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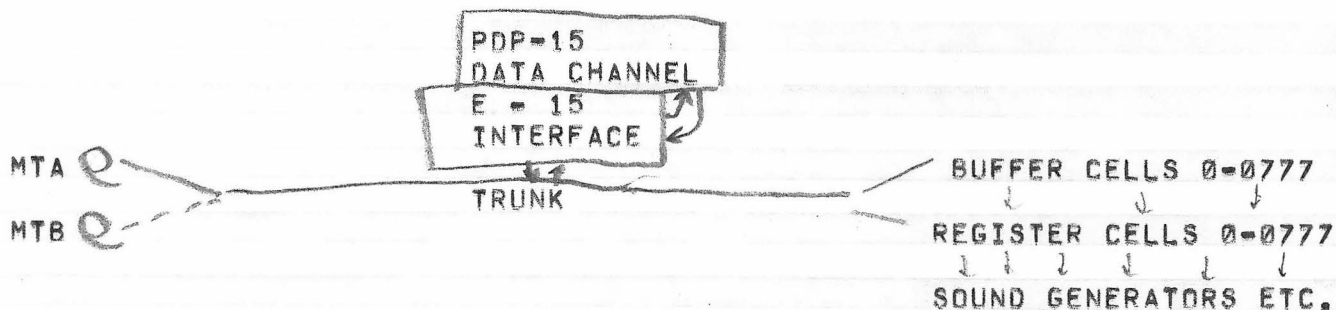
EMS-PDP 15 INTERFACE
PROGRAMMING SPECIFICATION
KLAUS APPEL 30.6 1970

INTRODUCTION

THIS SPECIFICATION IS WRITTEN FOR SYSTEM PROGRAMMERS WHO INTEND TO WRITE PDP-15 SUBROUTINES TO CONTROL THE ELECTROACOUSTIC STUDIO (EMS) THROUGH THE E15 INTERFACE. A GOOD KNOWLEDGE OF THE PDP-15 SYSTEM REFERENCE MANUAL DEC-15-GRZA-D IS ASSUMED.

SUMMARY OF EMS ORGANIZATION

A SCHEMATIC BLOCK DIAGRAM OF THE EMS AND INTERFACE IS SHOWN IN FIGURE 1.



THE STUDIO HAS TWO SEPARATE MAGNETIC TAPE UNITS, WHICH ARE DENOTED MTA AND MTB, TO DISTINGUISH THEM FROM THE COMPUTER SYSTEM'S OWN TAPE UNITS MTO AND MT1. THE COMPUTER CAN READ, POSITION, OR REWIND EITHER OF MTA OR MTB, BUT NOT WRITE ON THEM. IN ADDITION, THERE IS A BUFFER AND A REGISTER EACH CONTAINING 512 ADDRESSABLE 6-BIT CELLS (THE ADDRESSING SCHEME ALLOWS FOR A FUTURE EXPANSION TO 4096 CELLS).

THE CONTENTS OF THE REGISTER CELLS CONTROL IMMEDIATELY THE PARAMETERS OF THE SOUND, SUCH AS FREQUENCIES, WAVE FORMS, AMPLITUDES, AND CONNECTION BITS. THE EXACT ADDRESSING AND CELL REPRESENTATION OF EACH PARAMETER IS DESCRIBED ELSEWHERE. THE CONTENTS OF THE BUFFER DO NOT INFLUENCE THE SOUND UNTIL THE MOMENT WHEN THE ENTIRE BUFFER IS COPIED SIMULTANEOUSLY INTO THE REGISTER. THE COMPUTER CAN WRITE INTO THE BUFFER OR REGISTER OR BOTH, OR READ FROM THE REGISTER (E.G. IF THE REGISTER WAS SET UP MANUALLY FROM THE STUDIO CONSOLE).

FURTHER, THERE IS A RECORD NUMBER COUNTER, AN "INDEX", A TIMER REGISTER (WHICH IS DISCONNECTED IF THE STUDIO IS CONTROLLED FROM THE INTERFACE), AND VARIOUS CONTROL BITS.

