



Recommendation ITU-R F.384-11
(03/2012)

**Radio-frequency channel arrangements
for medium- and high-capacity digital
fixed wireless systems operating
in the 6 425-7 125 MHz band**

F Series
Fixed service

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

Policy on Intellectual Property Right (IPR)

ITU-R policy on IPR is described in the Common Patent Policy for ITU-T/ITU-R/ISO/IEC referenced in Annex 1 of Resolution ITU-R 1. Forms to be used for the submission of patent statements and licensing declarations by patent holders are available from <http://www.itu.int/ITU-R/go/patents/en> where the Guidelines for Implementation of the Common Patent Policy for ITU-T/ITU-R/ISO/IEC and the ITU-R patent information database can also be found.

Series of ITU-R Recommendations

(Also available online at <http://www.itu.int/publ/R-REC/en>)

Series	Title
BO	Satellite delivery
BR	Recording for production, archival and play-out; film for television
BS	Broadcasting service (sound)
BT	Broadcasting service (television)
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

Electronic Publication
Geneva, 2012

© ITU 2012

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without written permission of ITU.

RECOMMENDATION ITU-R F.384-11

Radio-frequency channel arrangements for medium- and high-capacity digital fixed wireless systems operating in the 6 425-7 125 MHz band

(1963-1966-1974-1982-1986-1990-1995-1999-2003-2006-2007-2012)

Scope

This Recommendation provides radio-frequency channel arrangements for fixed wireless systems operating in the upper 6 GHz band (6 425-7 125 MHz), which may be used for high-, medium- and low-capacity fixed systems. The channel separation recommended in the main text are 40, 30, 20, 10 and 5 MHz with the interleaved arrangements with possible use of the co-channel arrangements; recommended arrangements with 14, 7 and 3.5 MHz channel separations in combination with the 30 MHz arrangement are also provided in Annex 2. The use of multi-carrier transmission based on these arrangements is also considered in the Annex 1 providing detailed description of this application.

The ITU Radiocommunication Assembly,

considering

- a) that fixed wireless systems (FWSs) with medium and high capacity should prove to be feasible in the upper 6 GHz band, if due care is exercised in the planning of radio paths to reduce multipath effects;
- b) that it is sometimes desirable to be able to interconnect, at radio frequencies, FWSs on international links in the upper 6 GHz band;
- c) that a common RF channel arrangement for FWS offers considerable advantages;
- d) that the use of digital modulation (see Recommendation ITU-R F.1101) permits the use of the RF channel arrangement for the transmission of a bit rate of the order of 140 Mbit/s or synchronous digital hierarchy (SDH) bit rates;
- e) that for these digital radio systems, further economies are possible by accommodating up to eight go and return channels on a single antenna with suitable performance characteristics;
- f) that many interfering effects can be reduced substantially by a carefully planned arrangement of the radio frequencies in FWS employing several RF channels;
- g) that single- and multi-carrier digital FWS are both useful concepts to achieve the best technical and economic trade-off in system design;
- h) that digital techniques such as cross-polar interference cancellers (XPIC) may significantly contribute to the cross-polar discrimination improvement factor (XIF, defined in Recommendation ITU-R F.746), thus counteracting the multipath-induced propagation depolarization;
- j) that when very high-capacity links (e.g. twice Synchronous Transfer Mode-1 (STM-1)) are required, further economy may be achieved using system bandwidths wider than the recommended channel separation, associated to highly efficient modulation formats,

recommends

1 that the preferred RF channel arrangement for up to eight go and eight return channels, each accommodating a bit rate of the order of 140 Mbit/s, or synchronous digital hierarchy bit rates (see Note 2), and operating at frequencies in the upper 6 GHz band, should be derived as follows:

Let f_0 be the frequency of the centre of the band of frequencies occupied (MHz),

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

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

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

$$\text{lower half of the band: } f_n = f_0 - 350 + 40 n \quad \text{MHz}$$

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

where:

$$n = 1, 2, 3, 4, 5, 6, 7 \text{ or } 8;$$

1.1 that, in the section over which the international connection is arranged, 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;

1.2 that different polarizations may be used alternately for adjacent RF channels in the same half of the band;

1.3 that the go and return channels on a given section should preferably use polarizations as shown below and in Fig. 1a (see Note 2 and Note 3):

	<i>Go</i>	<i>Return</i>
H(V)	1 3 5 7	1' 3' 5' 7'
V(H)	2 4 6 8	2' 4' 6' 8'

1.4 that for improving the spectral efficiency the co-channel arrangement in Fig. 1b) may also be used for digital FWS;

