

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
5 October 2006 (05.10.2006)

PCT

(10) International Publication Number
WO 2006/105100 A2

(51) International Patent Classification:
G01S 13/08 (2006.01)

(21) International Application Number:
PCT/US2006/011302

(22) International Filing Date: 28 March 2006 (28.03.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/666,242 28 March 2005 (28.03.2005) US
11/000,000 21 March 2006 (21.03.2006) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

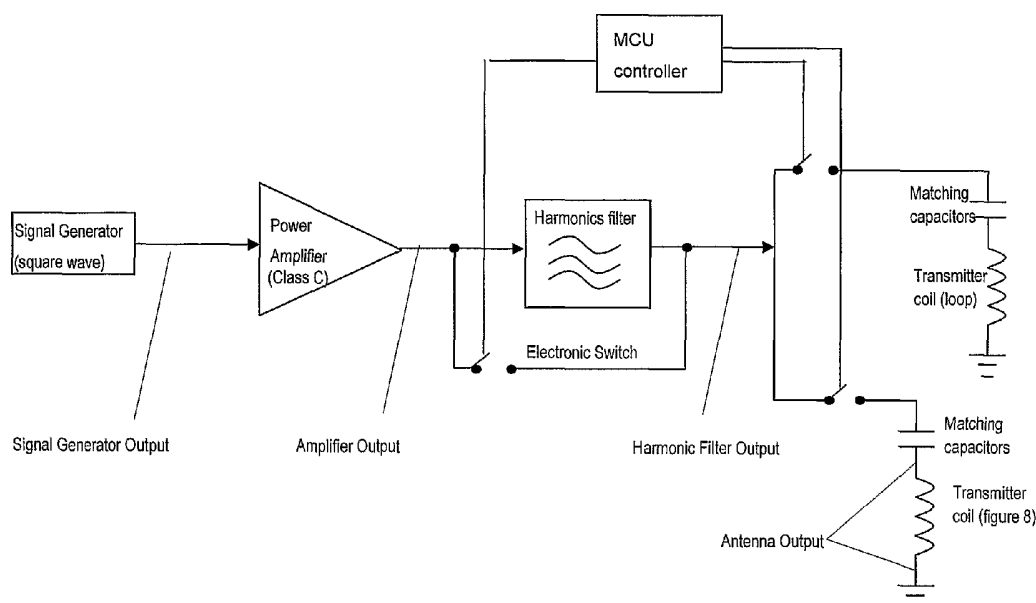
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished upon receipt of that report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SUPPRESSION OF EMI RADIATION IN EAS SYSTEM



(57) Abstract: An electronic article surveillance system (EAS) comprises a transmitter and a receiver. An amplifier is associated with the transmitter whereby non-linear signals are generated. A filter is provided for filtering the transmitted signal to reduce the strength of the harmonic content of the transmitted signal. A switch bypasses the filtering and turns off the transmitter to shorten ringing transient duration of the transmitted signal and thereby reduce interference at the receiver.

SUPPRESSION OF EMI RADIATION IN EAS SYSTEM

Field and Background of the Invention

5 [001] This invention relates to the suppression of EMI radiation in an Electronic Article Surveillance (EAS) system. More specifically, the invention in one form relates to a method to suppress the EMI radiation in Accusto-magnetic EAS systems and/or non-linear transmitters of Accusto-magnetic EAS system with EMI suppression.

Summary of the Invention

10 [002] According to one aspect of the invention, there is provided an electronic article surveillance system (EAS) comprising: a transmitter and a receiver; an amplifier associated with the transmitter whereby non-linear signals are generated; a filter for filtering the transmitted signal to reduce the strength of the harmonic content of the transmitted signal; and a switch
15 which bypasses the filtering and which turns off the transmitter to shorten ringing transient duration of the transmitted signal and thereby reduce interference at the receiver.

[003] Preferably, the non-linear signal is a square-wave signal. The amplifier may be a Class
20 C non-linear amplifier.

[004] In one form of the invention, the filter comprises a harmonics filter. The harmonics filter may be configured so as to suppress the higher order of harmonics generated by the amplifier generating non-linear signals.

25 [005] Preferably, the transmitter, amplifier, filter and switch together maintain radiation levels within the parameters set out in the table of Figure 2 of the drawings while also maintaining sufficient performance levels to detect an article reflecting the signal to the receiver.

[006] The switch may comprise an electronic switch, and the electronic switch may be either
30 outside the filter or inside the filter.

[007] According to another aspect of the invention, there is provided a signal generator for an

electronic article surveillance system (EAS) having a transmitter and receiver, the signal generator comprising: a non-linear wave signal generator; an amplifier associated with the non-linear wave signal generator for generating non-linear signals; a filter for filtering the non-linear signal to reduce the strength of the harmonic signal power; and a switch which bypasses the filtering process to shorten ringing transient time of the transmitter and thereby reduce interference at the receiver.

[008] Preferably, the non-linear wave signal is a square wave signal.

[009] According to yet a further aspect of the invention, there is provided a signal generator for an electronic article surveillance system (EAS) having a transmitter and receiver, the signal generator comprising: a non-linear wave signal generator; an amplifier associated with the non-linear wave signal generator for generating non-linear signals; and a filter for filtering the non-linear signal to reduce the strength of the signal harmonics.

[010] According to still a further aspect of the invention, there is provided a signal generator for an electronic article surveillance system (EAS) having a transmitter and receiver, the signal generator comprising: a non-linear wave signal generator; an amplifier associated with the square wave signal generator for generating non-linear signals; and a switch to shorten ringing transients and thereby reduce interference at the receiver.

