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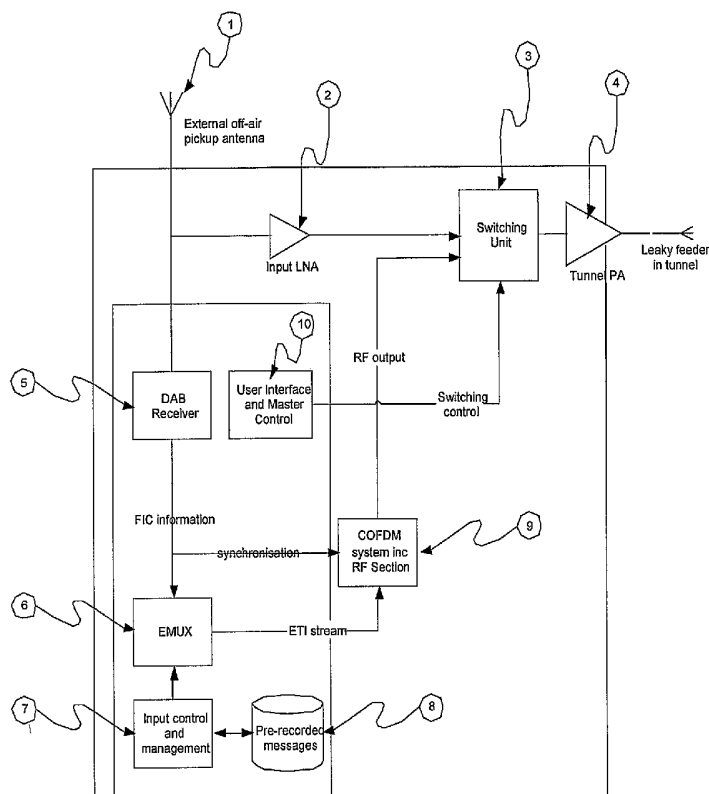
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(54) Title: EMERGENCY MESSAGE TRANSMITTER SYSTEM AND RELATED METHOD



(57) Abstract: Emergency message transmitters are deployed in tunnels etc. to transmit emergency messages to users (e.g. motorists) equipped with radio receivers. Configuration information is derived from a normal, broadcast digital signal using a receiver situated at the tunnel mouth; this configuration information can include information defining the sub-channel structure. A pre-recorded or live audio emergency message is then processed so that, when transmitted, it will conform to the configuration information. The processed message is then transmitted within the tunnel during an emergency. Because the configuration information of the message matches that of the broadcast signal that was being processed by a user's radio receiver immediately prior to receipt of the emergency message, processing is far faster since the user's radio receiver does not have to re-configure itself.

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## EMERGENCY MESSAGE TRANSMITTER SYSTEM AND RELATED METHOD

### FIELD OF THE INVENTION

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This invention relates to a message transmitter system and method; it finds particular application in systems for transmitting emergency messages in tunnels.

### 10 DESCRIPTION OF THE PRIOR ART

Transport tunnel and bridge systems are often required to provide a method of emergency communications to the users of the systems, whether they be public or commercial. Typically, this has been achieved using FM transmissions. In tunnels, the off-air signal fades rapidly after entering the tunnel. In larger tunnels, a repeater system is often provided. This repeater system 'sniffs' the off-air signal and then retransmits it within the tunnel. This then gives the flexibility for alternative use. For FM, the retransmitted signal can easily be replaced with a locally generated and modulated signal. In this case the local signal simply 'overpowers' the off-air signal due to the attenuation of the off-air signal in the tunnel. FM receivers then pick-up the local content and play-out that audio to the listener. For the emergency situation this could be an emergency message from the local tunnel control centre. Hence, someone driving a car through a tunnel can stay tuned to a FM radio station, but in the event of an emergency will hear a message transmitted by the tunnel control centre.

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For DAB (Digital Audio Broadcasting) and other digital broadcast transmissions the ability to simply overpower the off-air signal is still possible, however, the format of the data streams contained within the transmitter signal vary with time. Indeed the DAB ensemble contains a number of sub-channels, each of which can have a different bit rate and FEC (Forward Error Correction) code rate. The structure of the ensemble is provided to receivers

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in the form of a Fast Information Channel (FIC). The FIC provides the information required to configure the receiver for a specific channel.

