Interface for Automatic Meter Reading System

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ABSTRACT

A system of automatically interrogating metering without the need for site visitation has many advantages, both to the supplier and to the consumer. This paper presents a case study of the design of such a system starting from scratch. The system design begins with interfacing the metering to a communications system. The development of an interface for an automatic meter reading system is described. In this case study, the power lines in a power system are used as the communications channel. A smart meter is the source of power data and communicates with a logging PC when interrogated. What is involved in the initial design process is described. Serial communication is used to collect the instrument data and to communicate with the logging PC. Specialised circuits in this design that make use of FSK are identified and the entailed implementation problems are described. Measurements of the interface's output is given.

Keywords Smart meter, automatic meter reading, interface,

1. INTRODUCTION

The School of Engineering at the University of Western Sydney offers undergraduate Bachelor of Engineering programs in electrical, computer, telecommunications engineering and in Mechatronics and Robotics. The programs are accredited by the Institution of Engineers, Australia and admit the graduates to the entry level graduate membership of the Institution. The undergraduates degrees take four years to complete and consist of two 14 week "sessions" each year. The course tuition fees may be paid up-front by the students or alternatively delayed and repaid once in the workforce.

The engineering programs have traditionally included considerable amount of practical work. The graduates must complete practical tasks that help to make them workforce "work ready". The Insitution of Engineers, Australia requires that specified graduate attributes be developed in the graduates and that these attributes be "observable on graduation". Student honours projects are designed to hone the practical skills of the undergraduates as they demonstrate the skills and attributes that have acquired via the completion of their respective projects. Many successful projects are work related, for those students who have workplace involvement. Many projects are the result of suggestions from the students themselves, based on some of their previous experiences, and interests.

This paper describes a case study of one such honours project. The topic was suggested by the student, carried over from her past experiences. The overall task was to investigate and design a "smart meter" application, involving the delivery of 50 Hz power to consumers. The design started without any prior knowledge of the subject, having examined the arrangements currently described in the published literature.

2. THE AUTOMATIC METER

Automatic Meter Reading (AMR) systems have been adapted in the power industry due to the many advantages they provide to both the end user and the supply authority [1] [2]. Such systems are in contrast to the accumulation meters in common use. AMR systems permit the interrogation of the meter readings without the necessity for human contact. There are advantages for all parties. For example, on the supply side, the bills received by customers with tricky access would never need to be estimated again. This would give a more equitable treatment since the actual power consumption of any one individual may vary widely from the aggregate demand of a group of similar users. On the demand side, supply is seen to be more efficient. The components of such a system would at least entail the appropriate meter, some means of interfacing to the power system and communicating with a central controller.

This paper describes the approach taken by an honours undergraduate to design a practical and working interface between a “smart meter”, in this case, a PowerTek ISW 8350 model, making use initially of a 50 Hz, 24 V AC supply. Figure 1 shows the front panel layout of the power meter [3]. It was intended that conversion to operation at full mains voltage would occur at a later time, once a working prototype was created. The topic was selected through discussions between the student and the supervisor, with a topic relevant to the power industry and producing a “work ready” graduate.

Building on the success of ripple control for the control of domestic hot water heaters, the communications channel for the interface was selected to be the readily available power lines through the method of power line carrier. The problems associated with the harsh, noisy channel that was the power lines would be addressed at a later stage.

3. INITIAL APPROACH

The first step in the process was to check that the power meter was fully operational. The meter came with Windows compatible software that allowed RS232 communications

Figure1: The Powertek smart meter

with a personal computer. The meter was duly tested in isolation and confirmed to operate correctly for a small single phase load at the reduced voltage of 24V ac. The meter was then connected to the logging PC to determine if RS232 communications could be established.

The power meter came with a USB port for serial communications and needed only to be connected to another USB port to set up communications. In this case setting up communications between the power meter and the logging PC entailed the use of a crossover cable and the Windows accessory Hyper-terminal, and after a small amount of adjustment 2-way communications were established with a local echo. A software driver supplied with the meter had to be installed on the logging PC so that its operating system would recognize the “new hardware” installed. In this manner data could be captured in a text file and forwarded on at least manually.

