

RECOMMENDATION ITU-R F.1099-2

**RADIO-FREQUENCY CHANNEL ARRANGEMENTS FOR
HIGH-CAPACITY DIGITAL RADIO-RELAY SYSTEMS
IN THE 5 GHz (4 400-5 000 MHz) BAND**

(Question ITU-R 136/9)

(1994-1995-1997)

The ITU Radiocommunication Assembly,

considering

- a) that high-capacity digital radio-relay systems of more than the order of 90 Mbit/s conveying plesiochronous or synchronous digital hierarchy (PDH or SDH) signals are required in the 5 GHz radio-frequency (RF) bands;
- b) that the centre gaps of the individual channel arrangements and the guard spacing at the edges of the band can be chosen by non-occupancy of a suitable number of RF-channel positions in a homogeneous basic pattern;
- c) that the uniform basic pattern spacing should not be unjustifiably small nor so large as to jeopardize efficient use of the available spectrum;
- d) that the absolute frequencies of the basic pattern should be defined by a single reference frequency;
- e) that single- and multi-carrier digital radio-relay systems are both useful concepts to achieve the best technical and economic trade-off in the system design,

recommends

1 that the preferred RF channel arrangement for high-capacity digital radio-relay systems of the order of 90 Mbit/s or more conveying PDH or SDH signals (see Note 1), operating in the 5 GHz band, should be selected from a homogeneous pattern with the following characteristics.

Centre frequencies f_p of the RF channels within the basic pattern:

$$f_p = 5\,000 - 10 p \quad \text{MHz}$$

p : integral 1, 2, 3 ... (see Note 2);

- 2** that all the go channels should be in one half of the band and all the return channels should be in the other half of the band;
- 3** that the channel spacing XS , the centre gap YS , the guard spaces Z_1S and Z_2S at the edges of the band and the antenna polarization should be agreed between the administrations concerned;
- 4** that the alternated or co-channel arrangement plan should be used, examples of which are shown in Fig. 1;
- 5** that RF channel arrangements derived from *recommends* 1 for the 5 GHz band and given in Annexes 1 and 2 should be regarded as part of this Recommendation;
- 6** that if multi-carrier transmission (see Note 3 and Annex 1, § 3) is employed, the overall number of n carriers will be regarded as a single channel, the centre frequency and channel spacing of which will be that defined according to Fig. 1, disregarding the actual centre frequencies of the individual carriers, which may vary, for technical reasons, according to practical implementations.

NOTE 1 – Actual gross bit rates including overhead may be as much as 5% or higher than net transmission rates.

