CICE/ECE 466

LAB NOTES

REVISED 6/79

The course is divided into four main phases in the lab. These are:

1. PDP-16 RTM Experiments.
2. 8008/MCS-8 Experiment.
3. I3000/MDS Experiment.
4. Student projects.

These notes cover the equipment used in the various experiments and discuss the operation of the MCS-8 and MDS computers. In addition, a number of support programs are stored on a mag tape. These are discussed and restoring these is explained. A complete list of all files on the tape is kept in the instructor's 466 file drawer, which includes lectures, labs and handouts.

A file cabinet in the lab contains copies of handbooks which are loaned to the students, MDS manuals, data sheets on components, updates, etc. The top drawer of this cabinet also contains many of the write-ups on past student projects, some of which are in use in the lab.

ECE 466 LAB NOTES

Notes about PDP-16 RTM Modules

Modules

There are a number of RTM modules available in the lab, enough for four groups working independently.

There are a few backup modules for important ones (K-bus, T-lights and switches) in case one goes bad. Get the technician to repair bad modules immediately.

Lab Stations

There are four lab stations. These consist of racks with 5 v. and 15 v. power supplies and a T-lights and switches module mounted on the front. RTM backplanes can be mounted on the racks above the T-l&s module. The T-l&s module is connected to the backplane in the appropriate slot via the ribbon cables. Note the markings on the cables.

RTM Backplanes

There are a number of RTM backplanes, enough for everybody to have one and not have to tear apart the wiring after each lab.

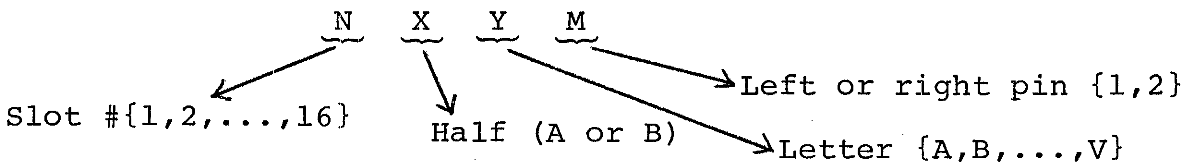
Each backplane has 16 slots and two levels. Note the pin numbering convention.

(1) Slots are numbered 1 through 16.

(2) Top half of each slot is A, bottom is B.

(3) Each slot has letters A-V. Each letter has a pin on either side. Left pin is 1, right pin is 2.

Hence, a pin number is typically:



Example: 10AR2

is the pin on the right of letter R on the top half of slot 10.

Module Placement

Since the bussing on the RTM backplane is not uniform for all slots, certain module placement rules must be observed.

(1) Double height, full length modules must be placed in slots 2-8.

(2) Single height, full length modules must be placed in slots 9A-15A, and 2B-13B.

(3) Single height, half length modules must be placed in slots 16A and 14B-16B.

The K-bus control and termination module (7332) must be placed in slot 1 since the switches on the backplane are connected to that slot only.

If DMgpa modules 7300, 7301 are used, they must be placed in adjacent slots and a connector block must be attached on the back to interface them.

Debugging Aids

Two lights (the leftmost two lights on T-1&s) are available for probing. They are attached to pins BP1 and BR1 of the T-1&s card. The lights are positive logic (off=low, on=high).

Another debugging aid is the monitor pin on the T-1&s module (pin BN2). When grounded the data lights will display the contents of the bus after each Keroke operation. This is useful when single-stepping through a program.

Note: When the MONITOR pin is grounded, the T-1&s module cannot be used for normal display. If such an operation is performed, the Data Accepted (DA) light will go off, indicating that the data was not accepted by the T-1&s module. Remove ground from BN2 (monitor) and the display operation will proceed normally.

The Data Ready and Data Accepted (DR and DA) lights on the T-1&s module are also helpful for debugging. If they go off during execution an error condition is indicated as follows:

(i) DR and DA off.--The source module did not place the data on the bus. Check wiring for correct connection of source module. This can be done with a probe. Remember that all control lines on the PDP-16 are negative logic. Hence, the evoke whose activate line is low is the active one.

(ii) DR on, DA off--Destination module did not accept the data from the bus. Check as above.

Misc. Notes:

(1) When connecting a serial merge never leave any unused inputs floating. Noise may cause spurious signals to be sent through the merge gate. Always connect unused inputs to +5 or some other input.

(2) When using the flag module (7306) as a flip-flop and not as a source or destination module you must ground the "DA disable" input to prevent the module from generating a Data Accepted signal.

(3) Right shifting on the DMgpa can be accomplished using the Result/2 input in conjunction with a transfer operation.

(4) Remember that the branch modules latch the boolean inputs at the moment the activate input light goes low. Hence changing the Boolean input while the activate input is low will not change the output from a branch.