[011] According to yet another aspect of the invention, there is provided a method for detecting the presence of tagged articles in an electronic article surveillance system (EAS), the method comprising: providing a transmitter and a receiver at a selected location; generating non-linear signals by means of a non-linear signal generator and/or amplifier associated with the transmitter; filtering the amplified signal to reduce the strength of the harmonic signal content; and providing a switch for bypassing the filtering process and turning off the transmitter to shorten ringing transient time of the filter and thereby reduce interference at the receiver.

[012] Preferably, according to the method, the signal generated is square wave signal.

[013] According to yet a further aspect of the invention, there is provided an electronic article

surveillance system (EAS) comprising: a transmitter and a receiver; an amplifier associated with the transmitter for generating non-linear or square-wave signals; a filter for filtering the transmitted signal to reduce the strength of the harmonic content of the transmitted signal; a switch which bypasses the filtering and which turns off the transmitter to shorten ringing transient duration of the transmitted signal and thereby reduce interference at the receiver; and a microcontroller to control the timing of transmission, reception and switch settings; wherein the filter bandwidth and transient characteristics are adjusted as a function of time to produce harmonic filtering during signal transmission, and to produce short transient response during signal reception.

[014] In a conventional accusto-magnetic EAS system, a non-linear amplifier transmitter usually utilizes a square wave signal generator and Class C amplifier (non-linear amplifier) to boost the transmitting antenna. Some of the advantages of a non-linear amplifier, compared with other conventional linear amplifiers (for example, sine wave amplifier) include: simple circuit design, low cost, obviation of the need for complicated tuning work, and the possibility of high amplification efficiency. Under the same receiver's performance, a non-linear amplifier will reach maximum overall system performance more readily than a linear amplifier.

[015] A consequential issue in the use of non-linear or switching amplifiers, such as Class C amplifiers, is the production of significant signal harmonics at multiples of the baseband frequency. This is largely due to the use of square waves, which have high harmonic energy. Regulator agencies throughout the world, such as the Federal Communications Commission (FCC) in the United States, regulate the electromagnetic spectrum, often placing severe limitations on the allowable bandwidth of transmitted signals. These restrictions, usually specified graphically or in a chart, specify frequency versus transmission power limitations. The limitations include restrictions on the harmonic signal power relative to baseband power. These specifications cover a wide bandwidth regulating the base band radiation and relative high orders harmonic frequencies radiations from a 10khz to 30Mhz range. Therefore, the conventional non-linear amplifier transmitter must sometimes compromise maximum system performance by the increase of transmission power and the FCC regulation on radiation power. The use of non-linear or Class C amplifiers thus pose a challenge in terms of meetings regulatory requirements, due to the high harmonic energy produced by such devices. It may therefore sometimes be difficult

to exploit the benefits of such transmitter amplifiers, while still meeting regulatory restrictions.

[016] Accordingly, one aspect of the present invention is to disclose a non-linear amplifier transmitter which could effectively suppress the ample high orders harmonics noise produced by a non-linear, such as a square wave, amplifier transmitter. Thus, the system can be within the limitation guidelines of an FCC radiation test without compromising the overall system's performance.

[017] In one embodiment, the invention discloses an EAS transmitter and a method to suppress the frequency bandwidth spread caused by high orders harmonics in order to meet regulatory requirements of regulatory authorities such as the FCC on radio frequency transmitters.

[018] An EAS system in operation will generate an electromagnetic field (also referred to as an interrogation field) to detect the presence of an EAS tag or label which comes into the field. When the electronics in the tag or label is excited by the interrogation field, it will reflect a response signal at the same frequency as the transmitter and the field. The receiver of the EAS system will open a receiving window at a certain time sequence (after each transmission burst) to detect the correspondent tag or label response to the transmission burst. If a response is verified, the receiver will trigger alarms.

[019] The above procedure is illustrated in Figure 1 of the drawings, which shows timed transmitter bursts, and the corresponding receiving window after such a transmitter burst when either a tag is detected in the detection zone or no tag is detected in the detection zone.

[020] The tag or label response is fully correlated with the strength or the power of the interrogation field. Thus, the higher the power a transmitter sends to generate the field, the higher the response the tag and label will reflect. But regulatory bodies, such as the FCC, place strict limits on the RF transmitter's radiation and emission power over a certain range of bandwidth. In particular, the higher frequency range will have a more strict limitation and allow lower power of the transmitter radiation than the lower frequency range. It is particularly in the higher frequency ranges that are so restricted that non-linear amplifiers produce undesirable harmonic content.

[021] As an example, FCC ESTI30030 has a frequency versus power limitation chart as shown in Figure 2 of the drawings under a 10 meters radiation test. The test frequency point is from 58khz (the base band frequency of the transmitter disclosed in accordance with one aspect of the invention) to 30M. The full range of frequency bandwidth can be further divided into two ranges, one from base band frequency to the 8th order harmonic frequency (58k to 464khz) which has a distance correction rate of -59.08db, the other from the 9th order harmonic frequency point (522khz) to an upper ceiling of 30Mhz which has a distance correction rate of -19.08db. In this context, the transmitter will have a sharp decline of the high frequency harmonics over the 464khz which present a significant challenge for the amplifier and RF circuit designer.

