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(54) **Electronic duplication prevention of keyless entry signal featuring energy conserving method of transmission.**

(57) A remote keyless entry device providing vehicle access which utilizes a friend/foe screening technique comprising an initial sequence of two pulses which precede a transmitted code. The first pulse (24) is transmitted on a 50 kHz carrier frequency while the second (26) is transmitted on a 38 kHz carrier frequency. Once the vehicle receives the pulses, a match is acknowledged permitting the subsequently following transmitted vehicle code to be received and compared to the code stored in the receiver memory (116). The specific vehicle code in the preferred embodiment consists of five integers. These integers are transmitted by the transmitter in serial fashion. Each integer is represented as a time interval between a start and a stop pulse. Each time interval is equal to a fixed increment of time multiplied by the respective integer value. The stop pulse of the first integer is the start pulse of the second and the stop pulse of the second is the start pulse of the third, etc. Once the vehicle receiver receives the sequence of integers, the receiver microprocessor (114) compares the integers received with integers stored therein. If a suitable match is accomplished a

logic signal is generated and communicated to the central locking unit (118). A central locking unit which controls individual door access mechanisms then positions the respective mechanisms according to the instruction received therefrom.

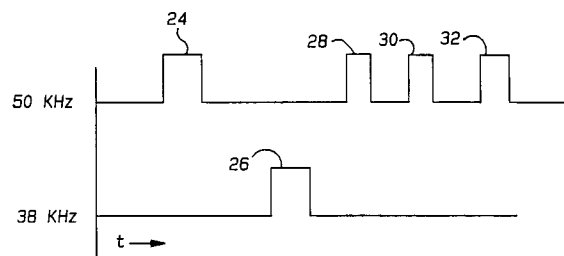


Fig-3

BACKGROUND OF THE INVENTION

This invention generally relates to keyless entry systems providing vehicle access and, more specifically, keyless entry systems featuring a method of signal transmission which conserves energy and resists duplication.

FIELD OF THE INVENTION

Keyless vehicle access codes are susceptible to unauthorized duplication. That is, the access code of the keyless transmitter can be duplicated by unauthorized individuals permitting unauthorized access to the vehicle. A specific duplication problem occurs with remote keyless entry systems using infrared as a communication band between the handheld transmitter and the receiver. Infrared keyless systems utilize similar technology to that used in infrared remote controls used on consumer entertainment products. As such, a universal programmable remote control unit for controlling consumer entertainment products may be used to learn, record and regenerate the electronic code of the system in the same manner that they may be used in conjunction with entertainment products. Once the code has been learned and recorded, it may be played back thereby providing access to the specific vehicle for which the transmitter message has been recorded. One approach to preventing use of a duplicated keyless entry code is to implement a rolling code. That is, the transmitter and receiver respectively change codes each time the unit is used. The receiver ignores previously acceptable codes. Therefore if a code is recorded by an unauthorized individual, the next time the system is used it has changed to a new code ignoring the old. The increased security provided by use of a rolling code comes at the cost of some inconvenience. That is, the rolling code in the transmitter and the receiver may not stay synchronized. The transmitter may be actuated beyond the range of the receiver resulting in the rolling of the code stored in the transmitter without corresponding roll of the receiver code. In this case, if the transmitter is within the look ahead range of the receiver, the receiver code will be advanced until a match occurs. However, if the transmitter is beyond the look ahead range, user action will be required. This inconvenience requires complicated techniques to resynchronize the transmitter-receiver pair. Such resynchronization technique is required if the transmitter batteries are changed. Therefore there is a need to prevent electronic duplication without the inconvenience and complexity of rolling codes.

