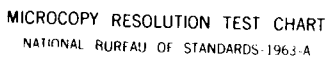


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TECHNICAL REPORT ARCCB-TR-85004

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THERMAL SHUTDOWN SYSTEM FOR IBM 4341 COMPUTERS

MARK JOHNSON

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes a thermal shutdown system designed to augment an IBM 4341 processor running the VM/CMS operating system. The microprocessor system monitors room temperature and alerts computer users to an impending shutdown when the temperature becomes too high. A user defined shutdown procedure is then executed prior to powering off the processor and all local peripherals.		

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LIST OF SYMBOLS

ASCII	American Standard Code for Information Interchange
CPU	Central Processing Unit
EPROM	Electrically Programmable Read Only Memory
I/O	Input/Output
MOS RAM	Metal Oxide Semiconductor Random Access Memory
RS-232	Standardized interface between a modem and associated data terminal equipment
TTL	Transistor-Transistor Logic
TWX	Teletype Exchange
USART	Universal Synchronous/Asynchronous Receiver/Transmitter
VM/CMS	Virtual Machine/Conversational Monitor System

INTRODUCTION

The resources of the central computer at Benet Weapons Laboratory (BWL), an IBM 4341 group 12, are shared by more than 100 engineers and scientists. Countless man-hours have been expended in the development, maintenance, and utilization of a wide variety of applications on the system. The computer has become a useful and necessary tool on a daily basis for many people at BWL.

The central computer must be maintained in a temperature and humidity-controlled environment. Unfortunately, the computer is not well equipped to effectively handle deviations from ideal climate conditions. Experience has shown that if the air conditioning units fail, the computer and its peripherals generate enough heat to raise the temperature beyond the allowed maximum in a matter of minutes. It has also been discovered that some of the circuitry is destroyed or severely weakened when the computer either fails to shut down or shuts down too late. Isolating and replacing the faulty circuitry may require a week or more. Even after the hardware is repaired, problems may arise in the operating system because the proper shutdown procedure was not executed prior to powering the system off. The net effect is disastrous to users who rely on the computer to help them generate satisfactory work output on a daily basis.

This report describes a system which monitors room temperature and alerts all computer users to an impending thermal shutdown. Shutdown date and time are recorded and an orderly operating system shutdown is executed prior to powering down processor and peripherals.

The goal of this project was to assure maximum availability of computing resources to Benet personnel.

SYSTEM DESIGN

Hardware

The system is designed around an Intel 8085A microprocessor. The 8085A processor was selected because a system design kit capable of simulating models of the design was available, and the 8085A was found to provide sufficient speed and processing power. 8085A series of compatible chips included in the design are the 8155 2K bit static MOS RAM with I/O ports and timer, 8251A programmable communications interface (USART), and the 8755A 16K bit EPROM. A Texas Instrument high speed SN74LS138 3-to-8 line decoder was used for address decoding. Motorola MC1488 and MC1489 line drivers convert the TTL level signals to/from RS-232C required levels used by the IBM 3704 communications controller. Power for all chips is provided by an Adtech TAPS series triple output power supply. Figure 1 shows the I/O ports of the 8155 as used for input and output, however, the need for the 8155 chip arises from its use as a program stack and baud rate generator for the USART. Input is taken from a standard Honeywell wall-mount thermostat and discrete transistors amplify port outputs to three pilot lamps and Potter & Brumfield dry reed relay. Shutdown status is maintained by the pilot lights, so large lamps were necessary to monitor the status from outside the secure area housing the central computer. Power is interrupted to the CPU and all peripherals by using the reed relay to bypass air flow sensor 202 on gate 02A at the CPU. The use of the relay isolates the electrical properties of the two systems.

Figure 1 shows the 8085A interrupt system as disabled since all I/O is program controlled. Isolated I/O is used for input and device control except for the memory-mapped interface to the 3704 through the USART. The address

space for the system is given below to aid in the readability of the source code.