DATA STRUCTURE

DATA IS TRANSFERRED BETWEEN THE DATA CHANNEL AND THE INTERFACE IN 18-BITS WORDS, AND BETWEEN THE INTERFACE AND THE TRUNK IN 8-BITS BYTES. ON READING FROM THE TRUNK, THE INTERFACE WILL BLOCK TWO BYTES INTO POSITIONS 2-9 AND 10-17 OF ONE WORD, AND ON WRITING TO THE TRUNK, EACH WORD IS UNBLOCKED INTO TWO BYTES (HIGH-ORDER BYTE FIRST). WORD POSITIONS 0 AND 1 ARE ZERO ON READING AND IGNORED ON WRITING. IN EACH BYTE, THE SIX LOW-ORDER BITS CONTAIN USEFUL INFORMATION



AND THE TWO HIGH-ORDER BITS SPECIFY THE USE MADE OF THE INFORMATION BY THE INTERFACE OR TRUNK, IF EACH BYTE IS WRITTEN IN A 3-DIGIT OCTAL FORM XYZ, THE INFORMATION BITS YY ARE PROCESSED AS FOLLOWS ON WRITING DEPENDING ON X:

XYZ

- 0YY THE BITS YY ARE PROCESSED BY THE TRUNK ACCORDING TO THE MOST RECENT COMMANDS OF THE FORM 2YY AND 3YY. GENERALLY, YY DENOTE A WAVEFORM, OR SIX BITS OF THE CONNECTION TABLE IN THE EMS EXCHANGE.
- 1YY THE BYTE IS IGNORED BY THE INTERFACE AND HAS NO EFFECT EXCEPT TO CONSUME STORAGE AND CHANNEL TIME. YY MAY BE USED TO STORE SIXBT CHARACTERS TO PUT ALPHANUMERIC LABELS ON A TAPE FOR FUTURE REFERENCE, OR TO FILL AN ODD NUMBER OF BYTES TO FULL DATACHANNEL WORDS.
- 2YY THE BYTE IS TRANSFERRED TO THE TRUNK AND INFLUENCES THE PROCESSING OF THE FOLLOWING BYTES OF TYPE 0YY. FOR PRACTICAL REASONS, BYTES 2YY ARE IMPLEMENTED IN THE EMS PART AND CALLED TRUNK COMMANDS, AND BYTES 3YY IN THE PDP-15 INTERFACE AND CALLED INTERFACE COMMANDS.

AT PRESENT, THE FOLLOWING TRUNK AND INTERFACE COMMANDS ARE DEFINED:

OCTAL

- 260 ADDRESS FOLLOWS. THE TWO FOLLOWING BYTES OF TYPE 0YY DEFINE A 12-BIT ADDRESS OF THE FIRST BUFFER OR REGISTER CELL, WHERE SUBSEQUENT DATA BYTES ARE STORED.
- 201 DATA FOLLOWS. THE FIRST 0YY BYTE WILL HAVE ITS YY BITS STORED IN THE CELL, WHOSE ADDRESS WAS SPECIFIED AFTER THE LATEST 260 COMMAND, OR IN CELL 000 IF NO START ADDRESS WAS GIVEN AT THE START OF A RECORD. SUBSEQUENT 0YY BYTES WILL BE STORED IN CELLS WITH CONSECUTIVE HIGHER ADDRESSES.
- 240 TIME FOLLOWS. THE NEXT FIVE 0YY BYTES ARE PLACED IN THE TIME REGISTER OF EMS.
- 220 RECORD NUMBER FOLLOWS. THE NEXT FIVE 0YY BYTES ARE PLACED IN THE RECORD NUMBER REGISTER.
- 224 INDEX FOLLOWS. THE NEXT FIVE 0YY BYTES ARE PLACED IN THE INDEX REGISTER, TO BE USED AS AN ARGUMENT IN A RECORD, SEARCH OPERATION.
- 200 RECORD END. THIS COMMAND, OR ONE OF 277 AND 214, MUST BE THE LAST ONE TO BE TRANSFERRED TO THE TRUNK IN EACH RECORD. BYTES AFTER THE ENDING COMMAND WILL BE IGNORED BY EMS.
- 277 STOP PLAY. EMS WILL STOP READING, AND PLAYING RECORDS FROM ITS TAPE STATIONS. THE RECORD ENDING IN 277 WILL NOT BE PLAYED.
- 214 SWITCH TAPES. EMS WILL STOP READING TAPES FROM THE PRESENTLY USED STATION MTA OR MTB, AND WILL START READING FROM THE ALTERNATE TAPE STATION.