SUMMARY OF THE INVENTION

The present invention features a remote keyless entry device providing vehicle access which utilizes a friend/foe screening technique comprising an initial sequence of two pulses which precede a transmitted code. The first pulse is transmitted on a 50 kHz carrier frequency while the second is transmitted on a 38 kHz carrier frequency. Once the vehicle receives the pulses, a match is acknowledged permitting the subsequently following transmitted vehicle code to be received and compared to the code stored in the receiver memory. The specific vehicle code in the preferred embodiment consists of five integers. These integers are transmitted by the transmitter in serial fashion. Each integer is represented as a time interval between a start and a stop pulse. Each time interval is equal to a fixed increment of time multiplied by the respective integer value. The stop pulse of the first integer is the start pulse of the second and the stop pulse of the second is the start pulse of the third, etc. Once the vehicle receiver receives the sequence of integers, the receiver microprocessor compares the integers received with integers stored therein. If a suitable match is accomplished a logic signal is generated and communicated to the central locking unit. A central locking unit which controls individual door access mechanisms then positions the respective mechanisms according to the instruction received therefrom.

In the preferred embodiment there is described a remote keyless entry system which implements a method to provide access command comprising the steps of receiving an incoming transmission comprising first and second carrier portions of first carrier frequency and second carrier frequency, respectively and further comprising a sequence of temporally spaced pulses including at least a first pulse, a second pulse and a third pulse, performing a friend/foe test on the incoming transmission by determining the frequency of at least one of the carrier portions and declaring the friend/foe test to have passed if the first carrier frequency is a first predetermined frequency and the second carrier frequency is a second predetermined frequency, performing a decode test upon the temporally spaced pulses by determining a first elapsed time between the first and second pulses and a second elapsed time between the second and third pulses and declaring the decode test to have passed if the first elapsed time equals the first predetermined time and the second elapsed time equals the second predetermined time, and implementing the access command if both friend/foe test and decode test have been passed. Further, the method of the preferred embodiment of the present invention may be implemented in the manner wherein the friend/foe test further comprises determining the frequency of both carrier portions and declaring the

friend/foe test to have passed if the first and second carrier frequency are received in a predetermined order within a predetermined time interval. It is contemplated that the method of implementing the present invention may be accomplished using first and second carrier frequencies that are not integer multiples of one another. In a similar manner, the first and second predetermined frequencies are not integer multiples of one another.

In another embodiment there is described a remote keyless entry system which implements an access command comprising the steps of

receiving an incoming transmission comprising a sequence of temporally spaced pulses including at least a first pulse, a second pulse and a third pulse;

performing a decode test upon the temporally spaced pulses by determining a first elapsed time between the first and second pulses and a second elapsed time between the second and third pulses and declaring the decode test to have been passed if the first elapsed time equals a first predetermined time and the second elapsed time equals a second predetermined time; and

implementing the access command if the decode test has been passed.

DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic of the transmitter of the present invention;

Figure 2 is a schematic of the receiver of the present invention;

Figure 3 is a diagram of the pulse transmission between transmitter receiver of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The preferred embodiment of the present invention as shown in Figure 1 includes a transmitter 10 featuring a microprocessor 12, a non-volatile memory 14, drive transistor 16 and infrared LED 18. A momentary contact switch 20 connects microprocessor 12 to battery 22 to power up transmitter 10. Upon energization, microprocessor 12 triggers memory 14 to produce a serial communication bit stream corresponding to a unique code word. The microprocessor 12 then transmits a pair of pulses 24, 26 (as shown in Figure 3). In the preferred embodiment, pulse 24 is on a carrier frequency of 50 kHz and pulse 26 is on a carrier frequency of 38 kHz. The carrier frequencies and order of pulses is recognized by the receiver which then adjusts the receiver gain control in anticipation of receiving subsequent coded data. In this manner, the pulse pair 24,26 provides a unique signa-

ture which identifies the transmitter as a friend. No other infrared devices are capable of operating in multiple carrier frequencies and providing the unique signature so as to accomplish friend/foe screening. Therefore it is not possible to learn, read and regenerate the multicarrier pulse pair using readily available commercial devices. After transmission of the pulse pair 24, 26 memory 14 produces a serially unique encoded bit stream which comprises a 25 bit binary number. Microprocessor 12 then converts the number into five, five bit integers which comprise a uniquely coded sequence of numbers. Each of the five, five bit numbers represent a value between 0 and 31. This provides 2 to the 25th power or 33 million combinations minimizing the likelihood that two vehicles will have the same vehicle access code. The five, five bit integers are further encoded in microprocessor 12 and are transmitted from the transmitter as a single start bit and a single stop bit for each integer with the time interval therebetween being representative of the respective integer value. For example, a zero value integer is represented as a start and stop pulse separated by a single fixed increment of time. The integer five would be transmitted as a start pulse followed by five fixed increments plus one followed by a stop pulse. All five integers are transmitted sequentially. That is, stop pulse 20 of the first interval provides a start pulse for the second interval. Stop pulse 32 of the second integer provides the start of the third and so on. In this manner, approximately one-half of the transmit energy is used as compared to using start/stop pulses for each integer. Therefore the energy per transmission is halved. In the preferred embodiment of the present invention, microprocessor 12 is a ZILOG Z86C08 and memory 14 is a Dallas semiconductor DS2224.

