A high speed computer interface for professional audio equipment control

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ABSTRACT.

The introduction of intelligent professional audio equipment and the wish to control multiple devices from a central position creates the need for remote control of these devices. Existing computer interfaces and protocols are unsuited for pro audio applications or suffer from high complexity and price. This paper describes a newly developed remote control network for professional sound, light and motor/servo equipment.
The network has been developed based on a dedicated serial interface processor. Connections consist of twinax cable and 4-pins XLR connectors. It is controlled by a network controller (primary) that can be inserted like an extension card into a personal computer. The maximum number of connected stations (secondaries) is 250. Key features of the network are:

- Serial multipoint configuration (efficient connections).
- Synchronous transmission (little overhead).
- Error free data transfer (correction by retransmission).
- High transmission speed (375 kbits/s).
- Distances up to 1000 m between primary and secondary.

0. INTRODUCTION.

In 1985, Stage Accompany introduced the PPE-2400; the first commercially available digital controlled analog parametric equaliser. With this equaliser it is possible to store various settings in presets. Recall of these presets is fast and easy. After the introduction of the PPE-2400, many users wanted to recall the presets remotely. For this reason the PPE-2400 has been provided with the well known MIDI interface.

During the development of new devices like the Blue Box [1], however, the need arose to control the complete set of system parameters remotely. The MIDI interface provides for individual control of system parameters with the "exclusive messages mode". For various reasons, described in chapter 1, the MIDI interface appears to be less suitable for communications purposes. This paper describes a new more universal interface, called SAnet (Stage Accompany network).

Chapter 1 gives a brief description and evaluation of existing interfaces, the decision of developing SAnet and the SAnet design specifiations.

1. MOTIVATION.

As mentioned in the introduction, within Stage Accompany a need arose for a universal interface to enable remote control of various equipment from a central point. This applies for the transmission of commands as well as the reception of status data. This chapter gives a brief overview of the most important design specifications, the existing interfaces and the final decision to develop SAnet.

The four most important interface specifications were as follows:

- The interface needs to have a network-like (multipoint) character to allow for efficient connections.

- The number of separately controllable devices needs to be at least one hundred to control, for example, a stack of one hundred Blue Boxes.

- The data transfer has to be transparant and error free.

- The maximum distance between the connected devices has to be 1000 meters.

The existing interfaces like RS-232C and MIDI are unsuited to realise multipoint connections, as this would require massive bundles of cable. Also, with these interfaces it is not easy to implement a protocol that provides for error correction. Finally, maximum possible distances between the devices are too short.

The synchronous interfaces known from administrative applications like Ethernet, Starlan, etc. are less suitable because of their high complexity and therefore high cost [2].

After evaluation of the existing interfaces, we decided to develop a simple and professional network around a special component from Intel; the 8344 Serial Interface Controller [3]. This controller uses a subset of the standard IBM Synchronous Data Link Control (SDLC) protocol. The most simple application needs only one external component; an inexpensive line transceiver.

Chapter 2 gives a detailed description of SAnet.

2. SAnet SYSTEM DESCRIPTION.

Figure 1 illustrates the SAnet configuration. It shows that each secondary is connected directly with the primary.

2.1 Adapted SDLC protocol.

In a network like SAnet, it is necessary to have strict agreements about matters like system control, data format, error detection and error correction. These standards are fixed in a protocol. The protocol used with SAnet was derived from IBM's standard SDLC protocol [2] [4].

In a dynamical environment like SAnet, it is neccessary to have the possibility of varying numbers of connected devices. Each device has a unique identity code (ID) that can serve as a network address. SDLC specifies a fixed number of connected stations with fixed one byte station addresses, allowing 255 unique ID's to be defined. It will be clear that one byte is not sufficient to give each produced device a unique number. So we adapted the SDLC protocol in the following way.

The identity code is a combination of device type and device serial number consisting of four bytes. For that reason the primary dynamically attaches a unique station address (one byte) to a unique identity code (four bytes) as long as the communication link with the secondary exists.

2.2 Asynchronous transmission and frames.

SAnet uses asynchronous transmission that means that the data clock is recovered from the data stream itself. To aid in the clock recovery process, the 8344 has a NRZI (non-return-to-zero inverted) data encoding and decoding option combined with zero-bit insertion.

Instead of single byte data transfer, SAnet uses data blocks or frames. This type of data transfer requires less overhead data. In stead of start and stop bits, frames use start and stop flags to signal start and end of a data package. A flag is a unique combination of bits.

Figure 2 shows the frame used by SAnet. The first flag is the opening flag and indicates the start of the frame. The address byte indicates the station the frame is going to or coming from. The command byte indicates the type of frame. There are supervision frames, control frames and data frames. Supervision frames are used to create and maintain data links. Control frames are used to supply devices with network status information. Data frames are used to transfer data. The data block indicates a block of data with 1 to 64 bytes. The frame check sequence (FCS) is used for error detection and will be described in the next paragraph. The second flag is the closing flag and indicates the end of the frame.

