

HIGH FREQUENCY IDENTIFICATION MEDIUM WITH PASSIVE, ELECTRONIC DATA CARRIER

The invention relates to a high frequency identification medium with a passive, electronic data carrier according to the preamble of claim 1, having a receiving antenna for receiving operating energy and for the contactless transmission of HF signals to an associated write and read station with a transmitting antenna, which has a carrier frequency of more than 1 MHz. High frequencies with a system clock or carrier frequency of over 1 MHz are necessary in order to be able to attain high communications and transmission efficiencies. An example for this is the Kaba AG Legic System.

As opposed to the situation with r.f. radio transmissions, where high efficiencies are sought in long range, with identification media a high transmission association in both directions is only necessary in close range, whereas in the long range the efficiency and also the corresponding losses are to be kept very small. This requires a very strong coupling of the two antennas, write and read station and identification medium, as well as a special configuration of the antennas.

In order with such passive identification media to pick up a good energy transmission with the receiving antenna and therefore so as to achieve a maximum range in the coupling region, use is made of receiving antennas with high inductance, i.e. with numerous turns, and only the inherent capacitance of the data carrier MI as the associated resonant circuit capacitance. However, with said known identification media there are still considerable limitations and problems. The tuning of the identification medium to the carrier frequency is only possible to a very limited extent. There is a non-constancy of the receiver frequency. There are also strong influences on the receiver frequency. This leads to a reduced range and communications efficiency.

The problem of the invention is to provide an identification medium, which has significant improvements in connection with these problems. This problem is solved by an identification medium according to claim 1, with which much better transmission characteristics can be achieved.

Contrary to the entire development trend, there is not a maximum input voltage at the identification medium or at the data carrier as a result of

high inductance antennas and instead the input voltage and inductance, i.e. the number of turns of the antenna are reduced and correspondingly the total capacitance is greatly increased by introducing an additional, external capacitance C_e , which is higher than the internal capacitance C_i of the data carrier MI.

This leads to several advantages, whose combination leads to much better transmission characteristics:

The receiver frequency of the identification medium can be set much better and more precisely to the carrier frequency.

The receiver frequency is substantially constant and less dependent on external influences.

This leads to a higher, constant range R of the communications and therefore to better communications efficiencies.

The dependent claims relate to advantageous further developments of the invention, which lead to further improvements of the transmission characteristics, as well as permitting a more universal use of such identification media. The invention is described in greater detail hereinafter relative to embodiments and the attached drawings, wherein show:

- Fig. 1 An inventive identification medium IM with external capacitance.
- Fig. 2 An associated write and read station WR.
- Fig. 3 Another example of an identification medium with coded communications.
- Fig. 4 An example with twin antenna and associated, external capacitances.
- Fig. 5 The communications characteristics as a function of the receiver frequency relative to the carrier frequency.

Fig. 6 The dependence of the receiver frequency on the coupling.

Fig. 7 The range R and solid angle W of the communications and the influence of the relative orientation of the antennas.

Fig. 8 An example of an identification medium in ISO card size with conducting paths as antenna.

Fig. 9 A small identification medium with ferrite antenna in the form of a bracelet.

Fig. 10 A small format key ring as an identification medium.

Figs. 1 and 3 show examples of inventive identification media IM and fig. 2 shows an associated write and read station WR. The diagrammatic representation of fig. 1 shows an identification medium IM with passive, electronic data carrier MI, which contains a processor 11, a control electronics 13 and a memory 12. A receiving antenna 15 with inductance L is used for receiving operating energy 20a and for the contactless transmission of HF signals 20 to the associated read or write and read station WR. An external capacitance C_e is connected in parallel with the receiving antenna 15 and is higher than the internal capacitance C_i of the data carrier MI. The inductance L of the antenna and the external capacitance C_e are so tuned, that a natural frequency f of the identification medium is obtained, which corresponds to the carrier frequency f_r . The carrier frequency f_r is determined by the write and read station WR and its transmitting antenna 24.

