Software Project Report
For
SIC/XE Assembler

[Phase 2]

Prepared by:

Omar Nasr	4730
Sherif Rafik	4635
Mohamad Tarek	4774
Mahmoud Salem	4643
Mohamed Harraz	4608

Introduction

Overview

This document defines the requirement for the SIC/XE Assembler that is being developed for Systems Programming course at Faculty of Engineering, Alexandria University. The purpose of this document is to represent the system requirements for operating the software as well as an overlook on the designing and implementation processes.

SIC/XE Assembler is a Graphical User Interface (GUI) based application for converting code written in assembly language into the object code used by the famous hypothetical microprocessor "SIC/XE".

Requirements:

It is required to process the code written in assembly language to:

- Handle all of the SIC/XE supported instruction
- Process a code that meets the SIC/XE specifications
- Check for possible errors
- Generate a list file to review instructions, addresses and errors
- Generate the object code to be passed to the microprocessor

Phase II of the project covers:

- Evaluating literals
- Evaluating arithmetic expressions
- Generating the object code passed to the processor
- Generating a process report for the assembly

Requirements Specifications

This software uses Java Development Kit which needs some system requirements to be met.

Supported Operating Systems

Windows

- 10 or above
- 8.x
- 7 SP1
- Vista SP2
- Server 2008 R2 SP1 (64-bit)
- Server 2012 and 2012 R2 (64-bit)

MAC OS X

- 10.8.3 +
- 10.9 +

Linux

- Oracle Linux 5.5+
- Oracle Linux 6.x (32-bit), 6.x (64-bit)
- Oracle Linux 7.x (64-bit)2 (8u20 and above)
- Red Hat Enterprise Linux 5.5+, 6.x (32-bit), 6.x (64-bit)
- Red Hat Enterprise Linux 7.x (64-bit) (8u20 and above)
- Suse Linux Enterprise Server 10 SP2+, 11.x
- Suse Linux Enterprise Server 12.x (64-bit) (8u31 and above)
- Ubuntu Linux 12.04 LTS, 13.x
- Ubuntu Linux 14.x (8u25 and above)
- Ubuntu Linux 15.04 (8u45 and above)
- Ubuntu Linux 15.10 (8u65 and above)

Environment

The software requires installation of

- Java Development Kit JDK 1.8 (or above)
- Java SE Runtime Environment JRE
- Java Virtual Machine JVM

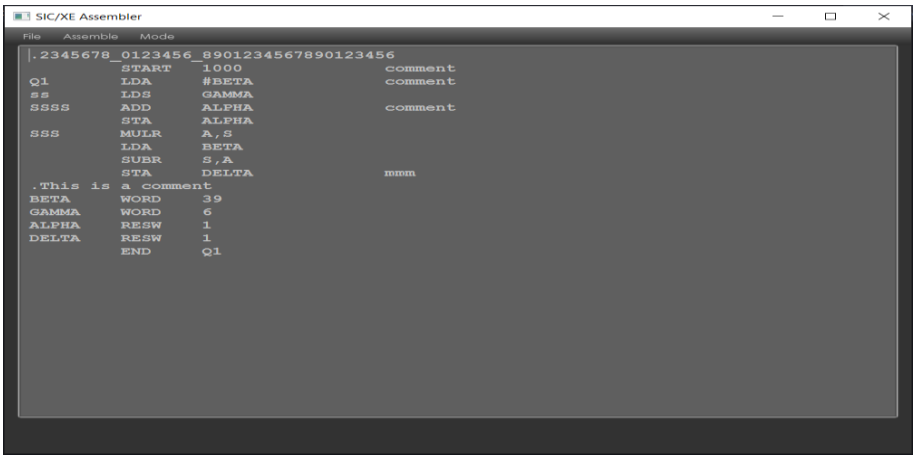
Design Aspects

Overall Design

The project follows an **MVC (model view controller)** design making it reusable and easily editable with an organized hierarchy. The main functionalities of the program are controlled by implementing the **Singleton** Design Pattern to make sure everything is globally handled.