2.3 Transparant data transfer.

One of the most important qualities of SAnet is the transparant data transfer. This means that you can transmit 1 to 64 bytes per frame with all 256 values per byte. The serial interface controller takes care of creating unique opening and closing flags.

In the previous paragraph the FCS was mentioned. The FCS is a sixteen bits word that is the result of a cyclic redundancy check (CRC) on the address, command and data fields that has been calculated by the transmitting station. The receiving station checks the frame in the same way. If this check results in a different CRC then an error has occurred. The receptor does not return an acknowledgement frame. The transmitter retransmits the frame until it is acknowledged.

2.4 Multipoint connections.

Figure 1 shows that SAnet is a multipoint network. This implies that all the network devices are connected with each other, the primary as well as the secondaries. This is an advantage because the SAnet can be routed from primary to secondary, from secondary to secondary, and so on. Therefore, SAnet is just one connection that goes from one device to another with each device having a SAnet input and a SAnet output, that are internally connected without buffer electronics.

The primary and secondary are connected with each other by means of a symmetrical two-wire connection, according to RS422. Under normal conditions, two-wire shielded microphone cable can be used. Under extreme mechanical or electrical conditions however, twinax (two-wire coax) cable should be used.

Four-pins XLR connectors have been chosen to interconnect the cables and the network stations. Since three-pins XLR connectors are widely used in the pro audio industry, the availability and use of four-pins connectors will not cause serious problems.

The maximum distance between primary and secondary depends on a few factors. If microfone cable is used, the distance will be limited to 500 metres, due to cable losses. With the use of twinax cable this distance increases to 1000 metres. With the aid of line buffers or repeaters it is possible to reach distances up to 10,000 meters or more.

2.5 Transmission speed.

The baud rate or transmission speed of SAnet is 375 kbits per second. This is the highest rate that can be achieved using the 8344 with one external component. In this case the controller uses the on-chip clock generator and digital phase locked loop (DPLL).

In special applications it is possible to increase the baud rate up to 2 Mbits per second. However, this requires more external components.

2.6 Primary (network controller).

Figure 3 shows the primary implemented as an IBM (-compatible) extension card. In SAnet, the primary acts as the network controller. There may be just one primary per SAnet. For example, the primary creates communication datalinks between secondary and PC. Another task of the primary is to create groups of secondaries to transmit common commands and to receive common data. At the same time, the primary accumulates, sorts and filters received data before it is sent to the PC.

The primary is based upon the 8344 serial interface controller from Intel. This controller contains the industry standard 8051 micro controller and a serial interface unit (SIU). The 8344 serves as input/output controller to relieve the PC from controlling SAnet. The 8051 part of the 8344 takes care of the interpretation of PC commands and accumulates network data that will be routed to the PC. The SIU of the 8344 creates and maintains communication links between primary and secondaries. SAnet is a polling network, i.e. the primary continuously polls the secondaries for data.

One of the most important advantages of the SIU is the ability to operate in two different modes; flexible mode and auto mode. In the flexible mode it is the 8051 part of the 8344 that takes control of the network activity, while in auto mode the SIU takes care of the network. In auto mode, most of the network commands are handled in hardware, making the turn around time neglectable. The turn around time is the time between the reception of a command and the transmission of a response. In SAnet the primary operates in flexible mode while the secondaries operate in auto mode. The very fast handling of the primary polls by the secondaries makes the SAnet a quasi real-time network.

The program memory of the primary consists of Electrically Erasable Programmable Read Only Memory (EEPROM). This type of memory enables the user to update his primary fast and easily without having to replace EPROMs. The primary software can be downloaded from floppy disk to primary through the PC. The second advantage of this kind of memory is the easy implementation of custom made software.

The primary contains 32 kbytes of EEPROM, so very advanced software can be downloaded. In this way, more and more intelligence can be integrated into the primary so the PC can optimally be used for control and/or monitor applications.

The software of the 8051 part of the 8344 contains a command interpretor that receives its commands from the PC. Following are a number of standard SAnet PC commands:

- open a station for communication
- close a station for communication
- create a group of stations
- send data to one or more station(s)
- send data to a group of stations

The 8051 part is connected with the PC by means of a dual port RAM (DPR). The handling of PC commands is done by an interrupt service routine in order to get a response as fast as possible. The size of the DPR is 8 kbytes, so very extensive commands and large data blocks can be handled efficiently.

It is well known that little interference can cause malfunction of a PC. To prevent this malfunction, SAnet has been separated from the PC's circuit by means of opto couplers. It will be clear that this is a very important feature with live concerts and the like.

The line transceiver is a bidirectional symmetrical receiver-transmitter that is protected against short circuit and high common mode voltages from outside. These features are a must regarding the earlier mentioned live concert conditions.

The currently available primary fits into an expansion slot of an IBM (-compatible) PC. This implies that current control applications run on an IBM (-compatible) PC. It is possible however, to implement the primary in any desired form. For example, think of an extension board for the Atari ST or Apple Macintosh, two other popular "audio" personal computers. It is even possible to implement the primary as a stand alone device because the 8344 contains a standard 8051 micro controller.

