(54) Title: ECONOMICAL EXTENSION OF THE OPERATING DISTANCE OF AN RF REMOTE LINK ACCOMMODATING IR REMOTE CONTROLS HAVING DIFFERING IR CARRIER FREQUENCIES

(57) Abstract: A system for economically extending the effective operational range of an infrared remote control system having a remote control unit with an infrared transmitter, and a controlled device having an infrared receiver. The system includes a first transmitter to receive IR signals from the remote control unit and transmit an RF output signal corresponding to the infrared signal received from the remote control unit. The RF signal is received by an RF receiver which generates a second IR signal corresponding to the received radio signal. The second IR signal is transmitted to and received by the IR controlled device. In some case, the first IR control signal, and in all cases the RF signal include information/data concerning the IR carrier frequency. This information/data of IR carrier frequency, instead of the RF transmission of the actual IR carrier frequency, permits a reduction of the RF bandwidth since the full frequency spectrum of possible IR carriers need not be transmitted, thus permitted amplitude shift keying (ASK) modulation to be used. The RF receiver decodes the received signal and uses the information/data to configure a second IR control signal that is compatible with and transmitted to the controlled device.
ECONOMICAL EXTENSION OF THE OPERATING DISTANCE OF AN RF
REMOTE LINK ACCOMMODATING IR REMOTE CONTROLS HAVING
DIFFERING IR CARRIER FREQUENCIES

FIELD OF THE INVENTION
The present invention relates to a system for extending the effective operating
distance of an infrared (IR) remote control system, and more particularly, to such a
system wherein the RF transmission uses ASK modulation.

BACKGROUND
The present invention relates to an arrangement and device for remote control
for electronic devices, in particular of entertainment electronics.

There are many types of remote controlled electronic devices which utilize
infrared signals between a remote control unit and the controlled device. Such types
of commonly known controlled devices include, for example, VCRs, television sets,
audio amplifiers, DVD players and the like.

Devices for extending the distance range for an IR remote control are known,
e.g., U.S. Patent Nos. 6,127,941; 5,142,397, and 4,809,359. The remote control
extension system sends a signal, connected in a wireless manner, e.g., microwave,
radio transmission, or the like by means of a transmitting device, to a receiving
device, which provides an IR signal containing specific commands which are
executable by a remote controllable device.

Also known are remote control transmitters which can recognize foreign
transmission formats, such as infrared formats from other manufacturers or for other
types of devices, store these and transmit them again as required. Such infrared
remote control transmitters are also called "learning" remote controls, e.g., U.S.
Patent Nos. 5,515,052 and 4,626,848.

SUMMARY OF THE PRESENT INVENTION
A system for economically extending the effective operational range of an
infrared remote control system having a remote control unit with an infrared
transmitter, and a controlled device having an infrared receiver. The system includes
a first transmitter to receive IR signals from the remote control unit and transmit an
RF output signal corresponding to the infrared signal received from the remote
control unit. The RF signal is received by an RF receiver which generates a second
IR signal corresponding to the received radio signal. The second IR signal is
transmitted to and received by the IR controlled device. In some cases, the first IR
control signal, and in all cases, the RF, signal include information/data concerning the
IR carrier frequency. This information/data of IR carrier frequency, instead of the RF
transmission of the actual IR carrier frequency, permits a reduction of the RF
bandwidth since the full frequency spectrum of possible IR carriers need not be
transmitted, thus permitting amplitude shift keying (ASK) modulation to be used. The
RF receiver decodes the received signal and uses the information/data to configure a
second IR control signal that is compatible with and transmitted to the controlled
device.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings:

Fig. 1A shows an arrangement according to two embodiments of the present
invention.

Fig. 1B shows an arrangement according to a third embodiment of the present
invention.

Fig. 2 shows a timing chart for the data of an IR remote control.

Fig. 3 shows a detailed timing chart for the data of Fig. 2.

Fig. 4 shows the timing chart for the data of Fig. 2 with data for the IR carrier
frequency added.

Fig. 5 shows the detailed timing chart of the data of Fig. 4 with data for the IR
carrier frequency added.