The associated read station or write and read station WR according to fig. 2 generates the system clock, the carrier frequency f_r , which is transmitted with the transmitting antenna 24 to the identification media IM. Both the energy 20a, which is required for operating the identification medium IM, and the data 20b are transmitted by the write and read station WR to the identification medium IM. In order to be able to achieve high communications efficiencies, the carrier frequency must be in the range above 1 MHz, preferably between 5 and 20 MHz and not above 30 MHz. This is inter alia linked with the fact that a very good transmission, i.e. a strong coupling must be

obtained in the close range, whereas in the long range a minimum power is to be emitted. With the indicated high frequency range, said near field range is between approximately 1 and 100 metres and therefore in a range which is important for identification media. A favourable carrier frequency is e.g. in the ISM band of 13.56 MHz with which optimum transmission characteristics can be obtained for communications distances up to several metres.

Contrary to the general development direction, the inventive principle of deliberately reducing the inductance L of the receiving antenna 15 and increasing the given capacitance C_i of the identification medium by a higher, external additional capacitance C_e , leads to a significant improvement to the communications efficiency K_L , despite a reduced input voltage, corresponding to the reduced inductance L at the receiving antenna 15.

This is illustrated in figs. 5 to 7. Fig. 5 illustrates the dependence of the communications efficiency K_L on the coincidence of the carrier frequency f_r of the write and read station and the transmitting antenna 24 with the natural frequency f of the identification medium and the receiving antenna 15. The communications efficiencies (or communications capacity or characteristics) are e.g. the range R and solid angle W of the communication, as well as the angular range W_2 of the relative position of the receiving antenna 15 with respect to the field of the antenna 24 in which communication is possible.

As is apparent from fig. 5, the communications efficiency is very strongly dependent on the coincidence of carrier frequency f_r and receiver frequency f , i.e. an optimum coupling is achieved in the case of coincidence of the two natural frequencies: $f = f_r$. With an increasing difference $f - f_r$, the communications efficiency drops very rapidly, so that even in the case of a divergence of a few per cent inadequate communications efficiencies K_L are obtained.

This coincidence of the two antenna frequencies f and f_r , i.e. the implementation of a natural frequency f of the identification medium, which corresponds to a given transmitter frequency f_r of the write and read station WR , was hitherto scarcely possible for various reasons.

Fig. 6 shows the dependence of the natural frequency f on the antenna coupling AK or the spacing of the two antennas. The natural frequency f_1 of a known identification medium drops in a very pronounced manner with increased coupling AK , e.g. by 10%. However, the frequency response f_2 of a novel antenna according to the invention shows a much smaller drop of e.g. only 1 to 3%. Thus, a permitted tolerance range Df of e.g. $\pm 2\%$ can be much more readily achieved with the stable, novel antenna according to curve f_2 than with the unstable, known antenna according to curve f_1 . Thus, the novel antenna leads to much higher communications efficiencies (R , W , W_2).

This is illustrated in fig. 7 with the field lines H of the transmitting antenna 24 of the write and read station WR and with an attainable range R and a maximum solid angle W within which communication with the identification medium IM is possible. This is additionally dependent on the relative position of the receiving antenna 15 in the field H . With increasing angle W_2 between the antenna normal and the field direction H , the communications capacity drops. Much higher values of R , W , W_2 are attained with the novel receiving antennas 15 according to the invention.

This is illustrated in the following comparison example for a carrier frequency f_r of 13.56 MHz and identification media in the ISO format (cf. fig. 8) for a known and a novel identification medium. In order that a natural frequency $f = f_r$ is obtained in the coupling state, the natural frequencies of the identification media in the unloaded state must be set to the following values:

For a known antenna $f_1 = 16.5 \pm 1.5$ MHz

For a novel antenna $f_2 = 13.6 \pm 0.3$ MHz

For the natural frequencies f of the identification media the following relationship applies: $(2\pi \cdot f)^2 \cdot L \cdot C = 1$.