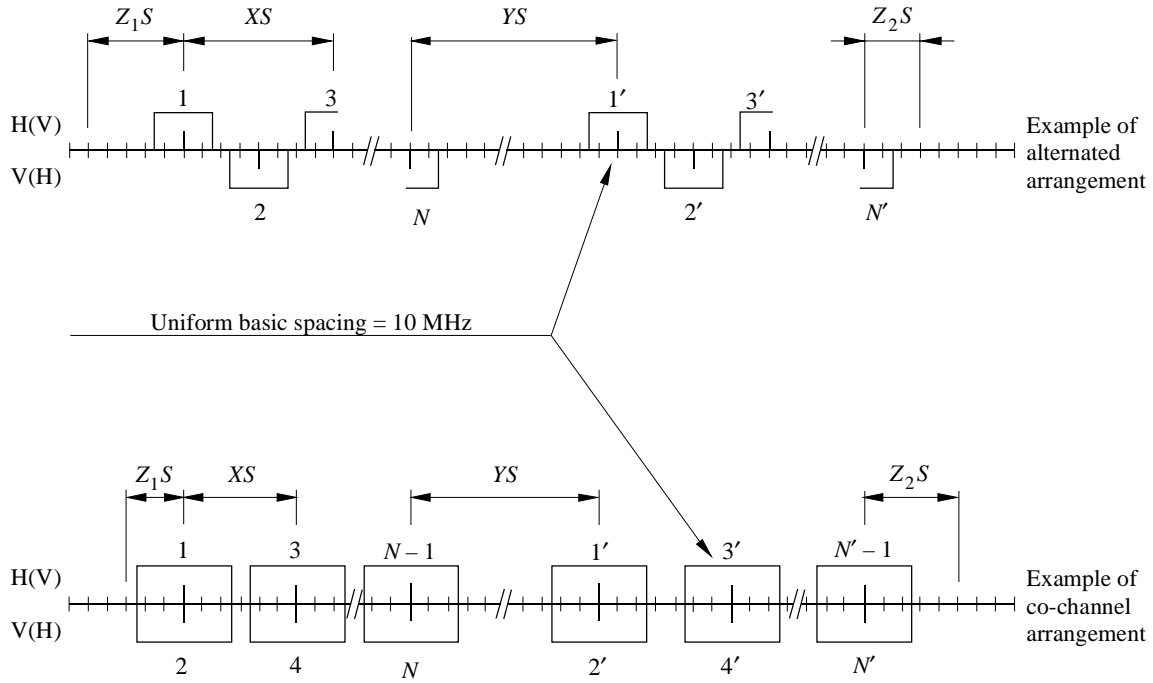
NOTE 2 – Due regard should be taken of the fact that in some countries where additional RF channels interleaved between those of main patterns are required, the values of the centre frequencies of these RF channels should be given by the following equation (see Annexes 1 and 2):

$$f_p = 4\,995 - 10 p \quad \text{MHz}$$

NOTE 3 – A multi-carrier system is a system with n (where $n > 1$) digitally modulated carrier signals simultaneously transmitted (or received) by the same RF equipment. The centre frequency should be regarded as the arithmetic average of the n individual carrier frequencies of the multi-carrier system.

FIGURE 1

Examples of channel arrangements based on *recommends 1 and 2*
(For definitions of X , Y , Z and S see Recommendation ITU-R F.746)



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ANNEX 1

RF channel arrangement for the band 4 400-5 000 MHz with channel spacings of 40 or 60 MHz

1 40 MHz RF channel arrangement

1.1 The following RF channel arrangement provides seven go and seven return channels with a transmission capacity up to 2×155 Mbit/s for radio systems with a suitable higher level modulation and spectrum efficiency up to 7.75 bit/s/Hz. The RF channel arrangement should be as shown in Fig. 2 and should be derived as follows:

let f_0 be the frequency (MHz) of the centre of the band of frequencies occupied, $f_0 = 4\,700$,

f_n be the centre frequency (MHz) of one RF channel in the lower half of the band,

f'_n be the centre frequency (MHz) of one RF channel in the upper half of the band,

then the frequencies (MHz) of individual channels are expressed by the following relationships:

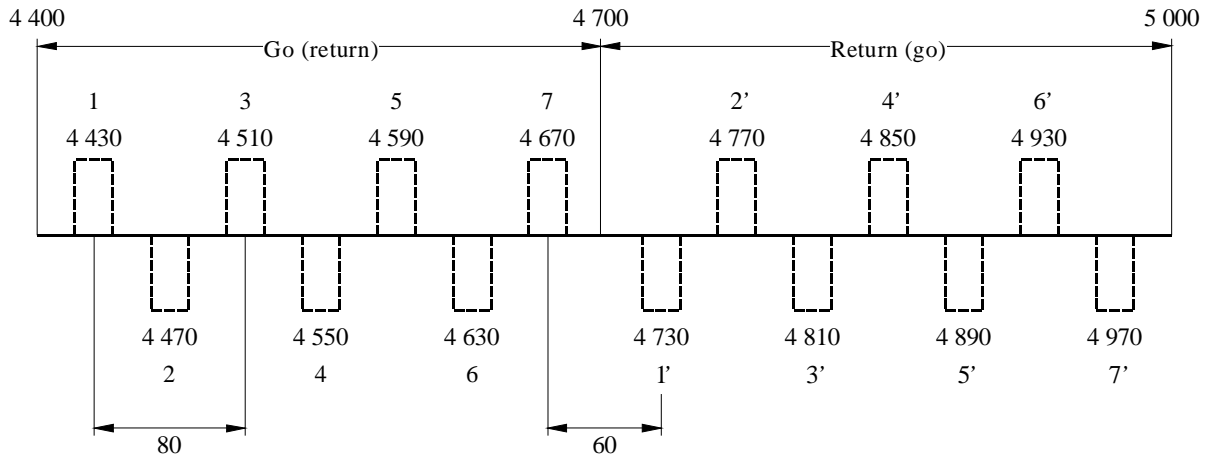
$$\text{lower half of the band: } f_n = f_0 - 310 + 40n$$