1.5 that when very high-capacity links (e.g. twice STM-1) are required and network coordination permits, with the agreement of the administrations concerned, the use of any two adjacent 40 MHz channels specified in *recommends* 1 is possible, for wider bandwidth systems, with the centre frequency lying in the central point of the distance between the two 40 MHz adjacent channels;

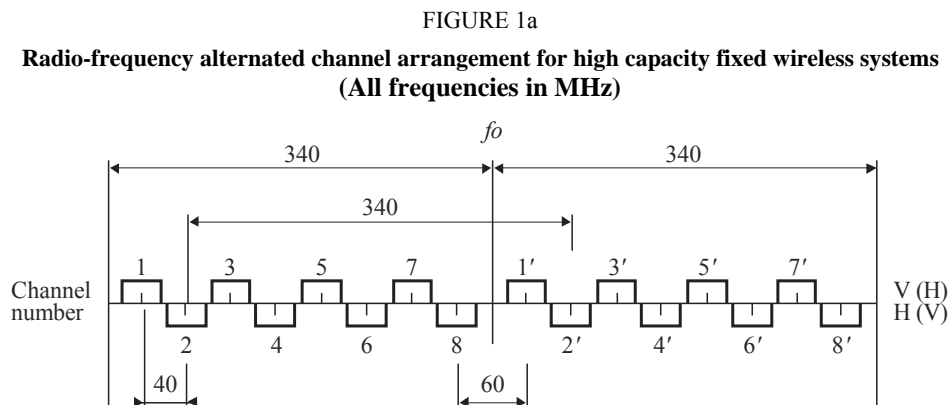
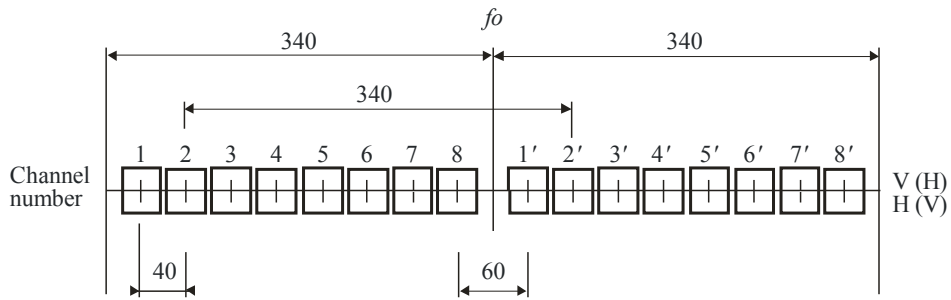


FIGURE 1b
Radio-frequency co-channel arrangement for high capacity fixed wireless systems
 (All frequencies in MHz)



F.0384-01b

2 that the preferred radio-frequency channel arrangement for up to 16 go and 16 return channels, each accommodating digital plesiochronous or synchronous medium capacity rates shown in Fig. 2, should be obtained by interleaving additional channels between those of the main pattern of *recommends 1* and should be expressed by the following relationship:

$$\text{lower half of the band: } f_n = f_0 - 350 + 20n \quad \text{MHz}$$

$$\text{upper half of the band: } f'_n = f_0 - 10 + 20n \quad \text{MHz}$$

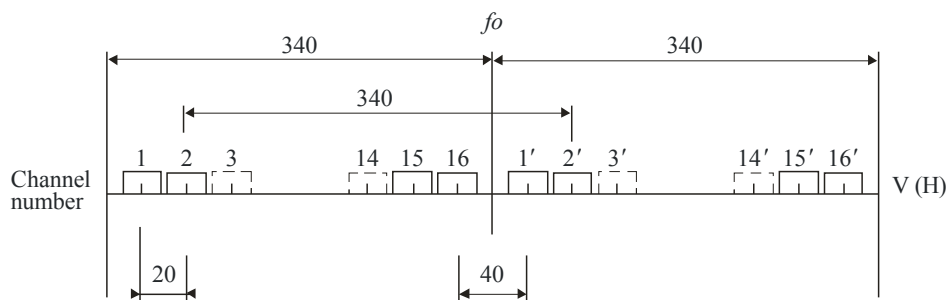
where:

$$n = 1, 2, 3, \dots, 15, 16;$$

2.1 that, in the section over which international connection is arranged, all the go channels should be in one half of the band and all the return channels in the other half of the band;

2.2 that different polarizations may be used alternately for adjacent RF channels in the same half of the band; co-channel frequency reuse may be used where appropriate;

FIGURE 2
Radio-frequency for medium capacity fixed wireless systems
 (All frequencies in MHz)



F.0384-02

3 that if multi-carrier transmission (Note 4) is employed, the overall number of n carriers will be regarded as a single channel. The centre frequency of that channel should be derived from *recommends 1*, *recommends 1.6* or *recommends 4.2*, disregarding the actual centre frequencies of the individual carriers, which may vary, for technical reasons, according to practical implementations. Operation of multi-carrier systems is addressed in greater detail in Annex 1;