Address Space of Chips Included in the Design

Device	Hex Address
8755A EPROM	0000 - 3FFF
8155 RAM	4000 - 7FFF
8215A (Data)	8000 - 9FFF
8215A (Command)	A000 - BFFF

Software

Figure 2 shows the machine code and assembler mnemonics for the program stored in the 8755A EPROM. On power up or a reset condition, the program branches to location 0000 where it continually monitors the input from the thermostat to determine if the temperature limit has been exceeded. If the temperature is too high, the input is tested again after one minute to insure that the reading was valid. If the temperature increase was temporary, the program returns to its reset state. Otherwise, the 8155 timer is set up to generate a 300 baud clock (based on a 6.144 MHz crystal) for the USART. The 8085A then connects to the IBM as a remote TWX terminal through the IBM 3704 communications controller. Once the 8085A attaches to the system as a virtual machine, it remains in a wait state until it receives a message from the host indicating that the system shutdown procedure has started. This handshaking scheme allows any procedure defined by the systems programmer to execute before the final shutdown procedure begins. Upon receiving these character(s) from the host, the 8085A delays for one minute to allow time for the operating

shutdown to complete. The CPU and all peripherals within the central site are then powered off.

CURRENT PROCEDURE

The VM/CMS operating system allows any shutdown procedure to be defined in a logon command file ('PROFILE EXEC') of the virtual machine under which the 8085A attaches to the system. A valid userid and password are all that is required to connect to the system, however, security is enhanced using a password containing ASCII control characters that cannot be manually entered from a keyboard (see Figure 2). The procedure currently defined for the 8085A initially notifies all users that a thermal shutdown is pending. A warning is given every minute for three minutes to allow time for anyone using the system to save all work generated during the current session that might be otherwise destroyed. Next, a file is created and transmitted to the operator informing him of the exact date and time the shutdown occurred. Finally, the message is transmitted to the 8085A enabling the power off sequence to begin.

FUTURE APPLICATIONS

The 8085A connects to the system as a virtual machine with as much capability as the systems programmer defines for it. This allows the 8085A access to any application available to the system operator including automatic file back-up and dial-up of authorized personnel. The system is not limited to the current procedures and can easily accommodate any future requirements.

The software resident in the 8755A EPROM indicates that not only a thermostat, but other devices such as a humidistat or water sensor, could be incorporated using other input ports available on the 8155. Only the code in

the EPROM locations 000F and 0011 would have to be changed unless individual procedures were implemented for each device.

The original design concept utilized high power 24V solenoids which called for the large Adtech power supply. The revised design requires much less power, so a smaller power supply could be used to house the unit in a more compact case than that shown in Figure 3.

SUMMARY

A system has been designed and implemented to effectively respond to adverse temperature conditions in the secure area housing the central computer at BWL. The unit was designed to minimize computer down time, thereby reducing the effect on BWL personnel who require access to computer resources on a daily basis. The unit has been installed for several months and successfully tested many times. Fortunately, no malfunction in the air conditioning units has yet forced it into operation.

