

Description

Eurobalise vehicle device and method for operating a
Eurobalise vehicle device

Eurobalise beacons are data transmission devices for spot transmission which are installed at fixed points in the track and transmit data like a transponder when passed over by a rail vehicle. When the rail vehicle passes over the Eurobalise, the transmitted data is picked up by a Eurobalise vehicle device and transmitted further for the purpose of automatic train control.

Eurobalise vehicle devices can be negatively affected by interference due to electromagnetic fields. The electromagnetic interference can be caused in particular by radio transmitters which are located relatively close to the track and transmit in the uplink frequency range of the Eurobalises, i.e. in the frequency range in which the Eurobalises send their useful information. The range from 2.5 MHz to 6.0 MHz may be regarded as the uplink range. In this frequency range, the Eurobalise vehicle device does not need to conform to the usual electromagnetic immunity requirements.

External (alien) radio transmitters not belonging to the system typically transmit over a very narrow bandwidth in the Eurobalise uplink frequency range and from the vehicle's perspective can look like balises constantly transmitting "0" or "1", and as a result can lead to an operational malfunction.

For this reason a discrimination threshold has been introduced which in many cases suppresses interfering radio transmitters;

these radio transmitters consequently have no effect on the Eurobalise vehicle device. Such a discrimination threshold is mandated to protect against crosstalk. However, this known method falls short if an interfering radio transmitter exceeds said discrimination threshold. This can be the case with radio transmitters that have a high transmit power and in addition may possibly be located close to the track.

A further measure against a disrupting influencing of the Eurobalise vehicle device by interfering radio transmitters consists in filtering the received signal with respect to time. This is because the signals from Eurobalises are always received over a certain minimum distance; taking the vehicle speed as a basis, this results in a minimum reception time. All received signals that are shorter than said minimum reception time are treated as interference by the Eurobalise vehicle device and ignored. However, this method proves inadequate if the interfering transmitter is received for longer than said minimum reception time, which will very frequently be the case.

The object underlying the invention is to propose a Eurobalise vehicle device by means of which interference due to radio transmitters is avoided with a high degree of reliability and probability.

In order to achieve this object, a Eurobalise vehicle device is equipped according to the invention with two reception frame antennas having identical reception characteristics and the same spatial orientation, and with an evaluation device connected to the reception frame antennas which, when a transmitter is passed, flags an alien, non-Eurobalise reception if the reception level difference of the reception

frame antennas has been predominantly below a predetermined lower reception level during the presence of a reference signal, wherein the reference signal corresponds to a received signal which can be determined during a passing of the transmitter. In this case each reception frame antenna preferably consists of a single winding and is therefore also often referred to in the technical jargon as a "loop".

A Eurobalise vehicle device having two reception frame antennas and an evaluation device connected thereto is in fact known from US patent specification 6 693 562 B2, though in that case the signals received by the frame reception antennas are evaluated in the evaluation device in such a way that a position of the vehicle centered precisely over the Eurobalise in the track can be reached.

The invention is based on the knowledge that a Eurobalise is characterized by an inhomogeneous transmit field, as shown in Figure 1. In contrast thereto, the transmit field of an - interfering - radio transmitter is generally considerably more homogeneous, as is shown in Figure 2. This difference can be exploited for the purpose of distinguishing between Eurobalises and interfering radio transmitters having relatively homogeneous transmit fields. To that end, the two reception frame antennas are provided with identical reception characteristics and the same spatial orientation and are used to compare the field strength and the phase of the magnetic field received in each case at the locations of the two reception frame antennas. In the case of a homogeneous or predominantly homogeneous field, field strength and phase are the same or very similar in both reception frame antennas. In an inhomogeneous field, in contrast, the reception frame antennas detect different field strengths and phases. By

forming the difference between the received signals of the two reception frame antennas it is then easy to identify an electric field homogeneity that may possibly be caused by an alien transmitter that is not associated with vehicle traffic. In a homogeneous field, the reception level difference of the reception frame antennas is practically zero, which is exploited according to the invention to flag a non-Eurobalise reception when the transmitter is being passed if the reception level difference of the reception frame antennas has been predominantly below a predetermined lower reception level (Sw) during the presence of the reference signal or signal received from the transmitter. An erroneous influencing of the automatic train control by an interfering transmitter can be avoided as a result.

