

The present invention relates to a system for data transmission by modulation-demodulation of an electromagnetic wave, for bidirectional communication between a fixed station, called beacon or reader, and a mobile station, called badge or responder. More precisely, the invention relates to the modem (modulator-demodulator) of the portable badge, for which an improvement contributed by the invention makes it possible to pass from the standby state, with corresponding low consumption but also a low data rate, to an active state, with corresponding higher consumption but a high data rate, multiplied by a factor of the order of 100 or several hundred.

This type of data exchange finds applications in monitoring mobile units, such as identification of wagons on a track, of motor vehicles at a toll or of pedestrians at a building entrance.

The mobile station or badge is presented as a chip card, and it has to be extremely economical in terms of energy, as it is powered by small batteries known as "button" batteries.

The overall diagram of a system for data exchange by electromagnetic or UHF radiation, according to the prior art, is fairly simple, and Figure 1, which represents it, makes it possible to detail the elements thereof, and the acronyms used.

A mobile station or badge 1 comprises a UHF part 3, an information processing part 4 and a power supply 5. The exchanges between these two parts relate to modulation-demodulation and the sending/receiving commands.

The fixed station or beacon 2 comprises a UHF source, a UHF part 6, an information processing part 7, and a computer 8 which makes it possible to manage all of the radio-frequency exchanges carried out with the badges, by means of the antennae 9 for each badge and 10 for the beacon or reader. The following will be used:

- d = distance between the antennae 9 and 10
- G_1 = gain of the antenna 10 of the reader 2
- G_b = gain of the antenna 9 of the badge 1

- P_{li} = power sent to the antenna of the reader 2
- P_{lr} = power received by the antenna of the reader
- P_{bi} = power sent to the antenna of the badge 1
- P_{br} = power received by the antenna of the badge

5 The modulations used in these systems are generally of OOK type (in On-Off-Keying amplitude modulation), of PSK type (in $0/\pi$ Phase-Shift-Keying modulation), or FSK (Frequency Shift Keying) type.

10 The operation of the modem is not the same according to whether the beacon is interrogating the badge or the badge is responding to the beacon.

 In the sense of the interrogation of the badge 1 by the reader 2, the latter generates (P_{li}) a modulated UHF signal. The badge receives this signal (P_{br}) and
15 demodulates it: this is a stage which makes it possible to activate the badge which was in the standby state.

 In the sense of the response from the badge 1 to the reader 2, the reader then generates an unmodulated UHF signal. The badge receives this signal, modulates it
20 - that is to say loads it with the information on the subject on which it has been interrogated - and resends a signal including either losses or gain, as the case may be.

 In fact, the badge may be:

25 - passive, that is to say that the power which it sends out is always less than the power which it receives ($P_{bi} < P_{br}$), and the energy is supplied to it by the reader,
 - or active, that is to say that it comprises a UHF amplifier ($P_{bi} > P_{br}$), which therefore assumes a power
30 supply source such as batteries. There are therefore energy consumption problems at the very least on the badge side, which equate to problems of obtaining sensitivity of the badge in the standby state, and therefore at very low consumption, and sensitivity of the reader
35 having regard to the low level of transmission from the badge, and of the strays contributed by other systems operating at a nearby frequency.

 However, there are additionally problems with digital information rates. The energy economy when the

badge is in the standby state - which is its most usual state - dictates that the demodulation function be carried out at very high impedance: the time constants, related to the input capacitances and to the impedances of the circuits, limit the rates to a few tens of kilobits/second, for example. These rates are not sufficient to provide a normal information traffic between a fixed station and several mobile stations or badges: it is necessary to reach several megabits/second, as soon as the badge is "awakened" and it starts to communicate with the reader.

A high information rate dictates, in turn, that the modulation function of the modem be at low impedance, which corresponds moreover to a higher energy consumption over the duration of the response of the badge to the reader.

The operation of a radio-wave telecommunications system at two "speeds" is a widespread and well-known phenomenon: a peripheral station operates at low energy, and low consumption, while awaiting the wake-up command sent by a central station, which triggers a data exchange at high rate, and thus with greater energy consumption. In order to fulfil these conditions, various devices are possible. For example, in the document EP-A-0 245 555, the peripheral mobile station is equipped with a system having two channels switched by an antenna switch: the receiving channel transmits the coded wake-up signals to a microprocessor and, from then on, the microprocessor switches the antenna onto a sending channel which, among other things, includes two frequency triplers, which provides a high-rate response.

