

Prepared (also subject responsible if other) ERA/RKF/VR Larry Lindström	No. B5KAKRC1311004-2		
Approved KI/ERA/RKF/VR (L Lindström)	Checked	Date 2002-09-18	Rev A

## Exhibit 12 – Cover Sheet

### Contents

<b>1</b>	<b>2.1033(c) Circuit Description</b>	<b>2</b>
1.1	(2) FCC Identifier: B5KAKRC1311004-2	2
1.2	(4) Type of Emission:	2
1.3	(5) Frequency range: 1930.4 to 1989.6 MHz	2
1.4	(6) Range of Operating Power:	2
1.5	(7) Maximum Power Rating:	2
1.6	(8) Final Amplifier Voltage and Current in normal operation	3
1.7	(10) Frequency Stabilizing Circuit Description	3
1.8	(10) Spurious and Harmonic Suppression	3
1.9	(10) Limiting Power	3
1.10	(10) Digital Modulation	5
1.10.1	Modulation format for GMSK	5
1.10.2	Modulation format for 8PSK	8

Prepared (also subject responsible if other) ERA/RKF/VR Larry Lindström		No. B5KAKRC1311004-2		
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## 1           **2.1033(c) Circuit Description**

### 1.1       **(2) FCC Identifier:       B5KAKRC1311004-2**

This dTRU (double Tranceiver Radio Unit) consist of two synthesized transmitters (TRX) operating in the frequency band of 1930.4 to 1989.6 MHz. There are 297 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 alternativately 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:       258KGXW**

**8-PSK:       258KG7W**

### 1.3       **(5) Frequency range:   1930.4 to 1989.6 MHz**

### 1.4       **(6) Range of Operating Power:**

This transmitter is designed to supply a nominal power level of 44.5 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 47 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 44.5 dBm plus a power level tolerance of + 1.3 dB. Therefore the maximum output power is 45.8 dBm equal to 38 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 47 dBm plus a power level tolerance of + 1.3 dB. Therefore the maximum output power with TCC is 48.3 dBm equal to 67.6 W at the antenna connector of the radio base station.

Prepared (also subject responsible if other) ERA/RKF/VR Larry Lindström		No. B5KAKRC1311004-2		
Approved KI/ERA/RKF/VR (L Lindström)	Checked	Date 2002-09-18	Rev A	Reference

## 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	4.9 Amps DC	0.7 Amps DC

## 1.7 (10) Frequency Stabilizing Circuit Description

The transmitter in each TRX contains three synthesized oscillators. One PLL gives a 160 MHz signal to the I/Q modulator. The two other generate a 1770 to 1830 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 downmixed 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 basestation.

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 bandpass filters of ceramic type in the exciter. A filter module at the output works like a bandpass 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 steer two variable gain amplifiers between the modulator and the power amplifier.

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Approved <b>KI/ERA/RKF/VR (L Lindström)</b>	Checked	Date 2002-09-18	Rev A

In TCC (Transmitter Coherent Combining) mode is the output power also measured with a RF detector in the non-output branch of the hybride 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 hybride combiner

Prepared (also subject responsible if other) ERA/RKF/VR Larry Lindström		No. B5KAKRC1311004-2		
Approved KI/ERA/RKF/VR (L Lindström)	Checked	Date 2002-09-18	Rev A	Reference

## 1.10 (10) Digital Modulation

### 1.10.1 Modulation format for GMSK

#### 1.10.1.1 Modulating symbol rate

The modulating symbol rate is  $1/T = 1625/6$  ksymb/s (i.e. approximately 270.833 ksymb/s), which corresponds to 1625/6 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.

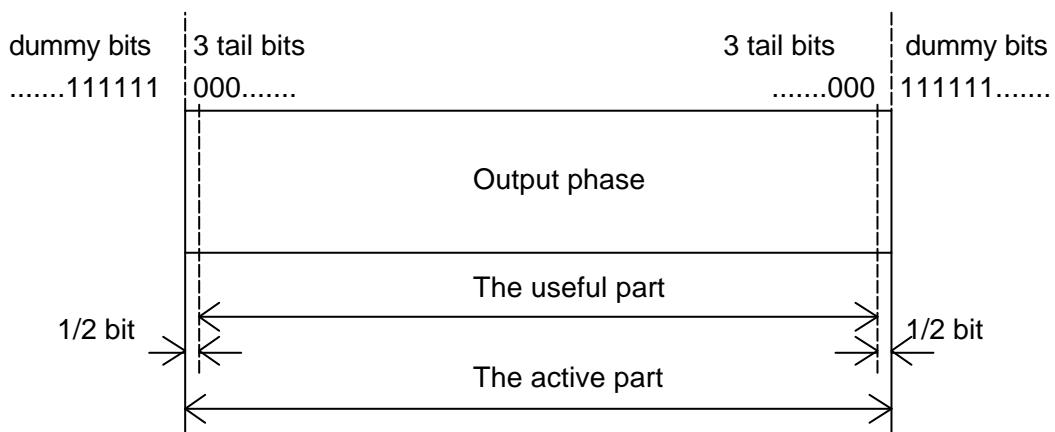


Figure 1: Relation between active part of burst, tail bits and dummy bits. For the normal burst the useful part lasts for 147 modulating bits

Prepared (also subject responsible if other) ERA/RKF/VR Larry Lindström	No. B5KAKRC1311004-2		
Approved KI/ERA/RKF/VR (L Lindström)	Checked	Date 2002-09-18	Rev A

### 1.10.1.3 Differential encoding

Each data value  $d_i = \{0, 1\}$  is differentially encoded. The output of the differential encoder is:

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

where  $\oplus$  denotes modulo 2 addition.