Graphical User Interface

The program provides a smooth, user friendly interface to load written assembly programs from the file system or edit new ones in the editor in order to process them to generate the required output files needed to run programs by the microprocessor



Data Structures

The mainly used data structures are:

ArrayLists as they are perfectly suitable to the program, because:

- They provide an efficient access time especially with the relatively small amount of data to manipulate
- They are dynamic which allows the user to add more valid instructions when needed

Hashmaps are used with *symbol table* & *literals table* as they provide efficient access time.

Algorithm

The main functionality of the program is processing a given code to get specific outputs. This is performed in sequential steps:

- The user specifies the input data (either by loading an existing file or by writing the program in the editor)
- The program gets the editing mode selected by the user to proceed with the processing stage
- Processing pass one:
    a. Input data is processed line by line to check its validity as follows
        1) Check if any of the line components is misplaced
        2) Check that the label is verified
        3) verify the mnemonic
        4) Identify the addressing mode
        5) Verify the operand(s)
    b. Pass one report is prepared
    c. Symbol table is filled & symbols file is generated
    d. Arithmetic expressions are evaluated
    e. Literals are processed & their addresses are evaluated
- Processing pass two:
    a. Header record is initialized:
        1) Get start address
        2) Get program name
        3) Initialize program length
    b. Processed instructions are parsed line by line:
        1) Check operand format
        2) Get operation code for mnemonic
        3) Calculate operand displacement (in case of format 3 with relative addressing)
        4) Set displacement error if it exists
        5) Append instruction code to text record
        6) Update program length
    c. End record is initialized
    d. Pass two report is appended to list file
    e. Object code is generated

Assumptions & User Requirements

SIC/XE specifications are met as described below and knowing them is a must for the user to be able to use the program efficiently

Registers

symbol	number	use
A	0	Accumulator: for arithmetic and I/O
X	1	Indexing
L	2	subroutine linkage to save the return address
B	3	base register
S	4	General working register
T	5	General working register
F	6	floating-point accumulator
PC	8	program counter
SW	9	status word

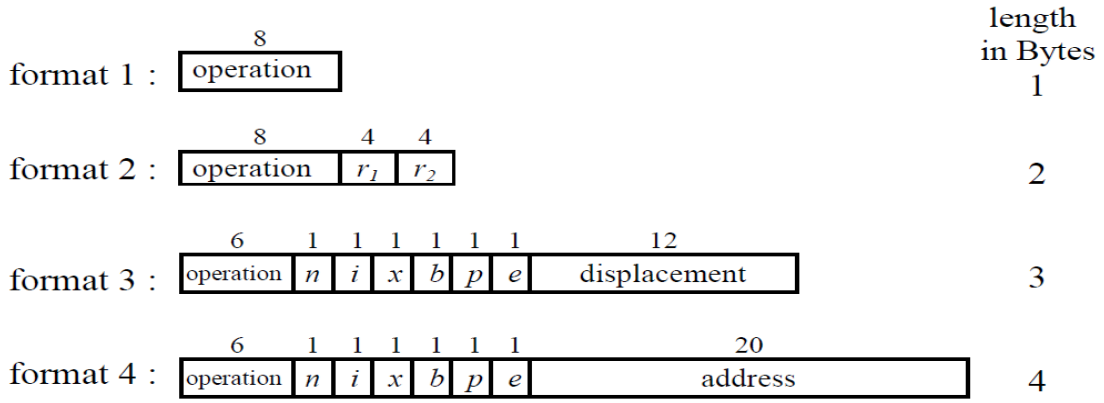
Memory:

- Consists of 8-bit bytes
- Any three consecutive bytes from a word (24-bit)
- Words are addressed by the location of the lowest numbered byte
- Memory size is 220 bytes on the SIC / XE system (1 MB)

Data Format

- Integer are stored in 24-bits as binary numbers using two's complement notation.
- Characters are stored using 8-bits ASCII code