Fig. 6 is a flow-chart showing the operation of the system according to aspects
of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

With reference to the drawings, two preferred embodiments of the present
invention are shown in Fig. 1A and comprise one or more IR controlled devices 10,
such as a VCR, DVD player, stereo system components or the like. Each IR
controlled device 10 includes a photodetector 14, which is adapted to receive an IR
signal to control the operation of controlled device 10.
A remote control unit 18 is typically used to control the operation of controlled device 10. The remote control unit typically includes a keypad 20 which, when one or more of the keys of keypad 20 are pressed, generates an infrared signal transmitted from an infrared emitter 22. As is well known in the art in order to operate, an infrared remote control unit is a line of sight device, i.e. the remote control unit 18 must be within the line of sight of the photodetector 14 of the controlled device 10, or else the controlled device 10 can be receptive to IR reflections off of the walls of the common room or other enclosure.

In order to overcome the line of sight (and reflections) limitation, the present invention provides a system to extend the effective range of such an infrared remote control system. As shown in Fig. 1A, the system comprises a first RF transmitter 24 having an infrared receiver or photodetector 26 which can be positioned in a room or enclosure along with controlled device 10. Photodetector 26 is responsive to the infrared signal transmitted from the remote control unit 18 and transmitter 24 generates an RF signal which is representative of the infrared signal received from remote control unit 18. As used herein, "RF" means electromagnetic energy below the far IR frequency range. This RF signal, which in the exemplary embodiment is an ultra high frequency (UHF) signal at antenna 32, is representative of the infrared signal generated by remote control unit 18.

The radio signal from transmitter 30 is, in turn, received by the antenna 34 of an RF receiver 38 which can be positioned outside of the line of sight (or reflections) of controlled device 10, e.g.; in another room or other enclosure. RF receiver 38 generates an IR signal which is representative of the received RF signal from RF transmitter 30. This output signal of RF receiver 36 activates controlled unit 10 in the desired fashion. Additional RF receivers 36 for other controlled devices 10 in a plurality of enclosures can be used without the need for multiplexing RF receivers 38.

The modulation of the RF signal of the exemplary embodiment is amplitude shift keying (ASK). This type of modulation is used because it affords substantial benefits and economies compared to the commonly used frequency shift keying (FSK) modulation, as will be further discussed below. These two types of modulation/demodulation are well known in the prior art, and thus, in the interest of brevity, ASK and FSK modulation and demodulation techniques and circuitry therefor
will not be further discussed except as deemed necessary to understand the present invention and/or claims.

There are bands of RF frequency which are allocated for low power unlicensed transmissions. In the U.S., the FCC currently allows the use of low power transmissions, i.e., in the range of 295 - 365 MHz. The average power for such transmissions is limited, e.g., to less than five milliwatts average power into the output stage. For transmitting power, FSK modulation requires complex electronics and a complex modulator compared to ASK modulation which can be achieved by simple AM modulation of the power supply of the class C output stage. Further, whereas FSK transmission is transmitting a carrier all of the time so that the same average power is constantly being transmitted, albeit at varying frequencies, the ASK transmission has a duty cycle "on" time and thus, the peak power can be much higher for the same average power into the transmitter output stage. Thus, ASK modulation will carry further in distance. It should be noted that the shorter the ASK modulation duty cycle "on" time, the higher the peak power can be for the same average power into the output stage, and thus, the further the distance that the signal can be transmitted.

On the receiver side, an ASK system is also more economical than an FSK system. An ASK receiving system basically needs a diode, maybe some amplification and tuned circuit prior to the diode, and a low pass filter after the diode. In contrast, an FSK receiving system requires a relatively expensive frequency discriminator, e.g., a ratio detector, and enough RF and IF wide-band amplification for the signal to be clipped prior to detection. Thus, compared to the FSK system, the ASK system is both more economical and has a longer range due to its much higher peak power as discussed above. Needless to say, given enough signal strength, the FSK system has lower noise. However, in the present case, the ASK system is more cost effective and has a greater transmission distance than the FSK system normally used.