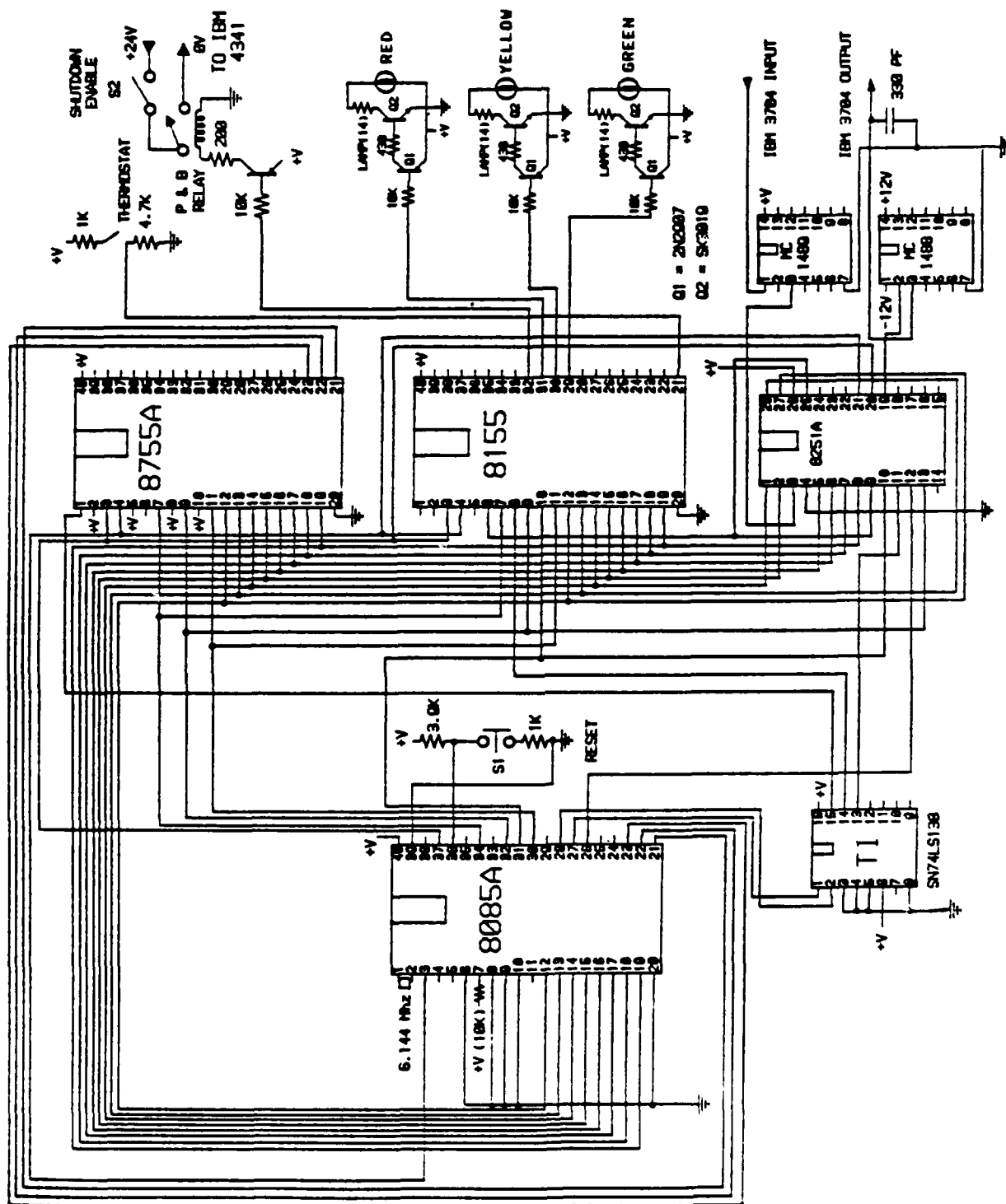


Figure 1. Circuit Diagram.