(5) Every Kevoke must activate a source and destination module but may also activate other operations such as:

Save OVF - Save overflow

F ← 0, F ← 1 - Flag operations (DA must be grounded)

Result/2 - right shift result.

Running *WIREWRAP

A wirewrap run for any RTM design can be made as follows:

The files needed for the run are:

*WIREWRAP - wirewrap program

RTMMACS - Macro descriptions of RTM modules

sourcefile - File with description of design.

The MTS command required to run is:

$RUN *WIREWRAP SCARDS=sourcefile

where "sourcefile" contains the WIREWRAP command deck. The source file must "$CONTINUE WITH RTMMACS RETURN." The file RTMMACS is on the ECE 466 tape and is named "RTMMACS". See "Restoring files" for details on how to restore it from the tape.

There is a sample WIREWRAP run on the tape too. WIREWRAPSAMP and WIREWRAPBTCH have the sample program and sample MTS commands to run off copies of this example. Make sure that you change the CCID in WIREWRAPBTCH before running.

For more details see the CCMEMO on *WIREWRAP (#267).

Notes on Intel MCS-8

Two Intel MCS-8 computers are available. Each has a ROM monitor (1K), a teletype interface and 1K of RAM.

The monitor is described in detail in the document entitled, "MCS/8 LOADER SYSTEM".

The starting address of the ROM is Ø. The starting address of the RAM is Ø4ØØØ$_8$.

The assembler to be used for the MCS systems is on the ECE 466 tape and is called MCS8ASM.

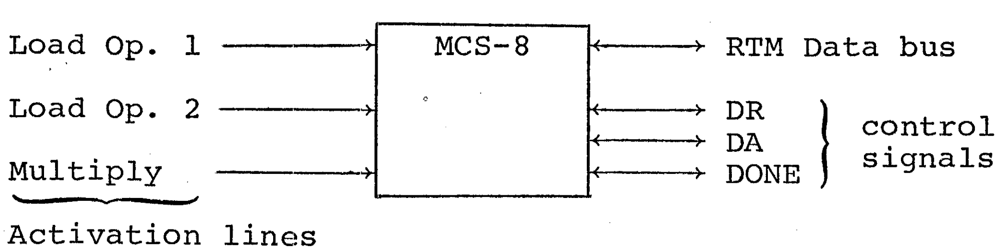
The assembler uses older, non-standard mnemonics (not Intel's current ones). These mnemonics are described in the writeup on the assembler entitled "MCS/8 ASSEMBLY LANGUAGE MANUAL".

For details on the wiring of the input and output ports and assorted sockets on the MCS-8 refer to the manual entitled, "8008 8-Bit Parallel Central Processor Unit - Users Manual".

Notes on Intel 8008 Multiply Experiment

In this experiment the MCS-8 is programmed and interfaced to behave like an RTM module that multiplies two 8-bit numbers to yield a 16-bit product.

We can think of the MCS-8 as an RTM module with three activation lines.