Instruction Format



Addressing Modes

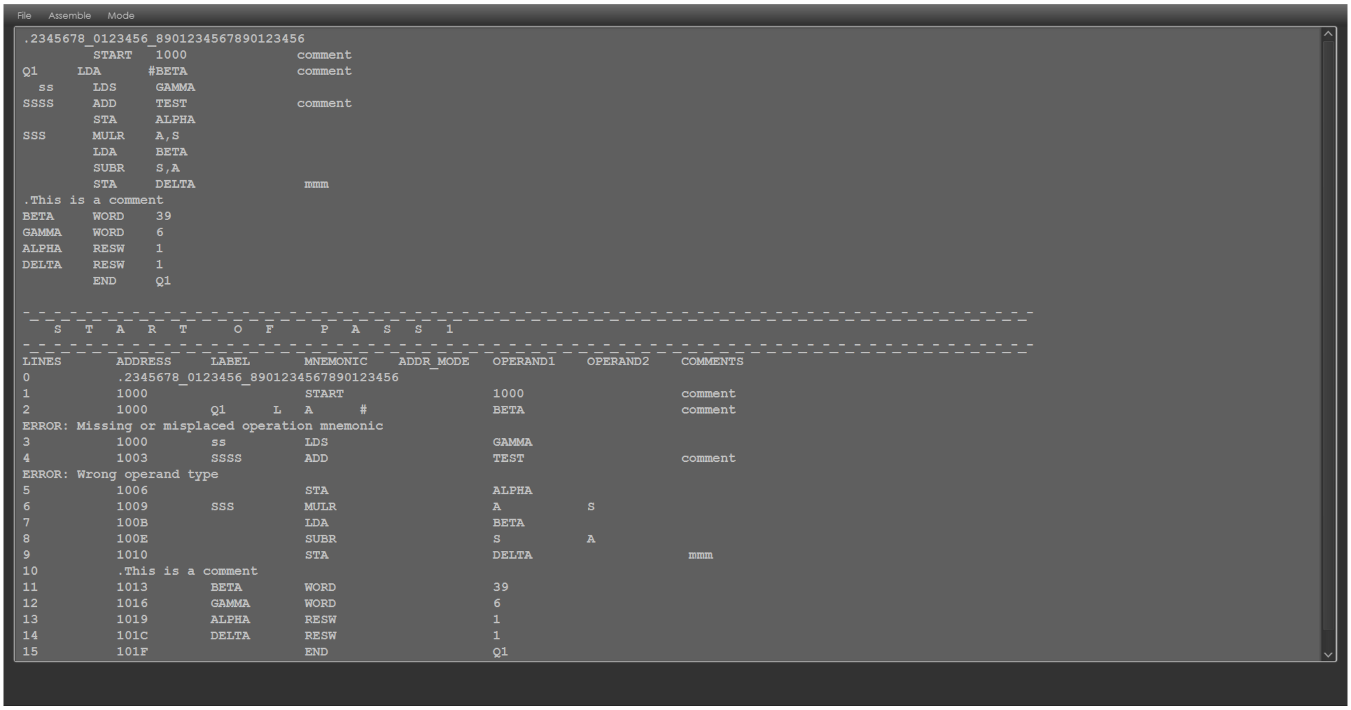
- immediate addressing
- direct addressing with/without indexing
- indirect addressing
- Base relative addressing
- Program counter relative addressing

THE USER IS REQUIRED TO:

- have good experience with assembly language and SIC/XE specifications
- be familiar with the Instruction Set as well as the required format
- provide an assembly program as a text file (file.txt) or as a written code in the editor

