RECOMMENDATION ITU-R F.754*,**

RADIO-RELAY SYSTEMS IN BANDS 8 AND 9 FOR THE PROVISION OF TELEPHONE TRUNK CONNECTIONS IN RURAL AREAS

(1992)

The ITU Radiocommunication Assembly,

considering

a) that there is urgent need for the provision of telephone trunk connections in rural areas, especially in national networks in developing countries;

b) that in planning of such circuits special attention should be paid to the reduction of establishment costs;

c) that equipment for such circuits should, as far as possible, be simple and reliable for easy maintenance and operation;

d) that radio-relay systems in bands 8 and 9 are suitable for the provision of such circuits and that it is necessary to provide technical information on these systems for the system designers,

recommends

1. that the basic characteristics specified in Table 1 are preferred for analogue and digital radio-relay systems operating in bands 8 and 9;

2. that the interconnection and baseband characteristics specified in Table 2 are preferred;

3. that the radio-frequency channel separations in Table 3 give typical guidelines for the frequency-channel plans (Note 10);

4. that in general the transmission performance should be in accordance with the Recommendations of the ITU-T. For the time being, the considerations given in § 1 of Annex 1 are useful for the design of radio-relay systems operating in bands 8 and 9;

5. that for other factors, such as radio equipment characteristics, power supplies, antennas, towers and housings, the information contained in § 2 of Annex 1 should be used as a guide for administrations and system planners.

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* This Recommendation should be brought to the attention of the Plan Committee of ITU-T.

** Radiocommunication Study Group 9 made editorial amendments to this Recommendation in 2000 in accordance with Resolution ITU-R 44.

TABLE 1

Basic characteristics

	Analogue systems	Digital systems
Radio-frequency bands	400 MHz band 800 MHz band 1 500 MHz band 2 000 MHz band 2 400 MHz band 2 600 MHz band (Note 1)	
Channel capacities	12 channels 24 channels 60 channels (Notes 2, 3)	up to 120 channels including: 24 channels (1 544 kbit/s) 30 channels (2 048 kbit/s) 2 × 24 channels (3 088 kbit/s) 2 × 30 channels (4 096 kbit/s) (Note 3)
Modulation	Frequency modulation with the following deviation: 12 channels: 35 kHz (r.m.s. per channel) 24 channels: 35 kHz (r.m.s. per channel) 60 channels: 35, 50, 100, 200 kHz (r.m.s. per channel) (Notes 4, 5)	4-level-keying (Note 6)

Note 1 – The use of other frequency bands is not excluded.

Note 2 – Radio equipment of lower channel capacity, for example 5 or 6 channels, is also available. It may, at a lower overall cost, include special integral non-ITU-T standard multiplexing equipment to derive the telephone channels.

Note 3 – The use of 60 channel or more equipment in the 400 MHz frequency band should only be considered in those areas where frequency congestion problems are unlikely to exist.

Note 4 – A higher frequency deviation may be used to improve the signal-to-thermal noise ratio under non-fading conditions. On the other hand, a lower frequency deviation will improve the fade margin at the expense of signal-to-thermal noise ratio.

Note 5 – Where closer channel spacing is required, to conserve frequency spectrum, the lower frequency deviations should be used. However, phase modulation may be used for systems of low capacity. A modulation index in the range 0.2 to 0.8 is suggested.

Note 6 – For 24/30-channel systems, 2-level keying may also be used.

TABLE 2

	Analogue systems	Digital systems
Baseband characteristics	Baseband frequency range (kHz): 12 channels: 12-60 6-54 24 channels: 12-108 6-102 60 channels: 12-252 60-300 (Notes 7, 9)	Interconnection up to the primary rates defined by ITU-T Recommendation G.703 (1 544/2 048 kbit/s) (Notes 8, 9)

Note 7 – Nominal impedances of 150 Ω (or 600 Ω balanced below 24 channels) or 75 Ω (unbalanced) are preferred. For the baseband input and output level, –45 dBr and –15 dBr respectively are suggested.

Note 8 – For national systems the regeneration and line terminating units of corresponding cable systems may be utilized to facilitate the interconnection of radio-relay equipment and multiplex equipment or radio-relay equipment and equipment of extension cable systems.

Note 9 – A speech service channel is desirable and may be used for supervision where necessary. The operation of the service channel should preferably be independent of the signal from the multiplex equipment.

TABLE 3

	Analogue systems	Digital systems
Radio-frequency separation between transmitter and receiver	10 to 120 MHz	20 to 120 MHz (Note 11)
Adjacent co-polar channel separation	12 channels: 0.5 or 1 MHz 24 channels: 1 or 2 MHz 60 channels: 2 or 4 MHz	24/30 channels (2 level): 2; 3.5 or 4 MHz 24 channels (4 level): 1.5 or 3.5 MHz 30 channels (4 level): 1.75, 2 or 3.5 MHz 2 × 24 channels (4 level): 3 or 7 MHz 2 × 30 channels (4 level): 3.5, 4 or 7 MHz 4 × 30 channels (4 level): 7, 8 or 14 MHz

Note 10 – See Recommendation ITU-R F.283.

Note 11 – For two-level 24/30-channel systems, separation of 10 to 60 MHz may also be used.

ANNEX 1

Supplementary information on radio-relay systems for use in trunk connections in rural areas

1. Transmission performance

1.1 Analogue systems

For circuits of length up to about 250 km, ITU-T Recommendation G.123 (Geneva, 1972) "Circuit Noise in National Networks", § B.a.3, required that the mean (for all channels of a system) of the psophometric power at a zero relative level point should not exceed 1 000 pW0p one minute mean power for more than 20% of any month. In no case should this noise power exceed a maximum of 2 000 pW0p for any of the channels of the system.