According to the invention, the badge, in the standby state, transmits a series of information at low rates to its processing circuit 4, which information is identified by the said circuit as an interrogation originating from the reader 2. The processing circuit 4 of the badge then "awakens" the modem 3 by sending signals which act on means which modify the impedance or impedances of the modem, and allow it to respond with a

high information rate to the interrogation from the reader.

More precisely, the invention relates to a portable badge, constituting a mobile station in a system for data exchange, by microwave electromagnetic waves, with a fixed station, this badge including a wake-up circuit and being defined by Claim 1.

The invention will be better understood by the more detailed explanation which is now given, based on two embodiment variants, and on the Figures attached in the annex which represent:

- Figure 1: general diagram of data exchange between a fixed station and a mobile station, by electromagnetic waves, according to the prior art, previously explained,
- Figure 2: block diagram of the improvement contributed by the invention to the mobile station or badge in a data exchange system,
- Figure 3: I(V) curve of a field-effect transistor, corresponding to a first variant of the means employed in the context of the invention,
- Figure 4: block diagram corresponding to a second variant of the means employed in the context of the invention,
- Figure 5: electrical diagram of the high-rate modem of a badge, according to the first variant of the invention,
- Figure 6: electrical diagram of the high-rate modem of a badge, according to the second variant of the invention.

Figure 2 repeats the part of the badge 1 of Figure 1, but shows a new link between the modem 3 and the information processing circuit 4.

In the UHF systems comprising a fixed station or reader and a mobile station or badge, the transmission rates are generally limited in the direction from the reader towards the badge. In fact, although there is no particular problem in a reader sending at high rate, since its consumption is of little importance, in contrast if the demodulation function of the badge is the only one, there is only one energy state and the

demodulation has to be carried out at very high impedance, as it corresponds to the standby state at very low energy consumption - because of the "button" batteries which are supplying the badge. The time constants, 5 related to the high impedances of the modem 3 and to the input capacitances of the processing circuit 4, limit the demodulation rate to a few tens of kilobits/second.

This low rate is sufficient to activate the information processing circuit 4, but insufficient to 10 carry out data exchanges between a reader and a plurality of badges: several megabits/second are necessary.

According to the invention, when the processing circuit 4 detects an interrogation originating from the reader 2, it sends the modem 3 of the badge a signal 15 which "awakens" it, and lowers its characteristic impedances, thus allowing a high information rate.

The various links between the modem and the processing circuit of the badge are:

- demodulation: transmits to the processing circuit the 20 demodulated interrogation originating from the reader, which activates the processing circuit,
- modulation: makes it possible to modulate the carrier sent out by the reader; this modulation constitutes the response from the badge sent towards the reader,
- 25 - wake-up: this is the subject of the invention. This link makes it possible to alter the electrical state of the circuits (lowering of impedance) in order to allow high transmission rates. The change of logic state of this signal takes place as soon as the badge is awakened;
- 30 - sending-receiving: as appropriate. This link exists in the case of a badge requiring a change of electrical state of the modem between receiving and sending. For example, a badge which is active in sending for which it is necessary to alter the bias point or points of the 35 transistor or transistors which are active as detectors or modulators.

The electrical states of the badge are thus:

A - Standby

- this is the quasi-permanent state of the badge, when it

is out of range, in space or in time, of a fixed station,
- the consumption is very low, a few microamperes,
limited to the demodulator 3 at very high impedance, and
to supplying the wake-up chain of the processing circuit

5 4,

- the rate of the wake-up information is thus low, at a
few tens of kilobits/second.

B - Reception

10 - this is the phase of the interrogation of the badge by
the reader, after having awakened it,

- the processing circuits are all powered,

- the consumption may be relatively high, a few milli-
amperes, as the reception mode represents only a very
short time compared with the lifetime of the badge,

15 - the information rates may be high, a few
megabits/second by reason of the degree of freedom in the
consumption, over a short period.

C - Sending

20 - this is the phase of response from the badge to the
reader,

- the processing circuits are all powered,

- the consumption, during the brief time interval for
which the response lasts, makes it possible to use a
function, which is active in sending, exhibiting gain at

25 UHF,

- the information rates may be high, for a short time.

The method of awakening the badge is based on a
changing of the bias point of the transistor which is
operating as a detector in the modem 3.

30 In order to increase the data rate of the
demodulator of the badge, higher bias current is used,
which reduces the impedances and the time constants.

Figure 3 gives the example of a field-effect
transistor, biased on its gate to a voltage V_{gs0} close to
35 the pinched-off voltage V_p : the transistor is in the
standby state, and a low drain current I_{ds} , $2\mu A$, for
example, corresponds to this voltage V_{gs0} . In order to
awaken the badge, the gate bias voltage is switched to a
higher value V_{gs1} , with a corresponding higher drain

current I_{ds} , lying between 10 and 100 μ A, for example, which reduces the impedances and time constants. If I_{ds} passes 2 μ A to 20 μ A, the information rate is multiplied by 10.