However, the ASK modulation system has a lower bandwidth capability. IR carrier frequencies can vary from 30 KHz to 500 KHz. If the RF transmissions were required to have a bandwidth sufficient to accommodate the IR carrier range from 30 KHz to 500 KHz, an ASK modulation system would not be sufficient and an FSK system would have to be used, which is currently the case in the prior art. However,
if instead of the RF transmission needing to have the capability of transmitting the
500 KHz or higher IR carrier frequency, it has been found that a four bit nibble of
information is sufficient to define the IR carrier frequency without having to actually
transmit the IR carrier frequency. This is because there are a limited number of
commonly used IR carrier frequencies and referral can be made to a look-up table
which will tell the system which IR carrier frequency is the selected one. Since the
present system is required to add only four bits to the signal, the RF system need not
be capable of transmitting a 500 KHz IR carrier signal, and a lower bandwidth system
can be used, i.e., an ASK modulated RF system with the advantages discussed
above over the FSK system.

The present system can be configured in three ways. Still referring to Fig. 1A,
in a first embodiment a four bit nibble defining the first IR carrier frequency is added
by RF transmitter 30 instead of RF transmitting the actual IR carrier, which is stripped
from the signal. As used herein RF transmitter 30 is also referred to an IR/RF
translator. This is done after analyzing the IR carrier frequency received from the
remote control 18. In this case, RF receiver 36 also referred to herein an RF/IR
translator, configures the second IR signal so that the IR carrier frequency is the
correct frequency for IR remote controllable device 10, as decoded from the data
included in the RF signal. This permits the remote control which came with the IR
remote controllable device to be used.

Still referring to Fig. 1A, a second embodiment is to use a remote control
which can be taught, e.g., a learning remote which, e.g., uses a look-up table for the
IR remote controllable device in its ROM, which may or may not be part of its
microprocessor, for determining what the IR carrier frequency is and add such
information as a nibble to the digital word transmitted to RF transmitter 30. In such a
case, RF transmitter 30 need not analyze the IR signal from remote control 18 to
determine the IR carrier frequency but can read the carrier frequency information
directly from the data added to the IR signal and transmit such data in a form
understandable by RF receiver 36, without including the IR carrier itself in its
transmission. In such a case, if the IR carrier is provided by the remote control, it is
stripped from the signal which is RF transmitted. Like above, RF receiver 36
configures the second IR signal so that the IR carrier frequency is the correct
frequency for the IR remote controllable device. In such a case, the learning IR
remote control can be used, or an off-the-shelf universal remote control, which happens to include such information about the IR carrier frequency as part of their transmitted word, can be used. In both the first and second embodiments, since the IR carrier is not included in the RF transmission, the RF transmitter carrier can be ASK modulated, as discussed above.

Referring now to Fig. 1B, in a third embodiment, remote control 18, instead of being just an IR remote control, can also be an RF remote control, which means that an RF output signal can be directly received by receiver 36, thus eliminating a separate transmitter 30. However, the RF remote control, like before, would not RF transmit the IR carrier but transmits a four bit nibble of data defining what would be the IR carrier frequency, and the RF carrier is ASK modulated. Receiver 38 still provides an IR control signal having the correct IR carrier frequency for remotely controlling the IR remote controllable device. It should be noted that in such a case, the RF remote control and RF transmitter are located within the same housing. In a like manner, for the two other embodiments discussed above in connection with Fig. 1A, the IR remote control 18 and the RF transmitter 30 can both be located within a common housing.

The RF remote also transmits IR, Thus, it is a simple matter of taking the IR code, appending the 4 bit nibble representative of the IR frequency, and coupling the nibble to the RF remote transmitter section. The micro in the remote already knows what IR frequency was needed because it had to synthesize it for the IR transmit, so it is a trivial matter to have the micro create this 4 bit nibble and append it to the RF message. This is similar to what the transmitter 30 is doing, but it eliminates the need for such a separate step.

Turning now to the four bit nibble, the size is based upon the number of carrier frequencies currently used. Thus, a four bit nibble designates 16 possible IR nominal carrier frequencies. However, more than four bits can be used if the situation warrants, e.g., an eight bit byte would be capable of designating 256 possible IR carrier frequencies. However, even such an enlarged IR carrier frequency bit length would still provide the advantages of ASK modulation, i.e., it is still more economical to include such information defining the IR carrier frequency than to use an RF bandwidth sufficient to transmit the full range of IR carrier frequencies which can be
used, due to the substantial reduction in transmission bandwidth required, and the increased peak power to average power ratio.