The modulating data value  $a_i$  input to the modulator is:

$$a_i = 1 - 2\bar{d}_i \quad (a_i \in \{-1, +1\})$$

### 1.10.1.4 Filtering

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

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

where the function  $\text{rect}(x)$  is defined by:

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

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

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

$$h(t) = \frac{\exp\left(\frac{-t^2}{2d^2T^2}\right)}{\sqrt{(2\pi)} \cdot dT}$$

where  $d = \frac{\sqrt{\ln(2)}}{2pBT}$  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].

Prepared (also subject responsible if other) ERA/RKF/VR Larry Lindström		No. B5KAKRC1311004-2		
Approved KI/ERA/RKF/VR (L Lindström)	Checked	Date 2002-09-18	Rev A	Reference

1.10.1.5 Output phase

1.10.1.6 The phase of the modulated signal is:

$$\mathbf{j}(t') = \sum_i a_i p h \int_{-\infty}^{t'-iT} g(u) du$$

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:

$$x(t') = \sqrt{\frac{2E_c}{T}} \cdot \cos(2\pi f_0 t' + \mathbf{j}(t') + \mathbf{j}_0)$$

where  $E_c$  is the energy per modulating bit,  $f_0$  is the centre frequency and  $\mathbf{j}_0$  is a random phase and is constant during one burst.

Prepared (also subject responsible if other) ERA/RKF/VR Larry Lindström		No. B5KAKRC1311004-2		
Approved KI/ERA/RKF/VR (L Lindström)	Checked	Date 2002-09-18	Rev A	Reference

## 1.10.2 Modulation format for 8PSK

### 1.10.2.1 Modulating symbol rate

The modulating symbol rate is  $1/T = 1625/6$  ksymb/s (i.e. approximately 270.833 ksymb/s), which corresponds to  $3*1625/6$  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

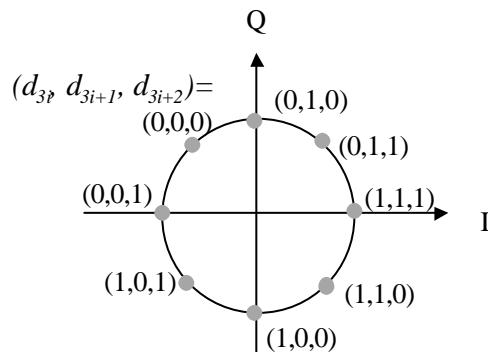
$$s_i = e^{j2\pi l/8}$$

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.

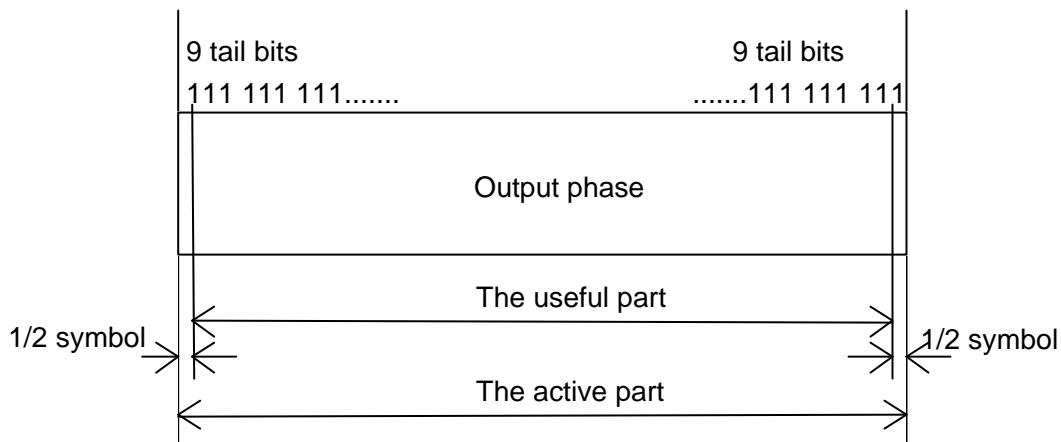


**Figure 2: Symbol mapping of modulating bits into 8PSK symbols.**

Prepared (also subject responsible if other) ERA/RKF/VR Larry Lindström	No. B5KAKRC1311004-2
Approved KI/ERA/RKF/VR (L Lindström)	Checked Date 2002-09-18 Rev A Reference

## 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  $3\pi/8$  radians per symbol before pulse shaping. The rotated symbols are defined as

$$\hat{s}_i = s_i \cdot e^{j i 3\pi/8}$$

## 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:

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

where

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

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

and

$$Q(t) = \frac{1}{\sqrt{2p}} \int_t^{\infty} e^{-\frac{t^2}{2}} dt.$$

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:

$$x(t') = \sqrt{\frac{2E_s}{T}} \operatorname{Re} [y(t') \cdot e^{j(2\pi f_0 t' + j_0)}]$$

where  $E_s$  is the energy per modulating symbol,  $f_0$  is the centre frequency and  $j_0$  is a random phase and is constant during one burst.