$$\text{upper half of the band: } f'_n = f_0 - 10 + 40n$$

where:

$$n = 1, 2, 3, 4, 5, 6 \text{ or } 7.$$

FIGURE 2
Radio-frequency channel arrangement for radio-relay systems operating in the 5 GHz band (see Note 1)
 (All frequencies in MHz)



Note 1 - Where a fewer number (four or less) of RF channels are initially planned or required, the go and return paired assignments may employ the same polarisation. In this case, only the even numbered or odd numbered channels are utilized.

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1.2 All the go channels should be in one half of the band and all the return channels should be in the other half of the band.

1.3 Different polarizations should be used in an alternated pattern for RF channels in the same half of the band or where it is possible, band re-use in the co-channel mode may be utilized.

2 60 MHz RF channel arrangements

This section describes examples of RF channel arrangements derived from *recommends* 1 and Note 2 of the main text of this Recommendation. The systems characterized by parameters in Table 1 achieve high spectrum utilization efficiency of the order of 5 bit/s/Hz or 10 bit/s/Hz employing 16-QAM or 256-QAM, respectively.

TABLE 1

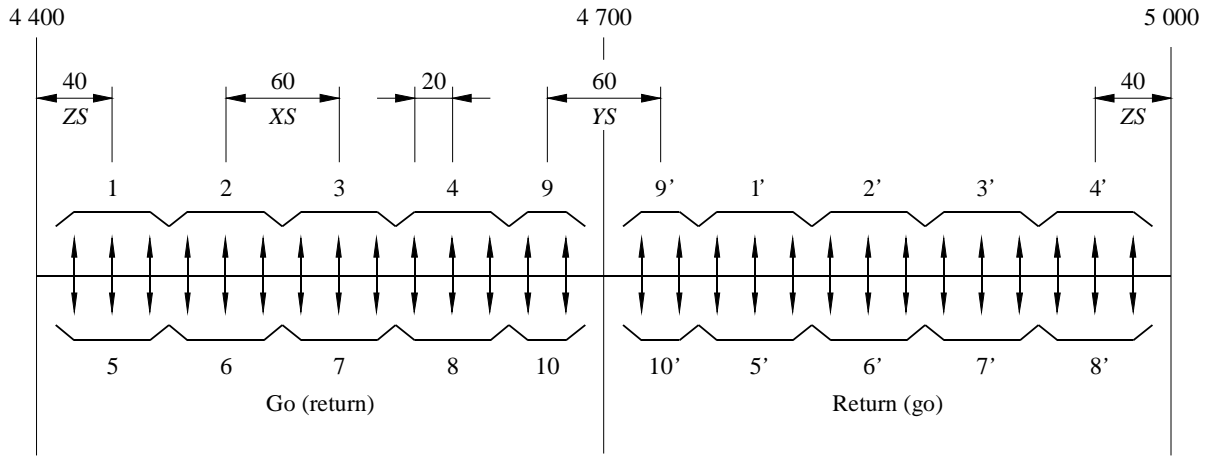
	Example 1a	Example 1b	Example 2 ⁽¹⁾
System capacity	(Synchronous)		(Synchronous)
	156 Mbit/s ⁽²⁾	2 × 156 Mbit/s ⁽²⁾	2 × 156 Mbit/s ⁽²⁾
Modulation	16-QAM	256-QAM	256-QAM
Polarization	Co-channel		Co-channel
Transmission method	3-carrier per channel		6-carrier per channel
Centre frequency of the carriers f_n (MHz)	$f_n = 5\,000 - 10\,m$ $m = 2, 4, 6... 28$ (upper) $m = 32, 34, 36... 58$ (lower)		$f_n = 4\,995 - 10\,m$ $m = 1, 2, 3... 27, 28$ (upper) $m = 31, 32... 57, 58$ (lower)
Number of channels	10 ⁽²⁾		10 ⁽²⁾

