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DESIGN AND DEVELOPMENT OF ASSISTIVE PRECISION MEASUREMENT DEVICE FOR VISUALLY IMPAIRED PERSONS

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Abstract: This paper describes an inexpensive, small scale embedded system for assistive precision measurement device to convert digital measurement device data into speech output. This system design uses 8051 microcontroller to process all digital data and control other system modules. In the present work measurement data is acquired from Digital vernier caliper through serial link which utilizes RS232 communication protocol. The microcontroller regulates input from caliper through a feed back from speech module along with real time processing and storage of processed data in internal RAM. This processed data is then sent to speech module to get voiced output. The developed device is a low cost but highly reliable and portable assistive measurement system.

Keywords: Assistive precision measurement device, serial communication, microcontroller, speech module

1. INTRODUCTION

For measurements most of the people rely on their visual senses i.e. eyes. But the persons who are visually deprived/impaired can't utilize that sense thus rely on other senses such as tactile and auditory senses. Traditionally, visually impaired and blind rely on Braille for learning and education but all scientific instruments can not be customized for Braille or sensory output thus other multimodal approaches are needed. As auditory approach could be implemented in Most of the simple scientific instruments, we are looking forward to develop such systems which could give their output in audio form. As measurement of dimensions is the routine job in process instrumentation, industrial control environments and small scale industries (Carpentry, Plumbing etc.).

This paper describes an inexpensive, small scale embedded system to convert digital measurement device data into speech output. Present system design utilizes ATMEL 8051 microcontroller to process and regulate all digital data along with the control of other system modules. The measurement data is acquired from Digital vernier caliper by serial link between microcontroller and vernier caliper through RS232 communication protocol. The measurement data is then processed in real time and stored in the internal RAM of 89c2051 microcontroller. The serial link is preferred from the view point of its simplicity and cost effectiveness. This system is a simple solution to convert measurement data into speech output. The hardware and software description of the developed embedded system are described individually in the following sections.

2. DESIGN AND OPERATION

In design both size and weight of electronic device should be smaller so that blind people will not feel any difficulties when using it. The more important requirement other than size and weight is energy consumption. Electronic device must be designed to consume less power, so blind people can use this as long as possible. Thus embedded system is employed to achieve these requirements. Sub-section A describes system model in terms of hardware, and sub-section B explains how system model described in section A is operated in terms of software.

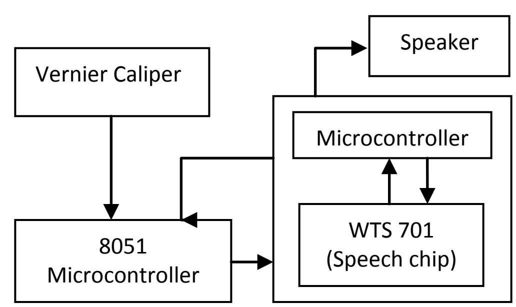

Figure 1. Block diagram indicating the sub-systems included in the described assistive electronic device.

2.1 Hardware Perspective

In terms of hardware, the system consists of five components: microcontroller, vernier caliper, speech module, MAX232 IC and serial communication system between vernier caliper and speech module. Block diagram shown in figure 1 shows the overview of the assistive electronic device. From block diagram shown in fig. 2 the system operation can be explained as follows. The Digital Vernier caliper [1], [2] interfaces with the microcontroller using an Opto-RS232 serial data cable. It communicates with microcontroller at different baud rate and serial communication protocol, than that of speech module. The RS232 signal from caliper is first converted into TTL signal by MAX232 IC as suitable input for microcontroller. Then controller do real time processing of input signal and saves it in internal RAM. After reception of complete data and processing, it sends out the stored RAM data through serial communication to speech module for speech output.