[022] With the conventional square wave transmitter, if without effective high order harmonics suppression, it is very difficult to achieve the great decline of the harmonics on the 464 khz frequency (8th order harmonic point). In order to decrease harmonic content, the baseband signal power has to be decreased, thereby reducing or eliminating the very benefit of the amplifier.

[023] It is possible to insert a band limiting filter to suppress a specific bandwidth harmonics. However, the transmitter is coupled to a very high Q factor antenna circuit in series connection to an antenna coil and a set of capacitors, such that any filter branch added into the whole antenna circuit will affect the damping factor and therefore the response of the antenna circuit. Band limiting filters tend to produce transients or "ringing", i.e. the filter continues to produce an output signal after the input stimulus has ceased. In the case of the EAS system in which the filter is connected to a highly tuned antenna circuit, the ringing problem is further exacerbated by the high-Q antenna circuit. The result is that after the transmitter has ceased transmission, the filter continues to produce signal output, such that there may no longer be a rapid termination of the transmission signal. This can be a critical issue for an EAS system as described below.

[024] In the EAS system, after the transmission has ceased, a receiver is activated to detect a response from the identity tag within the interrogation field. The receiver is activated during a window of time immediately following the end of transmission. If the transmission signal has not sharply terminated prior to the opening of this time window, due potentially to ringing in the filter and/or filter/antenna combination, the receiver will detect the transmitter, rather than or in addition to the tag. The receiver amplifier has a gain of 10000-20000, since detection of the tag

response in the field requires sensitivity to very small signals. The transmitter ringing can therefore overwhelm the receiver circuit, and actually or potentially cause swamping of the tag response. It is therefore important that the transmission terminate or effectively end to avoid this type of response, and this would preferably be done prior to or at the opening of the receiver window.

[025] The use of non-linear, or Class C, transmitter amplifiers in EAS systems therefore presents a number of trade-offs, some almost or nearly incompatible, to the designer of the system. In order to reduce harmonics produced by the Class C amplifier and produce a system that complies with regulatory requirements, a filter is required. The filter in turn produces ringing which extends the transmission signal timing. The receiver relies on the transmitter to turn off rapidly, in order to detect the much weaker tag or label signal. However the ringing may swamp the tag return signal during the very time that the receiver has to detect the tag.

[026] The present invention, in one aspect thereof, thus provides a method for including a filter in the transmission circuitry while eliminating or reducing the ringing problem. A preferred method is disclosed for preventing or reducing the filter ringing from being transmitted into the electromagnetic interrogation field. This configuration is thus able to provide the benefits of the filter in band-limiting the transmission frequency spectrum, while at the same time reducing or eliminating the problems presented by filter ringing.

[027] The present invention, in one aspect thereof, discloses the step of adding signal switching into the transmission signal path in such a way that transmission occurs via the filter during the transmission burst, followed by a switching sequence that prevents the filter transients from propagating to the antenna circuit. The switching sequence in such an embodiment can thus provide for the benefits of a non-linear Class C amplifier with filtering, without the drawbacks of continued ringing and slow termination of transmission signal.

[028] Reference is made to Figure 3 of the drawings which illustrates in the upper portion thereof the point at which the transmitter halts the transmitter burst and the subsequent burst ring off or transient. In the lower portion of this figure, the receiving window is shown, from which it can be seen that the burst ring off or transient is received and amplified by the receiver of the

EAS and can results in significant interference. The issue is of particular concern, of course, when a tag is present in the interrogation zone and sends back a receiving signal together with the transient caused interference, thus making it more difficult to properly detect the presence of the tag in the interrogation zone.

5

Brief Description of the Drawings

[029] In the drawings:

[030] Figure 1 representation of a transmitter burst at timed intervals and the response signal with and without a tag in the detection zone;

10 [031] Figure 2 is a table prepared by the FCC of a radiation test showing the results of a 10 meter distance measurement at open field;

[032] Figure 3 is a graph showing a transmitter burst and ring off time and the interference effects thereof when a response signal may be generated;

15 [033] Figure 4 is a representative embodiment of a circuit in accordance with one aspect of the invention including the signal generator, harmonics filter and electronic switch, among other components for the preferred operation of the invention;

[034] Figure 5 is a graph of a transmission signal generated, its amplification and subsequent filtering by a harmonic filter output;

20 [035] Figure 6 is graph showing more details of the representation illustrated in Figure 5 of the drawings in higher time resolutions; and

[036] Figure 7 shows a graph illustrating interference by means of a comparison of circuits with a filter switch and without a filter switch.

Detailed Description of the Invention

25 [037] Based on the limits and specifications discussed above, the conventional EAS transmitters can be faced with following paradoxes:

[038] (a) To improve system detection range and performance, it is desired to increase the base band transmission power. But the higher base band power produces higher power of high order harmonics.

30

[039] (b) To pass regulatory EMI requirements, such as the FCC standards, the radiation power of high-order harmonics must be filtered.

[040] (c) To have lower power of high order harmonics, it is necessary to decrease the transmission power (base band power) thereby decreasing the system performance. Alternatively, signal power can be maintained, but harmonics must be filtered without compromising other system requirements.

5

[041] (d) Though the harmonics filter can suppress the high order harmonics brought by a square wave amplifier, it also changes the damp or transient response characteristic of the antenna circuit and forms a very long ring off or ringing transient of the transmission burst at the transmitter turn-off time. The extended ringing can occur during a window of time when the receiver is attempting to detect the tag or label return signal, thereby compromising system performance.

10

[042] In one aspect, the present invention addresses all or some of the above paradoxes and problems and provides an improved EAS transmitter which does not compromise the system's performance, and attempts or succeeds in meeting the FCC radiation and emission requirements.