As FM signals are all the same format, no receiver reconfiguration is required. However for  
5 variable structure digital signals such as DAB, if the emergency transmitter simply transmits  
using a structure that very likely differs from that of a normal broadcast on a given sub-  
channel, the receiver will then take a considerable time to provide the emergency audio  
output to the user: Typically the receiver will need to determine that the channel structure  
has changed rather than it is just receiving a poor signal and the resulting BER is poor  
10 (typically 0.5). It then needs to receive the FIC to determine the new channel structure, select  
a channel for reception, configure the receiver for the parameters of that channel and then  
operate and decode the signal. There are a number of pitfalls in this process and indeed it is  
expected that some receivers would need to be, at least, manually retuned.

15 Clearly in an emergency situation time is critical and hence the emergency transmitter system  
architecture needs to ensure the minimum time for the receiver to provide understandable  
audio to the listener.

The present invention provides solutions to the above recognised problems.

## SUMMARY OF THE PRESENT INVENTION

In a first aspect, there is a method of transmitting a message comprising the steps of:

- 5 (a) deriving configuration information from a broadcast digital signal;
- (b) processing the message so that, when transmitted, it will conform to the configuration information;
- (c) transmitting the processed message into a region using a transmitter.

10 The present invention provides, in one implementation, a method of transmitting an emergency message using a DAB (Digital Audio Broadcasting) signal. Such a system is of particular relevance to transport tunnels and bridges. The concept is to provide an Emergency Warning via DAB radio by replacing the current broadcast content on all channels and sub-channels with an emergency audio warning message. Such a message may  
15 be pre-recorded or live.

A normal, broadcast transmission signal contains details of the transmission configuration (e.g. the sub-channel structure). This is typical in a DAB system, as well as other systems such as Digital Video Broadcasting (DVB) and Digital Radio Mondiale (DRM). This  
20 configuration information is, in the present invention, automatically extracted and then used to pre-configure an alternative transmission system, the emergency system, to have exactly the same configuration. The content, or carried information, of the normal broadcast is replaced with emergency warning information. Because both the normal broadcast and the  
25 end users' receivers can quickly decode any emergency message since no receiver re-configuration needs to occur.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be described with reference to:

- 5 **Figure 1**, which shows the system block diagram of an emergency transmitter in accordance with the present invention; and
- Figure 2** which shows a low cost implementation of this kind of system.

## DETAILED DESCRIPTION

### Overview

Emergency message transmitters are deployed in tunnels etc. to transmit emergency messages to users (e.g. motorists) equipped with radio receivers. Configuration information is derived from a normal, broadcast digital signal using a receiver situated at the tunnel mouth; this configuration information can include information defining the sub-channel structure. A pre-recorded or live audio emergency message is then processed so that, when transmitted, it will conform to the configuration information. The processed message is then transmitted within the tunnel during an emergency. Because the configuration information of the message matches that of the broadcast signal that was being processed by a user's radio receiver immediately prior to receipt of the emergency message, processing is far faster since the user's radio receiver does not have to re-configure itself.

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While the DAB system is used to aid the description below the techniques are equally applicable to other systems based on digital broadcasting with variable structure, e.g. COFDM (Coded Orthogonal Frequency Division Multiplexing) signals such as those used in DVB and DRM.

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The emergency transmitter system derives configuration information for the DAB signal from the FIC contained within that signal. This allows the emergency transmitter to provide the emergency warning message in exactly the same data format as the original off-air signal, thus eliminating the need for the receiver to reconfigure itself. Indeed the time taken for the 'hand-over' will simply be a function of the time to enter the tunnel (or bridge etc) transmission field, which, if the vehicle is moving at a reasonable speed (e.g. >30kph) will occur over approximately 1 sec (or, say, 10m). If the receiver is already in the tunnel's local field then the change over time is dictated by the signals interleaving depth, which for DAB E147 [1] is 384mS.

In this section, we describe the operation of a DAB emergency transmitter system based on modified off-the-shelf equipment, as well as a customised low cost system. Both systems have the same fundamental operation. However the low cost version is clearly the preferred commercial solution when large numbers of sites are targeted.