Besides using the 8344 from Intel there are a number of different serial interface controllers that can be used. Examples are the 8273 Programmable HDLC/SDLC Protocol Controller from Intel, the Z8530 Serial Communications Controller from Zilog, etc...

2.7 Secondary (network station).

Like the primary, the secondary uses the 8344 serial interface controller from Intel. The 8051 part of the 8344 can be used as main controller or input/output controller of the device. Examples of our devices that have been equipped with a SAnet interface realised by means of the 8344 are the Blue Box, the PPE-2400 parametric equaliser and the PPA-1200 power amplifier.

The SIU of the secondary operates in auto mode, so most of the network commands are handled by hardware. The poll command for example, that is contineously transmitted by the primary, is handled by the SIU. The 8051 part is not being interrupted. If the 8051 part wants to transmit some data to the primary, it will present the data to the SIU. Next the SIU transmits the data as a response to a primary poll command. Thus routine network tasks will not put a strain on the 8051 part. It can be used fully to control the device.

The reception of SAnet data, transmitted by the primary, is performed by an interrupt server. The interpretation of the SAnet data is handled by a network server that is called from the main program.

If the secondary is not being used in combination with a primary, it is possible for the secondaries to communicate with each other. For that reason the secondary can operate in master mode. In this master mode the SIU operates in flexible mode so it is able to transmit data without a request (poll) from the primary. In this way it is possible to control several slave devices by means of a master device. A second feature is to multitrack a number of similar devices.

Like the primary the program memory of the secondary consists of Electrically Erasable Programmable Read Only Memory (EEPROM). Again it is possible to update the secondary software fast and easily from the PC through SAnet.

There are many possibilities to implement the secondary. Think, for example, of a multi-processor device with an 8344 serial interface controller as a dedicated SAnet processor. Besides the 8344, the components called in paragraph 2.6 can be used. Notice that those components have lower performance than the 8344 because they handle network commands by software in stead of hardware.

The use of SAnet is not limited to audio equipment. Other devices like light and motor/servo equipment can be provided with a SAnet interface for remote control or monitoring.

3. APPLICATIONS.

SAnet is a universal network with numerous applications. This chapter tries to present some examples.

From a central point equipment can be controlled separately or in groups. The kind of control depends on the application. We use an IBM (-compatible) PC as the central operating point of SAnet. By means of this PC all parameters of our processor controlled equipment can be controlled remotely. An advantage using a PC as central operating point is the fact that the setting of all parameters can be stored on disk (floppy or harddisk). Presets can be created by storing combinations of parameters. The use of presets will decrease sound check time significantly. Besides recalling presets manually, it is possible to synchronise them to a master like SMPTE, MIDI or a Compact Disc.

Another advantage using a PC is to make system control a lot easier by using the graphic capabilities of the PC's screen. Think for example of a parametric equaliser with its many parameters. In stead of showing the user a list of gains, central frequencies and Q-factors, it is possible to calculate and show the actual frequency response.

Monitoring is another important application of SAnet. Specially routine tasks like power and temperature monitoring can be done by the PC. If a threshold is exceeded, the PC can automatically perform some action to avoid undesired situations.

All Stage Accompany processor controlled equipment have an internal log-book that stores several system parameters like hours of operation, duration of overloads, etc. These data can be accessed through SAnet and can be used as a basis for a maintenance system.

Another application of SAnet is downloading of control software to update a secondary. Of course this implies the use of EEPROM for program memory. Besides updating secondary software, it is very easy to develop custom made programs that can be downloaded as well.

4. CONCLUSION.

The described network system offers a high speed (375 kbits/s) multi point system existing out of one host (primary) and up to 250 slaves (secondaries). The host manages and controls the network and can, like an extension card, be built into an IBM (-compatible) PC.

The available control functions depend on the connected device and can vary from the recall of presets to the setting of all available parameters. Any processor controlled device, equipped with a SAnet interface, can serve as a network station. All desired communication directions, from primary to secondary, from secondary to primary and from secondary to secondary are possible.

Because SAnet has an open structure it will always be possible to improve it. The SAnet primary board has been provided with a basic software package. This package can be improved and extended in the future.

Other manufacturers are encouraged to implement the network controller (primary) on other personal computers like the Atari ST, the Apple Macintosh, etc. In addition there is no basic problem to integrate a SAnet interface into equipment (secondaries) from other manufacturers. For these two purposes SAnet information from Stage Accompany will be available soon.

Currently available software packages include Blue Box control and software downloading. In the near future, information about commands and responses of equipment that is provided with a SAnet interface will be available from Stage Accompany to enable software developers to write there own control programs.

No doubt SAnet will be compared with the well known MIDI interface. However a comparison is not appropriate, because MIDI is a typical synchronisation interface while SAnet is a typical communication interface. Of course you can use SAnet as a synchronisation interface too.

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