15

[043] The present invention may include some or all of the following features:

[044] (a) The transmitter of the invention may consist of one or more non-linear, switching or Class C amplifiers. While the amplifier is referred to as Class C, it should be understood that this invention includes all methods of amplification which involve non-linear or switching processes or apparatus which provide greater efficiency coupled with the generation of harmonic signals.

20

[045] Whereas linear amplifiers operate on a principle of continuous variation of current or voltage, non-linear amplifiers switch between two or more discrete states producing signals such as, for example only, square waves or stepped signals. Such discrete-level signals are referred to as non-linear signals. An example of a non-linear signal would be a square wave or a digital signal comprising two discrete signal levels. Circuits that operate on such principles are often simpler, more efficient, and can be more readily controlled by microcontrollers or digital control circuits.

25

30

[046] A class C non-linear transmitter has many advantages such as higher amplification

efficiency, simple circuit structure, low parts count, and lower production costs. In mass production, Class C amplifiers also require less tuning, and have less parameter variation.

[047] (b) The transmitter of the invention may include a harmonic noise filter.

[048] The harmonic filter can effectively suppress the higher order harmonics produced by square wave or other non linear amplifiers.

[049] (c) The transmitter of the invention may further include one or more electronic switches in the signal path between the transmitter and the antenna.

[050] The switch or switches can bypass the harmonics filter from the antenna circuit when the transmitter turns off, or otherwise change the signal path such that during the time that the filter is ringing, such ringing transients are not radiated by the antenna. Therefore the transmission burst can be more quickly turned off with shorter ringing transients and cause less interference to the receiver during the receiving window time period.

[051] The following illustration, in accordance with only one example of the present invention, is for a system block diagram to illustrate the main blocks of the EAS transmitter and different signal test points.

[052] The invention can be described in terms of the structure shown in the block diagram, as well as the timing sequence of signal path switching.

[053] Reference is now made to Figure 4 of the drawings which illustrates just one of many possible embodiments of the invention which fall within the bounds of the present invention.

[054] The diagram of the embodiment in Figure 4 shows a signal generator to produce the square wave, a non-linear amplifier such as a Class C amplifier to amplify the transmission signal, an harmonics filter to attenuate harmonics in the amplified signal, and an antenna circuit with capacitors and transmission coils. The diagram also shows one or more switches controlled by a microcontroller (MCU), providing for changes in the transmission signal path.

[055] A first switch is shown connected in this illustrated embodiment in parallel to the harmonics filter. It should be appreciated, however, that this first switch can be connected in other locations, such as, for example only, in the filter, to achieve the same purpose. When the switch is open, the output of the amplifier is filtered by the harmonics filter and then coupled to the antenna circuit. The signal being radiated by the antenna is therefore a filtered version of the amplifier output. The baseband frequency of the amplifier output is preferably unattenuated or only slightly attenuated, while harmonic content is more significantly attenuated. Thus the signal of importance is coupled to the antenna with little or no attenuation, to achieve maximum output of the desired signal.

[056] When the first switch is closed, the transmitter output is coupled directly to the antenna, and the harmonics filter does not drive the antenna.

[057] There are also a second and third switch which connect the circuitry of the filter and/or transmitter to the antenna. These switches can also be opened in order to decouple the harmonics filter from the drive circuitry.

[058] The invention can also be described in terms of timing of the switch control signals i.e. the topology of the signal path as a function of time.

[059] During transmission of the main signal burst i.e. when the interrogation field is being driven by the transmitter and the Class C amplifier, the first switch is open, and the second and third switches are closed. Filtered signals are therefore coupled to the antenna containing the baseband frequency, but filtering out the harmonic signal content. At the end of the transmission burst, at or just prior to the timing of the opening of the receiver detection window, the first switch is closed. At this moment, the harmonics filter no longer drives the antenna, and the transmitter drives the antenna directly. However, at this time, the transmitter is actually producing a null or quiescent output while the filter is continuing to ring. The effect of switching at this moment is therefore to preferably couple the antenna to a zero output signal, and decouple it from the ringing transients of the harmonics filter. The result is that during transmission, the output signal is filtered with the attendant benefit of reduced harmonics, and at the end of transmission the output signal is unfiltered, and has the benefit of reduced or eliminated ringing

transients.

[060] An alternative method included in this invention, is to short the output of the harmonics filter to a ground referenced signal in order to prevent the ringing signal from coupling to the antenna. The same or similar topology shown achieves this result in that when the first switch is closed, the amplifier output can be set to a ground-referenced signal, essentially shorting the output of the filter to a ground or null signal output. This is equivalent to shorting the filter output to any null signal in order to damp or decouple the filter output.

[061] The first switch can also be equivalently embedded within the filter circuitry itself, and switched according to the timing sequence described herein. By connecting the first switch as an element of the filter itself, the filter frequency and transient characteristics can be modified, under MCU control, to have one characteristic during signal transmission (filter harmonics), and have a different characteristic (low transient response with reduced ringing) during the time that the transmitter is turned off. The filter characteristic then becomes programmable, under the control and timing programmed in the MCU.

[062] The structure shown in the block diagram therefore includes a number of methods by which the transmitter-filter-antenna chain can be programmed with one transfer function or filtering characteristic during signal transmission, and a different transfer function or filtering characteristic during transmission off-time, or during receiver detection window time.

[063] An important aspect of one form of the invention is the timing of the switching sequence.