This e.g. gives the following values:

Known identification medium	$C = C_i = 16$ pF
	$L = 6$ μ H

Number of turns $N = 5$ to 6

Novel identification medium $C = C_i + C_e = 16 \text{ pF} + 100 \text{ to } 300 \text{ pF}$
 $L = 1.2 \text{ to } 0.5 \text{ } \mu\text{H}$

Number of turns $N = 2$ to 3

The strong dependence of the coupling AK of the known antennas according to curve f_1 in fig. 6 results from a strong dependence of the internal capacitance C_i of the data carrier MI on the coupling. This dependence is very significantly reduced with the relatively large, external capacitance C_e , which is independent of the coupling AK in the novel antenna according to curve f_2 in fig. 6.

Preferably the stable, external capacitance C_e with high quality is chosen several times greater than the internal capacitance C_i , e.g. 5 to 10 times. This leads to a much higher quality factor $Q = f_r/B$ (resonant frequency/band width) of the resonant circuit of the identification medium. Preferably the quality factor Q is at least 50.

The non-constancy or changes to the antenna frequency f in the known identification media result from different influences. These include a change to the internal capacitance C_i of the data carrier which, apart from the indicated dependence on the coupling intensity, is also influenced by ambient conditions, stray fields, conductors in the field, parasitic capacitances and ageing effects. Added to this is the high loss factor (poor quality) of the internal capacitance C_i , as well as relatively large production dispersions of the C_i values. All these influences and changes to the C_i values lead to corresponding changes to the natural frequency f in the known identification media.

In the inventive antenna, these influences are removed by the external, high quality capacitance C_e , stability or constancy, as well as the precisely defined, selectable capacitance values, at least to a very significant extent, so that there is a correspondingly constant, clearly defined and selectable frequency f , which leads to the indicated high communications efficiencies KL .

The inventive concept also leads to significant advantages with respect to the design and production of identification media. As the natural frequency f is much more precisely defined and is also measurable, it can also be much more accurately tuned to the carrier frequency f_r . The setting of a desired nominal value for the natural frequency f is possible in a much simpler and more precise manner, because the additional, external capacitance C_e has a precisely defined, constant value, which can be randomly selected. Thus, also the relatively large dispersions of the C_i values during the manufacture of integrated circuits are compensated in a simple manner. In addition, e.g. also with an antenna design (with regards size and number of antenna loops) by the choice of different, external capacitance values, it is easy to achieve corresponding different, desired natural frequency values f of the identification medium.

As there must be an integral number of antenna turns N and there is a given internal capacitance C_i of the data carrier MI , the implementation of a desired nominal value for the natural frequency f is very difficult and imprecise during production in the case of the known identification media.

Fig. 3 illustrates an example of an identification medium for coded communications. The data carrier MI , preferably constructed as an ASIC chip 16, here contains a support capacitor 17 for storing the received energy and for bridging transmission pauses or intervals, a voltage regulator 3, a clock processing means 4, a receiving demodulator 5, a transmitting modulator 6 and a coding and communications logic 7, as well as a writable EEPROM 12, which preferably has at least 256 bytes. An advantageous energy and data transmission between the write and read station WR and identification medium IM can be achieved by pulse modulation (pulse-pause modulation) from the write and read station WR to the identification medium IM and by load modulation in the opposite direction from IM to WR .

Such identification media with access and authorization functions are known for various installations and applications, e.g. as access cards for certain areas within a company (electronic keys), for time management, as access media for equipment, e.g. data installations, or as check card systems for obtaining services. The inventive identification media with much higher

transmission efficiencies and capacities are therefore particularly suitable for applications having high demands with respect to functional reliability and data integrity, monitorability, prevention of misuse, etc. For this purpose use is made of a coded communication between identification medium IM and write and read station WR, e.g. in that the latter generates new initializing data for each identification process and transmits it to the identification medium IM, which is linked there with a fixed-stored encoding code 32 (in fig. 3) and is transmitted back in coded form to the write and read station, where said information is decoded and checked and then a synchronized communication takes place between WR and IM.