Long-distance circuits (about 250 to 2 500 km) should meet the requirements of ITU-T Recommendation G.152.

From information submitted by several administrations, it is evident that 24-channel systems operating in the 400 MHz band may meet the ITU-T Recommendations for one or two hops only. However, for temporary use in developing countries, some relaxation (3 dB) in the noise requirements may be allowed if a significant reduction in the system cost is obtained.

The high noise values are mainly due to thermal noise and intermodulation noise caused by long delayed side reflections.

One method of satisfying the noise requirement mentioned in ITU-T Recommendation G.123 would be to use a compandor (ITU-T Recommendation G.162) for each telephone circuit, provided a significant reduction in system cost is obtained (due regard should be paid to ITU-T Recommendation G.143, § 2, which restricts the systematic use of compandors in long-distance national and international networks).

Since the improvement by using a compandor is effective for all the noise involved in signal transmission, external noise such as interference noise, man-made noise, etc., can be reduced, as well as thermal noise and intermodulation noise.

A high equipment selectivity can be advantageous, to allow for an effective frequency plan.

1.2 Digital systems

The transmission performance of a digital transmission system is expressed in terms of bit error ratio. The permissible values for bit error ratio have not yet been established by the ITU-T. The way in which the error ratio of a digital radio-relay system will be specified and the error-ratio objectives for long-distance systems, are given in Recommendation ITU-R F.634. From these objectives and the characteristics of a digital radio-relay system, it follows that the most significant is the higher error-ratio objective (defining system "outage") which may be exceeded for small percentages of the time.

The permissible error ratio which may be exceeded for small percentages of the time is determined on the basis of the required system availability. The values given in Recommendation ITU-R F.634 for long-distance circuits may also be used as a guide to the values of permissible bit error ratio and to the percentage of time for circuits of length up to 250 km.

Because of favourable fading conditions in bands 8 and 9, digital radio-relay systems may, in certain regions, be designed for higher hop attenuation than corresponding analogue systems in which the mean noise power is the dominant parameter to be considered. Furthermore, the effect of side reflections, which may produce relatively high intermodulation noise in analogue systems, is usually negligible in digital systems.

In the digital radio systems that regenerate the digital signal by the use of repeaters, the degradation of transmission quality caused by increased numbers of hops results in bit error accumulation, and not in noise power accumulation. The bit error ratio of any regenerative radio-relay system can be improved significantly by a slight increase of the carrier-to-noise ratio.

Digital radio-relay systems can economically provide for trunk circuits of 250 km or longer that meet the performance objectives specified in Recommendation ITU-R F.594.

2. Special conditions in developing countries

2.1 General

It is necessary to reduce to a minimum the cost of establishing the infrastructure required for systems used in rural areas. This infrastructure includes, in particular:

– the provision of adequate access roads;

– the provision of housing for the equipment, and if necessary, accommodation for maintenance personnel;

– the provision of accommodation for power supplies, together with fuel tanks, if necessary;

– the provision of antenna supports, etc.

In existing radio-relay systems, this infrastructure has often been found to account for a very high proportion of the expenditure.

It may be noted, that in certain cases (when crossing marshy land, deserts, mountainous regions or foreign territory) the use of trans-horizon radio-relay systems working in a relatively low frequency band may be advantageous, since this will avoid the provision of stations remote from important centres of population without necessitating a large installation. In these cases solid-state components might not be suitable for the transmitter power-amplifier.

While it is generally difficult to forecast the long-term requirements for trunk circuits in developing countries, the choice of system capacity is an economic optimum based on such forecasts. An initial installation of equipment will be uneconomic if its final capacity exceeds future requirements. On the other hand, replacement of an initially installed smaller system, when its capacity becomes inadequate, should only be necessary after several years' growth. A higher capacity system will then be justified, and the initial equipment can be recovered for use on another light-traffic link.

2.2 Equipment, antennas and power supplies

Solid-state equipment should be employed to reduce power requirements and maintenance. Reduction in the size of the equipment is possible with solid-state circuits. However, reduction in size should not be made at the expense of reliability and ease of maintenance.

The use of a simple synthesized local oscillator could be advantageous to reduce the number of spare parts required, provided that a suitable channel arrangement is utilized.

The antennas should be simple, sturdy and with a small surface exposed to wind. A Yagi antenna could be suitable at 1 500 MHz and below, while a dipole-array, helical antenna or corner reflector are suitable in the 400 MHz band and a parabolic antenna is suitable at 1 500 MHz and above. The antenna should be close to the equipment building to minimize the length of transmission line. Foam dielectric and solid dielectric cables have the advantage of not requiring pressurization.

The use of the same antenna for transmission and reception is generally more economical, but in such a case a larger frequency separation must be adopted to avoid blocking the receiver (e.g. 3% to 5% of the mean frequency).

Where intermodulation due to long-delayed unwanted side reflections is observed in systems operating in the lower bands, for example, in the 400 MHz band, some improvement can be expected by using antennas having narrower horizontal beamwidths. One method of reducing the beamwidth is to use two or more antennas coupled side by side.

In many cases, the equipment will operate far from any existing power sources. It should therefore have low consumption so that the necessary power supply installation, as well as its maintenance and replenishment, may be as simple as possible.

Low-power requirements may be supplied by batteries that are replenished by line chargers connected to a commercial power supply when available. Alternatively, the achievement of a sufficiently low power consumption may enable solar power supply to be used.

The problems of primary power supply raised by systems of this kind have been studied by ITU-T GAS 4, who have published a manual "Primary Sources of Energy", on this subject in 1985.