CSN-252 Project
SIC-XE Assembler Design

By-
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The design of the SIC-XE Assembler is implemented in a single cpp file named- “Assembler1.cpp”. It includes the implementation of control sections but not program blocks.
To use the assembler, open the C++ code in any IDE and run it. In the IDE terminal, input the assembly program. The input format is discussed below.

Input format:

- Write the assembly program in **uppercase characters** only.
- Blank spaces are only allowed to make the distinction between the “label”, “opcode” and “operand” fields. Only one blank space is allowed to make this distinction and other than these, no blank spaces are allowed. If no “label” field element is present in an instruction then start directly from “opcode” field element.
- In the “operand” field where multiple elements are required like “BUFFER+BUFEND” or “BUFFER,X” or “X,A” or “BUFFER-BUFEND,X” make sure there are no blank spaces.
- No blank lines or comments are allowed between instructions.
- Unless “END” or “END *label”* instruction is written, the code will keep on taking input instructions. So to complete the assembly and see the output, this instruction is required.

Some sample programs are provided at the end of this document.

Output format:

- If no errors are encountered, then the listing file and the object program of the assembled program will be printed.
- In the listing file, the first column shows the addresses or location counter of the respective instructions. The second column shows the assembly instruction elements and the third and last column shows the respective object codes.
- The format of the SIC-XE object program is as specified by the textbook “System Software: An Introduction To Systems Programming” by LL Beck. It includes all the required types of records.
- In case of control sections, the listing files and object programs of individual assembly codes are printed separately.

Assembler Design Explanation:

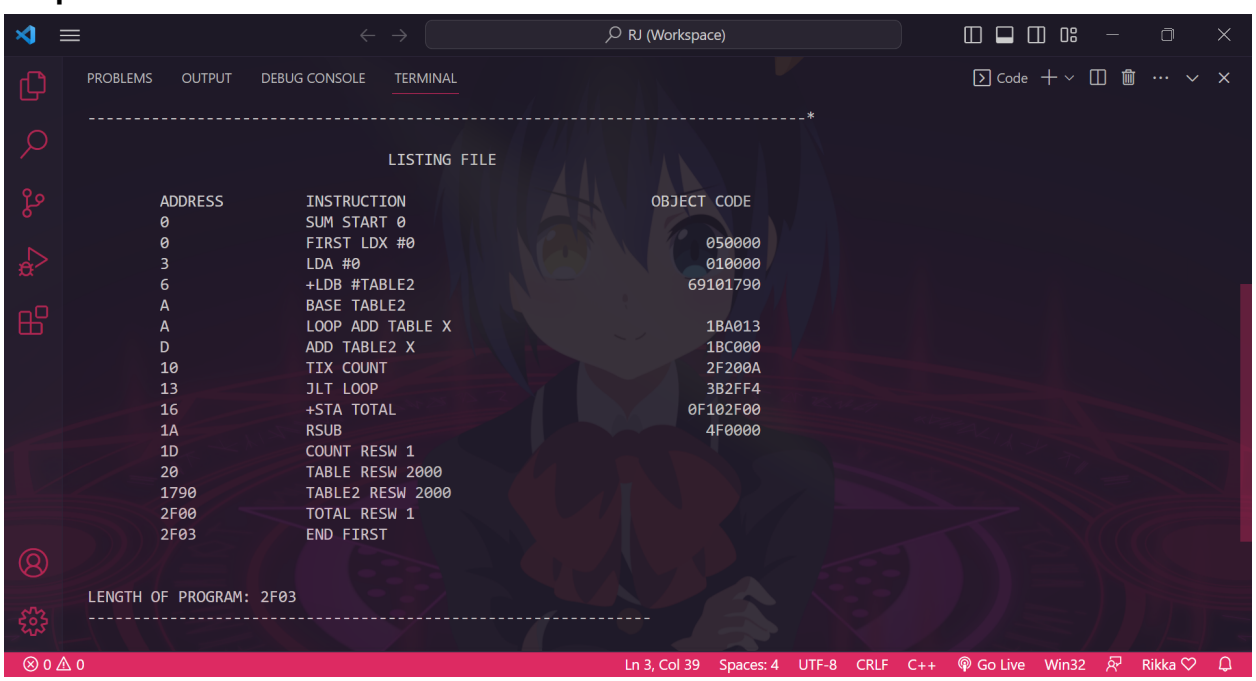
- The provided code implements a standard two pass assembler. The code is divided into different functions which perform specific tasks as specified by their name.