ONLY THE COMMANDS 260, 201, AND 224 ARE USEFUL WHEN EMS IS CONTROLLED FROM THE INTERFACE. THE OTHERS ARE SIGNIFICANT ONLY IF EMS IS CONTROLLED FROM ITS OWN TAPE STATIONS WITHOUT INTERFERENCE FROM THE COMPUTER.

THE INTERFACE COMMANDS 3YY CAN BE MULTIPROGRAMMED, I.E. A

COMBINED EFFECT CAN BE OBTAINED BY SETTING MORE THAN ONE BIT=1 IN THE YY PORTION OF THE COMMAND. NOTE PARTICULARLY THAT A BIT=0 IN ONE OF THE TWO LOWEST POSITIONS HAS THE EFFECT OF CLEARING THE FUNCTION OF A PREVIOUS 1-BIT IN THE SAME POSITION. FOR EXAMPLE, THE COMMAND 303 IS NOT EQUIVALENT WITH THE COMMANDS 301, 302 TRANSMITTED AFTER EACH OTHER, SINCE THE 0 BIT IN THE LOWEST POSITION OF 302 WILL OPEN THE CONNECTION TRUNK-REGISTER, WHICH WAS CLOSED BY 301.

OCTAL

301: WRITE FROM THE TRUNK TO THE REGISTER. THE CONNECTION TRUNK TO REGISTER WILL BE OPENED BY ANY 3YY COMMAND WITH 0 IN THE LOWEST POSITION.
302: WRITE FROM THE TRUNK TO THE BUFFER. THE CONNECTION TRUNK TO BUFFER WILL BE OPENED BY ANY 3YY COMMAND WITH 0 IN THE 2-POSITION (SECOND LOWEST BIT).
304: THE SIX LOWEST BITS OF THE NEXT 0YY BYTE WILL BE WRITTEN IN EACH CELL OF THE REGISTER AND/OR BUFFER (ACCORDING TO THE CONTENTS OF THE TWO LOWEST BITS IN THIS COMMAND).
310: TRANSFER THE ENTIRE BUFFER TO THE REGISTER IN PARALLEL.
320: TURN ON THE STUDIO SOUND. IT WILL REMAIN ON UNTIL THE NEXT
340: TURN OFF THE STUDIO SOUND.

INTERFACE REGISTERS AND IOT INSTRUCTIONS

MEMORY ADDRESS REGISTER IS A 15-BIT REGISTER. IT IS SET BY THE INSTRUCTION EMAR TO CONTAIN THE CORE STORAGE ADDRESS OF THE FIRST PDP WORD READ INTO OR WRITTEN OUT OF. ITS CONTENTS ARE INCREMENTED BY ONE AFTER EACH WORD READ OR WRITTEN. THE CONTENTS CANNOT BE READ BACK INTO THE COMPUTER.
WORD COUNT REGISTER IS A 15-BIT REGISTER. IT IS SET BY THE INSTRUCTION EMWC 0 CONTAIN THE TWO'S COMPLEMENT OF THE NUMBER OF WORDS TO BE READ OR WRITTEN.
ACTUALLY THERE ARE TWO REGISTERS WC1 AND WC2 THAT ARE BOTH SET TO THE SAME VALUE BY EMWC. WC1 IS INCREMENTED BY ONE FOR EACH PAIR OF BYTES SENT FROM THE TRUNK. WC2 IS INCREMENTED BY 1 AFTER EACH WORD TRANSMITTED OVER THE DATACHANNEL. IF WC1#WC2 AT THE END OF AN OPERATION, THE LOST DATA FLAG IS SET TO 1. WC1 AND THE LOST DATA FLAG CAN BE READ INTO THE COMPUTER BY THE

INSTRUCTION EMCTA.

SOURCE/DESTINATION REGISTER SELECTS, IN CASE OF A READ OR TAPE POSITIONING OPERATION, THE PART OF EMS CONNECTED TO THE TRUNK. IT IS A TWO-BIT REGISTER SET BY EMWC:

00 OR 01 SELECT EMS REGISTER AND/OR BUFFER
10 SELECT MAGNETIC TAPE A
11 SELECT MAGNETIC TAPE B

IN A WRITE OPERATION, ONLY 00 OR 01 ARE LEGAL.

