

RECOMMENDATION ITU-R SA.1805

Technical and operational characteristics of space-to-space telecommunication systems operating around 354 THz* and 366 THz**

(Question ITU-R 235/7)

(2007)

Scope

This Recommendation specifies technical parameters (frequencies, link direction, signal and data characteristics, antenna parameters, etc.) and operational characteristics of telecommunication systems operating in the space-to-space direction around 354 THz and 366 THz, which could be used in sharing studies.

The ITU Radiocommunication Assembly,

considering

- a) that telecommunication links are planned for use on some satellite systems for inter-orbit telecommunication at frequencies in the region of 354 THz and 366 THz;
- b) that using recent technological developments, astronomers are making a concerted effort to build telescopes and make observation in this segment of the spectrum;
- c) that this segment of the spectrum is also being used for other terrestrial and space services;
- d) that this segment of the spectrum is also being used for scientific and industrial purposes other than telecommunication,

recommends

- 1 that sharing studies considering space research satellites operating in the space-to-space direction around 354 THz and 366 THz should take into account the technical and operational parameters presented in Annex 1.

Annex 1**1 Introduction**

Due to increased pressure for use of the electromagnetic spectrum and the advancement of technology, there is more attention being given to the use of frequencies above 3 000 GHz for free-space telecommunications. Free-space telecommunication at frequencies above 3 000 GHz has the ability to support higher data rates with less mass than traditional RF systems as well as meet gain and directivity requirements of beams used for space-to-space applications.

* 1 THz = 1 000 GHz.

** This Recommendation should be brought to the attention of Radiocommunication Study Group 1.

1.1 Frequency considerations

Currently, most of the interest in free-space telecommunications links above 3 000 GHz is focused around the frequencies 200, 283, 311 and 353 THz, whose corresponding wavelengths are approximately 1.5, 1.06, 0.965 and 0.850 μm . These frequencies are the same as those most widely used for telecommunications in optical fibres. For inter-orbit telecommunication, attention is being focused on the use of high power semiconductor lasers operating around 0.850 μm or the use of a semiconductor laser beam amplified by an Erbium-doped (Er) fibre-optical amplifier (EDFA) at the wavelength of 1.5 μm . The system with semiconductor lasers operating around 0.85 μm is superior to that with EDFA in reliability and power consumption for relatively low data-rate applications which do not require high transmitter power.

1.2 Generic mission parameters

Technical parameters suitable for interference analyses should be based on generic inter-orbit telecommunication links near the Earth. Therefore, link distances will be between a few to several hundred thousand km. A summary of the fundamental technical parameters around 354 THz and 366 THz near-Earth inter-orbit telecommunication link is provided in Table 1.

TABLE 1

Technical parameters of a reference inter-orbit telecommunication system operating around 354 THz and 366 THz in the space-to-space direction

Parameter	Forward link	Return link
Transmitter power (mW)	10	40
Transmitter aperture (cm)	25	26
Transmitter frequency (wavelength) (THz)	Comm: 366 (0.819 μm) Beacon: 374 (0.801 μm)	354 (0.847 μm)
Modulation	2PPM	NRZ
Pointing accuracy (μrad)	$\pm 2.6 (3\sigma)$	
Range in free space (km)	up to 40 000	
Data rate (Mbit/s)	2.048	49.3724
Receiver aperture (cm)	26	25
Detector type	APD detector	APD detector

APD: avalanche photodiode

NRZ: non-return to zero

PPM: parts per million

2 Link considerations

Inter-orbit links are established between a geosynchronous Earth orbit (GEO) satellite and a low-Earth orbit (LEO) satellite in the space-to-space direction, operating around 366 THz for the

forward link and 354 THz for the return link. A beacon signal at 374 THz is emitted to assist with telescope pointing and tracking.

2.1 Link performance

Like a space-to-space system operating in the traditional RF spectrum, performance of a link operating around 354 THz and 366 THz is measured in terms of data rate and BER. Performance is calculated as a function of power, telescope quality, propagation considerations, noise and receiver sensitivity. Each of these parameters is a function of additional variables.

2.1.1 BER

Frames of data must have a BER of less than 10^{-6} after error correction in order to be retained. A link must retain 99% of data frames.

2.1.2 Margin requirement

The typical margin requirement of an inter-satellite link operating around 354 THz and 366 THz is on the order of 1 to 3 dB.

2.2 Modulation

The return link operating around 354 THz utilizes NRZ. The forward link operating around 366 THz utilizes 2PPM. This modulation technique allows for direct detection by the receiver rather than implementing coherent receivers.

2.3 Received signal

The general method for calculating the signal level around 354 THz and 366 THz received by the space-to-space station is the same as that used with traditional RF systems.

$$P_S = P_t + G_t + G_r + L_t + L_r + L_p + L_S \quad \text{dBW} \quad (1)$$

where:

- P_S : received signal power (dBW)
- P_t : average laser output power (dBW)
- G_t : transmitter antenna gain (dBi)
- G_r : receiving antenna gain (dBi)
- L_t : transmitter losses (dB)
- L_r : receiver losses (dB)
- L_p : pointing losses (dB)
- L_S : free-space loss (dB).

2.4 Link losses

- L_t includes the effects of absorption, scattering and reflection losses in the optical system of the transmitter;
- L_r includes the effects of absorption, scattering, and reflection losses in the optical train of the receiver;
- L_p includes the effects of antenna or satellite jitter and mispointing of the transmitting antenna;
- L_S is due to the physical separation between the transmitter and receiver.