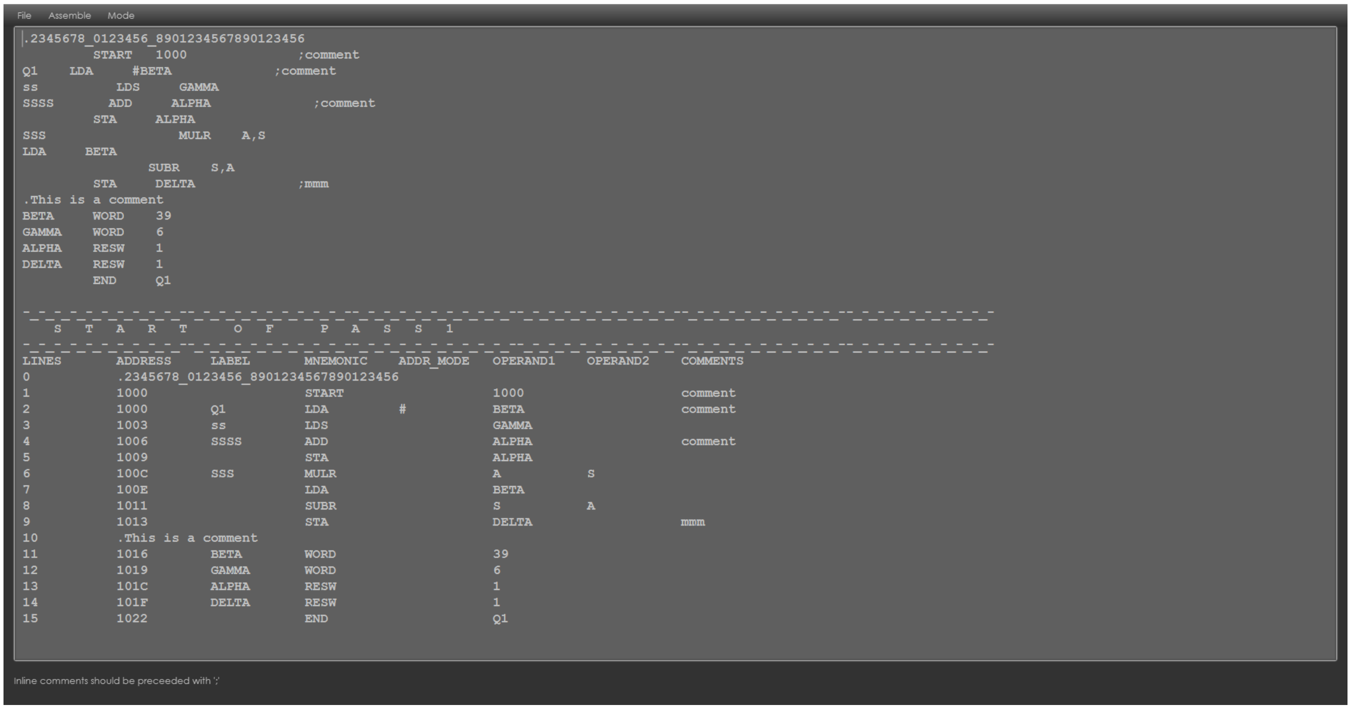
Sample runs

Assembling using the restricted format mode



```
.2345678_0123456_8901234567890123456
         START   1000              comment
Q1     LDA      #BETA              comment
  ss     LDS     GAMMA
SSSS     ADD     TEST              comment
         STA     ALPHA
SSS      MULR    A,S
         LDA     BETA
         SUBR    S,A
         STA     DELTA              mmm
.This is a comment
BETA     WORD    39
GAMMA    WORD    6
ALPHA    RESW    1
DELTA    RESW    1
         END     Q1

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
    S   T   A   R   T      O   F      P   A   S   S   1
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
LINES       ADDRESS     LABEL       MNEMONIC    ADDR_MODE   OPERAND1    OPERAND2    COMMENTS
0           .2345678_0123456_8901234567890123456
1           1000                    START                   1000                    comment
2           1000        Q1      L   A      #                BETA                    comment
ERROR: Missing or misplaced operation mnemonic
3           1000        ss          LDS                     GAMMA
4           1003        SSSS        ADD                     TEST                    comment
ERROR: Wrong operand type
5           1006                    STA                     ALPHA
6           1009        SSS         MULR                    A           S
7           100B                    LDA                     BETA
8           100E                    SUBR                    S           A
9           1010                    STA                     DELTA                    mmm
10          .This is a comment
11          1013        BETA        WORD                    39
12          1016        GAMMA       WORD                    6
13          1019        ALPHA       RESW                    1
14          101C        DELTA       RESW                    1
15          101F                    END                     Q1
```