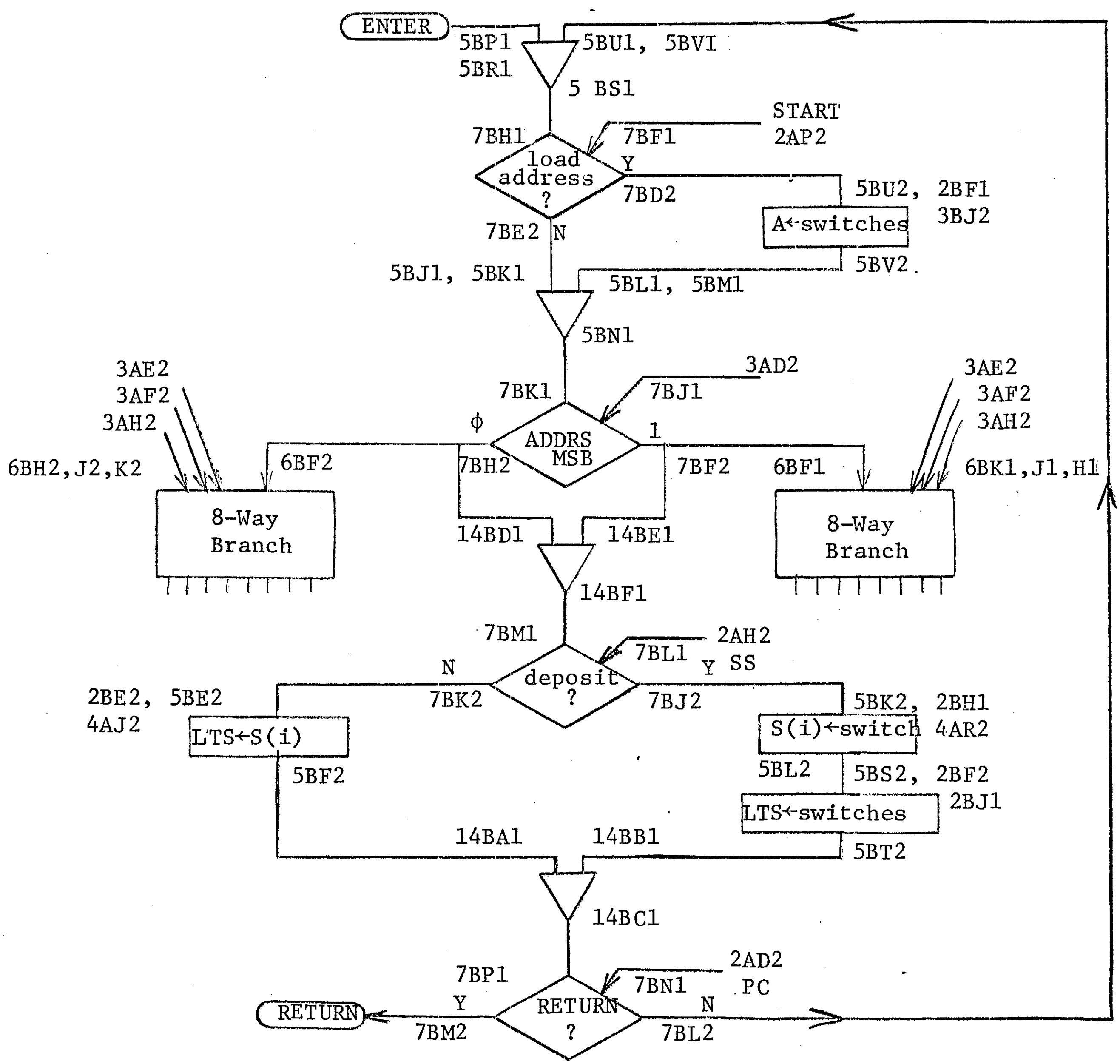


The MCS-8 must perform all handshaking like other RTM modules and is interfaced to the RTM backplane via the open collector data bus and control signals.

RTM Soubroutine Setup

The experiment is driven by the RTM subroutine solution derived in the previous experiment.

The instructor should wire up two identical solutions and let the entire class use them. This allows for greater uniformity and less confusion in the lab. The following is the solution to the subroutine experiment used.



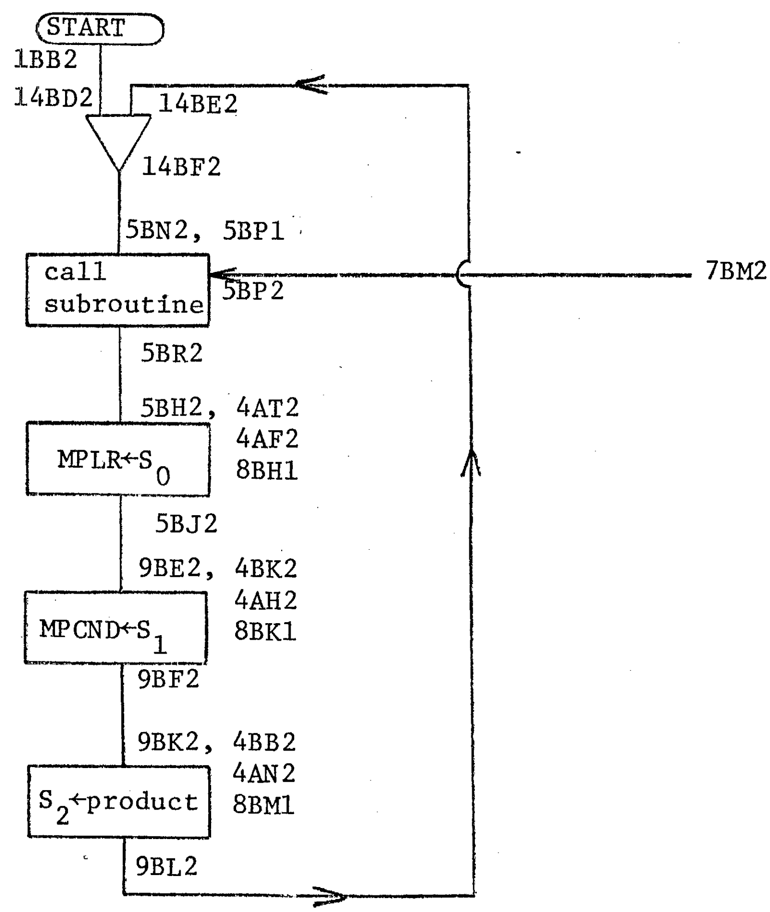
Connect 3 outputs from the 8-way branches to the address inputs of the scratchpad memory module. Only connections for S_0, S_1 and S_2 are necessary. These connections are:

6BU2 ↔ 4BJ2

6BV2 ↔ 4AS2

6BS2 ↔ 4AU2

The main routine that calls the scratchpad routine and the MCS-8 module is as follows:



Module placement for the subroutine is as follows:

Slot #	Module	
1	7332	Kbus control
2	7334	T-1&s
3	7305	Transfer Register
4	7318	M_{sp} 16 words
5B	7310	Kevoke
6B	7314	8 way branch
7B	7312	2 way branch
8	(8008) →	Ribbon cables from MCS
9B	7310	Kevoke
14B	M1103	2 way merge

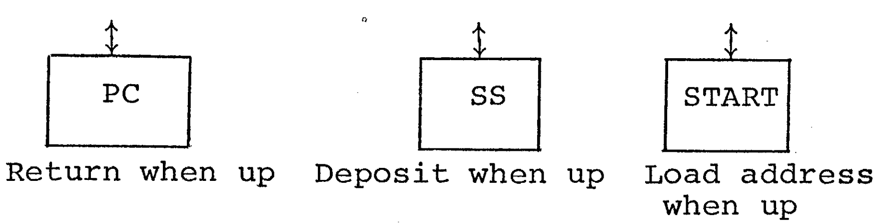
Subroutine Usage

Three switches are used to operate the scratchpad subroutine. Switches are those on the T-1&s card.

(i) START Switch--when up, loads the address from the switches. Similar to PDP-8 load address switch. Contents of address are displayed on lights.

(ii) Single Step Switch--When up, deposits the data in switches into the currently addressed location.

(iii) Power Clear Switch--When up, returns from subroutine to main program.

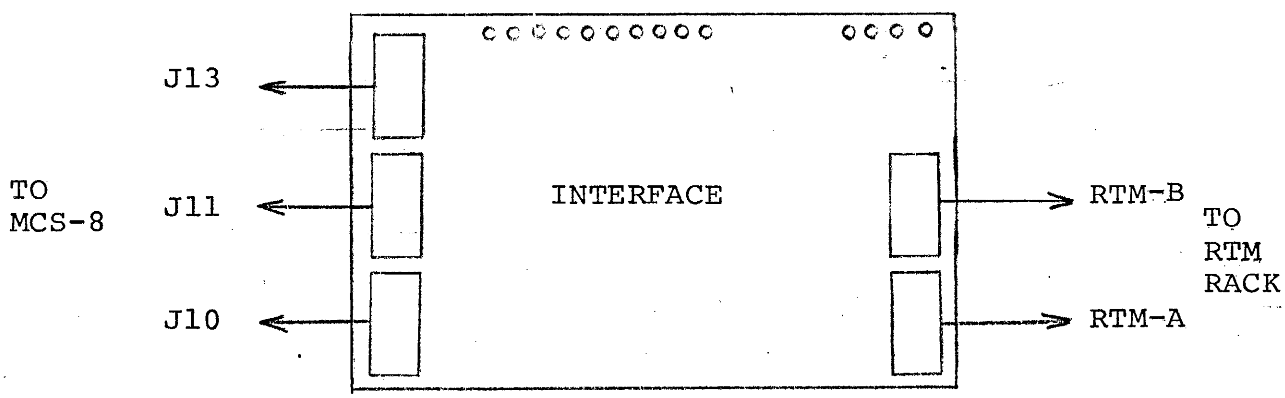


Interface Connection

A special circuit is used to interface the MCS-8 to the RTM backplane. The purpose of the interface is to provide open collector outputs for those data and address lines connected from the MCS-8 to the bidirectional RTM lines. The circuit consists of a series of chips used as open collector buffers.

Connectors

The following cables are to be connected from the interface to the MCS-8 and RTM. The following diagram illustrates this.



Connectors to the MCS-8 are 16 pin dip cables. Those to the RTMs have 16 pin dip on one end and RTM cards on the other end. Make sure the dip plugs are oriented properly.

RTM cards are plugged into the backplane with the card finger contacts on the 1 (left) side of the slot. Note that all data and control lines are on the 1-pin side of the slot.

IMPORTANT This experiment will not work unless you have grounded the RTM, MCS and interface together.

Notes:

(i) Lights on interface are connected to control lines and data lines. Data will be displayed in positive logic mode.

(ii) Remember to ground all three units, RTM, MCS and Interface.

(iii) A solution to the multiplication problem is located in MCS ROM at location 02000_8. To test out the hardware just:

R 02000

on the MCS system.

(iv) Remind students that the RTM system will not work unless the program in the MCS has put 1's on all the output ports. This is because of open collector bus and control lines.