4 that the preferred RF channel arrangement for up to ten go and ten return 30 MHz channels, each accommodating a bit rate of the order of 155 Mbit/s, or SDH bit rates (see Note 1), should be derived as follows:

Let f_0 be the frequency of the centre of the band of frequencies occupied (MHz),
 f_n be the centre frequency of one RF channel in the lower half of the band (MHz),
 f'_n be the centre frequency of one RF channel in the upper half of the band (MHz),

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

$$\text{lower half of the band: } f_n = f_0 - 340 + 30 n \quad \text{MHz}$$

$$\text{upper half of the band: } f'_n = f_0 + 30 n \quad \text{MHz}$$

where:

$$n = 1, 2, 3, 4, 5, 6, 7, 8, 9 \text{ and } 10.$$

$n = 11$ may also be considered, taking into account the limited centre-gap (10 MHz) between channels 11 and 1' and the overlapping with channel 1' of the 20 MHz channel arrangement in *recommends* 2. However, its usage might add further flexibility in coordinating congested areas of the network;

4.1 that when the equipment and network characteristics permit, co-channel frequency reuse can be employed, with the agreement of the administrations concerned, for improving spectral efficiency;

4.2 that when very high capacity links (e.g. twice Synchronous Transfer Mode-1 (STM-1)) are required and network coordination permits, with the agreement of the administrations concerned, the use of any two adjacent 30 MHz channels specified in *recommends* 4 is possible, for wider bandwidth system, with centre frequency lying in the central point of the distance between the two 30 MHz adjacent channels;

4.3 that RF channel arrangements with 14 MHz, 7 MHz and 3.5 MHz may be obtained by a suitable channel subdivision coherent with the 30 MHz RF channels as shown in Annex 2;

5 that the preferred RF channel arrangement for up to 32 go and 32 return 10 MHz channels, each accommodating digital synchronous medium capacity rates, should be expressed by the following relationships:

$$\text{lower half of the band: } f_n = f_0 - 340 + 10 n \quad \text{MHz}$$

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

where:

$$n = 1, 2, 3, \dots 31, 32;$$

6 that the preferred RF channel arrangement for up to 64 go and 64 return 5 MHz channels, each accommodating digital synchronous medium capacity rates, should be expressed by the following relationships:

$$\text{lower half of the band: } f_n = f_0 - 340 + 5 n \quad \text{MHz}$$

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

where:

$$n = 1, 2, 3, \dots 63, 64;$$

7 that the preferred centre frequency f_0 , is 6770 MHz; in addition, other centre frequencies may be used by agreement between the administrations concerned;

8 that RF channel arrangements with 20 MHz, 10 MHz, and 5 MHz may also be alternatively obtained by subdividing the 40 MHz RF channels of the arrangement in *recommends* 1.

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

NOTE 2 – When common transmit-receive antennas are used and channel 8 is used together with channel 1', either in the arrangement of Fig. 1a or in the even more problematic arrangement of Fig. 1b, special branching and filters arrangement may be needed for limiting mutual impairments and permitting their common operation.

NOTE 3 – In previous versions of this Recommendation, the alternative arrangement of polarization, shown below, has been recommended and used in past deployment of analogue systems up to 2 700 channels. Such an arrangement is possibly maintained in the migration to digital systems and may still be in use by agreement between the administrations concerned:

	<i>Go</i>	<i>Return</i>
H(V)	1 3 5 7	2' 4' 6' 8'
V(H)	2 4 6 8	1' 3' 5' 7'

NOTE 4 – 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.

Annex 1

Description of a multi-carrier system

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.

For high capacity multi-carrier transmission, the centre frequency of the channel should coincide with one of the corresponding frequencies of the basic channel arrangements given in *recommends* 1, *recommends* 1.6 or *recommends* 4.2. The channel spacing may be an integer multiple of the basic values defined by *recommends* 1, 2 or 4. Compatibility with existing configurations has to be taken into account when choosing the appropriate alternative.