(1) Example 2 is applicable to hops under very severe propagation conditions.

(2) The capacity of the innermost RF channels is limited to two-thirds of the full capacity.

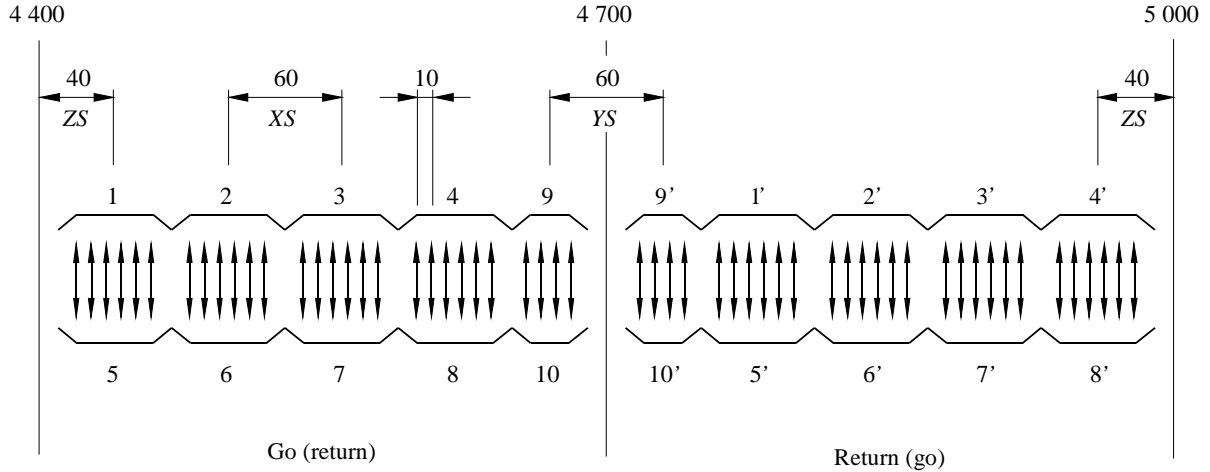
The systems representing examples 1a, 1b and 2 are designed to transmit SDH signals, using a multi-carrier transmission method. In case of the multi-carrier systems “Number of channels” means the number of transmitters (or receivers), each of which accommodates three or six carriers within 60 MHz. Also, XS, YS and ZS are stated for the centre frequency of the transmitter (or receiver) (see Figs. 3 and 4).

FIGURE 3
Radio-frequency channel arrangement in the 5 GHz band for a 3-carrier transmission method
 (All frequencies in MHz)



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FIGURE 4
Radio-frequency channel arrangement in the 5 GHz band for a 6-carrier transmission method
 (All frequencies in MHz)