For information purposes, a characteristic of a commonly used IR remote control is as follows:

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<th>Characteristic</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infra-red wavelength</td>
<td>915</td>
<td>950</td>
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<td>Nm</td>
</tr>
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<td>Modulation frequency</td>
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<td>58.5</td>
<td>KHz</td>
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<tr>
<td></td>
<td>69</td>
<td>75</td>
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<td></td>
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<tr>
<td>Modulation duty-cycle</td>
<td></td>
<td>50</td>
<td>81</td>
<td>%</td>
</tr>
</tbody>
</table>

Fig. 2 shows a timing chart for a prior art IR remote control. IR transmissions comprise bursts of amplitude-modulated IR, with data encoded by means of the interval between pulses (without IR). This is called Pulse Position Modulation (PPM) because the width of the pulses do not vary, only the timing of the leading edges. This is why there is a sync pulse which sets the initial timing. A timer looks at discrete times after this sync pulse for another leading edge of a pulse to determine what information was sent (bit 0, bit 1, end of transmit, etc). These are all based on timing from the last valid pulse edge received. This PPM data, without the four bit nibble of data designating the IR carrier frequency, is then modulated onto the IR carrier for the normal transmission of the IR control code.

Referring again to Fig. 2, for the IR envelope, a logic "high" represents the presence of modulated IR, and a logic "low" represents the absence of IR. The mark and space convey no information; they are present to settle the automatic gain-control (AGC) in the IR receiver. The first sync pulse signals the start of the data and establishes the point from which to begin timing the subsequent data bits. The intervals between consecutive IR pulses encode twenty-four data bits.

Fig. 3 shows a detailed timing chart of the timing chart of Fig. 2 showing a protocol for sending information. The first four bits represent the preamble (device address), and the next eight bits represent the specific command followed by the logical complements of the preamble and data (four and eight bits, respectively). Data is transmitted most significant bit first.

Fig. 3 shows the details of the data portion of a typical message shown in Fig. 2. These elements form a complete message. As long as the remote button is depressed and the command is considered to be active, the identical message is
continuously repeated with the specified wait between messages. No partial messages are transmitted. If the key is released before a complete message has been transmitted, the remaining portion will still be transmitted. Note that each command is sent twice.

It is within the contemplation of the present invention that the four bit nibble would be inserted before each preamble of data, i.e., after the mark and space. This arrangement is shown in Figs. 4 and 5 where the four bit nibble is appropriately indicated. However, such an arrangement is only exemplary and other arrangements can be used.

Fig 6 shows a flow chart of the operations concerning the four bit nibble for identifying the IR carrier frequency for the embodiments, as follows: at 600 the user presses a desired button function on remote 18 and, at 602 the microprocessor in the remote determines the proper message code using the code table in memory for various products in 604. Now three possibilities exist with the two embodiments of Fig. 1A being shown in branch 606 and the embodiment of Fig. 1B being shown in branch 608.

Taking branch 606 first, at 608 the code is transmitted via IR using the correct IR carrier frequency for embodiment one and without the IR carrier but with the IR carrier frequency data for embodiment two, at 610 transmitter 30 receives the IR signal, at 612 the microprocessor appends the original message with the four bit data if it has not been added at 602, and strips the message of the actual IR carrier frequency if it had been sent according to the second embodiment, at 614 the message from 612 with the IR frequency data and without a carrier is ASK modulated onto an RF carrier which is received by receiver 36 at 614, where the message is decoded and the four bit nibble is separated from the original message.

Taking branch 608 where remote control 18 is an RF remote, at 616 the microprocessor appends the four bit nibble to the message representing the IR carrier frequency and strips the IR carrier, if any, from the message. At 618, the message with the appended bits is ASK modulated onto an RF carrier, which is received at 614.