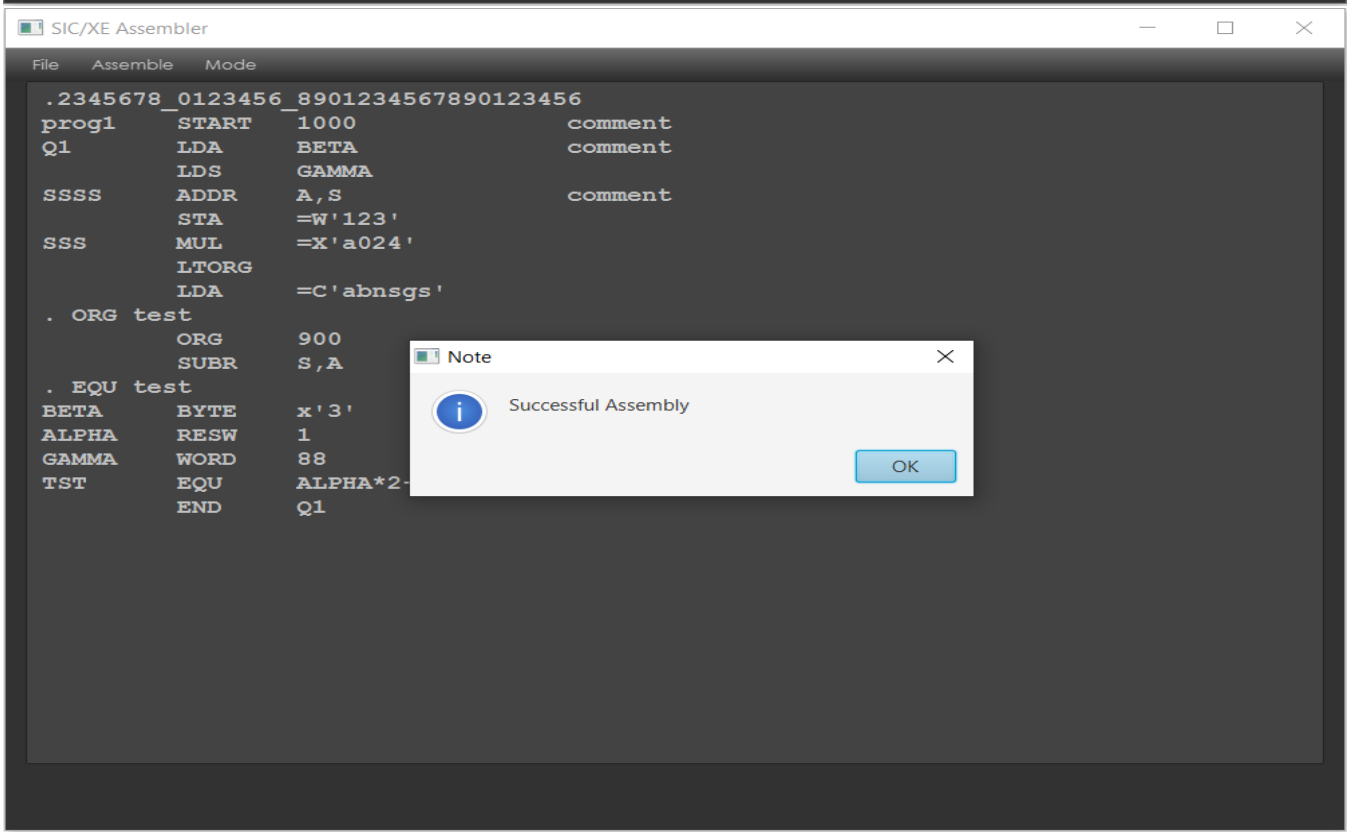
Assembling using the free format mode



```
.2345678_0123456_8901234567890123456
         START   1000              ;comment
Q1    LDA     #BETA             ;comment
ss          LDS     GAMMA
SSSS       ADD     ALPHA                ;comment
         STA     ALPHA
SSS                MULR    A,S
LDA     BETA
                SUBR    S,A
         STA     DELTA              ;mmm
.This is a comment
BETA     WORD    39
GAMMA    WORD    6
ALPHA    RESW    1
DELTA    RESW    1
         END     Q1

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
    S   T   A   R   T      O   F      P   A   S   S   1
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
LINES       ADDRESS     LABEL       MNEMONIC    ADDR_MODE   OPERAND1    OPERAND2    COMMENTS
0           .2345678_0123456_8901234567890123456
1           1000                    START                   1000                    comment
2           1000        Q1          LDA         #           BETA                    comment
3           1003        ss          LDS                     GAMMA
4           1006        SSSS        ADD                     ALPHA                   comment
5           1009                    STA                     ALPHA
6           100C        SSS         MULR                    A           S
7           100E                    LDA                     BETA
8           1011                    SUBR                    S           A
9           1013                    STA                     DELTA                   mmm
10          .This is a comment
11          1016        BETA        WORD                    39
12          1019        GAMMA       WORD                    6
13          101C        ALPHA       RESW                    1
14          101F        DELTA       RESW                    1
15          1022                    END                     Q1
```

