output branch of the hybrid combiner

1.10 (10) Digital Modulation

1.10.1 Modulation format for GMSK

1.10.1.1 Modulating symbol rate

The modulating symbol rate is 1/T = 1 625/6 ksymb/s (i.e. approximately 270.833 ksymb/s), which corresponds to 1 625/6 kbit/s (i.e. 270.833 kbit/s). T is the symbol period.

1.10.1.2 Start and stop of the burst

Before the first bit of the bursts as defined in GSM 05.02 [3] enters the modulator, the modulator has an internal state as if a modulating bit stream consisting of consecutive ones ($d_i = 1$) had entered the differential encoder. Also after the last bit of the time slot, the modulator has an internal state as if a modulating bit stream consisting of consecutive ones ($d_i = 1$) had continued to enter the differential encoder. These bits are called dummy bits and define the start and the stop of the active and the useful part of the burst as illustrated in figure 1. Nothing is specified about the actual phase of the modulator output signal outside the useful part of the burst.

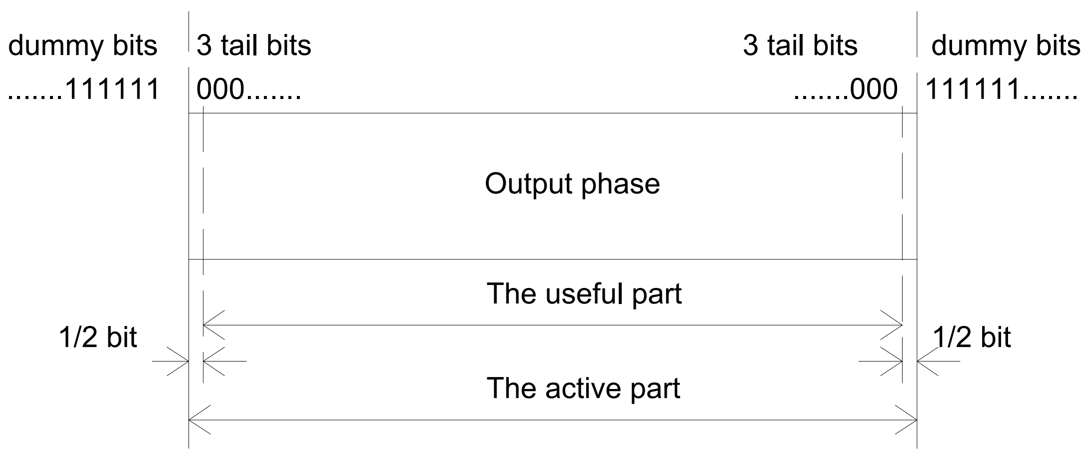

Figure 1: Relation between active part of burst, tail bits and dummy bits. For the normal burst the useful part lasts for 147 modulating bits

1.10.1.3 Differential encoding

Each data value d_i = *[0,1]* is differentially encoded. The output of the differential encoder is:

$$\hat{d}_i = d_i \oplus d_{i-1} \qquad (d_i \in \{0,1\})$$

where ⊕ denotes modulo 2 addition.
The modulating data value α_i input to the modulator is:

$$\alpha_i = 1 - 2\hat{d}_i \qquad (\alpha_i \in \{-1,+1\})$$

1.10.1.4 Filtering

The modulating data values α_i as represented by Dirac pulses excite a linear filter with impulse response defined by:

$$g(t) = h(t) * rect\left(\frac{t}{T}\right)$$

where the function *rect(x)* is defined by:

$$rect\left(\frac{t}{T}\right) = \frac{1}{T} \qquad for\ |t| < \frac{T}{2}$$

$$rect\left(\frac{t}{T}\right) = 0 \qquad otherwise$$

and * means convolution. *h(t)* is defined by:

$$h(t) = \frac{\exp\left(\frac{-t^2}{2\delta^2 T^2}\right)}{\sqrt{(2\pi)}\ .\ \delta T}$$

where $$\delta = \frac{\sqrt{\ln(2)}}{2\pi BT} \qquad and\ BT = 0.3$$

where B is the 3 dB bandwidth of the filter with impulse response *h(t)*. This theoretical filter is associated with tolerances defined in GSM 05.05 [4].

1.10.1.5 Output phase

1.10.1.6 The phase of the modulated signal is:

$$\varphi(t') = \sum_i \alpha_i \pi h \int_{-\infty}^{t'-iT} g(u)du$$

where the modulating index h is 1/2 (maximum phase change in radians is $\pi/2$ per data interval).
The time reference $t' = 0$ is the start of the active part of the burst as shown in figure 1. This is also the start of the bit period of bit number 0 (the first tail bit) as defined in GSM 05.02 [2].

1.10.1.7 Modulation

The modulated RF carrier, except for start and stop of the TDMA burst may therefore be expressed as:

$$x(t') = \sqrt{\frac{2E_c}{T}} \cdot \cos(2\pi f_0 t' + \varphi(t') + \varphi_0)$$

where E_c is the energy per modulating bit, f_0 is the centre frequency and φ_0 is a random phase and is constant during one burst.

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1.10.2 Modulation format for 8PSK

1.10.2.1 Modulating symbol rate

The modulating symbol rate is 1/T = 1 625/6 ksymb/s (i.e. approximately 270.833 ksymb/s), which corresponds to 3*1 625/6 kbit/s (i.e. 812.5 kbit/s). T is the symbol period.

1.10.2.2 Symbol mapping

The modulating bits are Gray mapped in groups of three to 8PSK symbols by the rule

$$s_i = e^{j2\pi l/8}$$

where *l* is given by table 1.