The Eurobalise vehicle device according to the invention can be embodied in different ways for the purpose of obtaining the reference signal. It is regarded as particularly advantageous if the two reception frame antennas are assigned an additional reception antenna, the received signal of which forms the reference signal, and the evaluation device has an additional input for the additional reception frame antenna.

The evaluation of the received signals supplied by the two reception frame antennas and the connection of the latter to the evaluation device can be implemented in different ways. It is regarded as advantageous if the two reception frame antennas are connected to a difference former in the evaluation device which forms an electrical signal corresponding to the reception level difference; connected to the difference former is a comparator which emits signals flagging a non-Eurobalise reception at the output of the Eurobalise vehicle device when the received signal is present

and if there is a reception level difference of the reception frame antennas that is predominantly below the predetermined lower reception level.

In this case it can be established with a high degree of reliability and probability by means of a comparison of the electrical signal formed by the difference former and corresponding to the reception level difference and the predetermined lower reception level whether the reception level difference is below the predetermined reception level. If this is the case while the received signal is present, then a source of interference is present and signals at the output of the Eurobalise vehicle device flag a non-Eurobalise reception.

It may, however, also be advantageous under certain conditions to connect the two reception frame antennas in series in a crossover arrangement in such a way that the reception level difference of the two reception frame antennas is present at the common output of the series connection; connected to the common output of the series connection in the evaluation device is a level comparator unit which emits signals flagging a non-Eurobalise reception at the output of the Eurobalise vehicle device when the received signal is present and if there is a reception level difference of the reception frame antennas that is below the predetermined lower reception level. The advantage of this embodiment variant of the Eurobalise vehicle device according to the invention consists in the fact that it manages without a special difference former, because a reception level difference is present at the common output of the series connection of the two reception frame antennas as a result of the interconnection by circuitry of said two frame antennas.

It is furthermore considered advantageous to connect the two reception frame antennas to a sum former in the evaluation device which determines a reception level sum of the reception frame antennas as the received signal of the transmitter; the reception frame antennas are connected to a difference former in the evaluation device which forms an electrical signal corresponding to the reception level difference, and connected to the difference former is a comparator which emits signals flagging a non-Eurobalise reception at the output of the Eurobalise vehicle device when the received signal is present and if there is a reception level difference of the reception frame antennas that is below the predetermined lower reception level.

The invention further relates to a method for operating a Eurobalise vehicle device and addresses the object of embodying such a method in such a way that a disrupting influencing of the Eurobalise vehicle device by interference signals is avoided with a high degree of reliability and probability.

Serving to achieve this object according to the invention is a method for operating a Eurobalise vehicle device having two reception frame antennas with identical reception characteristics and the same spatial orientation, and having an evaluation device connected to the reception frame antennas, in which method an alien, non-Eurobalise reception is assumed when a transmitter is passed if the reception level difference of the reception frame antennas has been predominantly below a predetermined lower reception level (Sw) during the presence of a reference signal, wherein the

reference signal corresponds to a received signal which can be determined during a passing of the transmitter.

By means of said method the same advantage as is disclosed hereinabove in connection with the Eurobalise vehicle device according to the invention can be achieved in an analogous manner.

The method according to the invention is particularly advantageous when the received signal of an additional reception antenna assigned to the two reception frame antennas is used as the reference signal, and an evaluation device having an additional input for the additional reception frame antenna is used as the evaluation device.

It is furthermore considered advantageous if an electrical signal corresponding to the reception level difference of the two reception frame antennas is formed by means of a difference former, and signals flagging a non-Eurobalise reception are emitted at the output of the Eurobalise vehicle device by means of a comparator connected to the difference former when the reference signal is present and if there is a reception level difference of the reception frame antennas that is predominantly below the predetermined lower reception level. In this case it is namely advantageously possible to achieve reliably and with little overhead the outcome that signals flagging a non-Eurobalise reception are issued in the event of interference.