[064] Reference is now made to Figure 5 of the drawings. Illustrated in this figure of the drawings, a signal generator will generate a sequence of base band transmission signal in a square wave form (first row). After the Class C non-linear amplifier, the signal is amplified by the amplitude (second row, but not shown in proportion to first row) but still in the form of a square wave. At this point, if without the harmonics filter on the amplified output of the square wave, the signal will cause serious radiation on high order harmonics and may not be able to pass FCC or other regulatory tests. However, with the disclosed harmonic filter added after the amplifier's output, the signal will be a more smoothed wave form with less sharp slopes of each

signal edge. This will effectively suppress the high order harmonics noise and facilitate the meeting of the requirements of FCC (or other regulatory) tests.

5 [065] Reference is now made to Figure 6 of the drawings. In this illustration, the time-stretched figure shows more details of each test point signal in higher time resolutions.

[066] Reference is made to Figure 7 of the drawings. This figure shows a comparison of the circuit without the disclosed electronics switch and with the switch to bypass the filter circuit at the point when the transmitter turns off.

10 [067] The first two rows of Figure 7 show the influence of the harmonic filter added into the antenna circuit and changes the damping factor and transient response of the antenna resonance circuit and produces a long ringing transient of the transmission burst. The prolonged ringing received by the receiver at the following receiving window is amplified by the receiver and, as
15 seen in Figure 7 of the drawings, can cause severe interference on a normal tag or label signal response detection.

[068] The bottom two rows of Figure 7 shows the difference when electronic switch is added to bypass the filter from the antenna circuit. It significantly decreases the transient ringing and prevents it from occurring during the open time of the adjacent receiver's window which would
20 cause interference with tag or label response detection.

[069] The invention is not limited to the precise details described herein, and many variations may be made in accordance with the general aspects of the invention.

CLAIMS:

1. An electronic article surveillance system (EAS) comprising:
a transmitter and a receiver;
an amplifier associated with the transmitter whereby non-linear signals are generated;
5 a filter for filtering the transmitted signal to reduce the strength of the harmonic content
of the transmitted signal; and

a switch which bypasses the filtering and which turns off the transmitter to shorten
ringing transient duration of the transmitted signal and thereby reduce interference at the
receiver.

2. An EAS as claimed in claim 1 wherein the non-linear signal is a square-wave
signal.

3. An EAS as claimed in claim 1 wherein the amplifier is a Class C non-linear
amplifier.

4. An EAS as claimed in claim 1 wherein the filter comprises a harmonics filter.

5. An EAS as claimed in claim 4 wherein the harmonics filter is configured so as
to suppress the higher order of harmonics generated by the amplifier generating non-linear
signals.

6. An EAS as claimed in claim 1 wherein the transmitter and associated amplifier
generate a square wave non-linear signal.

7. An EAS as claimed in claim 1 wherein the transmitter, amplifier, filter and switch
together maintain radiation levels within the parameters set out in the table of Figure 2 of the
drawings while also maintaining sufficient performance levels to detect an article reflecting the
signal to the receiver.

8. An EAS as claimed in claim 1 wherein the switch comprises an electronic switch.

9. An EAS as claimed in claim 8 wherein the electronic switch is outside the filter.

10. An EAS as claimed in claim 8 wherein the electronic switch is inside the filter.

11. A signal generator for an electronic article surveillance system (EAS) having a
transmitter and receiver, the signal generator comprising:

a non-linear wave signal generator;

an amplifier associated with the non-linear wave signal generator for generating non-
linear signals;

a filter for filtering the non-linear signal to reduce the strength of the harmonic signal

power; and

a switch which bypasses the filtering process to shorten ringing transient time of the transmitter and thereby reduce interference at the receiver.

12. A signal generator for an electronic article surveillance system (EAS) as claimed
5 in claim 9 wherein the non-linear wave signal is a square wave signal.

13. A signal generator for an electronic article surveillance system (EAS) having a transmitter and receiver, the signal generator comprising:

a non-linear wave signal generator;

10 an amplifier associated with the non-linear wave signal generator for generating non-linear signals; and

a filter for filtering the non-linear signal to reduce the strength of the signal harmonics.

14. A signal generator for an electronic article surveillance system (EAS) having a transmitter and receiver, the signal generator comprising:

a non-linear wave signal generator;

15 an amplifier associated with the square wave signal generator for generating non-linear signals; and

a switch to shorten ringing transients and thereby reduce interference at the receiver.

15. A signal generator as claimed in claim 14 wherein the non-linear wave signal generator generates a square wave signal.

20 16. A method for detecting the presence of tagged articles in an electronic article surveillance system (EAS), the method comprising:

providing a transmitter and a receiver at a selected location;

generating non-linear signals by means of a non-linear signal generator and/or amplifier associated with the transmitter;

25 filtering the amplified signal to reduce the strength of the harmonic signal content; and providing a switch for bypassing the filtering process and turning off the transmitter to shorten ringing transient time of the filter and thereby reduce interference at the receiver.

17. A method as claimed in claim 6 wherein the signal generated is square wave signal.

30 18. An electronic article surveillance system (EAS) comprising:

a transmitter and a receiver;

an amplifier associated with the transmitter for generating non-linear or square-wave

signals;

a filter for filtering the transmitted signal to reduce the strength of the harmonic content of the transmitted signal;

5 a switch which bypasses the filtering and which turns off the transmitter to shorten ringing transient duration of the transmitted signal and thereby reduce interference at the receiver; and

a microcontroller to control the timing of transmission, reception and switch settings;

10 wherein the filter bandwidth and transient characteristics are adjusted as a function of time to produce harmonic filtering during signal transmission, and to produce short transient response during signal reception.