ADDRESS	HEX CODE	MNEMONIC	COMMENT
0000,0001,0002	31FF7F	LXI SP,7FFF	SET UP STACK POINTER
0003	F3	DI	DISABLE INTERRUPTS
0004,0005	3E02	MVI A,02	PORT A,C = INPUT, PORT B = OUTPUT
0006,0007	D340	OUT 40	
0008,0009	3EFE	LOOP1 MVI A,FE	RELAY,RED,YELLOW,GREEN = 1110
000A,000B	D342	OUT 42	TURN GREEN LIGHT ON
000C,000D	DB41	LOOP2 IN 41	CHECK FOR THERMAL CONDITION
000E,000F	E601	ANI 01	CHECK BIT 1 OF INPUT
0010,0011	FE01	CPI 01	
0012,0013,0014	C20C00	JNZ LOOP2	
0015,0016	3EFD	MVI A,FD	INPUT RAISED TO 1 -- TOO HOT !
0017,0018	D342	OUT 42	RELAY,RED,YELLOW,GREEN = 1101
0019,001A	16E0	MVI D,E0	1 MINUTE = 240 * .25 SECONDS
001B,001C,001D	CD4600	CALL DELAY	WAIT 1 MIN & RECHECK TEMPERATURE
001E,001F	DB41	IN 41	
0020,0021	E601	ANI 01	CHECK INPUT AGAIN
0022,0023	FE01	CPI 01	
0024,0025,0026	C20800	JNZ LOOP1	JUMP IF A FALSE ALARM
0027,0028	3E00	MVI A,00	L.S.B. OF TIMER COUNT
0029,002A	D344	OUT 44	
002B,002C	3E68	MVI A,68	M.S.B. OF TIMER COUNT
002D,002E	D345	OUT 45	
002F,0030	3EC2	MVI A,C2	START TIMER (ALT = 11)
0031,0032	D340	OUT 40	
0033,0034	26A0	MVI H,A0	SET UP FOR 8251A I/O
0035,0036	2E00	MVI L,00	ADDRESS OF COMMAND = A000
0037,0038	36C9	MVI M,C9	SEND MODE COMMAND (C9)
0039,003A	3637	MVI M,37	SEND COMMAND (37)
003B,003C	2680	MVI H,80	SET UP FOR 8251A DATA I/O
003D,003E,003F	CD8B00	CALL CHKXMT	CHECK FOR TXRDY = 1
0040,0041	360D	MVI M,0D	SEND 'CR'
0042,0043,0044	CDD400	CALL CHKDOT	CHECK FOR DOT '.' -- HOST INPUT PROMPT
0045,0046,0047	CD8B00	CALL CHKXMT	CHECK FOR TXRDY = 1
0048,0049	364C	MVI M,4C	SEND 'L' -- LOGON TO HOST
004A,004B,004C	CD8B00	CALL CHKXMT	WAIT FOR TXRDY = 1
004D,004E	3620	MVI M,20	SEND ' '
004F,0050,0051	CD8B00	CALL CHKXMT	WAIT FOR TXRDY = 1
0052,0053	3658	MVI M,58	SEND 'X' -- 'XX' IS NOT ACTUAL USERID
0054,0055,0056	CD8B00	CALL CHKXMT	WAIT FOR TXRDY = 1
0057,0058	3658	MVI M,58	SEND 'X'
0059,005A,005B	CD8B00	CALL CHKXMT	WAIT FOR TXRDY = 1
005C,005D	360D	MVI M,0D	SEND 'CR'
005E,005F,0060	CDD400	CALL CHKDOT	WAIT FOR DOT '.' WAIT FOR ENTER PASSWORD PROMPT
0061,0062,0063	CD8B00	CALL CHKXMT	WAIT FOR TXRDY = 1
0064,0065	3605	MVI M,05	SEND '5' '05' IS NOT THE ACTUAL PASSWORD
0066,0067,0068	CD8B00	CALL CHKXMT	WAIT FOR TXRDY = 1
0069,006A	360D	MVI M,0D	SEND 'CR'
006B,006C,006D	CDD400	CALL CHKDOT	WAIT FOR DOT '.' WAIT FOR 'CMSZER' PROMPT
006E,006F,0070	CD8B00	CALL CHKXMT	WAIT FOR TXRDY = 1
0071,0072	360D	MVI M,0D	SEND 'CR' --- SHOULD BE LOGGED ON NOW
0073,0074,0075	CDC600	LOOP3 CALL CHKRCV	WAIT FOR A 'B' FROM EXEC TO BEFORE CONTINUING
0076,0077	FE51	CPI C2	
0078,0079,007A	C27300	JNZ LOOP3	
007B,007C	2620	MVI H,20	FLASH YELLOW LIGHT

Figure 2. Program Listing.