At 620 the receiver microprocessor decodes the four bits to determine the IR carrier frequency and at 622 reconstructs the IR message at the specified IR carrier
frequency, and transmits the IR message which is received at 624 by the IR remote controllable device.
CLAMS

1. A remote control system for transmitting commands to an IR remote controllable device comprising:
   a first control device for transmitting a first IR control signal;
   a second control device for receiving the first IR control signal and transmitting an RF signal corresponding to the first IR control signal; and
   a third control device for receiving the RF signal and transmitting a second IR control signal corresponding to the RF signal, the second IR control signal being receivable by the IR remote controllable device;
   the RF signal being amplitude shift keying modulated.

2. A remote control system for transmitting commands to an IR remote controllable device comprising:
   a first control device for transmitting a first IR control signal without an IR carrier;
   a second control device for receiving the first IR control signal and transmitting an RF signal corresponding to the first IR control signal; and
   a third control device for receiving the RF signal and transmitting a second IR control signal corresponding to the RF signal, the second IR control signal being receivable by the IR remote controllable device for controlling the controllable device;
   the first control device transmitting within the first IR control signal data identifying an IR carrier frequency, said data being included in the RF signal received by the third control device and used by the third control device to configure the second IR control signal to be at the identified IR carrier frequency.

3. A remote control system for transmitting commands to an IR remote controllable device comprising:
   a first control device for transmitting a first IR control signal including an IR carrier frequency;
   a second control device for receiving the first IR control signal and transmitting an RF signal corresponding to the first IR control signal; and
a third control device for receiving the RF signal and transmitting a second IR control signal corresponding to the RF signal, the second IR control signal being receivable by the IR remote controllable device for controlling the controllable device,

the second control device transmitting within the RF signal data identifying the IR carrier frequency but not transmitting the IR carrier, said information being used by the third control device to configure the second IR control signal to be at the identified IR carrier frequency,

4. A remote control system for transmitting commands to an IR remote controllable device comprising:
a first control device for transmitting a first IR control signal without an IR carrier;
a second control device for receiving the first IR control signal and transmitting an RF signal corresponding to the first IR control signal; and

a third control device for receiving the RF signal and transmitting a second IR control signal corresponding to the RF signal, the second IR control signal being receivable by the IR remote controllable device for controlling the controllable device;

the first control device transmitting within the first IR control signal data identifying an IR carrier frequency, said data being included in the RF signal received by the third control device and used by the third control device to configure the second IR control signal to be at the identified IR carrier frequency;

the RF signal being amplitude shift keying modulated.

5. A remote control system for transmitting commands to an IR remote controllable device comprising:
a first control device for transmitting a first IR control signal including an IR carrier frequency;
a second control device for receiving the first IR control signal and transmitting an RF signal corresponding to the first IR control signal; and

a third control device for receiving the RF signal and transmitting a second IR control signal corresponding to the RF signal, the second IR control signal being receivable by the IR remote controllable device for controlling the controllable device,
the second control device transmitting within the RF signal data identifying the
IR carrier frequency but not transmitting the IR carrier, said data being used by the
third control device to configure the second IR control signal to be at the identified IR
carrier frequency;

the RF signal being amplitude shift keying modulated.

6. The remote control system of claims 1-5 wherein the first control device
and the second control device are locatable in an enclosure different from the third
control device and the controllable device.

7. The remote control system of claims 1-6 wherein there are a plurality of
third control devices and respective controllable devices, each third control device
being responsive a single second control device.

8. The remote control system of claims 1-7 wherein the first control device
and the second control device are disposed together within a common housing.

9. The remote control system of claims 1, 4 or 5 wherein a version of the first
IR control signal modulates the power supply of an RF output transmitter stage of the
second control device.

10. The remote control system of claim 9 wherein the peak signal output
capability from the first control device 100 percent modulates the RF transmitter.

11. The remote control system of claim 9 wherein less than peak signal output
capability from the first control device 100 percent modulates the RF transmitter.

12. The remote control system of claim 11 wherein the RF transmitter is
overmodulated and has a duty cycle "on" time which is shorter than an "off" time.

13. The remote control system of claims 2, 3, 4 or 5 wherein the data
designating the IR carrier frequency is at least four bits long.
14. A remote control system for transmitting commands to an IR remote controllable device comprising:
   a first control device for transmitting an RF signal, and
   a second control device for receiving the RF signal and transmitting an IR control signal corresponding to the RF signal, the IR control signal being receivable by the IR remote controllable device;
   the RF signal being amplitude shift keying modulated.