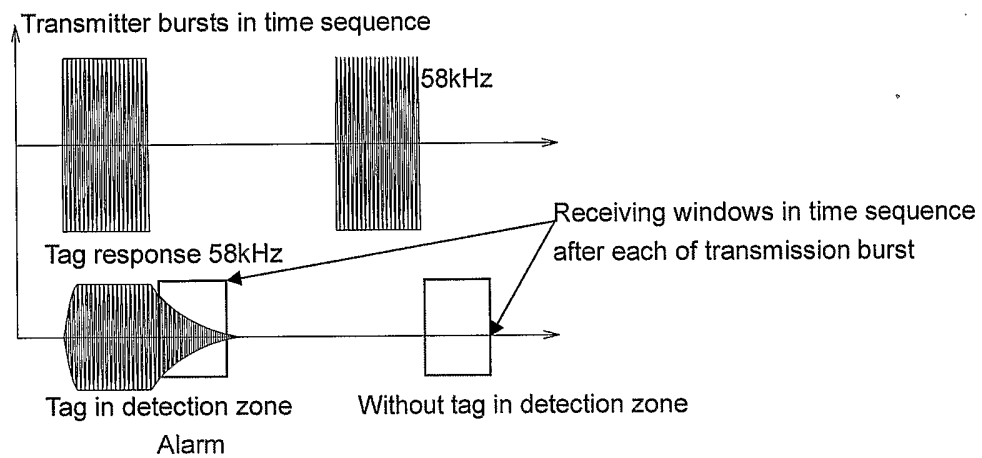
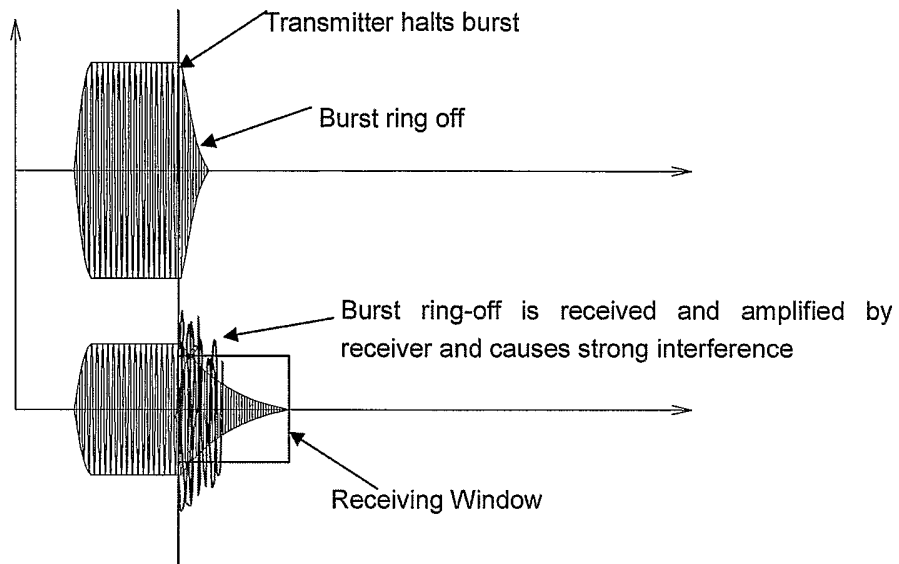


FIGURE 1

FCC Part 15, Subpart B & C 10 Meter Distance Measurement At Open Field												
Frequency (MHz)	PK (dBuV)	QP (dBuV)	AV (dBuV)	AF dB/m	Distance Correction (dB)	PK Corrected Reading (dBuV/m)	AV Corrected Reading (dBuV/m)	QP Limit (dBuV/m)	AV Limit (dBuV/m)	PK Margin (dB)	AV Margin (dB)	Notes
Loop Antenna Face On:												
0.058	107	95.4	78.7	11.05	-59.08	48.38	30.68	52.34	32.34	-4.0	-1.7	10m distance
0.116	68.2		37.9	10.488	-59.08	17.60	-10.70	46.32	26.32	-28.7	-37.0	10m distance
0.174	68.9		58.6	10.445	-59.08	36.26	9.96	42.79	22.79	-4.5	-12.8	10m distance
0.232	65.9		37.6	10.401	-59.08	17.22	-11.08	40.29	20.29	-23.1	-31.4	10m distance
0.29	76.7		48.4	10.358	-59.08	27.97	-0.33	38.36	18.36	-10.4	-18.7	10m distance
0.348	68.9		28.6	10.314	-59.08	8.13	-20.17	36.77	16.77	-26.6	-36.9	10m distance
0.406	61.3		33	10.271	-59.08	12.49	-15.81	35.43	15.43	-22.9	-31.2	10m distance
0.464	58.1		27.8	10.227	-59.08	7.24	-21.06	34.27	14.27	-27.0	-35.3	10m distance
0.522	55.5	40.3		10.204	-19.08	31.42		33.25		-1.8		10m distance
* No more emissions were found up to 30MHz												
Note: The emission limits are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.												
P.K. = Peak												
Q.P. = Quasi Peak Readings												
A.F. = Antenna factor												

