DEVELOPMENT OF A MICRO-PROCESSOR CANE TRACKER FOR USE IN SOUTH AFRICAN SUGAR FACTORIES

By E. P. EAST
Sugar Industry Central Board

Abstract

The development of a microprocessor controlled device for the demarcation and identification of individual parcels of cane along the cane carriers, from the offloading point in the mill yard to the cane sampling installation after the shredder, is described. This unit supersedes the previous hard-wired logic cane trackers. The advantages of the micro-processor cane tracker over the earlier system are described.

Introduction

The design and development of earlier types of cane trackers have been described by Calboutin[1]. The hard-wired logic of these units was a disadvantage in that each tracker had to be purpose-built for a particular carrier configuration, and any alteration to the latter required rebuilding of the tracker. In general, sampling considerations and administrative control necessitated two interconnected logic units per tracker system, thus adding to the modification and maintenance problems, and cost.

The hardwired systems are prone to interference caused by power fluctuations and noise induced on the cables. Spikes (see Appendix) may cause "ghost" samples to appear on one or other of the units causing it to be out of step and necessitating resetting of the system.

It was recognised that a programmable microprocessor controlled tracker would overcome these problems in that an alteration to a cane carrier configuration would only require adjustment to the variables within the software model and would require no changes to the electronics. The problems of multiple core cables between two identical units would not arise as the single microprocessor unit could transmit information to slave terminals, continuously replacing the display with updated information.

Specification

The following specification for the design of a microprocessor tracker were defined :

(a) It must be totally modular with all electronic components on printed circuit boards, and all to be of the plug in type, and inter-changeable.

(b) It must lend itself to easy modification in order to accommodate changes to mill cane carrier configurations.

(c) Noise spikes and mains interference must not adversely affect the operation of the unit.

(d) A single program shall cater for any and all mill configurations.

(e) It must be easily reinstated by the end user at site, i.e. the local CTS chemists must be able to identify and exchange faulty component boards which are to be returned to the Central Board electronic workshop for repair.

(f) It must have the ability to communicate with weighbridge/laboratory computer.

(g) It must be attractive in terms of cost.

Development and Evaluation

An Intel 8085 microprocessor was chosen and development work commenced on the fabrication of the prototype hardware and the development of the software in September 1979, and several weeks later the wire-wrap prototype was installed at the Tongaat mill. This operated without fault until the end of the season. The wire wrap modules were converted to printed circuit boards, and another two such systems were also built and installed at the Illovo and Amatikulu mills at the beginning of 1980/81 season. The only fault experienced during the 1980/81 season was at Illovo where a capacitor in the power supply unit failed after only one week of operation.

Overall Hardware Design

There are five distinct sections in the hardware :

(a) Processor, Program and Memory.

(b) CRT Controller.

(c) Keyboard, proximity switch and Start/Stop switch inputs controller.

(d) Sample Point Information Transmitter.

(e) Sample Point Receiver, hatch, bell and subsampler controller.

Each section relates to one printed circuit board which is of the plug in type, and inter-changeable. Faulty boards are exchanged in the field, and returned to the central workshop for repair.

The central workshop is equipped with Tektronix microprocessor development system which has an Intel 8085 in-circuit emulator.

This allows the processor to be removed and with the emulator plugged in, permits total control of all the hardware.

The programs are blown onto UVEPROM's (ultraviolet erasable, electrically programmable, read only memory). If at any stage a program needs to be altered, this UVEPROM is placed under an ultra-violet lamp with a wavelength shorter than 4 000 Angstroms for approximately 1 hour. The information held internally is erased and new program information can be electronically pulsed into this memory.

(a) *The processor, program and memory*

The Intel 8085 6 M.Hz cycle time processor is capable of 800 000 machine code instructions per second. The full assembler program resides on just over 3 K bytes and the configuration table in just less than 1 K byte of PROM. The processor has available to it 1 K bytes of random access memory and another 1 K bytes of displayable random access memory which is physically located on the CRT controller card.

(b) *CRT Controller*

The CRT controller displays the location of individual consignments against a diagrammatical representation of the carrier system. It can transmit this same picture to a number of different CRT monitors strategically placed i.e. the cane tracker control console, the cane sampling station and the C.T.S. chemist's office, the latter two being optional. Any composite video display can be used, e.g. CCTV monitors.

(c) *Keyboard, Start/Stop Switches and Proximity Switch Controller*

This card controls the input of information to the computer from three sources:

(1) The keyboard which allows the operator to initiate various control functions e.g. it allows the operator to identify portions of cane which are mixed on the carrier and ensure preclusion of this mixed cane from being sampled.

(2) The start/stop switches which allow the operator to initiate the start of a cane sample. When the switch is depressed, it latches and lights, indicating that a sample is being transferred onto the carrier system.