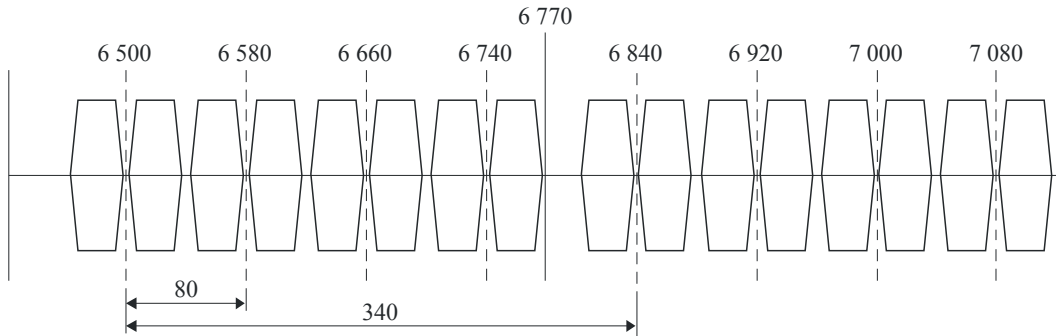
Examples of co-polar frequency reuse channel arrangements using a two-carrier system with 64-QAM are shown in Fig. 3. Each carrier is modulated with 155.52 Mbit/s (STM-1).

The centre frequencies of the channel arrangement in Fig. 3a) are derived from *recommends* 1 by setting $n = 2, 4, 6, 8$. Channel spacing is 80 MHz. Each RF-channel contains 2×2 carriers allocated at ± 17.5 MHz around the centre frequency using both polarizations. This was preferable when analogue to digital transition was in progress.

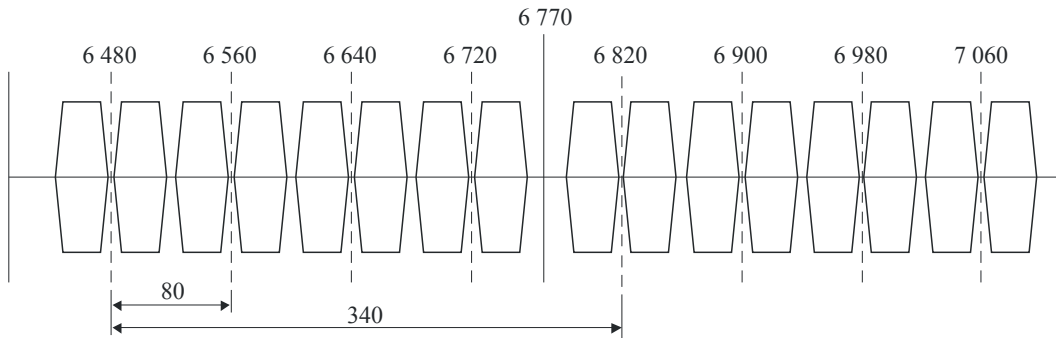
Figure 3b) shows an interleaved channel arrangement where centre frequencies are derived from *recommends* 1.6 by combining channels with $n = 1$ and 2, 3 and 4, 5 and 6, 7 and 8. This channel arrangement is preferred because it provides more symmetrical guardbands at the band edges.

FIGURE 3

Example of radio-frequency channel arrangements for a $2 \times 2 \times 155.52$ Mbit/s ($4 \times$ STM-1) fixed wireless system operating with 80 MHz channel spacing in the upper 6 GHz band
(All frequencies in MHz)



a) Channel arrangement preferred if compatibility with analogue radio-relay systems is required



b) Channel arrangement preferred if compatibility with analogue radio-relay systems is not required

F.0384-03

Annex 2

14 MHz, 7 MHz and 3.5 MHz arrangements referred to in *recommends 4.3*

Narrow-band 14 MHz, 7 MHz and 3.5 MHz channels are obtained formally subdividing each of the 30 MHz channels provided in *recommends 4* using the residual 2 MHz as internal guardbands between each 30 MHz slot as shown in Fig. 4.

The whole set of channels centre frequencies may be obtained by the following relationships:

a) for systems with a carrier spacing of 14 MHz:

$$\text{lower half of the band: } fn = f_0 - 340 + 9 + n \cdot 14 + 2 \cdot \text{integer}((n-1)/2)$$

$$\text{upper half of the band: } fn' = f_0 + 9 + n \cdot 14 + 2 \cdot \text{integer}((n-1)/2)$$

where:

$$n = 1, 2, 3, \dots, 21, 22$$

- b) for systems with a carrier spacing of 7 MHz:
 lower half of the band: $fn = f_0 - 340 + 12.5 + n \times 7 + 2 \times \text{integer}((n - 1)/4)$
 upper half of the band: $fn' = f_0 + 12.5 + n \times 7 + 2 \times \text{integer}((n - 1)/4)$

where:

$$n = 1, 2, 3, \dots, 43, 44$$

- c) for systems with a carrier spacing of 3.5 MHz:

lower half of the band: $fn = f_0 - 340 + 14.25 + n \times 3.5 + 2 \times \text{integer}((n - 1)/8)$
 upper half of the band: $fn' = f_0 + 14.25 + n \times 3.5 + 2 \times \text{integer}((n - 1)/8)$

where:

$$n = 1, 2, 3, \dots, 87, 88$$