The standard form of the AMR system makes use of the power lines as the communication channel to convey information to its destination. Once the communication lines had been selected, the means of modulation had to be decided. A review of the possible modulation methods indicated that the use of frequency shift keying (FSK) had many advantages, in particular its insensitivity to amplitude attenuation, and was selected as the method to use in the application [4]. Typical measured FSK waveforms are shown in Figure 2.

The dark bands in Figure 2 indicate lower frequencies corresponding to logic 0’s; logic 1’s being represented by higher frequencies. To utilize FSK, which is a digital method, the output of the power meter would need to be in the form of a square wave. This could be achieved by converting the USB output of the power meter to RS232 signals. A survey of commercially available applicatioon specific integrated

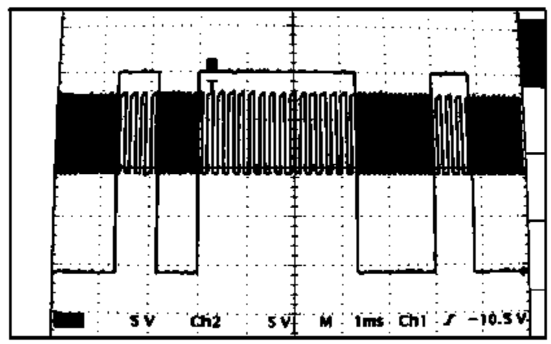

Figure 2: Measured FSK waveforms

circuits identified two possible matched pair contenders: the demodulator chip XR2206 and the corresponding modulator chip XR2211 [5] [6] [7].

Some means of converting to the RS232 waveforms was needed. A simple cable change would not suffice due to the differences between the RS232 formats and that of USB.

It was of interest to discover that data received by the logging PC from the power meter could be captured and stored in a separate file via the features of Hyper-terminal. The file could be output via the RS232 port of the capturing PC. This was, however, not exactly convenient for a proposed AMR system. Some form of active device would be needed to modify the power meter output.

4. NEXT STEPS

Since the power meter output was readily available at the USB port of the power meter, in order to make use of FSK modulation, the USB output had to be converted to RS232 format. Also to add versatility, it was recognized that more than one meter may need to be interrogated in any practical AMR system. A way in which meter outputs may be multiplexed was by incorporating a complex programmable logic device (CPLD) to select the meter in question, among other things. This complicated the design in that the TTL voltage levels associated with the CPLD then had to be accounted for; a level translator had to be included. The overall arrangement is shown in Figure 3.

For this conversion, a commercially available device was identified and used. This was the VDIP1 (Vinculum Dual In Line Package) module [9]. The output of the power meter could be connected to the VDIP1 module which outputs TTL (transistor-transistor logic) voltage levels for further processing. Once the TTL digital signal was generated, it had to be converted into a suitable form for transmission down the power line channel.

In keeping with ripple control technology, a means of modulation was adopted, as mentioned above, the digital method of FSK.