The identification medium can additionally be combined with a personal coding function, in order to satisfy particularly high security requirements. For this purpose e.g. a PIN code or biometric data codes can be used. Personal, biometric data are e.g. established from fingerprints or finger, hand or head geometry and compared with the corresponding code 33 stored in the data carrier MI (fig. 3) for personal identification and checking of an authorized carrier.

Another very important application, which is only made possible with identification media having a high communications capacity, is a higher data organization of the memory 12 of the data carrier MI and several independent applications can be written in a segmentable application data field ADF. Thus, due to the higher communications efficiency of the inventive identification medium there is a virtual increase in its number of functions.

Fig. 4 shows another example of an identification medium with a receiving antenna constructed as a twin antenna with two loops 15.1 and 15.2. Here the first antenna loop 15.1 is used for receiving electromagnetic field energy 20a for supplying the data carrier and for receiving the data 20b of the write and read station WR. The second antenna loop 15.2 is used for transmitting data 20b to the write and read station WR. The antenna parts 15.1 and 15.2 correspond to the internal capacitances C_{i1} and C_{i2} of the data carrier MI. The external capacitances C_{e1} and C_{e2} connected in parallel to each antenna loop 15.1 and 15.2 are so dimensioned that the antenna frequencies of the two antenna loops are the same and for the same partial

inductances L_1 , L_2 this means: $C_{e1} + C_{i1} = C_{e2} + C_{i2}$.

Figs. 8a and b show as a particularly frequently used size or format an identification medium in ISO card size 28 (85 x 54 mm) with conducting paths 26 on a printed circuit board, here serving as a transmitting antenna 15. The antenna loops can be integrated with the external capacitance C_e and with the data carrier MI on a carrier 29 (inlet) and consequently form a unit manufacturable in a particularly rational manner. The external capacitance C_e can e.g. be a ceramic capacitor having a very shallow construction of e.g. 0.3 to 0.5 mm thick and with a higher quality in the MHz frequency range.

Figs. 9 and 10 show examples of identification media with a small format (30), the diameter DA of the receiving antenna 15 utilizing as completely as possible the space available, so that the antenna surface FA corresponds to almost the entire surface of the identification medium. With such small format identification media with antenna diameters of 30 mm and less, e.g. only 10 mm, it is particularly difficult to obtain good communications characteristics and long ranges. As a result of the inventive combination with the additional, external capacitance C_e and the correspondingly reduced inductance L of the antenna 15 correspondingly fewer loop turns are required than hitherto and it is possible to operate with smaller antenna surfaces than hitherto. Thus, with small identification media such as keys, key rings, tokens, etc. it is possible to obtain roughly the same communications ranges as have been possible with the hitherto known relatively large ISO format cards, so that completely new applications arise.

Fig. 9 shows an example in which the receiving antenna is constituted by a ferrite antenna 19 with a bar-shaped ferrite and an electrical winding. In this example the identification medium is worn on a bracelet 36.

The small format identification medium of fig. 10 is a pendant 37, e.g. a key ring. However, this identification medium could also be combined with a key, e.g. on the key grip, or could be associated with a carrier in some other form. An example of a very small identification medium is constituted e.g. by rings, which can be fixed to the foot of homing pigeons for identifying individual pigeons during races.

For such small format identification media in accordance with figs. 9 and 10 for a carrier frequency f_r of 13.56 MHz, e.g. external capacitances C_e of 50 to 150 pF are used and there is a corresponding reduction of the number of turns of the antenna loops e.g. to less than half.