007D,007E	3EFF	LOOP4 MVI A,FF	RELAY,RED,YELLOW.GREEN = 1111 (YELLOW OFF)
007F,0080	D342	OUT 42	
0081,0082	1602	MVI D,02	
0083,0084,0085	CDA600	CALL DELAY	
0086,0087	3EFD	MVI A,FD	RELAY,RED,YELLOW.GREEN = 1101 (YELLOW ON)
0088,0089	D342	OUT 42	
008A,008B	1602	MVI D,02	
008C,008D,008E	CDA600	CALL DELAY	
008F	25	DCR H	FLASH TO ALLOW TIME FOR HARDWARE DISABLE
0090	7C	MOV A,H	
0091,0092	FE00	CPI 00	
0093,0094,0095	C27D00	JNZ LOOP4	LAST CHANCE TO DISABLE HARDWARE
0096,0097	3EF3	MVI A,F3	RELAY,RED,YELLOW,REAL = 0011
0098,0099	D342	OUT 42	
009A	76	HALT	DONE !
009B	00	NOP	
009C	00	NOP	
009D	00	NOP	
009E	00	NOP	
009F	00	NOP	
00A0	00	NOP	
00A1	00	NOP	
00A2	00	NOP	
00A3	00	NOP	
00A4	00	NOP	
00A5	00	NOP	
00A6,00A7	06BE	LOOP1 MVI B,8E	***** SUBROUTINE DELAY *****
00A8,00A9	0EC6	MVI C,C6	÷ OF .25 SECOND DELAYS IN REG.D
00AA	7A	MOV A,D	
00AB,00AC	FE00	CPI 00	
00AD,00AE,00AF	C2B100	JNZ LOOP2	
00B0	C9	RETURN	
00B1	0B	LOOP2 DCX B	
00B2	7B	MOV A,B	WAIT FOR ALL BITS = 0
00B3	B1	ORA C	
00B4,00B5,00B6	C2B100	JNZ LOOP2	
00B7	15	DCR D	
00B8,00B9,00BA	C3A600	JMP LOOP1	
00BB,00BC,00BD	3A00A0	LDA A000	***** SUBROUTINE CHKXMT *****
00BE,00BF	E601	ANI 01	CHECK TXRDY = 1
00C0,00C1	FE01	CPI 01	
00C2,00C3,00C4	C2BB00	JNZ CHKXMT	
00C5	C9	RETURN	
00C6,00C7,00C8	3A00A0	LDA A000	***** SUBROUTINE CHKRCV *****
00C9,00CA	E602	ANI 02	CHECK RCVRDY = 1
00CB,00CC	FE02	CPI 02	
00CD,00CE,00CF	C2C600	JNZ CHKRCV	
00D0,00D1,00D2	3A0080	LDA 8000	
00D3	C9	RETURN	
00D4,00D5,00D6	CDC600	CALL CHKRCV	***** SUBROUTINE CHKDOT *****
00D7,00D8	FE11	CPI 11	
00D9,00DA,00DB	C2D400	JNZ CHKDOT	
00DC	C9	RETURN	

Figure 2. Program Listing (Cont'd).

