REPORT 1021

EQUIPMENT CHARACTERISTICS FOR DIGITAL TRANSMISSION IN THE LAND MOBILE SERVICES

(Study Programme 7A/8)

(1986)

1. Introduction

This Report describes major characteristics of land mobile digital modulation equipment: BER performance, adjacent signal selectivity, and acceptable bandwidth.

2. BER performance (sensitivity)

The measured BER performance of a bit rate of 8 kbit/s under no-fading conditions using different modulation methods is shown in Fig. 1. The reference sensitivity is defined as E_b/N_0 (signal energy per bit/noise power density) corresponding to BER of 1×10^{-2}. The reference sensitivities were less than 12 dB for these modulation methods. Similar results were obtained for other transmission bit rates, such as 2.4 kbit/s, 4.8 kbit/s and 16 kbit/s.

The E_b/N_0 = 12 dB corresponds to the receiver's input level of $(\sqrt{R}/2)$ μV (R: bit rate in kbit/s) when the receiver noise figure is equal to 13 dB.

3. Adjacent signal selectivity

Typical adjacent signal interference performance of bit rates of 8 kbit/s is shown in Fig. 2. The measurements were conducted by setting the level 3 dB above the sensitivity level given in § 2, and adjusting the unwanted signal level until the bit error ratio degraded to 1×10^{-2}. Similar results were obtained for transmission bit rates of 2.4-16 kbit/s.

At the normalized frequency difference (the ratio of frequency difference to transmission bit rate) of 1.5 kHz/kbit/s, the ratio of unwanted to wanted signal level (U/W) becomes greater than 45 dB.

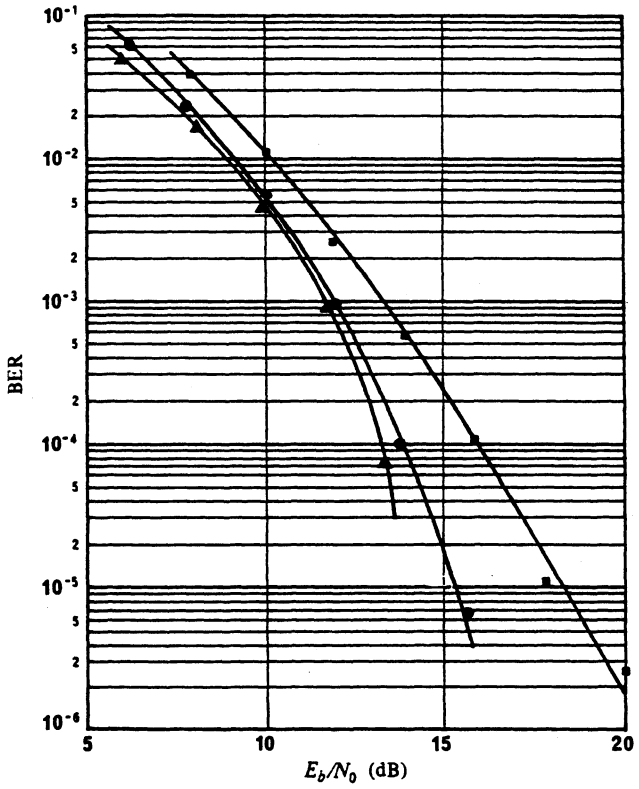

FIGURE 1 – *BER performance under no-fading condition (measured)*

Modulation:

■ : GMSK with coherent detection

● : 4-level FM with discriminator detection

▲ : PLL-4-PSK with discriminator detection

Transmission bit rate: 8 kbit/s

E_b/N_0 : signal energy per bit/noise power density

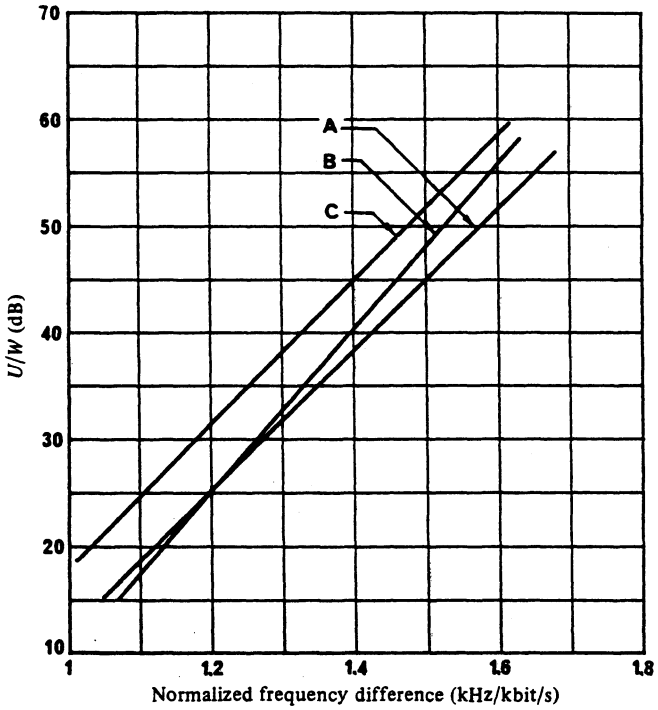

FIGURE 2 – *Adjacent signal interference performance (measured)*

U/W:	ratio of unwanted to wanted signal level
Wanted signal:	*W*-level corresponds to BER = 1×10^{-2}
Unwanted signal:	*U*-level corresponds to BER = 1×10^{-2} when wanted signal level is 3 dB in excess of *W*-level
Modulation:	wanted and unwanted signals are modulated by
	A: GMSK;
	B: 4-level FM;
	C: PLL-4-PSK.

4. Acceptable bandwidth

The acceptable bandwidth of a receiver can be defined as the frequency bandwidth within which a bit error ratio of less than 1×10^{-2} is obtained when the signal level is set at the level 6 dB above the sensitivity level given in § 2.

Typical measured values of the acceptable bandwidth for 2.4-16 kbit/s are shown in Fig. 3. All measured values were more than 0.4 kHz/kbit/s. Taking account of performance fluctuations due to production, the acceptable bandwidth should be specified as wider than $0.3R$ kHz (R: bit rate in kbit/s).

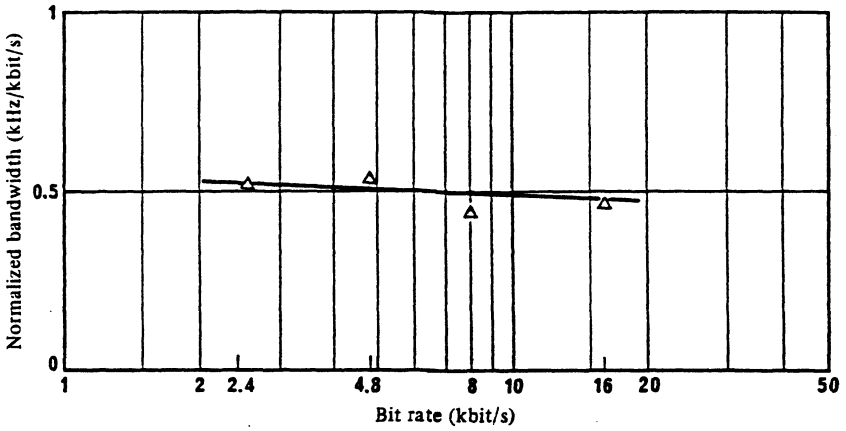

FIGURE 3 – *Acceptable bandwidth (typical measured value)*

4-level FM with discriminator detection

$BT = 1.0$

(B: bandwidth; $T = 2R$; R: bit rate in kbit/s)

5. Conclusion

As mentioned above, the following specification is desirable:

- the sensitivity should be such that for a 1×10^{-2} bit error ratio, the input signal level should not be greater than $(\sqrt{R}/2)$ μV (R: bit rate in kbit/s);
- the adjacent signal selectivity should be more than 45 dB at the normalized frequency difference of 1.5 kHz/kbit/s;
- the acceptable bandwidth should be wider than $0.3R$ kHz (R: bit rate in kbit/s).

In addition to these specifications, the following technical characteristics require study in accordance with Study Programme 7A/8:

- frequency tolerance;
- occupied bandwidth;
- adjacent-channel power;
- spurious response;
- spurious emissions;
- radio-frequency intermodulation;
- low-pass filtering modulation signal.