15. A remote control system for transmitting commands to an IR remote controllable device comprising:
   a first control device for transmitting an RF signal, and
   a second control device for receiving the RF signal and transmitting an IR control signal corresponding to the RF signal, the IR control signal being receivable by the IR remote controllable device for controlling the controllable device;
   the first control device transmitting within the RF signal identifying an IR carrier frequency, said data being used by the second control device to configure the IR control signal to be at the identified IR carrier frequency.

16. A remote control system for transmitting commands to an IR remote controllable device comprising:
   a first control device for transmitting an RF signal, and
   a second control device for receiving the RF signal and transmitting an IR control signal corresponding to the RF signal, the IR control signal being receivable by the IR remote controllable device for controlling the controllable device;
   the first control device transmitting within the RF signal identifying an IR carrier frequency, said data being used by the second control device to configure the IR control signal to be at the identified IR carrier frequency,
   the RF signal being amplitude shift keying modulated.

17. A remote control system for transmitting commands to an IR remote controllable device comprising:
   a first control device for receiving a first IR control signal and transmitting an RF signal corresponding to the first IR control signal; and
a second control device for receiving the RF signal and transmitting a second
IR control signal corresponding to the RF signal, the second IR control signal being
receivable by the IR remote controllable device;
the RF signal being amplitude shift keying modulated.

18. A remote control system for transmitting commands to an IR remote
controllable device comprising:
a first control device for receiving a first IR control signal and transmitting an
RF signal corresponding to the first IR control signal; and
a second control device for receiving the RF signal and transmitting a second
IR control signal corresponding to the RF signal, the second IR control signal being
receivable by the IR remote controllable device for controlling the controllable device,
the first control device transmitting within the RF signal data identifying the IR
carrier frequency but not transmitting the IR carrier, said data being used by the third
control device to configure the second IR control signal to be at the identified IR
carrier frequency;
the RF signal being amplitude shift keying modulated.
Code Table in memory for various products

User Presses desired button function on remote

Micro In remote determines proper message code

This side used if IR remote used, and additional IR/RF translator is then needed

Micro also appends four bits to message representing IR carrier

Message with appended bits is sent to RF carrier for ASK transmission

Code is transmitted via IR

IR

IR/RF translator box receives IR signal (with multiple IR receivers)

Micro determines which IR receiver was used, and appends original message sent with 4 bits

IR/RF translator takes message plus 4 bits and ASK modulates on RF carrier

Transmission is received by RF/IR translator and decoded, 4 bits are separated from original message

Receiver Micro decodes four bits to determine IR carrier

Micro modulates original message onto determined IR carrier and transmits IR

Receiver device (TV, etc) receives correct IR signal, decodes and performs action

FIG. 6
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 G08C23/04 G08C17/02 G08C19/28 H04B7/15 H04B10/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G08C H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tr>
<td>Y</td>
<td>US 4 897 883 A (HARRINGTON CHRISTOPHER C) 30 January 1990 (1990-01-30) column 2, line 34 -column 4, line 5</td>
<td>1-5,8, 13-18</td>
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<td>Y</td>
<td>WO 93 05580 A (THOMSON CONSUMER ELECTRONICS) 18 March 1993 (1993-03-18) page 1, line 22 -page 4, line 6</td>
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Further documents are listed in the continuation of box C. Patent family members are listed in annex.

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- Special categories of cited documents:
  - "A" document defining the general state of the art which is not considered to be of particular relevance
  - "E" earlier document but published on or after the international filing date
  - "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or special reason (as specified)
  - "O" document referring to an oral disclosure, use, exhibition or other means
  - "P" document published prior to the international filing date but later than the priority date claimed
  - "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principles or theory underlying the invention
  - "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  - "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  - "X" document member of the same patent family

Data of the actual completion of the International search: 24 October 2002

Date of mailing of the International search report: 31/10/2002

Name and mailing address of the ISA

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Authorized officer

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<table>
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<th>Publication date</th>
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<tbody>
<tr>
<td>US 4897883 A</td>
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