The operation of the emergency transmitter is based on the use of the received off-air FIC to configure a local ensemble multiplexer which then provides the emergency transmission system signal via a local COFDM modulator and power amplifier. As the off-air FIC has been used to ensure that the local emergency transmission has exactly the same structure as the off-air signal, the receiver will experience a rapid transition between the off-air signal and the emergency signal.

Referring to **Figure 1**, normal operation involves the use of an external off-air pick-up antenna (1), which is connected to the input LNA (2). The received and amplified signal is applied to a switching unit (3) which selects its output as either the current off-air signal or the emergency signal and applies the selected signal to the power amplifier and output antenna system (4). Typically leaky feeder cables are used for antennas in tunnels, however other solutions are possible. This signal path is used for normal operation where the off-air signal is simply retransmitted in the tunnel. The delay in the tunnel transmission due to the processing delays of the LNA, switching unit and PA are small enough to ensure that the off-air signal and the tunnel transmission at the tunnel entrance are simply perceived as multiple paths of the same signal as is normally encountered in reflective propagation environments.

During normal, non-emergency operation, the DAB receiver (5) also receives the signal from the antenna (1). The receiver (5) demodulates the signal and then decodes the FIC information. It then passes that FIC information to the Ensemble Multiplexer (EMUX) (6). The EMUX configures itself to have a sub-channel structure which is identical to that of the off-air signal. This includes all the sub-channel data rates, FEC parameters, start and stop

CU and the actual FIC information transmitted in the emergency signal. Hence, if there are 10 different sub-channels to the off-air broadcast, each with a different sub-channel structure, the EMUX configures itself so that each corresponding sub-channel has a matching sub-channel structure and all audio channels would have the emergency warning.

5 Any data channels would be loaded with null (all zeros) data, essentially as padding.

The emergency warning message can be either a live or pre-recorded audio message. For larger tunnels with staffed operation centres the live option is available, however, for smaller un-staffed tunnels an automatic system will generally be required.

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Here, we use the pre-recorded option for the initial description. The emergency warning content is delivered to the EMUX via an input and control management function (7) which reside in the EMUX or a separate device such as a Personal Computer (PC). The pre-recorded messages are in the form of a database of files (8), or other suitable format, which will generally reside on the same platform as the input and control management function.

15 The off-air signal has the MPEG-1 Audio Layer II format [2] and can have a range of different data rates from 8kbps to 384kbps in steps of 8kbps. Indeed the audio may also have one of 4 modes (single channel mono, dual channel mono, stereo and joint stereo) as well as two sampling rates 24 and 48kHz [1]. This gives 48 rates and a total of 384 rate,

20 mode and sampling rate combinations. In addition, the recording of different languages will often be required, increasing the total number of combinations. Note that it is not seen as difficult for someone skilled in the art of programming to develop a system which can take an audio recording and generate a set of files which fulfil the above combinations automatically.

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Also storage is not seen as an issue. For example using an average bit rate of 192kbps and a message of 30secs, a database containing 5 languages would require  $192\text{kbps} * 30\text{secs} / 8\text{bits/byte} = 720\text{kbytes}$  per file which results in a total storage requirement of approximately 1.4Gbytes. Such capacity is a fraction of the hard disk capacity of current PCs. An alternative

30 embodiment to the pre-recorded database approach is to simply store the audio signals in a

PCM format and then encode the audio in real-time using a bank of musicam devices which have been configured to conform with the requirements of the off-air signal structure. While this option requires less pre-processing of the signal it will generally require more equipment, as typically a single ensemble will contain in excess of 8 sub-channels, and in the case of low rate channels possibly up to 12 or more. It will however be required if a live broadcast, e.g. from the tunnel operations centre, is to be used.

The EMUX (6) takes the input MPEG-1 layer II streams and multiplexes them into the appropriate locations within the ETI stream. The ETI stream also contains the details of the modulation and coding to be used for the transmission. The ETI stream is then fed to the COFDM (9) which then performs the required coding and modulation functions. In addition the receiver (5) supplies the COFDM (9) with timing synchronisation information to ensure that the output signal is aligned with the off-air repeater signal. The alignment of the off-air and emergency signals needs to be less than the minimum guard interval for the DAB transmission symbols. This is approximately 31 microseconds for Mode III, however Mode II with a guard interval of approximately 62 microseconds is the smallest guard interval that would be used for terrestrial broadcasts.