As shown in Figure 2, receiver 110 includes a photo diode D1, preferably a Siemens SFH206. Photo diode D1 is biased to compensate for ambient light level interference by transistor Q1 and associated bias resistors R1, R2 and capacitor C4. In this manner, current generated by D1 as a result of ambient sun light is blocked by the bias from Q1 therefore eliminating photovoltaic background noise allowing D1 to remain sensitive to a signal from transmitter 10. The output of D1 is provided to preamp 112 which is preferably a Telefunken 2509. Preamp 112 serves as the automatic gain control (AGC) of the transmitter receiver pair. Preamp 112 includes a bandpass filter comprising capacitors C8, C9 and resistors R3, R4. The bandpass filter eliminates amplification of signals outside the carrier frequencies 38 to 50 kHz. The output of preamp 112 is then provided to microprocessor 114 which is preferably ZILOG Z86E2112VSC. External memory 116 connected to microprocessor

114 is preferably a Dallas Semiconductor DS2222. Microprocessor 114 monitors the status of sensors indicating the position of the vehicle access doors (i.e., open or closed). If a door is open, microprocessor 114 writes to memory 116 thereby enabling the learning of transmitter codes. If the door is closed, the code in stored memory 116 is compared to that received from a transmitter.

In operation, an infrared signal incident upon D1 is converted to a voltage at the respective frequency incident thereon. The signal is then filtered and amplified by preamp 112. The filtering at this point is broad band allowing anything between 38 and 50 kHz to pass. Next, the signal is supplied to microprocessor 114. Microprocessor 114 then determines if the signal is a friend or a foe. As indicated previously, transmitter 10 produces a pair of pulses; one pulse at 50 and a second at 38 kHz carrier frequency. If a 50 kHz pulse is received, the microprocessor 114 will open a window of limited duration and look for a 38 kHz pulse. If the respective pulses are received, the respective transmitter is recognized as a friend and microprocessor 114 opens a window. Next, data pulses 28,30, 32 of Figure 3 from transmitter 10 are communicated to microprocessor 114. Each data pulse is a 263 micro sec burst on a 50 kHz carrier frequency. The data pulses are temporally spaced in a manner which represents the respective transmitter code previously described. Microprocessor 114 stores each integer as a modulo 32 number that is then converted to a string of 8 bit binary numbers that are then compared to the code stored in memory 116. When a match is recognized, microprocessor 114 produces a logic level signal which is communicated to the central locking unit 118 of the vehicle to implement the respective instruction. (i.e., lock or unlock the doors to access the vehicle.)

One skilled in the art will readily recognize that certain specific details shown in the foregoing specification and drawings are exemplary in nature and subject to modification without departing from the teachings of the disclosure. Various modifications of the invention discussed in the foregoing description will become apparent to those skilled in the art. All such variations that basically rely on the teachings through which the invention has advanced the art are properly considered within the spirit and scope of the invention.

Claims

1. In a remote keyless entry system, a method for implementing an access command, comprising the steps of:
 - receiving an incoming transmission comprising first and second carrier portions of first carrier frequency and second carrier frequen-

cy, respectively, and further comprising a sequence of temporally spaced pulses including at least a first pulse, a second pulse and a third pulse;

performing a friend/foe test on said incoming transmission by determining the frequency of at least one of said carrier portions and declaring said friend/foe test to have passed if said first carrier frequency is a first predetermined frequency and said second carrier frequency is a second predetermined frequency;

performing a decode test upon said temporally spaced pulses by determining a first elapsed time between said first and second pulses and a second elapsed time between said second and third pulses and declaring said decode test to have passed if said first elapsed time equals a first predetermined time and said second elapsed time equals a second predetermined time; and

implementing said access command if both friend/foe test and decode test have passed.