5 This phenomenon is limited only by the non-linearity of the field-effect transistor as a function of V_{gs} : it is known that if V_{gs} is too high, the I_{ds} (V_{gs}) characteristic of the transistor, which is quasi-linear, no longer makes it possible to have the detector
10 function.

 In the case in which the information rate demanded is such that it cannot be reached by simply increasing the current, it is possible to use one (or more) amplifier 31, in series with the detector transistor 11, in the modem 3, as represented in Figure 4: it is
15 the amplifier which is "awakened", in order to transmit at high rate.

 The amplifier or amplifiers 31 works at the demodulation frequency, and its bias voltage is changed,
20 while the transistor 11 continues to be in an optimum bias region for the detection function. The basis of this configuration consists in lowering the load impedance of the detector, and thus in increasing the information rate, without changing its bias point, and in compensating for the drop in level associated with the reduction
25 in the output impedance by the change of bias and thus the increase in the gain of the amplifier 31 which follows the detector 11.

 Figure 5 gives the detailed electrical diagram of a high-rate modem, produced as an integrated circuit
30 according to the invention, in which the bias point of the transistor used as detector is modified. The circuit represented is active in reception and passive in transmission, but other types of circuit may be adapted
35 according to the invention.

 This modem comprises a known UHF part, in which 11 is a field-effect transistor which operates as a detector, and equipped:

- on its gate with an impedance-matching circuit 13+14+15

for the antenna 9. The microstrip 12 matches the antenna to the input of the integrated circuit. The divider bridge 16 + 17 makes it possible to adjust the gate bias voltage, and the diode 18 makes it possible to modulate the gate by means of an alternating signal.

- on its source with a decoupling capacitor 15 and with a circuit for self-biasing in standby mode 19 + 20

- on its drain with an impedance-matching circuit 21 + 22, connected to the +V power supply via a resistor 23, and to the demodulated output DEM via a coupling capacitor 24.

The capacitors 15 and 22 are UHF decoupling capacitors. The resistors 23 and 19 are of high values, of the order of 100 k Ω and 500 k Ω respectively. It is these which, in the standby state, bias the drain and the source, and consequently determine V_{gs} and I_{ds} .

In order to awaken the badge, these two bias resistors 23 and 29 are practically short-circuited by the two resistors 25 and 26, respectively, which are of the order of 10 k Ω , that is to say markedly lower in value than 100 and 500 k Ω .

The switching between the resistors 23 and 25, on the one hand, and 19 and 26, on the other hand, is performed by means of the transistors 27 and 28 respectively, when they are in the conducting state. These switching transistors 27 and 28 are controlled by the information processing circuit 4, by a signal applied to the wake-up terminal AWA, and limited by the resistor 29.

The resistor 30 sets the gates of the switching transistors 27 and 28 to -V, if the latter are not under control or if the wake-up function is at high impedance: in fact, the high-impedance state is often that of the logic gates of a processing circuit in "standby" mode. The transistors 27 and 28 are then turned off.

Figure 6 gives the detailed electrical diagram of a high-rate modem, produced as an integrated circuit, according to the invention, but including an amplifier behind the detector transistor 11. By comparison with the preceding Figure, the person skilled in the art will have

no difficulty in recognizing the parts common to these two circuits, that is to say:

- to the left of the Figure and of the line AA, the UHF part, surrounded by a dashed line,

5 - to the right of the Figure and of the line BB, the system of the two switching transistors 27 and 28, as well as their switched resistors 25 and 26 and their feed resistors 29 and 30.

10 The index markings have not all been applied in order not to overload the Figure: if necessary, they can be deduced from Figure 5.

The amplifier, at the demodulation frequency, consists essentially of at least one transistor 31, connected by means of a decoupling capacitor 32 to the
15 load of the UHF transistor 11. At the relatively low demodulation frequencies, the LF load of the transistor 11 consists of the resistor 23 (about 100 k Ω), the capacitor 32 and the resistor 33 (about 500 k Ω - 1 M Ω).

The transistor 34, when it is driven by the wake-up signal AWA at the same time as the transistors 27 and 28, switches the LF load of the detector transistor 11: its load resistor 33 (0.5 - 1 M Ω) in the standby state is shunted by the low-value resistor 35 (10 k Ω) in the awakened state.