The same advantageous result can be achieved using a different embodiment variant of the method according to the invention in which two reception frame antennas connected in series in a crossover arrangement are employed in such a way that the

reception level difference of the two reception frame antennas is present at the common output of the series connection, and signals flagging a non-Eurobalise reception are emitted at the output of the evaluation device by means of a level comparator unit connected to the common output of the series connection in the evaluation device when the received signal is present and if there is a reception level difference of the reception frame antennas that is below the predetermined lower reception level.

It is furthermore advantageously possible using the method according to the invention to determine, by means of a sum former in the evaluation device connected to the two reception frame antennas, a reception level sum of the reception frame antennas as a received signal and to form an electrical signal corresponding to the reception level difference by means of a difference former in the evaluation device connected to the reception frame antennas; signals flagging a non-Eurobalise reception are generated at the output of the Eurobalise vehicle device by means of a comparator connected to the difference former when the received signal is present and if there is a reception level difference of the reception frame antennas that is below the predetermined lower reception level.

In the interests of explaining the invention further,
Fig.3 shows an exemplary embodiment of a Eurobalise vehicle device according to the invention having two reception frame antennas and an additional reception frame antenna,

Fig.4 shows a diagram intended to indicate the variation of the reception level difference of the two reception frame antennas when passing over a Eurobalise,

- Fig.5 shows a similar diagram in the case of interference when passing over a Eurobalise,
- Fig.6 shows a further exemplary embodiment of the Eurobalise vehicle device according to the invention having only two reception frame antennas, and
- Fig.7 shows an exemplary embodiment having reception frame antennas connected in series in a crossover arrangement.

As Figure 3 shows, the illustrated Eurobalise vehicle device 1 has a first reception frame antenna 2 and a further reception frame antenna 3, each consisting of a single winding. The two reception frame antennas 2 and 3 are embodied identically, i.e. they possess identical reception characteristics and have the same spatial orientation, in other words they are dimensioned to be of equal size and are arranged next to one another on a surface F, which corresponds in terms of its size to the surface area of a transmit frame antenna (not shown) of an associated Eurobalise (likewise not shown). Also arranged on the surface F is an additional reception frame antenna 4 which comprises the two reception frame antennas 2 and 3.

The reception frame antenna 2 is connected via terminals 5 and 6 to a difference former 7 in an evaluation device 8. The further reception frame antenna 3 is also connected to the difference former 7 by means of further terminals 9 and 10. An electrical signal Sd is accordingly generated by means of the difference former 8 at its outputs 11 and 12, said electrical signal Sd corresponding to a reception level difference of the two reception frame antennas 2 and 3.

The additional reception frame antenna 4 is likewise connected to the evaluation device 8 by means of its outputs 13 and 14

and supplies a reference signal which, when a transmitter is passed, corresponds to the received signal caused by the same.

In order to explain the mode of operation of the Eurobalise vehicle device 1 illustrated in Fig. 3, reference is made in the following to Figures 4 and 5:

Figure 4 reproduces the reception level conditions in absolute values P when a rail vehicle passes over a Eurobalise on a section of track x without spurious signals caused by an interfering radio transmitter. A curve $K1$ indicates the absolute value of the received signal at the outputs 13 and 14 of the additional reception frame antenna 4. The curve $K2$ shows how the absolute value of the reception level difference of the two reception frame antennas 2 and 3 or, as the case may be, the electrical signal S_d changes when the rail vehicle passes over the Eurobalise. At the point designated by "0" or the center of the Eurobalise (not shown), the reception level difference or the electrical signal S_d assumes a value of zero. It can be seen that while the received signal according to curve $K1$ is present, the absolute value of the reception level difference of the two reception frame antennas 2 and 3 or the electrical signal S_d according to curve $K2$ is predominantly above a threshold value S_w (cf. Fig. 5), which is determined by a comparator (not shown). A signal indicating that a Eurobalise has been passed over is then present at an output 15 of the evaluation device 8 or of the Eurobalise vehicle device 1.