(3) The proximity switches which are solid 24 volt units are optically coupled to the microprocessor, thus preventing any induced spikes having an effect on the system. The old type of mechanical limit switches can also be used. All are optically coupled with an electronic debounce system which prevents more than one pulse appearing at the processor. Multiple pulse cams are fitted to carrier head shafts to increase the resolution (especially necessary on slow moving carriers).

(d) *The Sample Point Transmitter*

This unit transfers to the sample point up to 16 characters of information at 9 600 baud (bits per second). The transmission of information is via ordinary telephone wire, using differential current loops with very high common mode rejection ratios. At the receiver, all transients, noise and other signals not falling into the very narrow band of current and voltage limits are rejected. These units can transmit up to 1,5 km at full speed and further at lower speeds. The speed of transmission is altered by merely moving a link. Standard transmission speeds from 75 to 9 600 baud can be accommodated.

(e) *Sample Point Receiver*

This unit receives the data signals which it uses to control the operation of the hatch, sub-sampler and audio visual signals. It has variable timeouts and displays the sample identification number on an 8 digit liquid crystal 7-segment display. Optically coupled triacs are used to activate the 220 v AC hatch controls. The receiver information is dynamically allocated ie if any transmission character fails, it has a short-term effect on the receiver control. There are two types of characters which are received. They are either display characters, or control characters. If the faulty data is a display character, it would appear on the liquid crystal for approximately 10 milliseconds. As the liquid crystal display requires 80 milliseconds to switch, this incorrect character would not in fact be visually detected. If the data is a control character, the electronics require the same character be received a minimum of 3 consecutive times. Thus, any short "glitch" would have no effect on any of the control electronics.

Software Design

Only one program is used for all cane trackers. The only variation is within one programmable chip and this defines the cane carrier configuration for that particular mill. On program initialisation the processor analyses the information in the carrier table and generates the carrier configuration.

Once the initialisation of the electronics in a cane tracker program has taken place, the program goes into a scanning loop. This loop checks:

(a) *The Start/Stop Switches*

When a switch is activated the next sequential sample number is allocated to that sample. The CRT is updated on the correct input and the program obtains information from the configuration table showing which proximity switch would move the sample.

(b) *The Proximity Switches*

If a proximity switch becomes active the program identifies that movement of the carrier with the identity of the cane positioned on it and depicts the movement along the carriers both diagrammatically and also in the form of a numerical distance countdown on the CRT.

(c) *The Transmission Loop*

The program checks to see if the transmitter has completed the last transmission and, if so, it generates the next byte of information to be transmitted, hands it over to the transmitter electronics which then sends it down to the sample point receiver.

(d) *The Keyboard*

The program scans the keyboard to determine whether the operator has activated a key to initiate an alteration.

Typed information is displayed on the CRT screen in the bottom left hand corner.

Principles of Operation

The CRT screen (see Figure 1) is divided into three sections. On the upper half of the screen is displayed a listing of consignments currently on the carrier system. Information includes: consignment reference numbers; position of head and tail of each consignment; point loaded onto the carrier and other data.