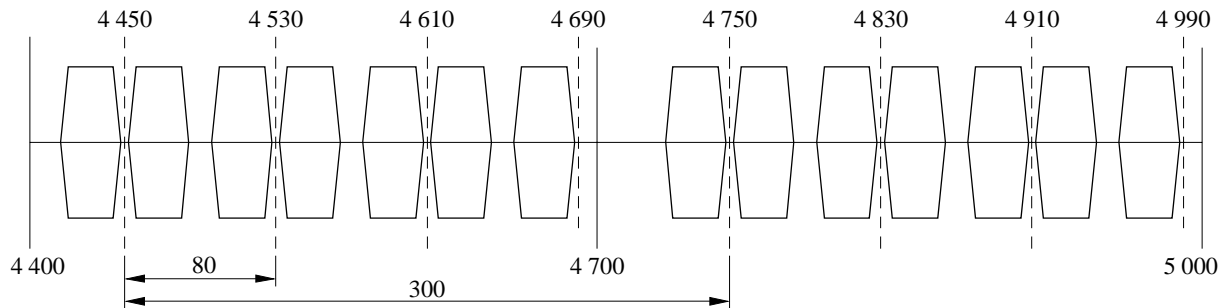
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3 80 MHz co-channel dual polarized channel arrangement

The channel arrangement depicted in Fig.5 is based upon the use of a 2-carrier system transmitting $2 \times 2 \times 155.52$ Mbit/s (STM-1) via two carrier pairs using both polarizations in the co-channel arrangement.

In addition to the quadruplets of carriers in both go and return sub-band, two cross-polar single carriers can be introduced as protection channels if necessary. Due to the fact that each carrier, i.e. baseband bit stream, can be switched individually, this $(n + 2)$ -configuration acts at least as efficient as a $(n/2 + 1)$ -configuration when used as frequency diversity.

FIGURE 5
Radio-frequency channel arrangement for a $2 \times 2 \times 155.52$ Mbit/s (STM-1) radio-relay system operating in the 5 GHz (4 400-5 000 MHz) band
 (All frequencies in MHz)



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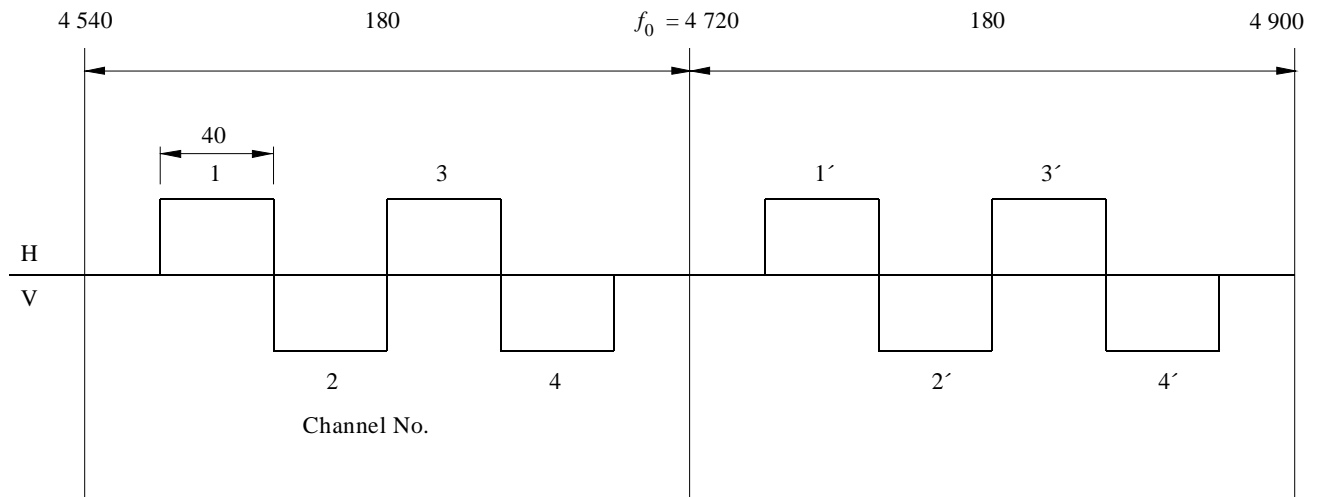
ANNEX 2

RF channelling arrangements for the band 4 540-4 900 MHz with channel spacings of 20 or 40 MHz

This Annex describes a RF channelling plan for digital radio systems in the band 4 540-4 900 MHz. The arrangement provides for up to four go and four return channels each accommodating either 4×45 Mbit/s, 6×45 Mbit/s or the SDH bit rate at 2×155 Mbit/s. A 512-QAM modulation scheme allows for system operation at STM-1 or $2 \times$ STM-1. An alternative arrangement provides up to eight go and eight return channels each accommodating either 2×45 Mbit/s, 3×45 Mbit/s or the SDH bit rate at 155 Mbit/s.

