



Synchronization method and system

The present invention relates to a method allowing frequency synchronization of a satellite terminal with a satellite or a terrestrial station. All of these elements belonging to one and the same system for transmitting
5 satellite data.

Methods of satellite pointing using a synchronization signal based on a modulated pseudo random sequence are known in the prior art. This modulation can for example be carried out by using a two-state phase
10 modulation (also known by the name of BPSK for Binary Phase Shift Keying). This synchronization signal, emitted in one or more temporal intervals, is also known in the prior art by the name of beacon.

However, as low-cost satellite terminals generally comprise a low-performance local oscillator, the terminals generally exhibit a frequency shift
15 with the satellite or the terrestrial station of several kHz, to which is added a possible shift caused by the Doppler effect.

These shifts in frequency slow down the synchronization between the satellite terminal and the satellite or the terrestrial station. Indeed, the terminal is required to make several assumptions about this possible shift in
20 frequency. The time required for the synchronization will therefore depend on the computation power available in the satellite terminal and on the number of assumptions to be made. For example if the receiver must search for the synchronization signal in a span of 50kHz in increments of 1kHz, then the satellite terminal is required to make 101 assumptions about the shift in frequency. If
25 each assumption requires a computation of 10 seconds, the total synchronization time is around 17 minutes. Moreover the computation power, required for a first synchronization, is in general greater than the computation power required for tracking this synchronization. The computation power used for the process of initial synchronization is therefore under-used during
30 the major part of the time.

The present invention is therefore aimed at remedying these problems by proposing a method and a system for frequency synchronization



limiting the computation power and the time required for carrying out this frequency synchronization.

Thus there is proposed, according to one aspect of the invention,
5 a method of emission of a frequency synchronization signal comprising a first step of determining at least two first emission frequencies respectively associated with at least one first set of at least two first temporal intervals separated temporally by a first duration. The said first temporal intervals are of identical duration. The said first durations are identical for identical first
10 frequencies and the said first durations are different for different first frequencies. The method also comprises a second step of emitting a synchronization signal in the first temporal intervals and by using respectively the first frequency associated with the temporal interval. The said synchronization signal emitted in the various first intervals is identical.

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The proposed method of emission therefore allows the emission of a synchronization signal having a greater spectral width relative to a normal method. Figure 1 illustrates the emission of a synchronization signal in four temporal intervals. These temporal intervals are grouped together into two
20 first sets C1 and C2. The first set C1 comprises the temporal intervals I1 and I2 and the first set C2 comprises the temporal intervals I3 and I4. The signals emitted in the temporal intervals of the first set C1 use a band of frequency F1 and the signals emitted in the temporal intervals of the first set C2 use a band of frequency F2. Moreover the two temporal intervals of the first set C1
25 are separated by the duration T1 and the two temporal intervals of the first set C2 are separated by the duration T2, different from the duration T1. Therefore the two frequencies F1 and F2 used to emit a signal in the temporal intervals of the first sets C1 and C2 are determinable by comparing the duration separating the two temporal intervals (I1 and I2 or I3 and I4) of
30 one and the same pair of temporal intervals.

According to a technical characteristic, the first step of the method of emission is adapted for determining at least two first frequencies whose spectral separation is greater than the spread spectrum bandwidth of the
35 synchronization signal.

This technical characteristic allows the emission of a synchronization signal having a double spectral width relative to a normal method.

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Advantageously the first temporal intervals belong to a set of contiguous temporal intervals.

Advantageously the least common multiple of the first durations T1
10 is greater than a threshold.

The least common multiple, known also by the name LCM, of two non-zero integers a and b is the smallest strictly positive integer which is at one and the same time a multiple a and of b . In an optimal manner the
15 threshold is equal to the number of first frequencies, multiplied by the duration of the first temporal intervals.

According to another technical characteristic the said first frequencies are respectively associated with at least three first temporal
20 intervals separated temporally by two first durations.

If these temporal intervals are denoted A, B and C and are ranked in chronological order, these two durations can be the duration between A and B, and the duration between B to C. It is also possible to define instead
25 of the duration between A and B or the duration between B and C, the duration between A and C.

This technical characteristic makes it possible to improve the synchronization signal reception performance by avoiding, in particular,
30 ambiguities and by limiting the errors of temporal estimation.

Figure 2 illustrates an embodiment in which the emission of a synchronization signal is carried out in six temporal intervals (I5 to I10). These temporal intervals are grouped together into two first sets (E1 and E2).
35 The first set E1 comprises three first temporal intervals (I5 to I7). The first

intervals I5 and I6 are separated by a duration T3 and the first intervals I6 and I7 are separated by a duration T4. The first set E2 comprises three first temporal intervals (I8 to I10). The first intervals I8 and I9 are separated by a duration T5 and the first intervals I9 and I10 are separated by a duration T6.