FIGURE 2

**FIGURE 3**

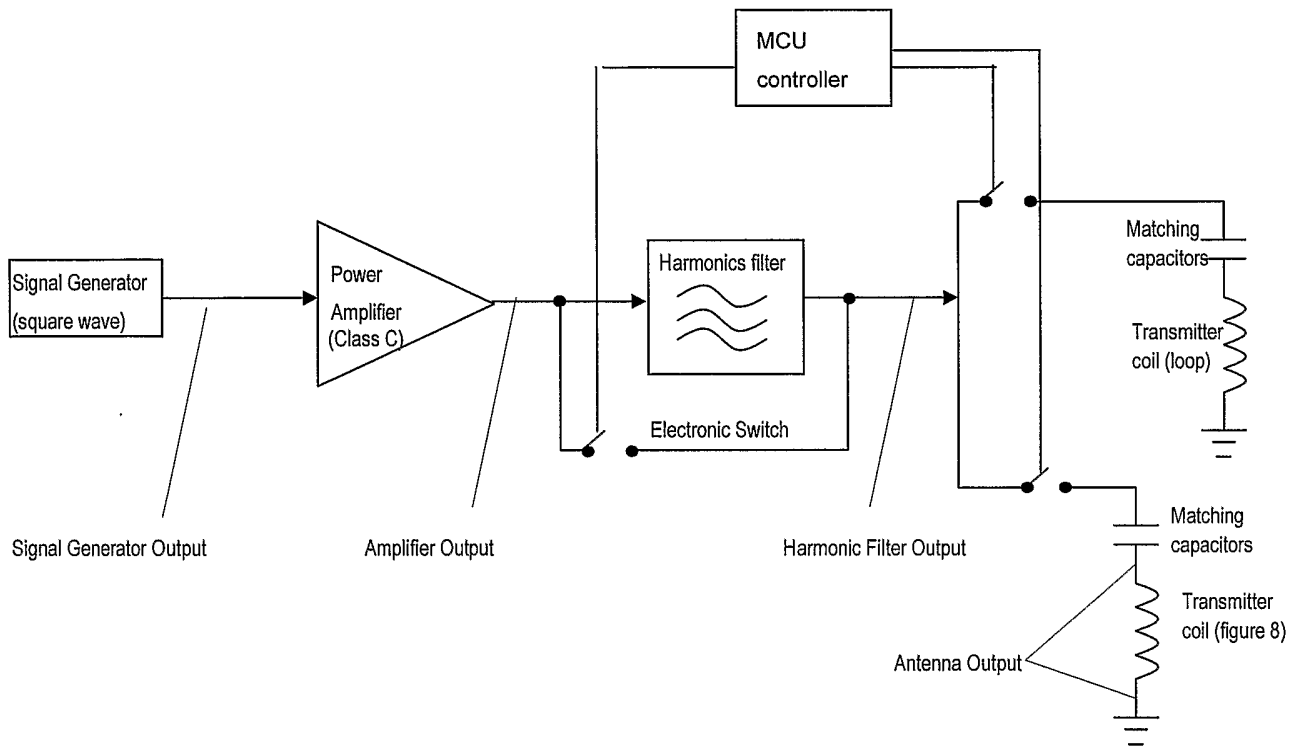


FIGURE 4

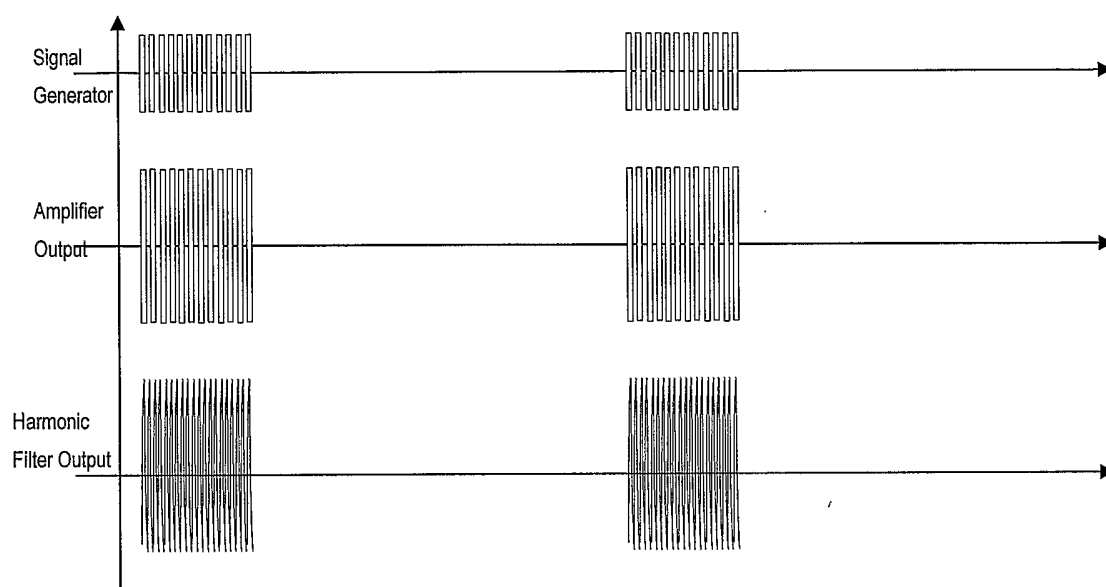


