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A Versatile Wireless System for Real-Time Telemetry Applications

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Abstract - ***This paper presents a two-way wireless system, capable of retrieving data dynamically from a large number of users or devices, with high accuracy and within a minimal period of time. The system uses unlicensed data transceivers, either in the UHF or in the 900 MHz band, and employs two communication protocols depending on the required data collection rate and accuracy. The paper presents the system architecture, the design of the remote unit, either hand-held device or locally installed, and the base station of that wireless system, and the communication protocols performance.***

I. Introduction

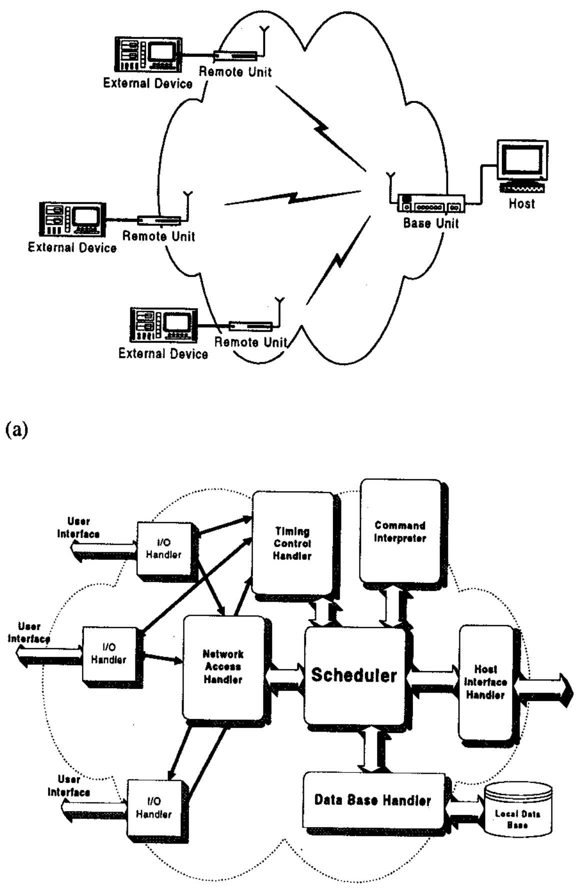
This paper presents the MarketLink wireless telemetry system, which is capable of retrieving data dynamically from a large number of users with high accuracy and within a minimal period of time. The MarketLink is controlled either locally via a host computer, or remotely using a wire-line modem. It is based on unlicensed data transmission and employs a new access protocol that results to high data collection rate with high accuracy. It is offering an optimum performance/cost solution for collecting data from multiple users (up to 4,000 with a single base station). The system consists of a single or multiple base stations and a multitude of hand-held devices (remote units). The base stations are connected to a host computer running the application software.

The MarketLink system is a distributed network that provides an error-free transparent link for data collection between a central location and a large number of remote units. The remote units are either hand-held devices, or fixed position terminals. Each remote unit acquires and stores locally the information of the interfaced device, and transmits it to the base station when it is requested to do so, or in predetermined time intervals. That system can be used to collect data during the voting process of a meeting, to collect sensorial data, to monitor and control remote devices in the residential or the industrial environment etc.

II. System Architecture

The MarketLink network is controlled by a base station, where all communication protocols are implemented to provide the required system functionality. The base station receives high-level commands from the host and then communicates with the remote units for either setting-up the network or for collecting data and updating a local data base. The remote units contain all protocol related functions that allow them to respond to commands issued by the base station. In order to minimise their complexity, no protocol state-machine has been implemented in the remote units, but the firmware returns to a predefined state after servicing either a network or a user request. The remote units firmware has been developed as slave to the base station primary functions, forming a distributed multi-tasking system, where each task has been implemented in a remote device and task access points have been implemented using data transaction functions. Figure 1 shows the system architecture and its functional structure.

The MarketLink uses two different addressing schemes for system operation and maintenance. Each remote unit contains a hardwired 16-bit ID code and temporary network address (NA). The permanent addressing scheme is based on the remote unit IDs and is used only during the registration procedure. The temporary addressing scheme is used during a session and is allocated during the registration procedure. Any host software is based on the permanent addressing scheme (IDs) and all relay functions between the two addressing schemes are implemented in the base station.