The correct sequence to test out the program is:

(a) Load tape and start program. All output port lights should go on.

(b) Power clear and start running RTM subroutine.

(c) Setup operands.

(d) Return from subroutine.

(e) Reenter subroutine and check results.

Debugging

The experiment can be debugged either by single stepping the RTM or by single stepping the MCS-8 or by setting break points in the program via the monitor.

To single step MCS-8, switch Wait switch and press step button.

Intel 3000

The INtel 3000 equipment consists of the following:

(1) 1 MCU card

(2) 2 CPE cards

(3) 1 TLS card with display panel.

MCU Card

The MCU card holds an Intel 3001 MCU and control store ROM. However, for the class the MDS system is used to emulate the 3001 using ICE 30 and ROMSIM is used to simulate control store.

Schematics for the MCU card are in the 466 lab cupboard (large blueprints).

CPE Cards

The CPE cards each hold 4-3002 CPE chips, providing a 16-bit processor altogether. One of the CPE cards has been modified so that it may be used as a 4 bit slice instead to provide an overall 12 bit processor. See the pin list sheets for details on how to use it.

Unfortunately there are no schematics of the CPE cards. However, the circuits used are almost identical to the example processor shown in the Intel 3000 series Reference Manual.

TLS Card

The TLS card provides interfaces to allow several busses to be displayed on the lights. It also provides the interface logic for the interrupt switches.

The TLS card schematic is in the 466 lab cupboard.

3000 Equipment Setup

The description here is for the 3000 experiment to implement a four function calculator.

Module Placement

The modules may be placed in the following slots:

slot 4 - MCU

slot 6 - CPE (hi order 8 bits)

slot 8 - CPE (low order 8 bits)