- 5 The first intervals of the first set E1 are emitted by using the first frequency F1 and the first intervals of the first set E2 are emitted by using the first frequency F2.

Thus there is also proposed, according to one aspect of the
10 invention, a method of reception comprising a first step of demodulating the signal received, the demodulation is carried out by using a second frequency. The method of reception also comprises a second step of determining the gap between at least one of the first frequencies and the second frequency by determining at least two second temporal intervals in which the energy of
15 the demodulated signal is a maximum.

The proposed method of reception therefore makes it possible to determine the first frequency which has been used for the emission of the synchronization signal in the pair of temporal intervals. This determination is
20 carried out on the basis of the duration separating the two temporal intervals of the pair. The method of reception also uses the fact that the synchronization signals are identical and therefore it requires only a single correlation with a synchronization signal. There is no need to effect several correlations associated with various synchronization signals.

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Advantageously the second step of the method of reception is furthermore adapted for the determination of a second duration separating the two second intervals and/or the comparison between the second duration and the said first durations.

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Advantageously the second step of the method of reception is furthermore adapted for the determination of at least three second temporal intervals in which the energy of the said demodulated signal is a maximum and/or for the determination of two second durations separating the two

second intervals and/or the comparison between the said second durations and the said first durations.

There is moreover proposed a frequency synchronization system
5 comprising at least one satellite and/or at least one terrestrial station able to emit a frequency synchronization signal by using the preceding method of emission. The system also comprises at least one satellite terminal able to receive a frequency synchronization signal by using the method of reception.

10 The invention will be better understood and other advantages will become apparent on reading the detailed description given by way of nonlimiting example and with the aid of the figures among which:

Figure 1 illustrates the emission of a synchronization signal in four temporal intervals

15 Figure 2 illustrates the emission of a synchronization signal in six temporal intervals

- Figure 3 presents the method of emission according to one aspect of the invention
- Figure 4 presents the method of reception according to one aspect of the invention
- 20 – Figure 5 presents the second step of the method of reception according to one aspect of the invention
- Figure 6 presents the system according to one aspect of the invention

25 The emission method described in Figure 3 comprises a first step 201 of determining at least two emission frequencies. Each of these frequencies is associated with a first duration which separates two temporal intervals using this frequency. This first step also comprises the selection of at least one pair of first temporal intervals separated by the first duration. The
30 emission method also comprises a second step 202 of emitting a synchronization signal in each of the two first temporal intervals of the pair and by using the first frequency associated with each pair. This signal is generally a pseudo random sequence, modulated by using a two-state modulation, known by the name of BPSK.

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In order for the reception method to operate it is required that the first durations associated with two pairs be different. In an optimal manner it is required that this difference be greater than ten times the symbol frequency of the baseband synchronization signal.

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The emission method therefore consists in emitting a synchronization signal (also known by the name of beacon in the prior art) in a pair of temporal intervals. The signals emitted in pairs of temporal intervals which differ are emitted with a different frequency. The emission method
10 therefore makes it possible to emit on a more significant frequency band than when emitting synchronization signals using a single frequency. Moreover on account of the relation between the duration separating two temporal intervals used to emit signals and the frequency used for this emission, the receiver can determine the first frequency used for the emission of the
15 signals of a pair of temporal intervals on the basis of the duration separating these two temporal intervals.

Figure 1 illustrates the emission of a synchronization signal in four temporal intervals. These temporal intervals are grouped together into two
20 first sets C1 and C2. The first set C1 comprises the temporal intervals I1 and I2 and the first set C2 comprises the temporal intervals I3 and I4. The signals emitted in the temporal intervals of the first set C1 use a band of frequency F1 and the signals emitted in the temporal intervals of the first set C2 use a band of frequency F2. Moreover the two temporal intervals of the first set C1
25 are separated by the duration T1 and the two temporal intervals of the first set C2 are separated by the duration T2. Therefore the two frequencies F1 and F2 used to emit a signal in the temporal intervals of the first sets C1 and C2 are determinable by comparing the duration separating the two temporal intervals (I1 and I2 or I3 and I4) of one and the same pair of temporal
30 intervals.

In one embodiment it is possible to determine first frequencies which are separated spectrally by a width greater than the width of the spread band of the synchronization signal.

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In another embodiment it is possible for the first temporal intervals to belong to a set of contiguous intervals.

In one embodiment the first durations are chosen in such a way
5 that the least common multiple of these first durations is greater than a threshold equal to the number of first frequencies, multiplied by the duration of the first temporal intervals.