According to a particularly advantageous further development of the invention, the carrier frequency f_r on the transmission side is stabilized in the same way, the transmitting antenna 24 of the write and read station WR is made more independent of external, capacitive influences. Although the carrier frequency f_r is in itself much more stable than the natural frequency f of the identification medium, through a further stabilization of the carrier frequency f_r it is possible to further improve the communications characteristics KL in the same sense as for the identification medium and in particular the range R can be increased.

In principle, the carrier frequency f_r is subject to the same influences as described hereinbefore, namely capacitive changes in the environment, e.g. through the approach of the human body and metal objects, manufacturing tolerances, ageing of components, etc. The accurate setting of a desired nominal value for the carrier frequency f_r has also hitherto involved a complicated tuning.

Through the application of the same principle to the transmitting antenna 24 as used for the receiving antenna 15, the indicated stabilization and improvements are achieved. As illustrated in fig. 2 as a variant, an additional capacitance C_z is connected in parallel to the transmitting antenna and its inductance is correspondingly reduced, so that the product L.C of the transmitting antenna 24 remains constant. The additional capacitance C_z is preferably chosen higher than the existing back-up capacitance of the write and read station WR, relative to the base of the transmitting antenna (i.e. without additional capacitance). The additional capacitance can advantageously be two to five times as high as the existing back-up capacitance.

This additional capacitance C_z comprises a standard component with a selectable, precisely defined and constant C values. Thus, a desired nominal value of the carrier frequency f_r can be achieved on a serial basis in

simple manner and without complicated individual tuning operations.

A particularly advantageous and universally usable transmitting antenna 24 can be constructed as a foil antenna, e.g. as an antenna loop in the form of a wide conducting path on a plastic carrier (in much the same way as the much smaller antenna 15 in the example of fig. 8).

In exemplified manner with a single conducting path loop with a diameter of 60 cm and a path width of 25 mm (appropriately round, oval, rectangular, etc.), it is possible to achieve ranges R of up to 1 m and more. Through a simple choice of the Cz value (as series components) it is possible to directly set any desired carrier frequency fr, without the hitherto necessary testing and tuning operations.

The following references are used in the present application:

3	Voltage regulator
4	Clock processing means
5	Receiving demodulator
6	Transmitting modulator
7	Coding and communications logic
11	Processor
12	Memory
13	Control electronics
15	Receiving antenna of IM
15.1,15.2	Twin antenna
16	ASIC chip
17	Support capacitor
19	Ferrite antenna
20	HF communication
20a	Energy transmission
20b	Data transmission
24	Transmitting antenna WR
26	Conducting path on circuit board
28	ISO card
29	Carrier, inlet

30	Small format
32	Coding
33	Personal, biometric coding function
36	Bracelet
37	Pendant
IM	Identification medium
MI	Electronic data carrier
WR	Read or write and read station
fr	Carrier frequency, system clock of WR
f	Frequency of IM
$Q=fr/B$	Quality factor of IM
H	Field line direction
KL	Communication efficiency, capacity, characteristics
R	Communications range
W	Solid angle for communication
W2	Angle between field direction H and antenna normal
DA	Diameter of transmitting antenna 15
FA	Surface of antenna 15
AK	Antenna coupling (distance)
Df	Tolerance range f - fr
N	Number of turns
L	Inductance
Ce	External capacitance
Ci	Internal capacitance
Cz	Additional capacitance with respect to 24
ADF	Application data field