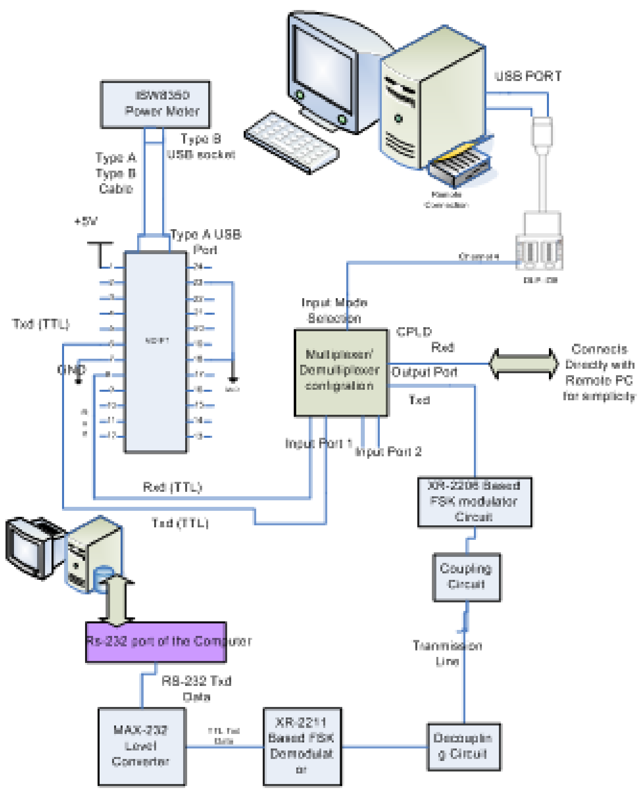

Figure 3: Overall design

As shown in Figure 3, the sequence involved in the proposed automatic meter reading process was therefore: meter output to VDIP1 module, to CPLD to FSK generator. At this stage, the signal would need to be injected into the power line acting as the communications channel via a suitable coupling circuit. At the receiving end, the signal would need to be de-coupled from the mains, FSK demodulated, returned to RS232 levels via a Max 232 device before connection to the logging PC.

5. COUPLING CIRCUIT

Once the data has been modulated, the signals needed to be injected into the power lines as the communication medium. The test arrangement is shown in Figure 4.

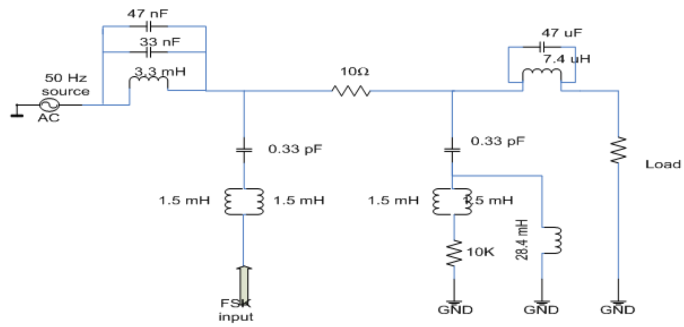

Figure 4: Coupling / decoupling circuits

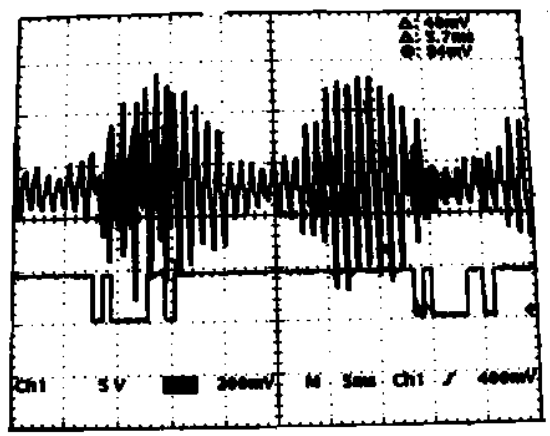

Figure 5: Decoupled output

Passive coupling using LC resonant circuits were utilized; voltages become summed depending on the relative impedances of the components connected. The parallel resonant circuits presenting minimal impedances at the modulated frequencies and considerable impedance to the 50 Hz signals present. The series resonant circuits acting in reverse, presenting a high impedance at the modulated frequencies and low impedance at 50 Hz. The connecting power line was represented by the 10 Ω resistor as a first test connection.

For the configuration shown in Figure 4, the output of de-coupling circuit would appear across the 10 kΩ resistor. The measured waveform is shown in Figure 5. There is considerable amplitude distortion of the FSK signal, but not the frequency. The data could still be retrieved correctly at the received end PC. Initial investigations indicated that the modulation of the FSK amplitude was a result of the manner of operation of the XR2206 demodulator module and is being investigated further.