2. The method of claim 1 wherein said friend/foe test further comprises determining the frequency of both carrier portions and declaring said friend/foe test to have passed if said first and second carrier frequency are received in a predetermined order within a predetermined time interval.
3. The method of claim 2 wherein said first and second carrier frequencies are not integer multiples of one another.
4. The method of claim 2 wherein said first and second predetermined frequencies are not integer multiples of one another.
5. The method of claim 1 wherein said first carrier frequency is about 50 kHz.
6. The method of claim 1 wherein said second carrier frequency is about 38 kHz.
7. The method of claim 1 wherein said sequence of temporally spaced pulses is transmitted on at least one of said carrier portions.
8. The method of claim 1 wherein said sequence of temporally spaced pulses is transmitted on the first carrier portion.
9. The method of claim 1 wherein said predetermined times each represent different integer values.

10. The method of claim 1 further comprising predefining a unit time representing a predetermined integer value and wherein said first and second predetermined times comprise integer multiples of said unit time. 5
11. The method of claim 1 wherein said friend/foe test further comprises detecting the onset of one of said carrier portions and declaring said friend/foe test to have passed if the said carrier frequency of the other of said carrier portions is detected within a predefined time window following said onset detection. 10
12. In a remote keyless entry system, a method for implementing an access command, comprising the steps of: 15
- receiving an incoming transmission comprising a sequence of temporally spaced pulses including at least a first pulse, a second pulse and a third pulse; 20
- performing a decode test upon said temporally spaced pulses by determining a first elapsed time between said first and second pulses and a second elapsed time between said second and third pulses and declaring said decode test to have been passed if said first elapsed time equals a first predetermined time and said second elapsed time equals a second predetermined time; and 25
- implementing said access command if said decode test has been passed. 30

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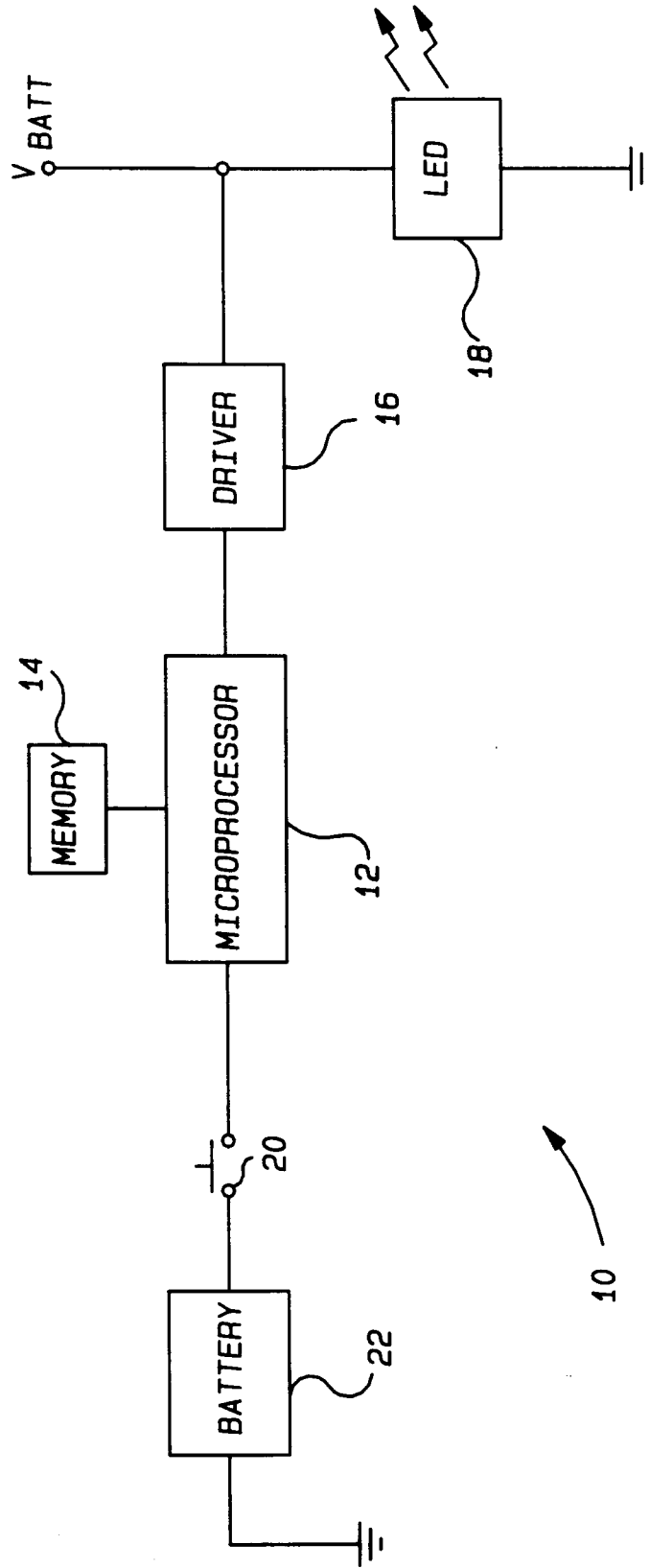