25 The resistors 36 and 37 are resistors for stabilizing the transistor 31 in the awakened state: its drain load consists of the high-value resistor 38 (about 100 k Ω) and the UHF decoupling capacitor 39. Its source, decoupled by a capacitor 15, is self-biased by a resistor
30 40 and a capacitor 41, in the same way as the source of the detector transistor 11: as for the resistor 19, the resistor 40 has a high value, about 500 k Ω .

Whereas in the previous case in point, the switching transistors 27 and 28 switch the source and drain resistors 19 and 23 of the detector transistor 11,
35 in the present case:

- the switching transistors 27 and 28 switch the source and drain resistors 40 and 38 of the amplifier transistor 31, which alters its bias,

- and the transistor 34 switches the output impedance of the detector transistor 11, by shunting the high-value resistor 33 by the low-value resistor 35.

5 In Figure 6, there is only one amplification stage lying between the lines AA and BB, between the detector stage and the stage for awakening by changing the bias points. If the information rate demanded from the badge has to be higher than that supplied with a single amplification stage, there is no difficulty for
10 the person skilled in the art in mounting several amplification stages in cascade which are identical to the one which is represented: it is necessary only to provide for each amplifier to include its own wake-up stage, i.e. the transistors 27 and 28, and the associated circuits. The
15 transistor 34, and its associated circuit 32+35, which switches the output impedance of the detector transistor 11, remains unique if there are several amplification stages. The demodulated output DEM is taken from the last amplifier.

20 Let us regard the signal processing circuit 4 (Fig. 1) as being equivalent to a load capacitor C_c , represented in dashed lines in Figures 5 and 6, and let us ignore the load conductance. The time constants which limit the information rate in reception are, to the first
25 order:

- for the circuit of Figure 5 (changing of bias of the detector).

in the standby state: $R_{23} (C_c + C_{22})$

in the awakened state: $R_{25} (C_c + C_{22})$

30 - for the circuit of Figure 6 (changing of bias of the amplifier),

in the standby state: $R_{23} \cdot C_{22}$

or $R_{38} (C_c + C_{39})$

in the awakened state: $R_{35} \cdot C_{22}$

35 or $R_{25} (C_c + C_{39})$

In each of the two states, it is one of the two time constants which limits the rate, before the other constant.

In order to have high information rates, it is

therefore necessary:

- in both cases, for the decoupling capacitors C_{22} and C_{39} of the transistors 11 and 31 to be as small as possible,
- in the case of Figure 5 (without amplifier) for

5 $R_{25} \ll R_{23}$

- in the case of Figure 6 (with amplifier), for

$$R_{35} \ll R_{23}$$

and

$$R_{25} \ll R_{38}$$

10 The two examples which have been set out use a modem of semi-active type. The invention is applicable to other types of modem, in which it is sufficient to change the bias of the detector transistor. Likewise, production as an integrated circuit does not limit the application of the invention, which can be produced as a hybrid
15 circuit, using microstrip lines which replace the self-conductors and the capacitors.

Patent claims

1. Portable badge, constituting a mobile station (1) of a system for data exchange by microwave electromagnetic waves with a fixed station (2) sending a wake-up signal for the badge at a low information rate, this badge including:
- a modulator and a demodulator (3),
 - an information processing circuit (4),
 - a wake-up circuit, controlled by the wake-up signal sent out by the fixed station (2) and transmitted by the demodulator and the information processing circuit, and the function of which is to increase the rate of information exchanged by the system, outside of the standby state,
- 15 this badge being characterized in that:
- the modulator and the demodulator consist of at least one first field-effect transistor (11), configured to act as a detector on receiving signals sent out by the fixed station (2), and as a modulator on sending signals towards the fixed station (2), and in that in order to obtain the increase in the information rate,
 - the wake-up circuit comprises means for reducing the output impedance of the first transistor (11) which consist of at least one second switching transistor (27, 28), which, controlled by the wake-up signal, is configured to substitute at least one of the high-value load resistors (23, 19) of the drain or of the source of the first transistor (11) by a resistor (25, 26) of lower value, and to cause an increase in the gate-source bias voltage V_{gs1} , which entails an increase in the drain-source current I_{ds1} and a reduction in the output impedance of the first transistor (11).
2. Badge according to Claim 1, characterized in that the demodulator (3) of the badge (1) including at least the first field-effect detector transistor (11) is followed by at least one third amplifier transistor (31), the means of reducing the output impedances consist, on the one hand, of at least one fourth transistor (34) which substitutes the high-value resistor (33) of the





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drain of the first detector transistor (11) by a resistor (35) of lower value, and, on the other hand, by at least the second switching transistor (27, 28) which substitutes at least one of the high-value load resistors (38, 40) of the drain or of the source of the third amplifier transistor (31) by a resistor (25, 26) of lower value.