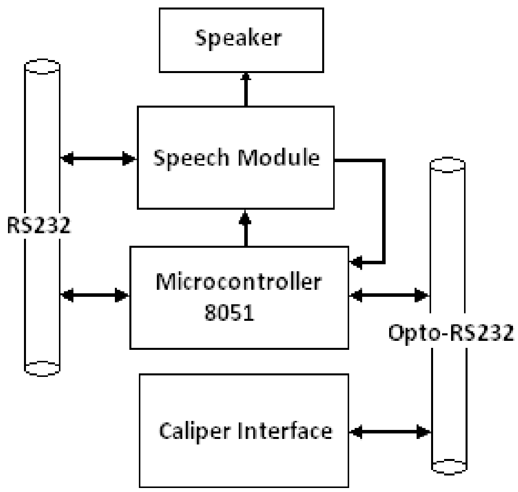

Figure 2. Block diagram of device controller

A. Microcontroller

An Atmel 8-bit IC number 89c2051 is used as a microcontroller for the control of Speech module and its output along with the regulation and processing of Vernier caliper input. The Vernier caliper interfaces with the microcontroller using an Opto-RS232 serial port. It communicates with system at different baud rate and serial RS232 communication protocol, than that of speech module. Thus real time data processing is needed which is efficiently handled by controller. This microcontroller gets feedback from speech module so that it would not accept any input from caliper till speech module has pronounced the output in form of speech from previous input. This is a compact 20 pin IC having the architecture and instruction set compatibility with 8051 microcontroller series. It consumes less energy and has all features as required to operate the device. This microcontroller is reprogrammable and has 2K flash memory (program space) that is ideal and sufficient for this project [3]. Fig. 3 illustrates the Circuit implemented for this assistive precision measurement device.

B. Level Converter (MAX 232)

The RS232 data signal from vernier caliper has to be converted into TTL signal before acquiring it into the microcontroller. This is done by using a level converter. In the present work MAX232 IC from Texas instruments is used as a level converter [4].

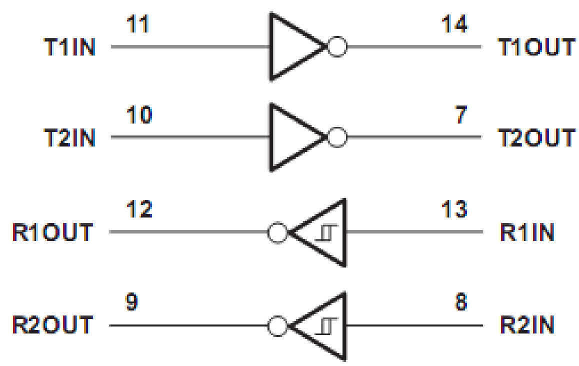

Figure 4. Logic diagram and pin configuration of

MAX232 IC.

The MAX232 is a dual driver/receiver that includes a capacitive voltage generator to supply RS232 voltage

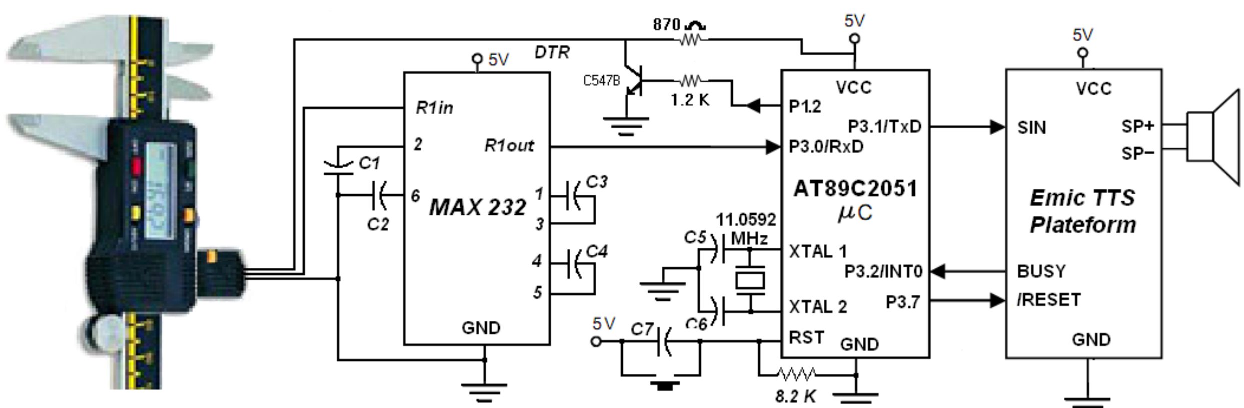

Figure 3. Circuit diagram of embedded system for assistive precision measurement device