In the centre of the screen, the individual carriers are represented by lines running across the screen. Consignments are represented by asterisks and the reference number. The position on the screen represents the actual position of the consignment on the carrier system. Messages from the computer or keyed in by the operator are displayed at the bottom lefthand corner of the screen. On the front panel a stop/start button is provided to demarcate the beginning and end of each consignment. Each pulse generator is represented by a LED, which flashes each time a pulse is generated. At the sample point, the sample reference number of the sample being processed is shown, as well as the length of consignment as yet unsampled.

```
        a     b    c      d    e      f        g  h  i  j   k
      XXXX   X   XXXX    X   XXXX   XXXXXXX  X  X  X  X   XXX
eg 1  0121   3   16,2    0   0000   BUNDLES  C  E  4  1   SAMPLING
eg 2  0122   5   14,2    4   0231   TABLE    B  C  6  5
eg 3  0123               5   3521   TABLE       B  6  6

****************0123——***************0122——————————————6
                                      *********0121————4

 XXXXXXXXXXX WAITING FOR INPUT
      l          m
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FIGURE 1 Layout of VDU screen.

KEY FOR FIGURE 1.

(a) Sample number.
(b) Carrier number of the position of the tail of the sample.
(c) Length in metres of the tail from end of the carrier (b) above.
(d) Carrier number of the position of the head of the sample 'O' means that the sample is being sampled.
(e) Length in metres of the head from the end of carrier (d) above.
(f) Type of cane loaded or name of load point.
(g) The P.G. switch that will move the tail forward.
(h) The P.G. switch that will move the head forward.
(i) The input point from which the sample originated.
(j) The carrier that the head of the sample was on last.
(k) Messages pertaining to an individual sample.
(l) Echo of keyboard.
(m) General messages.

e.g. 1) Sample number 0121 is sampling and its tail has 16,2 metres to go down carrier 3, its head is at the sample point, BUNDLES make up this sample. P.G. switch C will be responsible for moving the tail forward, P.G. switch E was responsible for moving the last carrier that the head was on i.e. 1, and the sample was originated at input number 4.

e.g. 2) Sample number 0122 has its head on carrier 4 and its tail on carrier 5.

e.g. 3) Sample number 0123 has its head on carrier 5 and its tail has not yet reached the input point.

Installation

Before installation the tracker is built at the CTS workshop at Mount Edgecombe and a maximum configuration chip is placed into the configuration section. Built into the hardware is a proximity simulator, and at any stage the simulation of carrier movement can be made. Most of the "bugs" can be eradicated and by using this maximum configuration chip the potential capacity of the system is tested, even though the mill for which this unit is destined may not necessarily require all the possible proximity and start/stop switch inputs. The unit is placed under test for an extended period and thereafter its own mill configuration UVEPROM is programmed and the start/stop switch keyboard section is fitted.

The head and tail interval timers (timing delays between a sample entering the hatch and existing the subsampler) are set, and the unit is ready for installation.

Cost Benefits

The enhanced facilities provided by the microprocessor cane tracker coupled with its versatility and ease of maintenance has resulted in significant benefits and cost savings when compared with the previous generation of cane trackers. A comparison of costs between the two types of trackers is given below:

Hard Wired Logic Cane Trackers

Original building costs (2 x consoles, 1 x display):

Average material	R6 500	
Average cable (1 000 M)	R850	
Manufacture :		
8 man weeks @ R10/hour	R3 200	R10 550

Modification to milling tandem, necessitating alteration to cane tracker :

Material	± R3 000	
Manufacture :		
6 man weeks @ R10/hour	R2 400	
(not including time needed to recover material)		R5 400

Micro Processor Cane Tracker

Original building costs (1 x Controller, 2 x CRT Display, 1 x S.P. Control)

Material	± R2 400	
Average cable (± 500 m)	R425	
Manufacture :		
2 man weeks	R800	
		R3 625

Modification to milling tandem, necessitating alteration to cane tracker.

Material (1 x Aluminium plate 200 x 100)	R4	
Manufacture :		
5 Hours @ R10/hour	R50	R54

Conclusion

In the 1981/82 season, a total of 6 trackers will be in operation. As existing hardwired logic trackers become obsolete due to mill carrier configuration changes, they will be replaced by micro-processor systems.

The complexity of cane carrier systems at many mills coupled with high mill throughputs place considerable demands on the Cane Testing Service for maintaining the identity of individual cane consignments on the carriers leading up to and at the sampling point. Correct identification and demarcation of cane consignments is a sine qua non of any sound cane testing system and the micro-processor controlled cane tracker described above will enable the Cane Testing Service to continue maintaining the high standards demanded of it in this field.

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REFERENCES

1. Calboutin, F. (1976). The Use and Development of Cane Tracking Equipment. *SASTA Proc* **50**: 208-211.

Appendix 1

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ASCII	American Standard Code for Information Interchange.
BAUD	Binary Digits per second.
BCD	Binary Coded Decimal.
BUG	A mistake or malfunction.
BYTE	A sequence of adjacent binary digits (typically 8) operated upon as a unit.
CRT	Cathode ray tube.
DEBOUNCE SYSTEM	Reduces multiple pulses due to contact bounce to a single pulse.
DEBUGGING	Detection of mistakes or malfunctions.
EIA	Electronic Industries Association.
EMULATOR	Emulates the operation of a microprocessor in the tracker.
HARDWARE	Physical equipment, e.g. electronic, magnetic and mechanical devices.
IC BOARD	Integrated circuit board.
INTERFACE	Hardware link between two devices.
INTERRUPTS	Signal to interrupt the sequential execution of a program.
K BYTES	1024 bytes.
LED	Light Emitting Diode.
MICROPROCESSOR	Minituarised processor (typically on a single chip).
MULTIPLEXER	Device for channelling two or more inputs into a single output.
NOISE	A random signal induced on a transmission line by outside magnetic/electrical interference.
OPTICALLY COUPLED	Signal is transferred by detection of light pulse.
PROXIMITY SWITCH	Electronic switch activated by metal passing in close proximity.
RAM	Random Access Memory.
RS 232 C	An International Standard for Asynchronous data transfer.
SOFTWARE	Set of computer programs or procedures.
SPIKES	Short duration, high amplitude noise.
TTY	Teletype corporation trade mark.
UVEPROM	Ultra-violet eraseable, programmable read only memory.
WIRE-WRAP	Method of connecting components in fabricating prototype electronic circuits.