Table 1: Mapping between modulating bits and the 8PSK symbol parameter *l*.

Modulating bits d_{3i}, d_{3i+1}, d_{3i+2}	Symbol parameter *l*
(1,1,1)	0
(0,1,1)	1
(0,1,0)	2
(0,0,0)	3
(0,0,1)	4
(1,0,1)	5
(1,0,0)	6
(1,1,0)	7

This is illustrated in figure 2.

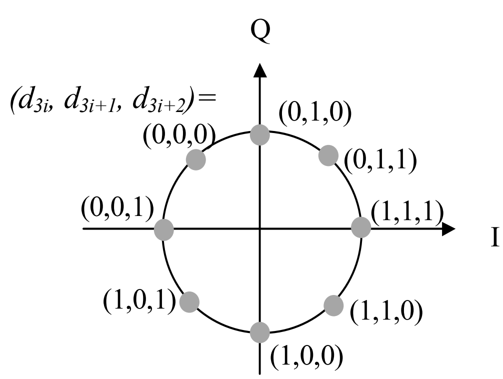

Figure 2: Symbol mapping of modulating bits into 8PSK symbols.

1.10.2.3 Start and stop of the burst

Before the first bit of the bursts as defined in GSM 05.02 [3] enters the modulator, the state of the modulator is undefined. Also after the last bit of the burst, the state of the modulator is undefined. The tail bits (see GSM 05.02) define the start and the stop of the active and the useful part of the burst as illustrated in figure 3. Nothing is specified about the actual phase of the modulator output signal outside the useful part of the burst.

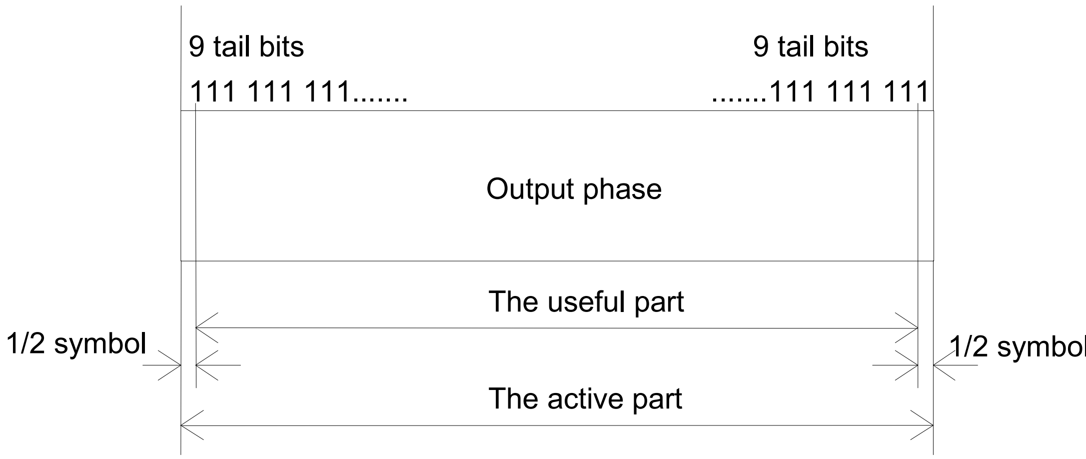

Figure 3: Relation between active part of burst and tail bits. For the normal burst the useful part lasts for 147 modulating symbols

1.10.2.4 Symbol rotation

The 8PSK symbols are continuously rotated with 3π/8 radians per symbol before pulse shaping. The rotated symbols are defined as

$$\hat{s}_i = s_i \cdot e^{ji3\pi/8}$$

1.10.2.5 Pulse shaping

The modulating 8PSK symbols $\hat{s}_i$ as represented by Dirac pulses excite a linear pulse shaping filter. This filter is a linearised GMSK pulse, i.e. the main component in a Laurant decomposition of the GMSK modulation. The impulse response is defined by:

$$c_0(t) = \begin{cases} \prod_{i=0}^{3} S(t+iT), & for\ 0 \le t \le 5T \\ 0, & else \end{cases}$$

where

$$S(t) = \begin{cases} \sin(\pi \int_0^t g(t')dt'), \; for \; 0 \le t \le 4T \\ \sin(\frac{\pi}{2} - \pi \int_0^{t-4T} g(t')dt'), \; for \; 4T < t \le 8T \\ 0, \; else \end{cases}$$

$$g(t) = \frac{1}{2T}\left(Q(2\pi \cdot 0.3 \frac{t-5T/2}{T\sqrt{\log_e(2)}}) - Q(2\pi \cdot 0.3 \frac{t-3T/2}{T\sqrt{\log_e(2)}}) \right)$$

and

$$Q(t) = \frac{1}{\sqrt{2\pi}} \int_t^{\infty} e^{-\frac{\tau^2}{2}} d\tau \,.$$

The base band signal is

$$y(t') = \sum_i \hat{s}_i \cdot c_0(t' - iT + 2T)$$

The time reference *t' = 0* is the start of the active part of the burst as shown in figure 3. This is also the start of the symbol period of symbol number 0 (containing the first tail bit) as defined in GSM 05.02 [2].

1.10.2.6 Modulation

The modulated RF carrier during the useful part of the burst is therefore:

$$x(t') = \sqrt{\frac{2E_s}{T}} \operatorname{Re}\left[y(t') \cdot e^{j(2\pi f_0 t' + \varphi_0)} \right]$$

where E_S is the energy per modulating symbol, f_0 is the centre frequency and φ_0 is a random phase and is constant during one burst.