The COFDM (9) outputs the signal at RF (e.g. for Band III in the region of 200MHz). This signal is input to the switching unit (3). The control of the switching point is done by the emergency transmitter control UI (10). To ensure minimum disruption to the receiver, the switch between the off-air repeated signal and the emergency signal should be done during the null symbol at the transmission frame boundary. The transmission frame structure is repeated every 96mS in Mode 1. Hence two levels of synchronisation are required to ensure minimum received signal interrupts and hence minimum time to switch to audible emergency warnings, symbol level and transmission frame level.

In an alternative embodiment of the emergency warning system a number of parts of the solution may be replaced with customisations which are considerably lower cost. Considering **Figure 2** the DAB receiver may be replaced with a DAB module, where here

the DAB module performs all the requisite DAB receiver functions but which typically does not require any unit specific power supplies, casings and control code which could be supplied by the master control unit (10). Here the Master control unit (10) could be a PC or a microcontroller. The interface between the DAB module and the Master control unit could  
5 be via a number of industry standard interfaces such as I<sup>2</sup>C, USB or PCI.

The EMUX (6) in **Figure 1**, could also be replaced with a lower cost unit which has its functionality limited. For example, an EMUX is required to perform a range of management functions and to obtain input streams from a variety of sources, however in this case both of  
10 these functions are very limited. In addition the CODFM modulator (9) could be simplified as the full range of commercial features are not required, e.g. control functionality could be supplied by the Master control (10), the case and displays could be common for the entire system and the RF section (9b) could be optimised.

15 For large tunnel systems, a local tunnel control centre usually exists. In this case the emergency warning system could have the ability to provide live warnings. Usually the Tunnel-side equipment will be located in a separate equipment room along with other equipment such as FM transmitters, fire control and air conditioning. Referring to **Figure 2**, an embodiment of the emergency warning system tunnel control centre would consist of a  
20 microphone (11) to allow the recording or live announcement of emergency warnings. The microphone (11) is connected via an Audio input processor (12) to a Musician (13) which produces the MPEG-1 Layer II (MP2) data stream. The stream's destination is controlled by a Control and management function (14) which can direct the input to a recording database (15) or directly to the tunnel-side equipment. In a preferred embodiment, the transfer of data  
25 whether it be live MP2 streams, pre-recorded audio databases or control information and signalling would be performed using Internet Protocol based communications, e.g. TCP/IP or UDP. The tunnel control centre also needs to be able to review any recordings made and stored in a database and hence the MP2 playback (16), Audio output (17) and speaker/headphone (18) need to be provided.

The activation of the emergency warning system may be by a number of methods including:

1. an emergency button located in the Tunnel Control Centre (TCC) and possibly also other locations both within the tunnel or other maintenance locations
2. via a PC interface on the TCC system
- 5 3. via a trigger from a Fire Alarm or other critical system

An addition to the audio provided by the emergency warning system is the inclusion of an emergency warning DLS (Direct Label Segment) [1]. This will provide the receiver user with a textual display as well as audio.

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In a preferred embodiment, particularly for live, but also for pre-recorded warnings, a single warning message may be recorded and then the MP2 data stream is adjusted to provide the required data rate. For example the original recording could be a MP2 recording at 64kbps. This recording can then be rate adjusted to a higher bit rate, e.g. 128kbps. The quality of the new bit rate will be essentially the same as the original bit rate. The 'up-sampling' can be achieved by padding the MP2 data. A 'down sampling' requirement, e.g. 128 kbps down to 96kbps can be achieved by truncating the data in the sub-band data streams [1].

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In a preferred enhancement the COFDM modulator (9) in **Figures 1 and 2** can also be frequency synchronised to the incoming signal. The frequency synchronisation is necessary to ensure that the receiver signal tracking is not lost and a reacquisition caused. Typically, the difference between the carrier frequency of the received off-air signal and the emergency warning signal should be less than 20Hz. Two main methods exist for performing such frequency synchronisation, the first being the use of a GPS receiver to provide a common frequency reference (all DAB transmitters are required to be time and frequency locked to GPS). This however does require the provision of additional equipment and the consequent cost of that equipment. A preferred alternative is the use of the frequency offset information derived by the DAB receiver (5). This frequency offset is relative to the local frequency reference provided within the DAB receiver. This local frequency reference is then used as the reference frequency input to the COFDM modulator (9). In addition the timing