levels from a single 5-V supply. Each receiver converts the RS232 input signal levels to 5-V TTL/CMOS signal levels. Each driver converts TTL/CMOS input levels into RS232 voltage levels. Fig. 4 shows the logic diagram and internal pin configuration of MAX 232 IC.

C. Speech Module

In this assistive device, speech output is generated using Emic Text to Speech (TTS) module from Parallax™ which includes a WTS 701 Speech chip from Winbond. This module intelligently handles values, sentences, numbers and common abbreviations with an extremely natural female voice with simple serial string sentences [5].

2.2 Software Perspective

The whole embedded program code is developed for the microcontroller in both C and assembly language [6], [7], [8]. Keil µVision 3 is the compiler used for software development and testing of microcontroller embedded program. Figure 5 shows the flowchart of

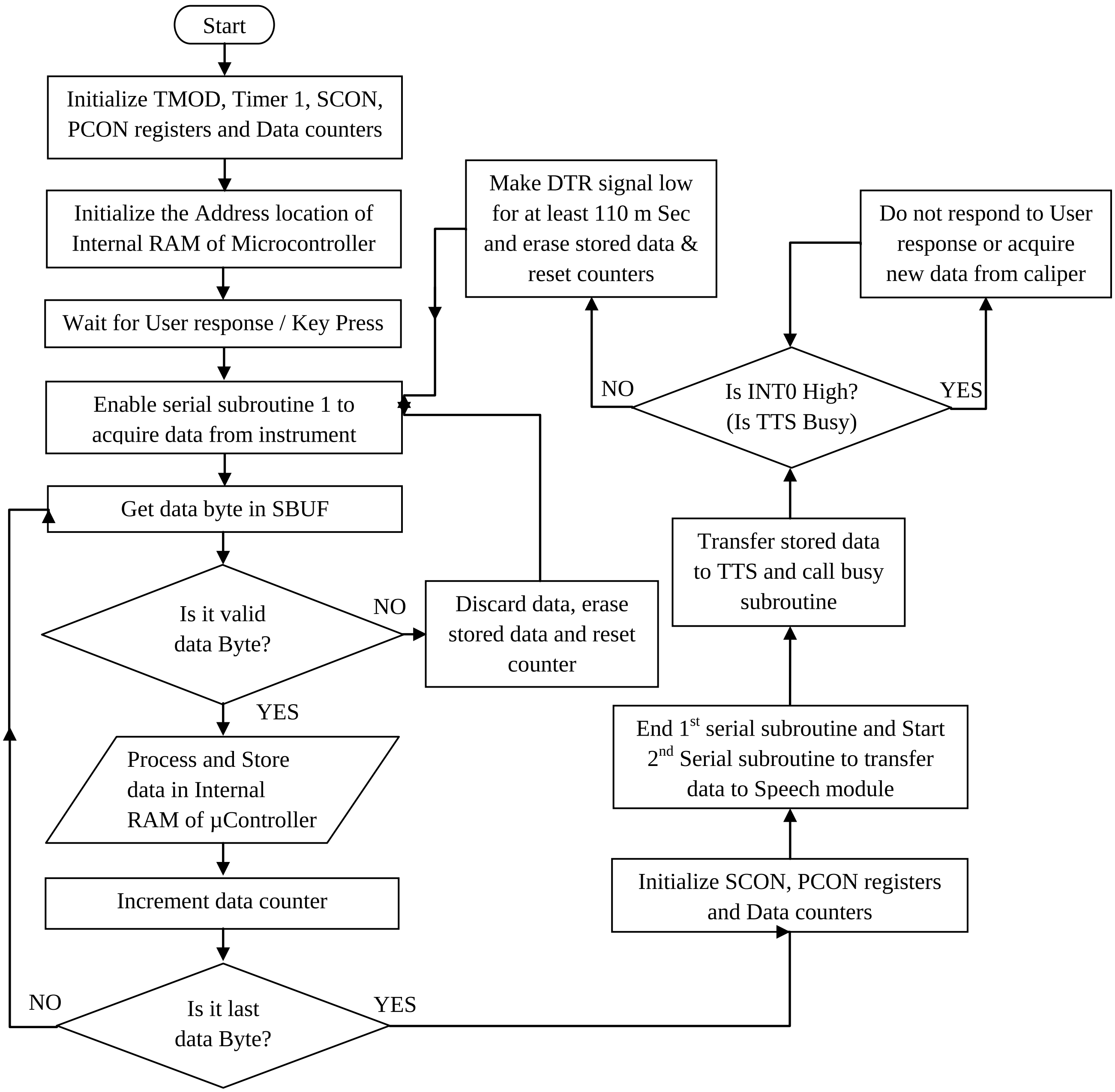

Figure 5. Software flow chart of system operation written in assembly language for assistive device

system operation. The software operation can be explained as follows. The program starts with the initialization of TMOD, SCON and PCON registers to regulate and get the desired baud rate. In the 8051 baud rate is set by the Timer 1 overflow rate which is regulated by TMOD register. SCON (serial port control register) is a bit addressable register used to program the start bit, stop bit and data bits of data framing among other things. Control bits of SCON set the operating mode for the serial port, and status bits indicate the end of a character transmission or reception. Status bits can also be used in software or programmed to cause an interrupt. SMOD has the effect of