Fig. 5 shows how the conditions in relation to the reception level difference appear when a rail vehicle passes over an arbitrary transmitter instead of a Eurobalise. There, a curve $K3$ represents the absolute value of the sound level P ,

received at the additional reception frame antenna 4, of the receive or reference signal caused by the transmitter, while the curve K4 or, as the case may be, the horizontal straight line indicates that the reception level difference is very low. In the case shown, the value of the curve K4 when the received signal is present is always below the threshold value S_w , which is evaluated to the effect that the received signals originate from a source of interference. A signal flagging a non-Eurobalise reception occurs at the output 15 of the evaluation device 8; interference due, for example, to a radio transmitter as transmitter has no effect on the automatic train control.

The Eurobalise vehicle device 16 according to Fig. 6 is comparatively simple in its design, because it in turn has only a first reception frame antenna 18 and a second reception frame antenna 19. The two frame antennas 18 and 19 are connected by means of their terminals 20 and 21 and 22 and 23, respectively, in each case independently to a difference former 24 and a sum former 25 in an evaluation device 26. A difference signal S_d corresponding to the reception level difference of the two reception frame antennas 18 and 19 is accordingly generated at outputs 27 and 28 of the difference former 24, whereas a sum signal S_s reflecting the sum of the reception levels of the reception frame antennas 18 and 19 occurs at the outputs 29 and 30 of the sum former 25. Said sum signal S_s corresponds to a received signal of a transmitter, i.e. it accordingly represents the signal of a Eurobalise in interference-free operation when a rail vehicle passes over the Eurobalise and is therefore present during interference-free operation as a Eurobalise signal at an output 31 of the evaluation device 26 or of the Eurobalise vehicle device 16,

because the difference signal S_d is predominantly above the predetermined threshold S_w .

If a reception level difference that is predominantly below a predetermined lower reception level occurs at the outputs 27 and 28 of the difference former 24 while the received signal corresponding to the sum signal S_s is present, then this is an indication that an arbitrary transmitter, and not a Eurobalise, has been passed, in which case a signal flagging a non-Eurobalise reception is emitted at the output 31.

In the exemplary embodiment according to Fig. 7, two reception frame antennas 40 and 41 are connected in series in a crossover arrangement and have common outputs 42 and 43. A signal corresponding to the reception level difference of the two reception frame antennas 40 and 41 is generated at said outputs. Also provided is an additional reception frame antenna 44, at the outputs 45 and 46 of which a received signal occurs when a transmitter is passed.

If the signal at the common outputs 42 and 43 of the two reception frame antennas 40 and 41 is predominantly lower than a predetermined threshold value S_w while the received signal is present (cf. Figure 5) - this is ascertained by means of a level comparator unit (not shown) - then a signal flagging a non-Eurobalise reception is emitted by the evaluation device 47 at its output 48, and no influencing of the automatic train control takes place because in this case the received signals are caused by an interfering radio transmitter.

Claims

1. A Eurobalise vehicle device (1;16;32) having two reception frame antennas (2,3;18,19;40,41) with identical reception characteristics and the same spatial orientation, and having an evaluation device (8;26;47) connected to the reception frame antennas (2,3;18,19;40,41) which, when a transmitter is passed, flags a non-Eurobalise reception if the reception level difference (Sd) of the reception frame antennas (2,3;18,19;40,41) while a reference signal is present has been predominantly below a predetermined lower reception level (Sw), wherein the reference signal corresponds to a received signal which can be determined during a passing of the transmitter.

2. The Eurobalise vehicle device as claimed in claim 1, characterized in that the two reception frame antennas (2,3; 40,41) are assigned an additional reception antenna (4;44), the received signal of which forms the reference signal, and the evaluation device (8;47) has an additional input for the additional reception frame antenna (4;44).