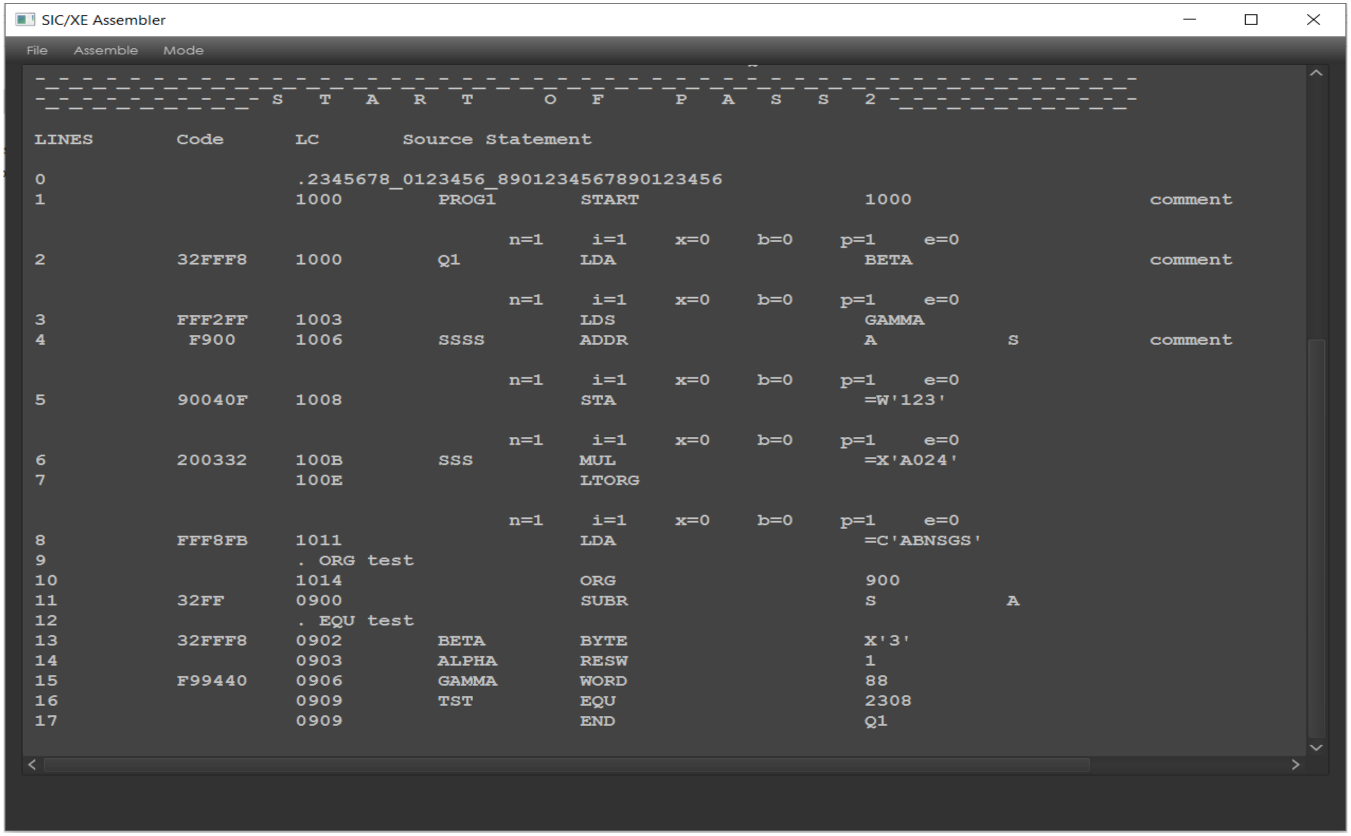
Inline comments should be preceeded with ';'