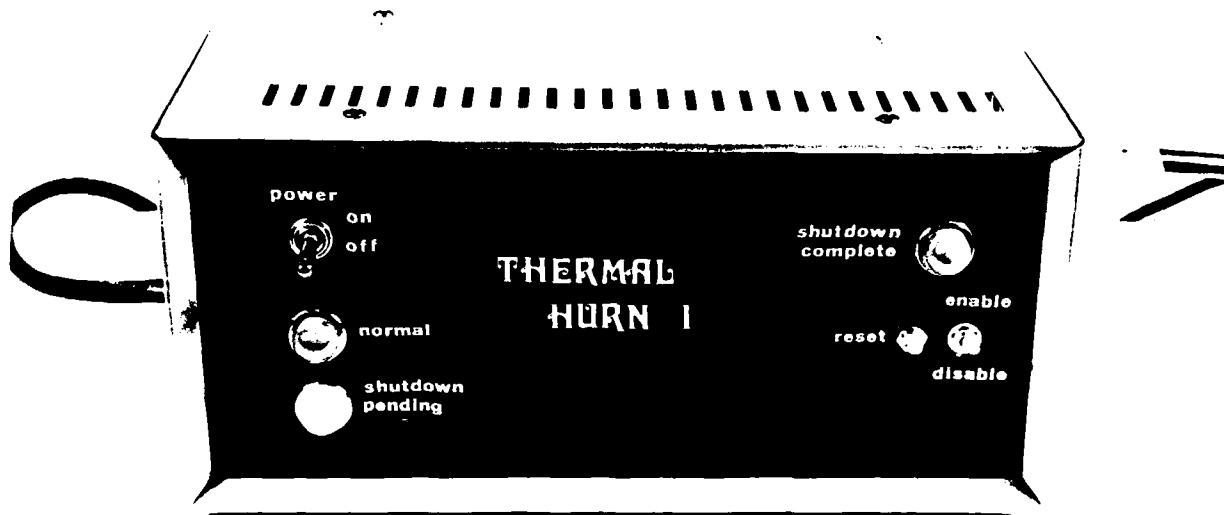


Figure 3a. Photograph of control unit.

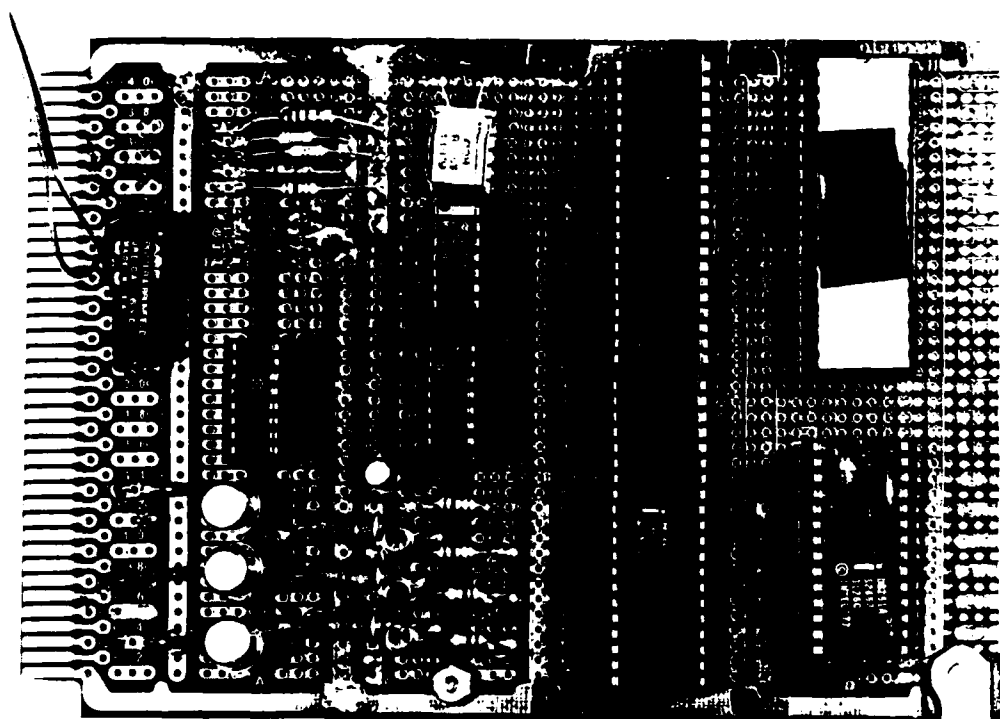


Figure 3b. Photograph of circuit design.

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