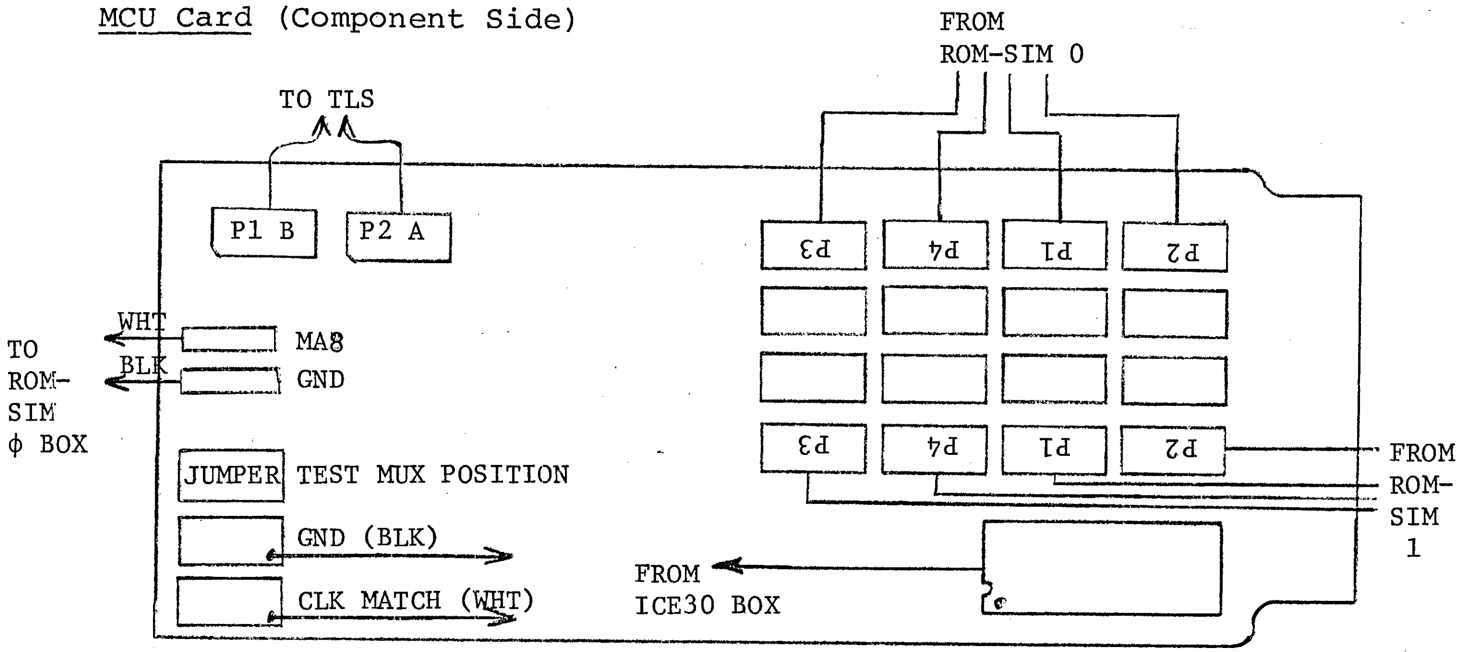
slot 14 - TLS

Module Interconnections

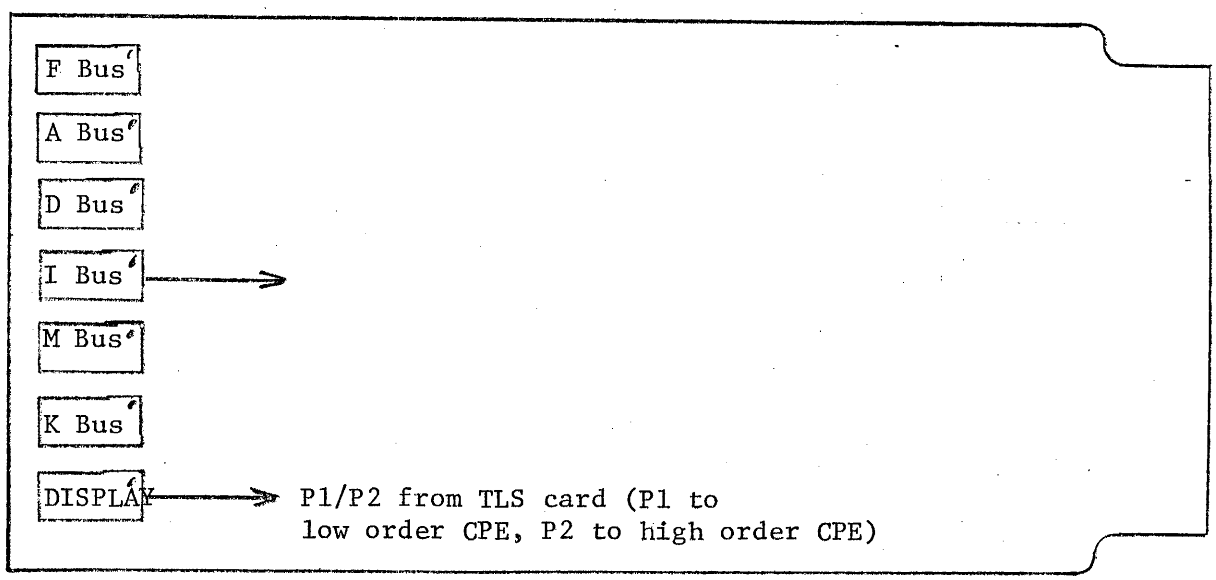
The following connections must be made using 16 pin dip cable from board to board. The schematics for each board are shown with the required connectors.

Note position of pin 1 on each card--they are not the same. Also check each plug carefully for broken pins. In addition, on some boards the sockets are not always oriented with pin 1 at the cut-away corner. Follow the label on each card for pin 1 position.

MCU Card (Component Side)