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reference required by the COFDM modulator (9) can also be provided by the DAB receiver (5). In both the frequency and time cases feedback will be required to ensure that closed loop synchronisation is achieved. Note that these feedback signals are not shown on **Figures 1 or 2.**

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In addition to time and frequency synchronisation, the signal level which is transmitted by the local transmitter could be adjusted to be similar to that of the normal, off-air retransmission signal. This is a useful additional 'synchronisation' as if the emergency transmission is a similar power to that which the receivers in the tunnel are receiving, then the AGC circuits in the RF section of the receivers will experience minimum disturbance and the probability of a receiver power induced decoding error will be minimised.

10

Referring to **Figure 1** or **Figure 2** this feature is easily implemented by measuring the received signal power in the receiver (5) and sending this signal level, or power, information to the COFDM (9) where the signal level is appropriately adjusted. In **Figure 2** the power level would normally be adjusted in the RF Section (9b). Generally a calibration procedure will need to be performed (usually at commissioning) to ensure that the difference between the receiver signal power measurement performed in (5) and the power output from the Input LNA is accurately determined. This calibration procedure can be done automatically by providing a power measurement from the Input LNA to the RF Section to ensure that the power output from both the RF Section (9a) and the Input LNA (2) are the same (or at least within a selected tolerance such as 1dB).

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It is proposed that any reconfigurations that occur in the off-air DAB signal would only be passed on to the EMUX (6) by the receiver (5) during non-emergency operation. If a reconfiguration was in progress when the emergency system was activated it would need to be completed. This would cause a slight delay to the output (possibly up to 6-8seconds) but such reconfigurations are relatively rare; indeed some ensembles reconfigure at a rate of less than once per day, if at all.

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## REFERENCES

[1] ETSI standard ETS 300 401, Radio broadcasting systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers

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[2] ISO/IEC 11172-3 (March 1993): "Coding of Moving Pictures and Associated Audio for Digital Storage Media at up to 1,5 Mbit/s - Audio Part".

**CLAIMS**

1. A method of transmitting a message comprising the steps of:
  - (a) deriving configuration information from a broadcast digital signal;
  - 5 (b) processing the message so that, when transmitted, it will conform to the configuration information;
  - (c) transmitting the processed message into a region using a transmitter.
- 10 2. The method of Claim 1 in which the region is a tunnel or bridge and the message is an emergency message transmitted across all channels or sub-channels.
3. The method of Claim 2 in which the transmitter normally repeats the broadcast digital signal but can switch to transmitting the message instead as the emergency message.
- 15 4. The method of Claim 3 in which the switch occurs during a null symbol at a transmission frame boundary.
5. The method of any preceding Claim in which the configuration information is derived from a FIC (fast information channel) in the broadcast digital signal.
- 20 6. The method of any preceding Claim in which the configuration information includes the sub-channel structure of the broadcast digital signal.
7. The method of Claim 6 in which the sub-channel structure configuration information includes one or more of: sub-channel data rates; FEC parameters; start and stop CU; actual FIC information present in the broadcast digital signal.
- 25 8. The method of any preceding Claim in which the message is a pre-recorded or live message.

9. The method of any preceding Claim in which the message is time aligned with the broadcast digital signal by using timing synchronisation information derived from the broadcast digital signal.
- 5 10. The method of any preceding Claim in which the message is an audio message.
11. The method of Claim 10 in which the message is a pre-recorded audio message that is adjusted to provide the required bit rate for transmission.
- 10 12. The method of any preceding Claim in which the message is a text message.
13. The method of Claim 12 in which the text message is transmitted using a DLS (Direct Label Segment) system.
- 15 14. The method of any preceding Claim in which the configuration information is used to configure an ensemble multiplexer feeding a modulator and power amplifier.
15. The method of Claim 14 in which the modulator is frequency synchronised to the broadcast digital signal.
- 20 16. The method of Claim 14 or 15 in which the frequency synchronisation is better than 20Hz.
17. The method of Claim 16 in which the frequency synchronisation utilises a GPS  
25 receiver to provide a common frequency reference.
18. The method of Claim 14 or 15 in which the frequency synchronisation utilises a frequency offset relative to a local frequency reference at a receiver for the broadcast digital signal; the local frequency reference then being used as the frequency input to the  
30 modulator.