FIGURE 5

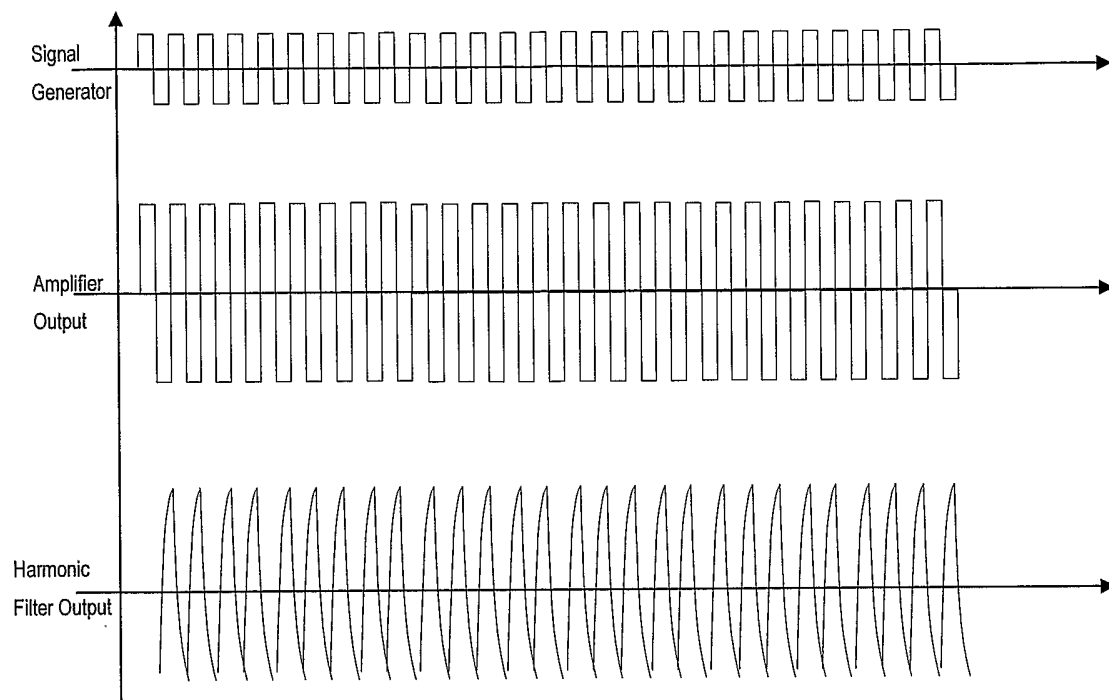


FIGURE 6

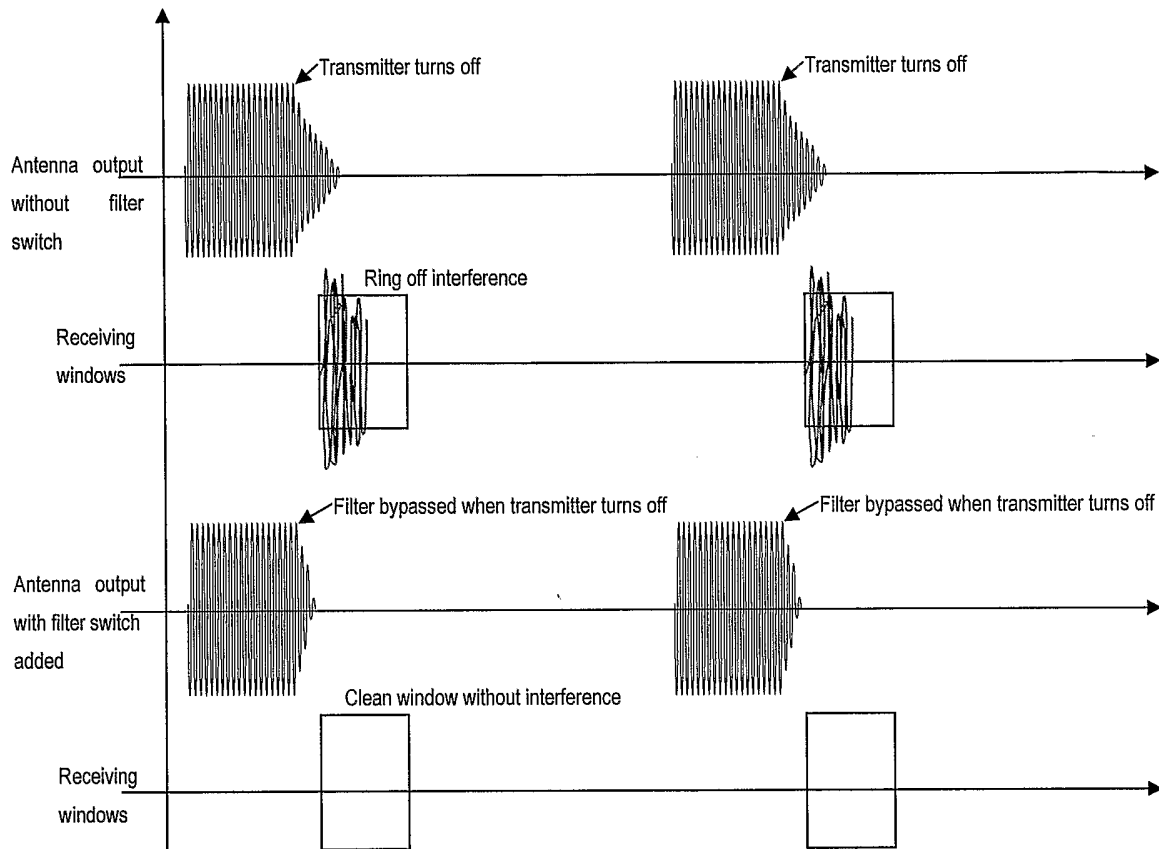


FIGURE 7