(a)

(b)

Fig. 1 The MarketLink Architecture

The MarketLink system data exchange can be organised in one of two different protocols:

- Polling Protocol
- Time-based Protocol

Both protocols are based on asynchronous characters transmissions with specific coding and timing constrains, thus implementing a packet-like operation. Each data packet consists of one or multiple characters, transmitted using the (9-bits, no parity, 1 stop bit) asynchronous format. There are two types of data transactions between the base station and the remote units. The polling protocol uses either the hard-wired IDs or the temporary network addresses. It is used when data accuracy is the main system requirement. The time-based protocol, which gives the best data collection rate, uses only the network addresses since all remote units are organised in subgroups, by using a part of their network address. Each subgroup contains up to 16 units, with their sub-addresses taking values from 0 to 15. Whenever a subgroup is addressed by the base station, the respective remote units respond in separate time intervals, using their sub-address. This protocol can be used to increase the network throughput, thus satisfying the performance requirements of different applications. The two protocols can easily be mixed in order to achieve the optimum data collection rate/accuracy performance.

Whenever the base station has to send data to a specific remote unit, the respective packet is transmitted and the remote unit response is expected in a specific time interval. During a packet reception, a 'packet reception watchdog' mechanism is activated for checking the packet integrity. Special data patterns are interleaved with the application data for measuring the channel BER at the base station.

The network maintenance is performed at the base station, where a data-base of registered or unregistered remote units is maintained. The network set-up is performed either using an automatic or a manual process. During the automatic process, the base station scans all possible IDs and updates its data-base, while during the manual process, the base station uses the Ids provided by the host computer to register the devices into the network.

III. Hardware Issues

The data are transmitted using a half-duplex RF transceiver, either at 900 MHz or in the UHF band. For modulating the digital information, Frequency-Shift

Modulation (FSK) is used, while the carrier frequency is quartz surface acoustic wave (SAW) stabilised. Front-end filtering is performed using low-loss coupled SAW resonators, thus resulting to excellent selectivity. Figure 2 shows the RF transceiver block diagram. The achieved data rate is 28.8Kbps, with 0 dBm RF output power. Different control signals are used for the local oscillator, antenna switch, transmit and receive enable etc. making the MarketLink transceiver ideal for a large number of telemetry applications. The RF transceiver power consumption is directly related to numbers and rates of transmissions. The nominal power dissipation during operation is in the order of 15mW. Transmissions are guaranteed for up 500 feet, but due to variations in operating environments, the distance may be greater or shorter.

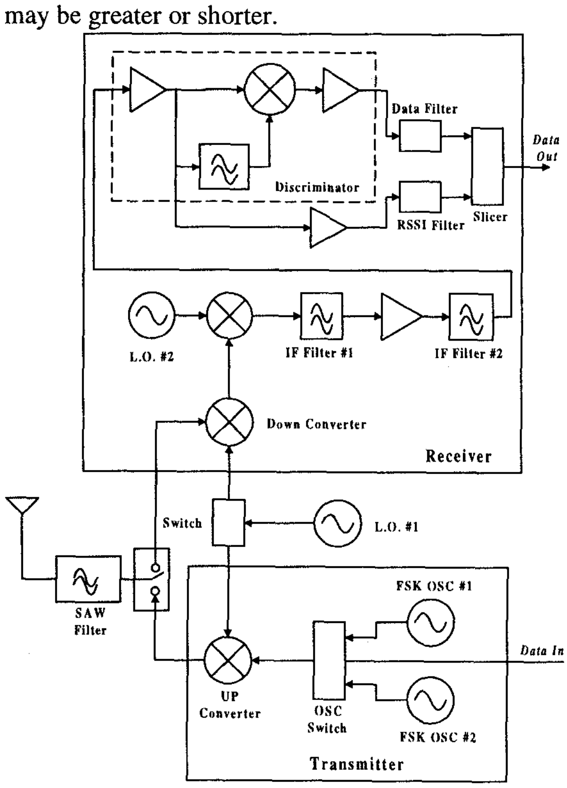


Fig. 2. The RF module block diagram

The remote unit has been designed to be small, require low power to operate, having a simple user interface and being flexible in its ability to configure a wireless data communications network. A single powerful micro-controller has been used in each remote unit, so various processing algorithms can be implemented. In applications where data are collected from sensors, up to sixteen inputs can be monitored and up to eight outputs can be controlled. Whenever a human interface is required, an LCD and a keypad can be easily interfaced. Local EEPROM saves the remote unit parameters and can be used to remotely change the factory default parameters. The system support remote configuration functions, protected by a password and timing mechanism.