Fig-1

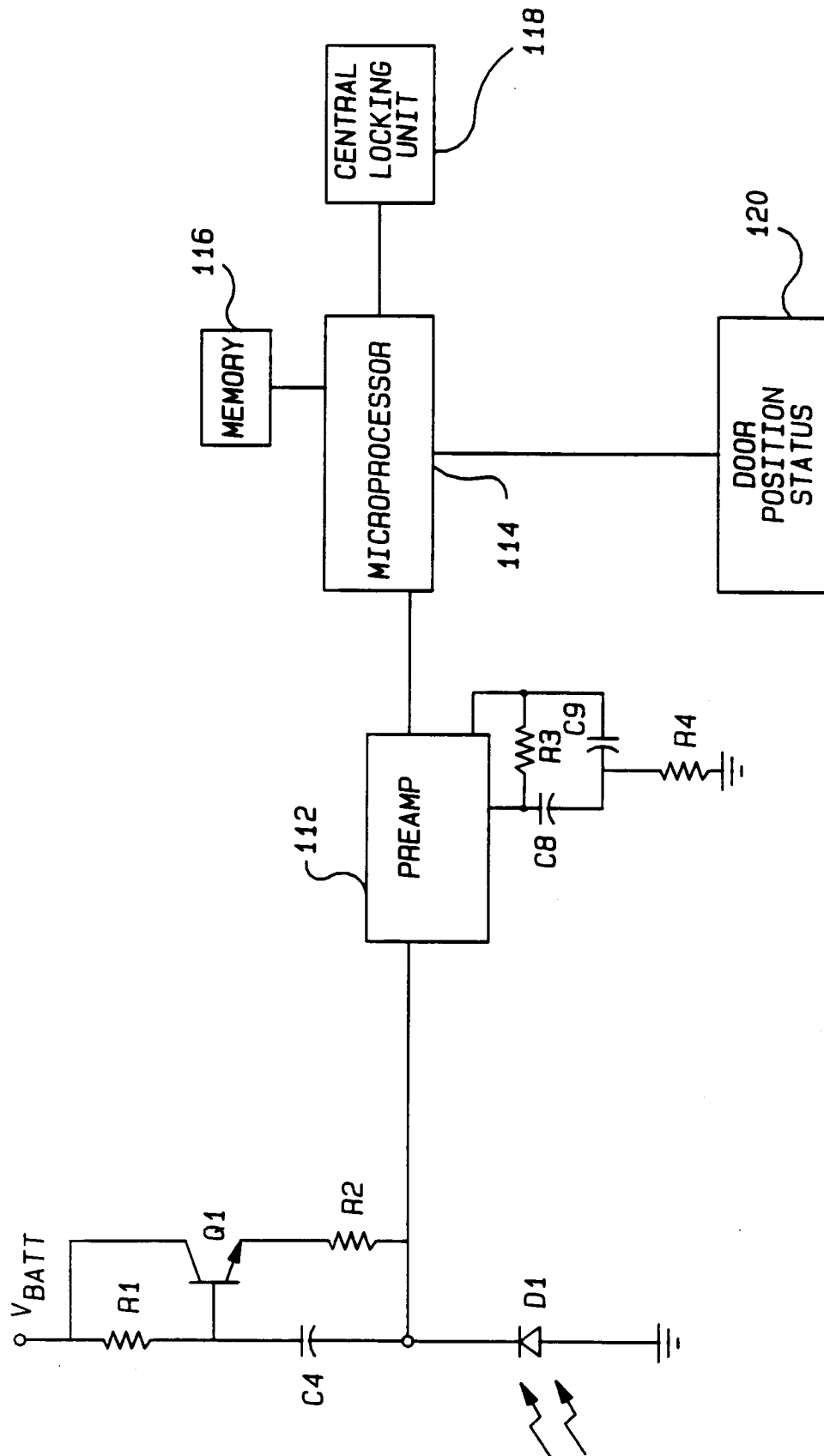


Fig-2

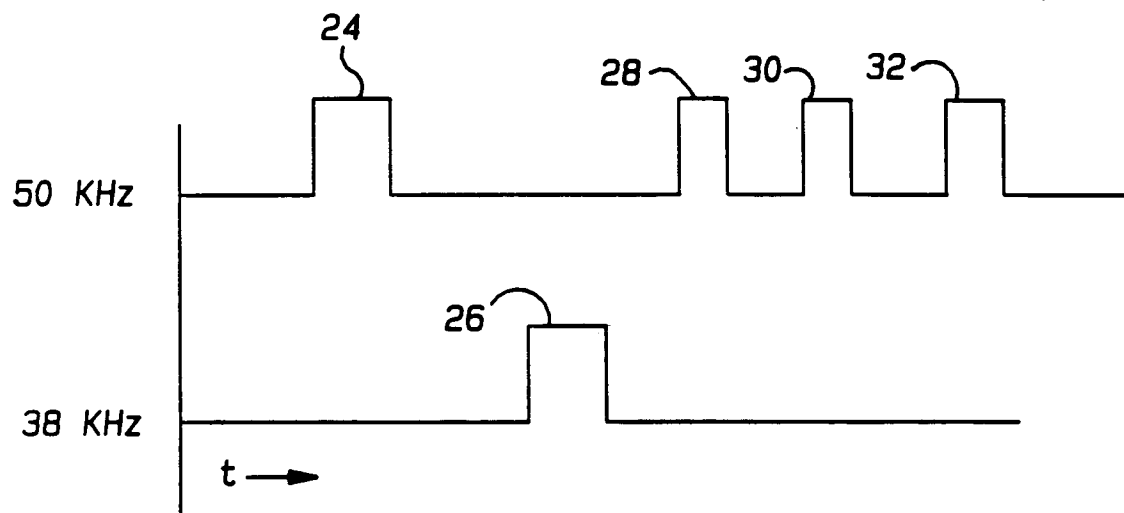


Fig-3



European
Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 91 11 6342

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	GB-A-2 196 203 (PARR) * page 2, line 86 - page 4, line 103; figures 1-8 ** - - -	1,2,7,11	E 05 B 49/00 G 08 C 19/24
A	ELEKTRONIK. vol. 34, no. 23, 1 November 1985, MUN- CHEN DE pages 99 - 102; PELTZ: 'selektive ir- garagantor-fernsteuerung' - - -	1,7,9	
A	FR-A-1 207 942 (COMPAGNIE POUR LA FABRICATION DES COMPTEURS ET MATERIEL D'USINE) * page 2, column 1, line 1 - page 3, column 2, line 22; figures 1-3 ** - - - - -	1	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			E 05 B G 08 C
Place of search		Date of completion of search	Examiner
The Hague		14 January 92	HERBELET J.C.
CATEGORY OF CITED DOCUMENTS			
X: particularly relevant if taken alone		E: earlier patent document, but published on, or after the filing date	
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