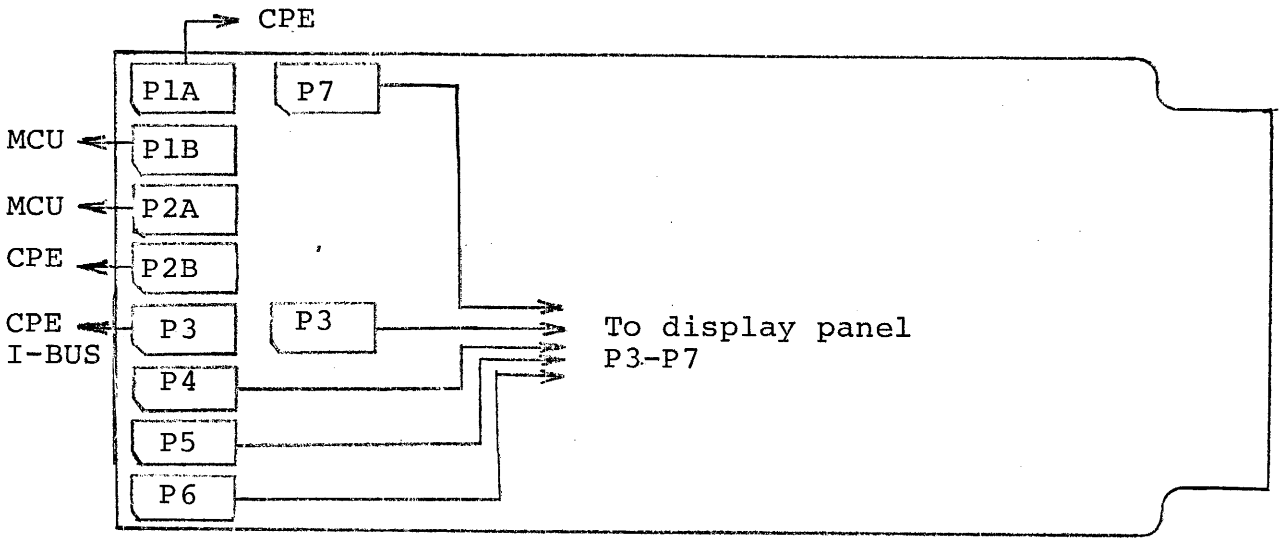


CPE Cards

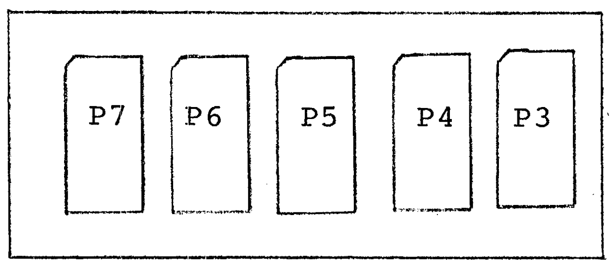


*The I bus is connected using a three plug daisy chain cable. 16 bits are picked off from the TLS card and 8 bits are connected to each CPE card. Connect cable and make sure I bus is displayed properly as the contents of the thumbwheel switches.

TLS Card



Display Board

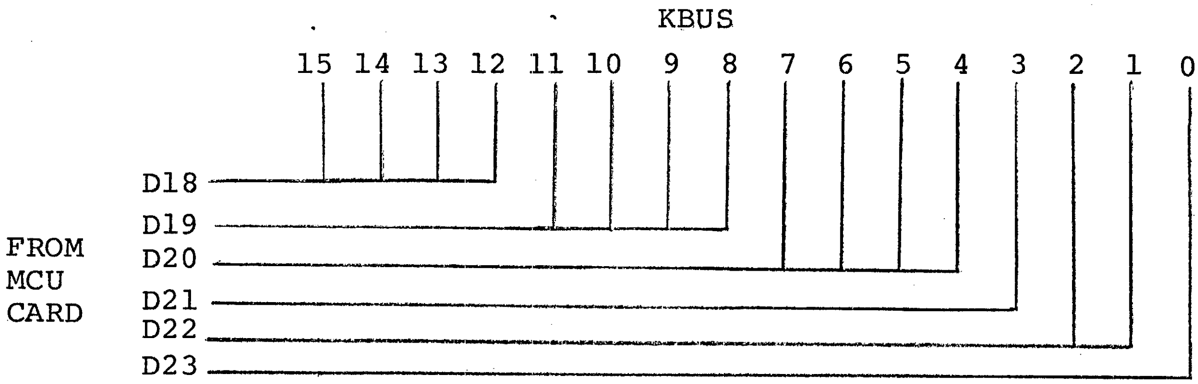


Front Panel Wiring

Besides the connections on the cards, the following connections must be made on the front of the RTM panel.

MCU Stot 4

(1) K bus on CPE's must be connected from pins D-18 through D-23 on MCU card. The following assignment of K bus bits from control store data bits are suggested.



(2) Ground LOAD (LD) line - pin 4BR1.

(3) Connect low order 4 bits of thumbwheels (I bus) to PX bus (pins 4BS2-4BV2).

(4) Jumper all pins for front panel switches from slot 1 to slot 4 (pins BD2, BE2, BF1, BF2, BH1, BH2, BJ1, BJ2).

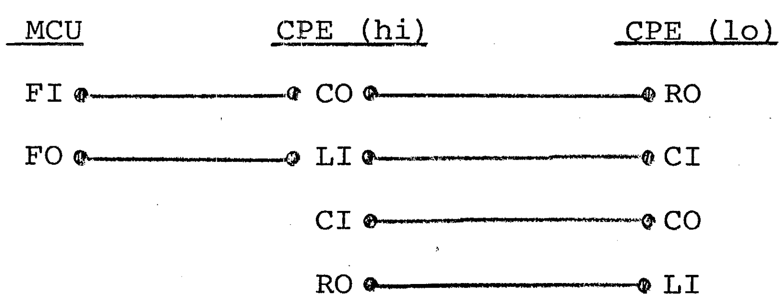
(5) Ground Mem Done (4AB1) line if macro memory module is not used.

(6) Clock inhibit line (4AV1) from one of the control store data bits (e.g., D-24) if used in microprogram.

CPE Cards

(1) Ground AE and DE lines (AR1 and AS1).

(2) Connect Flag lines as follows.



On CPE (hi) (slot 6) connect RO (HI) to LI (LOW) (pin 5BD1 - 5BE1) to use the CPE card as 8 bit CPE.

TLS

(1) Clock (14 AP1) must be connected from MCU since it is not bussed to slot 14.

(2) Wire interrupt addresses by grounding appropriate lines, e.g., for interrupt Ø to start at location OEF, the lines must be wired for row E = 01110_2.