- First the “getInstructions()” function is used to take the input instructions and then the program is assembled by making two passes over the program. This is done by the functions “firstPass()” and “secondPass()” respectively.
- In the first pass, all the input instructions are checked for validity. The location counter vector is maintained and all labels and their addresses are calculated and stored in the symbol table denoted by vector “symTab”.
- If required, the literal table is also maintained in form of vector “litTab” and if any expressions are used, their validity is checked and their value is calculated at the end of the first pass by using functions “containsArithmetic()”, “isExpression()” and “absOrRelative()”.
- Errors detected are reported as they are found. If there are no errors, then the execution goes to the function “secondPass()”. If there are errors, then execution stops here.
- In the second pass, the object codes for all the instructions are generated and stored in the vector “objCode”. If there are any addressing related errors, they are reported here as they are found and the execution stops after this. If no errors are found, then the execution goes to function “printListingFile()”, “generateObjProgram()” and “printObjProgram()” and the output is shown.
- When control sections are used, external definitions and external references are maintained in vectors “extDef” and “extRef” respectively.
- In control sections, the individual programs can be categorized into 3 types- first program of the control section, last program of the control section and middle programs of the control section.
- To assemble these 3 different types of individual programs, slight variations of functions “firstPass()”, “secondPass()”, and “generateObjProgram()” are used.
- These functions are named “firstPass1()”, “secondPass1()”, “generateObjProgram1()”, “firstPass2()”, “secondPass2()”, “generateObjProgram2()”, “firstPass3()”, “secondPass3()”, and “generateObjProgram3()” and they are used to handle these 3 different types of individual programs in control sections.