Figure 2 illustrates an embodiment in which the emission of a
10 synchronization signal is carried out in six temporal intervals (I5 to I10). These temporal intervals are grouped together into two first sets (E1 and E2). The first set E1 comprises three first temporal intervals (I5 to I7). The first intervals I5 and I6 are separated by a duration T3 and the first intervals I6 and I7 are separated by a duration T4. The first set E2 comprises three first
15 temporal intervals (I8 to I10). The first intervals I8 and I9 are separated by a duration T5 and the first intervals I10 and I11 are separated by a duration T6. The first intervals of the first set E1 are emitted by using the first frequency F1 and the first intervals of the first set E2 are emitted by using the first frequency F2.

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The reception method described in Figure 4 comprises a first step
301 of demodulating the signal received. This demodulation is carried out by considering that the frequency spread band of the signal received is centred on a second frequency. Various demodulators are known in the prior art. This
25 reception method also comprises a second step 302 which makes it possible to determine the gap between at least one first frequency used for the emission of the synchronization signal and the second frequency.

This second step is separated into two sub-steps such as presented in Figure 5. A first sub-step 401 which allows the determination of two second temporal
30 intervals in which the energy of the demodulated signal is a maximum. This step also comprises the computation of a second duration separating these two second temporal intervals. A second sub-step 402 then compares this second duration with the first durations associated with the various first frequencies. This step makes it possible to determine the first frequency
35 which has been used to emit the synchronization signals, in these two

second temporal intervals. The receiver can then synchronize its local oscillators so that the second demodulation frequency depends on one of the first frequencies of emission of the synchronization signals.

- 5 Thus stated otherwise the method of the invention allows, on emission, the matching of each emission frequency with a duration separating the intervals over which the synchronization signal using this frequency is emitted. A different duration is defined for each of the various frequencies. This matching can for example be carried out via a lookup table.
- 10 Thereafter during reception, the receiver detects the temporal intervals for which the power of the signal is a maximum and determines the duration separating these temporal intervals in which the power of the signal is a maximum. Thereafter the receiver can perform the matching inverse to that carried out on emission and thus retrieve the synchronization signal emission
- 15 frequency. This inverse matching can for example be carried out via a lookup table.

Figure 6 presents a system using the method of emission and the method of reception. This system comprises a satellite 501, a terrestrial

20 station 502 and a satellite terminal 503.

In one embodiment of this system the terrestrial station generates the frequency synchronization signal by using the method of emission and sends it to the satellite via the link 504. This signal is thereafter repeated by the satellite and transmitted to the satellite terminal via the link 505. The satellite

25 terminal is then able to carry out the method of reception.

In another embodiment the satellite is adapted for generating the synchronization signal by using the method of emission and sends it to the satellite terminal via the link 505. The satellite terminal is then able to carry out the method of reception.

CLAIMS

1. Method of emission of a frequency synchronization signal comprising;
 - a first step (201) of determining at least two first emission frequencies (F1 and F2) respectively associated with at least two first intervals (I1 and I2, I3 and I4) separated temporally by a first duration (T1 and T2), the said first intervals (I1 and I2, I3 and I4) being of identical duration, the said first durations (T1, T2) being identical for identical first frequencies (F1 and F2) and the said first durations (T1, T2) being different for different first frequencies (F1 and F2),
 - a second step (202) of emitting at least one synchronization signal in the said first temporal intervals and by using the said first frequency, the signal emitted in the said first intervals being identical.
2. Method of emission according to Claim 1, in which the said first step (201) is adapted for determining at least two frequencies whose spectral separation is greater than the spread spectrum bandwidth of the synchronization signal.
3. Method of emission according to Claim 1 or 2, in which the said first temporal intervals belong to a set of contiguous temporal intervals.
4. Method of emission according to one of Claims 1 to 3, in which the least common multiple of the first durations is greater than a threshold.
5. Method of emission according to one of Claims 1 to 4, in which the said first frequencies are respectively associated with at least three first temporal intervals separated temporally by two first durations.
6. Method of reception of a frequency synchronization signal emitted by using at least two first frequencies and in two pairs of temporal intervals separated by a different first duration for each frequency comprising;
 - a first step (301) of demodulating the signal received, the said demodulation is carried out by using a second frequency
 - a second step (302) of determining the gap between at least one of the first frequencies and the said second frequency by determination of

at least two second temporal intervals in which the energy of the said demodulated signal is a maximum.

7. Method of reception according to Claim 6, in which the said second step (302) is furthermore adapted for the determination of a second duration separating the two second intervals and/or the comparison between the said second duration and the said first durations.

8. Method of reception according to Claim 6 and 7, in which the said second step (302) is furthermore adapted for the determination of at least three second temporal intervals in which the energy of the said demodulated signal is a maximum and/or for the determination of two second durations separating the two second intervals and/or the comparison between the said second durations and the said first durations.

9. Frequency synchronization system comprising;

- at least one satellite (501) and/or at least one terrestrial station (503) able to emit a frequency synchronization signal according to one of Claims 1 to 5 and
- at least one satellite terminal (502) able to receive a frequency synchronization signal according to one of Claims 6 to 8.