INTØ - 9 - ground
INTØ - 8 - }
INTØ - 7 - } float
INTØ - 6 - }
INTØ - 5 - ground.

Writing 3000 Program

The instructions for programming are given in the Intel 3000 Series Microprogramming Manual.

To run XMAS assembler:

```
$RUN E.E.:XMAS SCARDS=XMAS.S
        SPRINT=*SINK* SPUNCH=XMAS.O

       XMAS.S=source code
       XMAS.O=intermediate object code
```

To run XMAP assembler:

```
$RUN E.E.:XMAP SCARDS=XMAP.S SPRINT=*SINK*
                    SPUNCH=XMAP.O Ø=XMAS.O
```

XMAP.S=Rom description source code

For details on XMAS.S and XMAP.S see file XMAS.MAP.SAMP on the 466 tape. This is a program for a simple processor which can be used to test the equipment and provide an example for the class.

Transferring a File to MDS

After program is successfully assembled, boot up MDS as follows.

Booting MDS

(1) Press boot switch

(2) Press reset switch

(3) Type space on Decwriter

(4) Release boot switch.

ISIS floppy disk must be in drive Ø. Insert and remove disk with power ON. Never turn power ON/OFF with disk in drive.

Then do the following:

```
-MTS                          This starts the communication program
Type a return                 This awakens the RDC.
sign on as usual

#copy XMAP.O (control-P)(control-Z)
ENTER FILENAME - FILEX        This is the new file name on MDS.
(beep-beep-beep)              This indicates data transfer.
FILE TRANSFER COMPLETED
#SIG (control-G)              This returns control to ISIS.
-ROMFIL FILEX                 This loads the information into ROMSIM.
*LOAD AØ
*LOAD A4
*LOAD A8
*LOAD A12
END OF FILE
-ROMSAV FILEY
```

\- From now on the object file has been saved in compact form in FILEY. FILEX may be deleted. The student need only do a ROMRES to rewrite object code in the ROMSIM. If changes are made in the program the file must be transferred again. If minor changed are made directly in ROM via ROMSIM, the file may merely be ROMSAVed in FILEY again.

```
-LOAD ICE30                   This loads the ICE-30 control program.
```

```
.G20                               This begins execution of ICE-30
NUMBER OF ROMSIM MODULES - 2  (or 3 if all ROMSIMs are used)
START OF ROM-SIM MEMORY - 9000H
TOTAL SIZE OF CONTROL MEM - 512 by 32(or 48)
CONFIG NO - 1
CHIP - A
CHIP - A
HIGH ORDER BITS - 1100
ADDRESS WIDTH - 9
```

MAG TAPE FILES

Saving Files

To save a file on the 466 tape, do the following:

$MOUNT C4504 9TP *T* RING=IN VOL=ECE466

(after tape is mounted)

#$RUN *FS Ø=*T*

=SAVE file 1 tapenamel

⋮

=STOP

#REL

File 1 will be saved on the tape and will be called tapenamel.

If you wish to get a listing of all files on the tape, enter the command:

=LIST [ON *PRINT*]

when running *FS.

Restoring Files

To restore a file from the ECE 466 tape, do the following:

$MOUNT C4504 9TP *T* VOL=ECE466 'ECE466'

(Hopefully, you will get a message saying that the tape was mounted. If not, try again later.)

```
$RUN *FS Ø=*T*
=RESTORE file 1
=RESTORE file 2
        .
        .
        .
=STOP
#REL *T*
```

(Files will get restored to the names on tape.)

Release the tape as soon as you are done. Keeping a tape on a drive can get very expensive.

To permit a file to the class:

```
$PERMIT filename R
```

Important Files on 466 Tape

File #	Name	Description
29	WIREWRAPSAMP	Sample wirewrap program
2	RTMMACS	Macros describing RTM modules
30	WIREWRAPBTCH	Batch cards to run sample
11	MCS8ASM	8008 assembler
31	XMAS	Don't restore. Already on E.E. account
32	XMAP	Don't restore. Already on E.E. account
40	XMAS.MAP.SMAP	Sample 3000 program
41	MDSMTS.S	Source for MTS communication program on MDS
42	MDSROMSAV.S	Source for ROMSAV program
43	MDSROMRES.S	Source for ROMRES program
48	3000.CALC.SOLN	Solution to 3000 Calculator program

Student Projects

The last portion of the term is dedicated to student projects. Examples of past projects are listed in the instructor's 466 files. Equipment for these projects includes all of the previously mentioned lab facilities plus anything the students wish to bring in. In addition, a great deal of equipment can often be borrowed from other laboratories and/or the technicians in 2514 EE. The cabinets also contain several μ-processor ICs, memories and various support components.