Sample inputs:

- Question 3 of section 2.2 of the textbook “System Software: An Introduction To Systems Programming” by LL Beck -

```
SUM START 0
FIRST LDX #0
LDA #0
+LDB #TABLE2
BASE TABLE2
LOOP ADD TABLE,X
ADD TABLE2,X
TIX COUNT
JLT LOOP
+STA TOTAL
RSUB
COUNT RESW 1
TABLE RESW 2000
TABLE2 RESW 2000
TOTAL RESW 1
END FIRST
```

Output:



```
OBJECT PROGRAM

HSUM   000000002F03
T0000001D0500000100000691017901BA0131BC0002F200A3B2FF40F102F004F0000
M00000705
M00001705
E000000

PS C:\Users\hp\OneDrive\Desktop\VSCode\Csn-252>
```

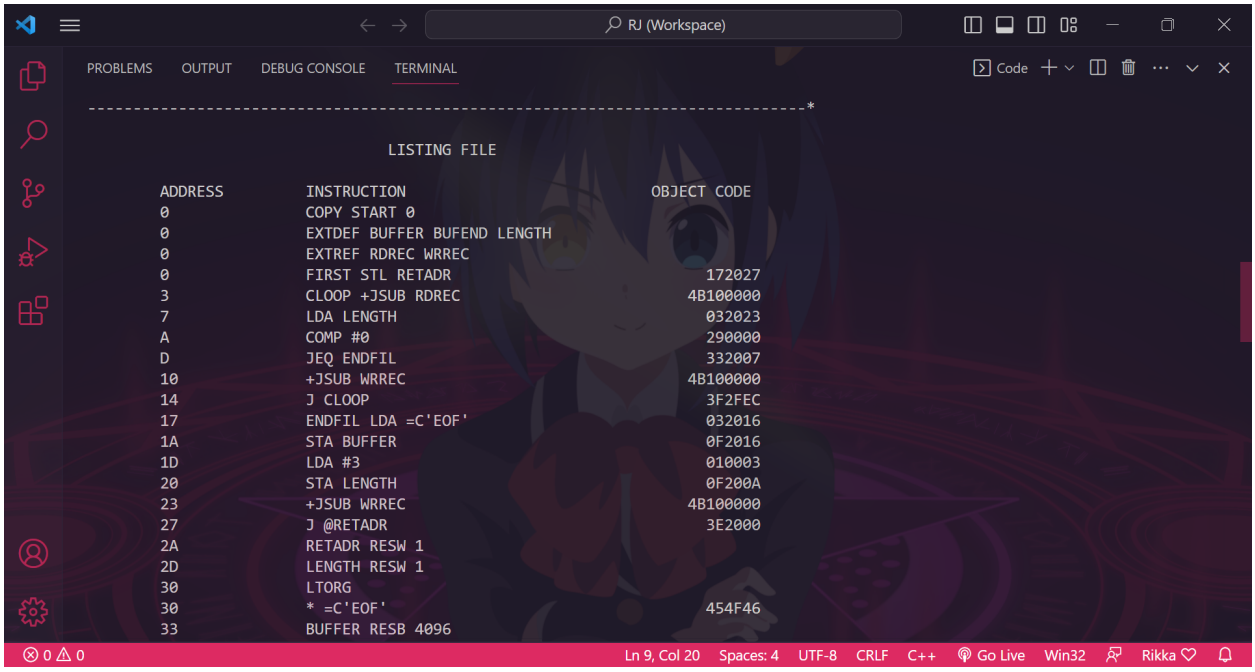
0 0 Ln 3, Col 39 Spaces: 4 UTF-8 CRLF C++ Go Live Win32 Rikka

- Sample input containing control sections (also from same textbook) -

```
COPY START 0
EXTDEF BUFFER,BUFEND,LENGTH
EXTREF RDREC,WRREC
FIRST STL RETADR
CLOOP +JSUB RDREC
LDA LENGTH
COMP #0
JEQ ENDFIL
+JSUB WRREC
J CLOOP
ENDFIL LDA =C'EOF'
STA BUFFER
LDA #3
STA LENGTH
+JSUB WRREC
J @RETADR
RETADR RESW 1
LENGTH RESW 1
LTORG
BUFFER RESB 4096
BUFEND EQU *
MAXLEN EQU BUFEND-BUFFER
RDREC CSECT
EXTREF BUFFER,LENGTH,BUFEND
CLEAR X
CLEAR A
CLEAR S
LDT MAXLEN
RLOOP TD INPUT
JEQ RLOOP
```

```
RD INPUT
COMPR A,S
JEQ EXIT
+STCH BUFFER,X
TIXR T
JLT RLOOP
EXIT +STX LENGTH
RSUB
INPUT BYTE X'F1'
MAXLEN WORD BUFEND-BUFFER
WRREC CSECT
EXTREF LENGTH,BUFFER
CLEAR X
+LDT LENGTH
WLOOP TD =X'05'
JEQ WLOOP
+LDCH BUFFER,X
WD =X'05'
TIXR T
JLT WLOOP
RSUB
END FIRST
```