3. The Eurobalise vehicle device as claimed in claim 2, characterized in that the two reception frame antennas (2,3) are connected to a difference former (7) in the evaluation device (8) which forms an electrical signal (Sd) corresponding to the reception level difference, and connected to the difference former (7) is a comparator which emits signals flagging a non-Eurobalise reception at the output (15) of the Eurobalise vehicle (1) device when the received signal is present and if there is a reception level

difference of the reception frame antennas (2,3) that is predominantly below the predetermined lower reception level (Sw).

4. The Eurobalise vehicle device as claimed in claim 2, characterized in that the two reception frame antennas (40,41) are connected in series in a crossover arrangement in such a way that the reception level difference of the two reception frame antennas (40,41) is present at the common output (42,43) of the series connection, and connected to the common output (42,43) of the series connection in the evaluation device (47) is a level comparator unit which, when the received signal is present and there is a reception level difference of the reception frame antennas (42,43) that is below the predetermined lower reception level, emits signals flagging a non-Eurobalise reception at the output (48) of the Eurobalise vehicle device (32).

5. The Eurobalise vehicle device as claimed in claim 1, characterized in that the two reception frame antennas (18,19) are connected to a sum former (25) in the evaluation device (26) which determines a reception level sum of the reception frame antennas as the received signal of the transmitter, the reception frame antennas (18,19) are connected to a difference former (24) in the evaluation device which forms an electrical signal (Sd) corresponding to the reception level difference, and connected to the difference former (7) is a comparator which, when the received signal is present and there is a reception level difference of the reception frame antennas (2,3) that is below the predetermined lower reception level (Sw), emits

signals flagging a non-Eurobalise reception at the output (15) of the Eurobalise vehicle device (1).

6. A method for operating a Eurobalise vehicle device (1;16,32) having two reception frame antennas (2,3;18,19;40,44) with identical reception characteristics and the same spatial orientation, and having an evaluation device (8;26;47) connected to the reception frame antennas (2,3;18,19;40,44), in which method a non-Eurobalise reception is assumed when a transmitter is passed if the reception level difference of the reception frame antennas (2,3;18,19;40,41) has been predominantly below a predetermined lower reception level (S_w) during the presence of a reference signal, wherein the reference signal corresponds to a received signal which can be determined during a passing of the transmitter.

7. The method as claimed in claim 6, characterized in that the received signal of an additional reception antenna (4;44) assigned to the two reception frame antennas (2,3; 40,41) is used as the reference signal, and an evaluation device (8;47) having an additional input for the additional reception frame antenna (4;44) is used as the evaluation device.

8. The method as claimed in claim 7, characterized in that an electrical signal (S_d) corresponding to the reception level difference of the two reception frame antennas (2,3) is formed by means of a difference former (7), and signals flagging a non-Eurobalise reception are emitted at the output (15) of the Eurobalise vehicle device (1) by means of a comparator connected to the difference former (7) when the reference signal is present and if there is a reception level difference of the reception frame antennas (2,3) that is

predominantly below the predetermined lower reception level (Sw) .

9. The method as claimed in claim 7 or 8, characterized in that two reception frame antennas (40,41) connected in series in a crossover arrangement are employed in such a way that the reception level difference of the two reception frame antennas (40,41) is present at the common output (42,43) of the series connection, and signals flagging a non-Eurobalise reception are emitted at the output (48) of the evaluation device (47) by means of a level comparator unit connected to the common output (42,43) of the series connection in the evaluation device (47) when the received signal is present and if there is a reception level difference of the reception frame antennas (40,41) that is below the predetermined lower reception level (Sw) .

10. The method as claimed in claim 6, characterized in that a reception level sum of the reception frame antennas (18,19) is determined by means of a sum former (25) connected to the two reception frame antennas (18,19) in the evaluation device (26) as the received signal of the transmitter, an electrical signal (Sd) corresponding to the reception level difference is formed by means of a difference former (24) connected to the reception frame antennas (18,19) in the evaluation device (26), and signals flagging a non-Eurobalise reception are generated at the output (15) of the Eurobalise vehicle device by means of a comparator connected to the difference former (7) when the received signal is present and if there is a reception level difference of the reception frame antennas (18,19) that is

predominantly below the predetermined lower reception level (Sw) .