The base unit has been implemented using a powerful micro-controller and various memory banks for implementing the local data base. The real-time kernel that is used inside the base station is an extended version of the Simplified Operating System (SOSystem), as it was shown in Figure 1b. It consists of a priority-driven scheduler and five resource managers, the Host Interface Handler, the Data Base Handler, the Command Interpreter, the Timing Control Handler and the Network Access Handler. The scheduler supports a limited set of real-time multitasking procedures and a pre-emptive priority driven CPU allocation mechanism and is also used for inter-task communication by allocating static buffers and using an ownership control mechanism. The Data Base Handler is used for associating parts of the extended memory map to specific remote units and for generating the system reports.. The Timing Control Hnadler nodifies the tasks for the expiration of predetermined time intervals and controls the Network Access Handler during the data collection process. The Command Interpreter is used to translate the high-level commands issued by the host to a list of system functions that have to be implemented by the other system tasks.

IV. Performance Issues

The system performance depends on various parameters. Most importanta are the RF transceiver ON/OFF time (T_{RF}), the data transmission rate (R) and the number of bytes collected per transaction.

For single byte collection/remote unit (like in voting applications) the following two equations give the maximum achieved data rate (R_{max}) for the polling and the time-based protocol.

$$R_{\max} = \frac{1}{(T_{RF} + 16/R) + (T_{RF} + 48/R)} \quad (1)$$

$$R_{\max} = \frac{16}{16.(T_{RF} + 16/R) + (T_{RF} + 48/R)} \quad (2)$$

Figure 3 shows the data collection rate that can be achieved by using that system for different data transmission rates and RF transceiver ON/OFF times. It is obvious that the data transmission rate becomes important only when the T_{RF} time is less than 2 msec.

For multiple bytes collection (like in sensorial applications) the following two equations give the maximum achieved data rate (R_{max}) for the polling and the time-based protocol.

$$R_{\max} = \frac{n}{(T_{RF} + n.16/R) + (T_{RF} + 48/R)} \quad (3)$$

$$R_{\max} = \frac{n.16}{16.(T_{RF} + n.16/R) + (T_{RF} + 48/R)} \quad (4)$$

where n is the number of bytes collected during each transaction. Figure 4 shows the data collection rate that can be achieved by using that system for different data transmission rates and RF transceiver ON/OFF times. In this figure, n is equal to 8. It is obvious that the T_{RF} time is also important, but becomes less important since a larger number of bytes is transmitted per transaction.

V. Conclusions

This paper presented a two-way wireless system, capable of retrieving data dynamically from a large number of users or devices, with high accuracy and within a minimal period of time. The system can be easily customised to different applications, like voting, sensorial data collection, remote monitoring and control etc. The supported protocol profile can be easily configured to support different accuracy/response times. The system operates in unlicensed radio bands and can be easily used either for hand-held or fixed location remote units.

References

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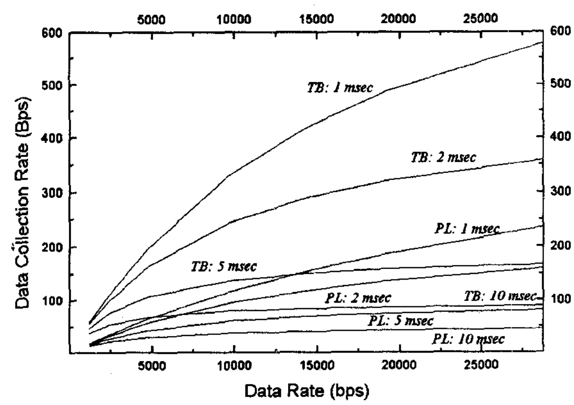

Fig. 3. System performance for 1 byte/transaction.

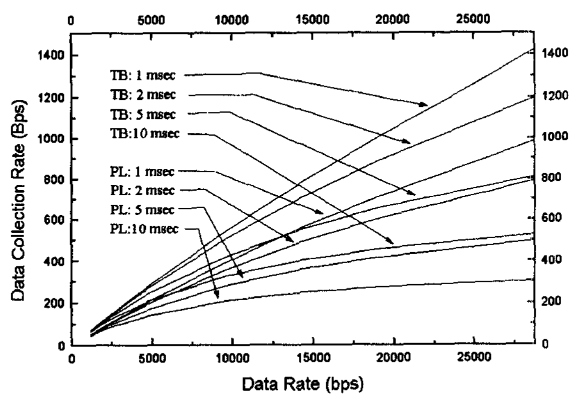

Fig. 4. System performance for n bytes/transaction