doubling the baud rate in timer mode 1, 2 and 3. Baud rate is also affected by bit 7 (the SMOD bit) in the power control register (PCON). Serial subroutines in the program are used to alter the serial communication parameters to settle the compatibility issues between two different devices i.e. vernier caliper and speech module. As per the requirement at each stage hardware and program code were tested together since final output depends on response of both. The code is written such that the operator can also control the volume and speed of the generated speech output. All commands are sent over serial interface for speech module using simple ASCII protocol.

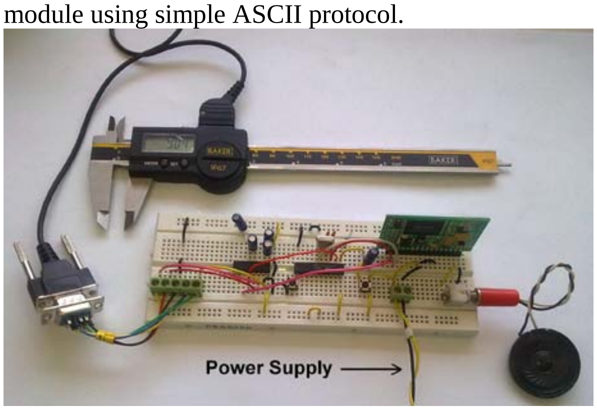

Figure 6. Experimental Setup for assistive precision measurement device.

3. EXPERIMENTAL RESULTS

The measured values as displayed on the vernier caliper digital display can be heard clearly in English language in female voice without delay using the embedded system developed in the present study. The embedded system could be easily reprogrammed to make it compatible with other serial output enabled digital calipers or measurement devices available in the market.

4. CONCLUSION

An assistive precision measurement device (embedded system) controlled by microcontroller has been designed and a viable prototype built. This prototype can pronounce the measured values as displayed on the vernier caliper digital display in English language in female voice without delay. This allows the user to use instrument in real field conditions. The developed device is a low cost but highly reliable and portable assistive measurement system.

5. ACKNOWLEDGEMENT

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