19. The method of Claim 14 or 15 in which the transmitter transmits the message at a signal level adjusted to be similar to that of the broadcast digital signal received at the transmitter.
- 5
20. The method of any preceding Claim in which the broadcast digital signal is any signal from which configuration information can be extracted.
21. The method of Claim 20 in which the broadcast digital signal is one of the following:  
10 DAB (Digital Audio Broadcasting); DVB (Digital Video Broadcasting); DRM (Digital radio Mondiale).
22. The method of any preceding Claim in which the message on a given sub-channel is configured to match the broadcast digital signal on that sub-channel.
- 15
23. An apparatus for transmitting a message, comprising:
- (a) a receiver for receiving a broadcast digital signal;
  - (b) a means for deriving configuration information relating to that broadcast digital signal;
  - 20 (c) a transmitter for transmitting the message so that it conforms to the configuration information.

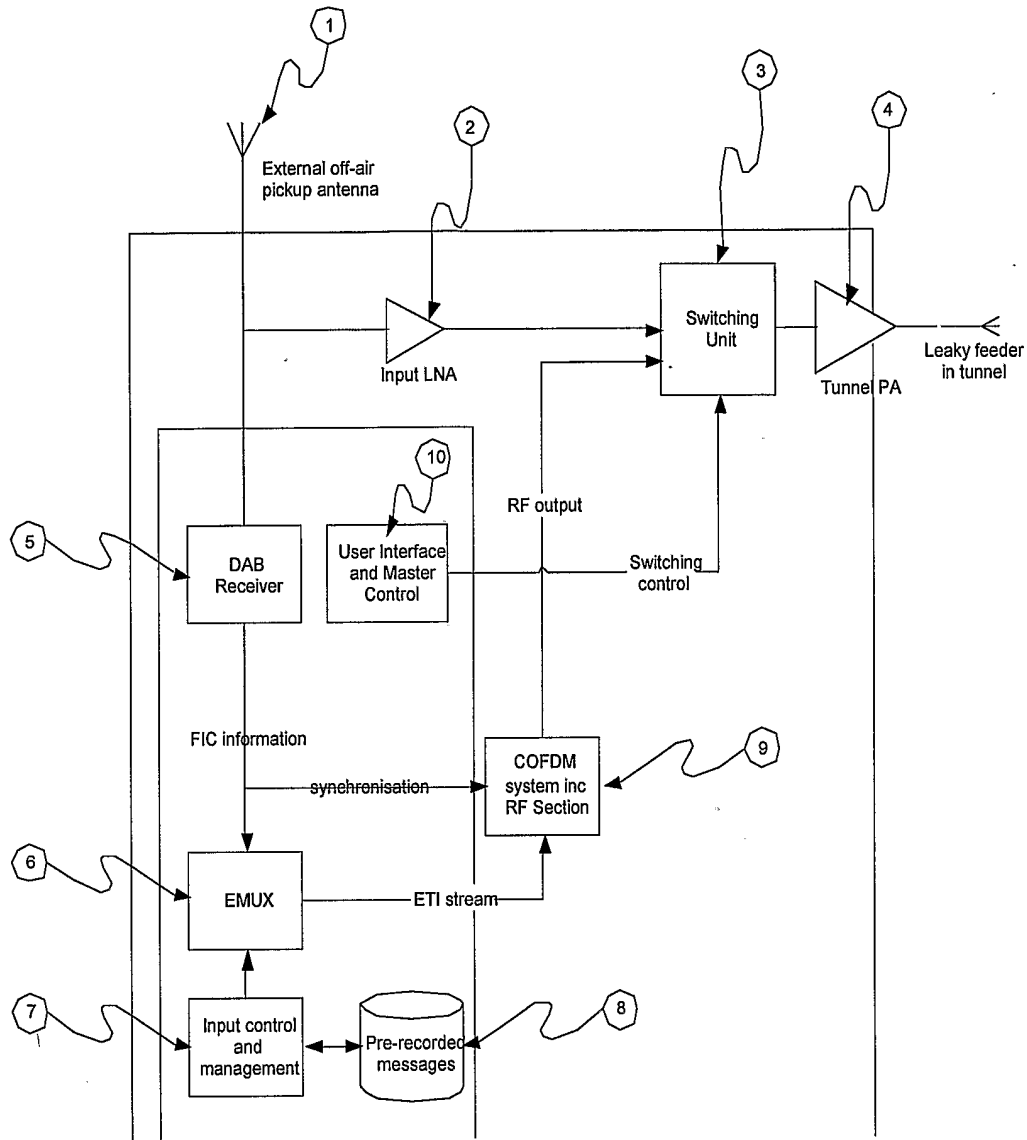


Figure 1

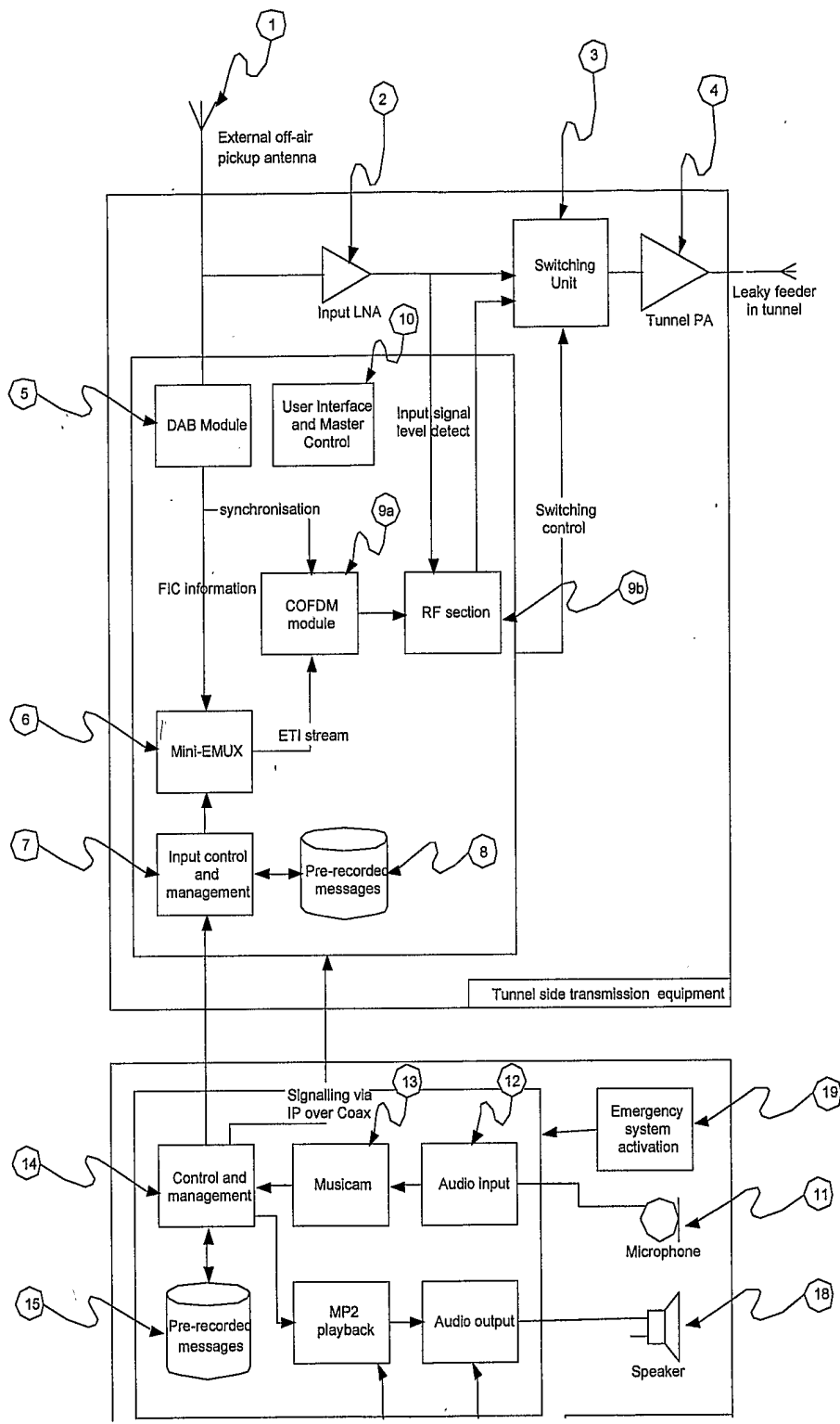


Figure 2