Output:



```
--------------------------------------------------------------------------------*

                                LISTING FILE

        ADDRESS         INSTRUCTION                     OBJECT CODE
        0               COPY START 0
        0               EXTDEF BUFFER BUFEND LENGTH
        0               EXTREF RDREC WRREC
        0               FIRST STL RETADR                  172027
        3               CLOOP +JSUB RDREC                4B100000
        7               LDA LENGTH                        032023
        A               COMP #0                           290000
        D               JEQ ENDFIL                        332007
        10              +JSUB WRREC                      4B100000
        14              J CLOOP                           3F2FEC
        17              ENDFIL LDA =C'EOF'                032016
        1A              STA BUFFER                        0F2016
        1D              LDA #3                            010003
        20              STA LENGTH                        0F200A
        23              +JSUB WRREC                      4B100000
        27              J @RETADR                         3E2000
        2A              RETADR RESW 1
        2D              LENGTH RESW 1
        30              LTORG
        30              * =C'EOF'                         454F46
        33              BUFFER RESB 4096
```

```
        2D              LENGTH RESW 1
        30              LTORG
        30              * =C'EOF'                                454F46
        33              BUFFER RESB 4096
        1033            BUFEND EQU *
        1033            MAXLEN EQU BUFEND-BUFFER


LENGTH OF PROGRAM: 1033
------------------------------------------------------------


                OBJECT PROGRAM

HCOPY  000000001033
DBUFFER000033BUFEND001033LENGTH00002D
RRDREC WRREC
T0000001D1720274B10000003202329000033200 74B1000003F2FEC0320160F2016
T00001D0D0100030F200A4B1000003E2000
T00003003454F46
M00000405+RDREC
M00001105+WRREC
M00002405+WRREC
E000000
```

```
                                LISTING FILE

        ADDRESS         INSTRUCTION                     OBJECT CODE
        0               RDREC CSECT
        0               EXTREF BUFFER LENGTH BUFEND
        0               CLEAR X                                B410
        2               CLEAR A                                B400
        4               CLEAR S                                B440
        6               LDT MAXLEN                           77201F
        9               RLOOP TD INPUT                       E3201B
        C               JEQ RLOOP                            332FFA
        F               RD INPUT                             DB2015
        12              COMPR A S                              A004
        14              JEQ EXIT                             332009
        17              +STCH BUFFER X                      57900000
        1B              TIXR T                                 B850
        1D              JLT RLOOP                            3B2FE9
        20              EXIT +STX LENGTH                    13100000
        24              RSUB                                 4F0000
        27              INPUT BYTE X'F1'                         F1
        28              MAXLEN WORD BUFEND-BUFFER            000000


LENGTH OF PROGRAM: 2B
------------------------------------------------------------
```

```
                OBJECT PROGRAM

HRDREC 00000000002B
RBUFFERLENGTHBUFEND
T0000001DB410B400B44077201FE3201B332FFADB2015A0043320095790000B850
T00001D0E3B2FE9131000004F0000F1000000
M00001805+BUFFER
M00002105+LENGTH
M00002806+BUFEND
M00002806-BUFFER
E


                        LISTING FILE

        ADDRESS         INSTRUCTION                     OBJECT CODE
        0               WRREC CSECT
        0               EXTREF LENGTH BUFFER
        0               CLEAR X                                B410
        2               +LDT LENGTH                         77100000
        6               WLOOP TD =X'05'                       E32012
        9               JEQ WLOOP                             332FFA
        C               +LDCH BUFFER X                      53900000
        10              WD =X'05'                             DF2008
```

```
        6               WLOOP TD =X'05'                       E32012
        9               JEQ WLOOP                             332FFA
        C               +LDCH BUFFER X                      53900000
        10              WD =X'05'                             DF2008
        13              TIXR T                                 B850
        15              JLT WLOOP                             3B2FEE
        18              RSUB                                  4F0000
        1B              * =X'05'                                   05
        1C              END FIRST


LENGTH OF PROGRAM: 1C
-------------------------------------------------------------


                OBJECT PROGRAM

HWRREC 00000000001C
RLENGTHBUFFER
T0000001CB41077100000E32012332FFA53900000DF2008B8503B2FEE4F000005
M00000305+LENGTH
M00000D05+BUFFER
E


PS C:\Users\hp\OneDrive\Desktop\VSCode\Csn-252>
```