FUNCTION REGISTER IS A 3-BIT REGISTER TO SELECT THE FUNCTION:

0 READ
1-2 POSITION MAGNETIC TAPE
3 REWIND MAGNETIC TAPE
4-7 WRITE

THE FOLLOWING COMBINATIONS OF SOURCE/DESTINATION AND FUNCTION

ARE LEGAL:

SOURCE/DEST	FUNCTIONS*)0-1)
SOURCE/DEST.	FUNCTIONS
0-1	0, 4-7
2-3	0-3

SKIP FLAG IS A ONE-BIT FLAG, CLEARED BY AN EMCF INSTRUCTION, AND SET WHEN THE LAST WORD HAS BEEN TRANSMITTED BY THE DATA CHANNEL (WC1 = 0 OR WC2 = 0 OR END-OF-RECORD SENT FROM EMS IN READ OPERATIONS).

THE SKIP FLAG MAY BE EXAMINED BY THE EMSF INSTRUCTION.

NOT BUSY FLAG IS A ONE-BIT FLAG, SET WHEN THE INTERFACE CAN ACCEPT AN OPERATION AND CLEARED WHEN SOME FUNCTION IS ACTIVE IN THE INTERFACE SUCH AS DATA TRANSFER, POSITION MAGNETIC TAPE, OR REWIND MAGNETIC TAPE.

IT MAY BE EXAMINED BY AN IORS INSTRUCTION, WHICH COPIES THE FLAG INTO BIT 17 OF THE ACCUMULATOR.

COMPUTER CONTROL FLAG IS A ONE-BIT FLAG WHICH IS CLEARED OR SET BY AN EMWC INSTRUCTION. IT IS DISPLAYED ON THE EMS CONSOLE AND CAN BE SET FROM A SWITCH ON THE CONSOLE. COMPUTER CONTROL FLAG = 0 MEANS THAT EMS IS CONTROLLED FROM THE PDP-15 INTERFACE AND IS NORMALLY CLEARED IN EVERY EMWC INSTRUCTION OF A PROGRAM EXCEPT THE LAST, WHICH WILL SET COMPUTER CONTROL FLAG = 1 TO RELINQUISH TO MANUAL CONTROL FROM THE EMS CONSOLE.

IOT INSTRUCTIONS:

EMSF=705001 EMS SKIP FLAG.
IF THE SKIP FLAG IS SET, SKIP NEXT INSTRUCTION.

EMCF=705002 CLEAR SKIP FLAG.

EMWC=705025 LOAD WORD COUNT REGISTER.
COPY AC3-17 TO WC1 AND WC2
COPY AC0 TO COMPUTER CONTROL FLAG
COPY AC1-2 TO SOURCE/DESTINATION REGISTER.

EMAR=705045 LOAD MEMORY ADDRESS REGISTER.
COPY AC3-17 TO MAR.
COPY AC0-2 TO FUNCTION REGISTER
INITIATE THE FUNCTION INDICATED.

AN INTERRUPT ON API CHANNEL 25 , PRIORITY 1, WILL OCCUR WHEN THE TRANSFER HAS TERMINATED.

EMCTA=705032 COPY WORD COUNT REGISTER
COPY WC1 TO AC3-17
SET AC0=1 IF LOAD POINT OR END-OF-TAPE IS SENSED ON THE LAST
SELECTED TAPE STATION
SEX AC1=1 IF THE EMS SOUND IS ON
SET AC2=1 IF WC1 WC2 (LOST DATA).

INTERRUPTS

THE E-15 INTERFACE WILL INTERRUPT THE COMPUTER IN THE FOLLOWING CASES, THE INTERRUPT OCCURS ON API CHANNEL 25 PRIORITY LEVEL 1.

A) AFTER A READ OR WRITE OPERATION, WHEN THE LAST WORD TRANS-
FERRED ON THE DATA CHANNEL HAS CAUSED EITHER WC1 OR WC2 TO
BECOME ZERO, IF THE DESTINATION OF THE READ OR WRITE OPERATION
WAS THE BUFFER OR REGISTER, NO FURTHER INTERRUPT WILL OCCUR
IN THIS OPERATION.

B) AFTER A READ, POSITION, OR REWIND OPERATION INVOLVING A
MAGNETIC TAPE, WHEN THE MAGNETIC TAPE MOTION IS STOPPED AND
THE NOT BUSY FLAG IS SET.

C) AFTER A READ OPERATION, IF THE INITIAL COUNT IN WC1 WAS LESS
THAN THE RECORD LENGTH, THE INTERRUPT WILL OCCUR WHEN THE END
OF RECORD OCCURS.

EMS ~~not~~ using the Data channel