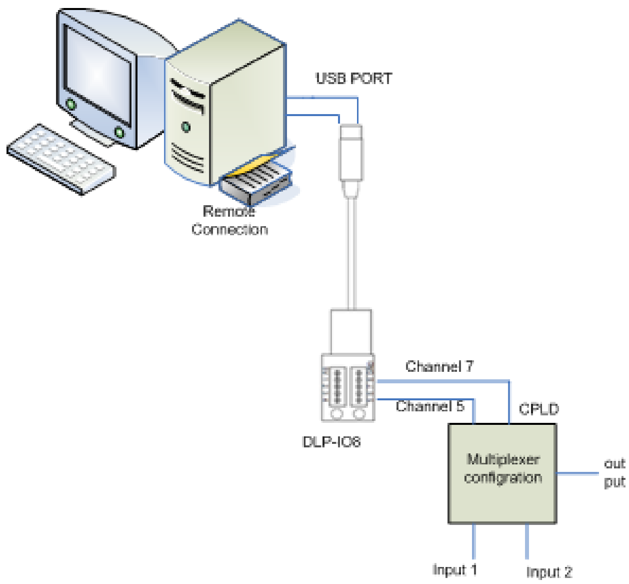

Figure 6: Remote access to meters

At the output of the XR-2211 the TTL voltage levels are converted to RS232 voltages via the MAX-232 IC. The RS232 voltages, typically negative logic level of -3 to -12 V for logic "1" and +3 to +12 V for logic "0" are translated into TTL voltage levels by the Max 232 device [8]. An added complication but necessary.

6. Remote Access

As shown in Figure 3 and enlarged in Figure 6, access to interrogate a meter located remotely is provided by another device, the DLP-IO8. This is a commercially available low cost data acquisition board that enables communication between the CPLD and the VDP1 module.

7. Summary

The design was tested with the power meter measuring some 35 W with the interrogation of the meter's reading via a remote PC. The transmission link used was the 10 Ω resistor representing a short length of power line. The results are shown in Figure 7. A more stringent test would have been to approximate a short transmission line by the usual RL series connection. Time did not permit this stage of the testing but further work is continuing on the design. The use of the design at power mains was also another factor to consider. However coupling with a suitable number of turns was deemed the correct approach to take. Considerations of OH&S meant that, at least in the initial studies, high voltage testing could not be used.

The design presented was started wioth minimal prior knowledge, with just the concept to begin the process. Having examined the configurations in the published literature, hardware was identified to realize the concept proposed. The design configuration finalised was original, making use of components available in the marketplace, reminiscent of development and integration tasks as found in the workplace. Despite the limitations of the voltage level and the transmission line model, a feasible design was demonstrated.

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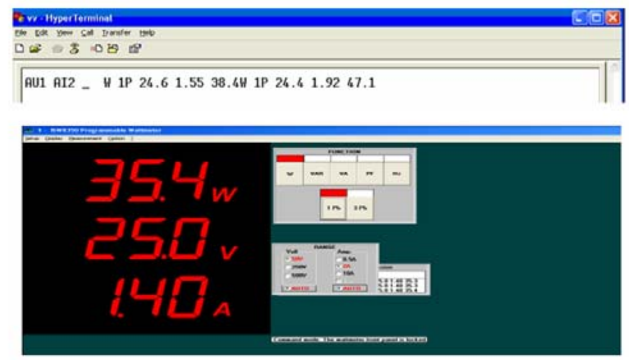

Figure 7: Final display at the received end.

The project work has allowed the student to not only apply but to also extend the technical knowledge and skills that have been acquired during the years leading up to the project. The student's contribution during development of the steps taken is central to a successful outcome. In this way the communication skills and the teamwork ability of the student is enhanced; technical points have to be presented, defended and concessions made, all in a professional atmosphere, as the project proceeds. Put these aspects together in the right mix and a successful outcome results, one in which the student emerges confident and ready to take on the working world.

In general terms a suitable project should be one that motivates the student. Ideally the student has contributed to the formulatrion of its aims and scope. The scope must not be too grandiose, but start small; it should be readily expandable as and when needed, depending on the time frame applicable. Most importantly the student must be committed to achieving a successful end result. Lastly the topic should be of interest to the engineering community.

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