1 The RF channel arrangement is shown in Fig. 6 and is derived as follows:

FIGURE 6
Radio-frequency channel arrangement for the 5 GHz band
 (All frequencies in MHz)



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Let f_0 be the frequency at the centre of the band:

$$f_0 = 4\,720 \text{ MHz}$$

f_n : centre frequency of one RF channel in the lower half of the band (MHz),

f'_n : centre frequency of one RF channel in the upper half of the band (MHz),

then the centre frequencies of the individual channels are expressed by the following relationships:

$$\text{lower half of the band: } f_n = f_0 - 195 + 40n$$

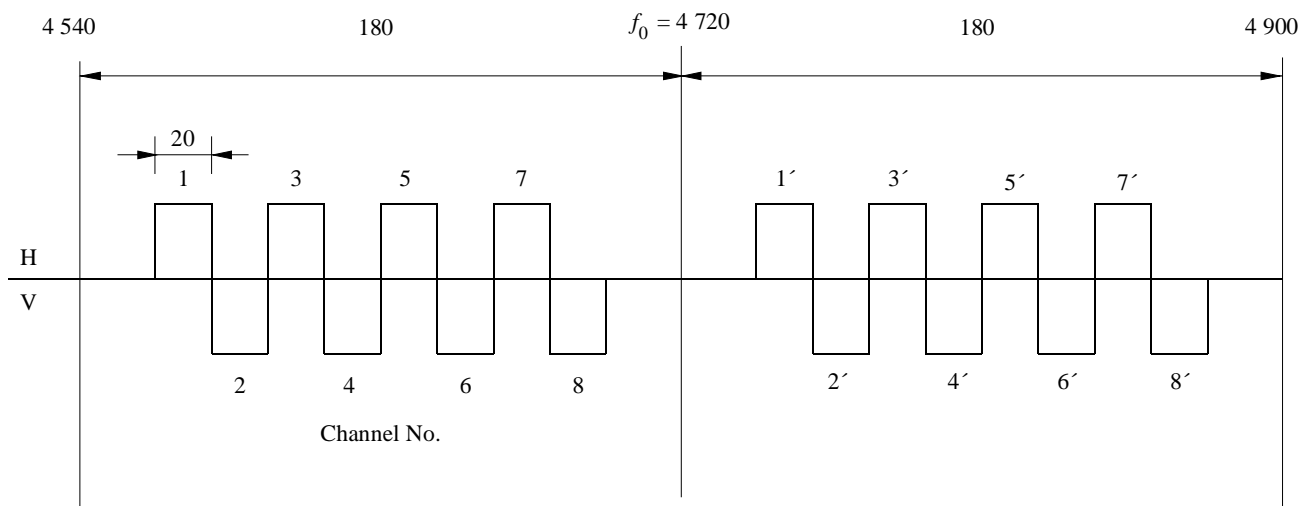
$$\text{upper half of the band: } f'_n = f_0 - 5 + 40n$$

where:

$$n = 1, 2, 3, 4.$$

2 An alternative arrangement is shown in Fig. 7 and the assignments are expressed as follows:

FIGURE 7
Alternative radio-frequency channel arrangement
for the 5 GHz band
(All frequencies in MHz)



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The centre frequencies of the individual channels are expressed by the following relationships:

$$\text{lower half of the band: } f_n = f_0 - 185 + 20n$$

$$\text{upper half of the band: } f'_n = f_0 + 5 + 20n$$

where:

$$f_0 = 4\,720 \text{ MHz}$$

$$n = 1, 2, 3, 4, 5, 6, 7, 8.$$

3 All the go channels should be in one half of the band and all the return channels should be in the other half of the band.