Sample run for a test program



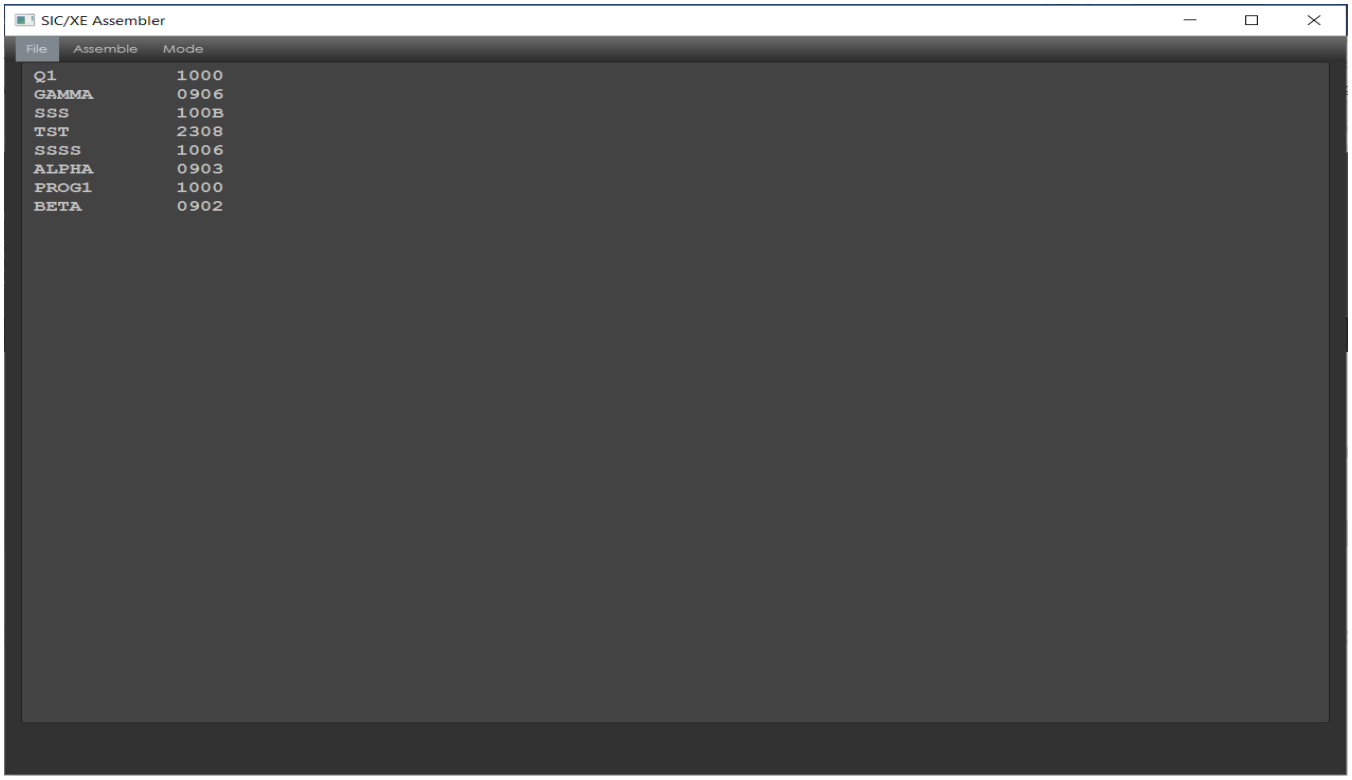
Assembly report

```
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - S   T   A   R   T     O   F     P   A   S   S   1 - - - - - - - - - - - - - - -

LINES       ADDRESS     LABEL       MNEMONIC    ADDR_MODE   OPERAND1    OPERAND2    COMMENTS
0           .2345678_0123456_8901234567890123456
1           1000        PROG1       START                   1000                    comment
2           1000        Q1          LDA                     BETA                    comment
3           1003                    LDS                     GAMMA
4           1006        SSSS        ADDR                    A           S           comment
5           1008                    STA                     =W'123'
6           100B        SSS         MUL                     =X'A024'
7           100E                    LTORG
8           1011                    LDA                     =C'ABNSGS'
9           . ORG test
10          1014                    ORG                     900
11          0900                    SUBR                    S           A
12          . EQU test
13          0902        BETA        BYTE                    X'3'
14          0903        ALPHA       RESW                    1
15          0906        GAMMA       WORD                    88
16          0909        TST         EQU                     ALPHA*2-BETA
17          0909                    END                     Q1
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - S   T   A   R   T     O   F     P   A   S   S   2 - - - - - - - - - - - - - - -

LINES       Code      LC        Source Statement

0                     .2345678_0123456_8901234567890123456
1                     1000        PROG1       START                   1000                    comment

                                        n=1    i=1    x=0    b=0    p=1    e=0
2           32FFF8    1000        Q1          LDA                     BETA                    comment