CLAIMS

1. High frequency identification medium IM with passive electronic data carrier MI, which contains a processor (11), a control electronics (13) and a memory (12), as well as with a receiving antenna (15) for receiving operating energy (20a) and for the contactless transmission of HF signals (20) to an associated write and read station (WR) with a transmitting antenna (24), with a carrier frequency f_r of at least 1 MHz, said carrier frequency being determined by the transmitting antenna, characterized in that an external capacitance C_e is connected in parallel to the receiving antenna (15) and the capacitance C_e is higher than the internal capacitance C_i of the data carrier MI.
2. Identification medium according to claim 1, characterized in that the carrier frequency f_r is determined by the transmitting antenna (24) of the write and read station WR and that the frequency f , as well as the external capacitance C_e and inductance L of the receiving antenna (15) of the identification medium IM is determined by the following relationship:
$$(2\pi \cdot f)^2 \cdot L \cdot (C_i + C_e) = 1, \text{ with } f_r = f \pm 3\%.$$
3. Identification medium according to claim 1, characterized in that the data carrier MI has a support capacitor (17) for storing the energy received, a voltage regulator (3), a clock processing means (4), a receiving demodulator (5), a transmitting modulator (6), a coding and communications logic (7) and an EEPROM (12).
4. Identification medium according to claim 1, characterized in that the data carrier is constructed as an ASIC chip (16) with an EEPROM (12) with at least 256 bytes.
5. Identification medium according to claim 1, characterized in that the carrier frequency f_r is between 1 and 30 MHz, preferably between 5 and 20 MHz.
6. Identification medium according to claim 1, characterized in that the carrier frequency f_r corresponds to the ISM band of 13.56 MHz.

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7. Identification medium according to claim 1, characterized in that the external capacitance C_e is at least five times as high as the internal capacitance C_i of the data carrier MI.
8. Identification medium according to claim 1, characterized in that the external capacitance C_e is between 100 and 300 pF.
9. Identification medium according to claim 1, characterized in that the quality factor $Q = f_r/B$ (resonant frequency/band width) of the IM resonant circuit is at least 50.
10. Identification medium according to claim 1, characterized in that the external capacitance C_e comprises a ceramic capacitor with a maximum thickness of 0.5 mm.
11. Identification medium according to claim 1, characterized in that the receiving antenna (15) is formed as a conducting path (26) on a printed circuit board.
12. Identification medium according to claim 1, characterized in that the antenna loops (15) correspond to the ISO card format (28).
13. Identification medium according to claim 1, characterized in that the antenna loops (15) are integrated with the external capacitance C_e and the data carrier MI on a carrier (29) (inlet).
14. Identification medium according to claim 1, characterized in that, in the case of small format identification media (30), the diameter of the receiving antenna (15) is max 3 cm.
15. Identification medium according to claim 1, characterized in that the receiving antenna is constructed as a twin antenna (15.1, 15.2) with in each case an external capacitance (C_{e1} , C_{e2}) with a centre tap, one antenna loop being used for the reception of energy (20a) and data and the other antenna loop for transmitting data.

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16. Identification medium according to claim 1, characterized in that the receiving antenna is constructed as a ferrite antenna (19) with a bar-shaped ferrite and electrical winding.

17. Identification medium according to claim 1, characterized in that the data transmission from the write and read station WR to the identification medium IM takes place by pulse modulation and in the opposite direction by load modulation.

18. Identification medium according to claim 1, characterized in that the communication (20) between the write and read station WR and identification medium IM is coded (32).

19. Identification medium according to claim 18, characterized in that the memory (12) has a segmentable application data field ADF for several independent applications.

20. Identification medium according to claim 18, characterized in that the data carrier MI contains an additional personal coding function (33), such as a PIN code or a biometric data code.

21. Identification medium according to claim 1 with associated write and read station, characterized in that the write and read station WR has a transmitting antenna (24), with which is connected in parallel an additional capacitance Cz.

22. Identification medium according to claim 21, characterized in that the additional capacitance Cz is at least as large as the back-up capacitance of the write and read station WR, relative to the base of the transmitting antenna (24) without additional capacitance Cz.

23. Identification medium according to claim 21, characterized in that the additional capacitance Cz is two to five times as large as the back-up capacitance of the write and read station WR, relative to the base of the transmitting antenna (24) without additional capacitance Cz.

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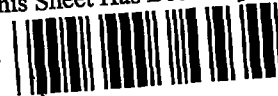
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24. Identification medium according to claim 21, characterized in that the transmitting antenna (24) is constructed as a foil antenna and preferably only has one antenna loop.

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