                                        n=1    i=1    x=0    b=0    p=1    e=0
```



```
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - S   T   A   R   T     O   F     P   A   S   S   2 - - - - - - - - - - - - - - -

LINES       Code      LC        Source Statement

0                     .2345678_0123456_8901234567890123456
1                     1000        PROG1       START                   1000                    comment

                                        n=1    i=1    x=0    b=0    p=1    e=0
2           32FFF8    1000        Q1          LDA                     BETA                    comment

                                        n=1    i=1    x=0    b=0    p=1    e=0
3           FFF2FF    1003                    LDS                     GAMMA
4            F900     1006        SSSS        ADDR                    A           S           comment

                                        n=1    i=1    x=0    b=0    p=1    e=0
5           90040F    1008                    STA                     =W'123'

                                        n=1    i=1    x=0    b=0    p=1    e=0
6           200332    100B        SSS         MUL                     =X'A024'
7                     100E                    LTORG

                                        n=1    i=1    x=0    b=0    p=1    e=0
8           FFF8FB    1011                    LDA                     =C'ABNSGS'
9                     . ORG test
10                    1014                    ORG                     900
11          32FF      0900                    SUBR                    S           A
12                    . EQU test
13          32FFF8    0902        BETA        BYTE                    X'3'
14                    0903        ALPHA       RESW                    1
15          F99440    0906        GAMMA       WORD                    88
16                    0909        TST         EQU                     2308
17                    0909                    END                     Q1
```

Symbol table



Object code