A. **Appendix for as6502 Frankenstein Assembler**

A.1 **Pseudo Operations**

A.1.1 *Standard_Pseudo_Operation_Mnemonics*

```
End                                   END
File Inclusion                        INCL INCLUDE
If                                    IF
Else                                  ELSE
End If                                ENDI
Equate                                EQU
Set                                   SET
Org                                   ORG
Reserve Memory                        RESERVE RMB
Define Byte Data                      BYTE DB FCB
Define Word Data                      DW FDB WORD
Define String Data                    FCC STRING
Define Character Set Translation      CHARSET
Define Character Value                CHARDEF CHD
Use Character Translation             CHARUSE
```

A.1.2 *Machine_Dependent_Pseudo_Operations*

A.1.2.1 *Define_Word_Data* The define word pseudo-operations generates the byte reversed (low byte, high byte) representation.

A.1.2.2 *Instruction_Set_Selection*

    CPU string

The instruction set can be specified in the source file with the CPU pseudooperation. The string, delimited by quotes or apostrophes, is scanned for a substring which selects which instruction set is used. When the program is invoked, this operation is performed on the name of the program, then the -p optional arguement, if any, and then any CPU statements. The last one selects which subset of the instructions the assembler will accept. The instruction set can be changed at any place in the source file.

```
    Instruction Set          Substrings
    ROCKWELL CMOS            R65C r65c
    CMOS                     65C 65c
    ROCKWELL Extended        R65 r65
    R65C00/21                21
    Standard NMOS            65
```

A.2 **Instructions**

A.2.1 *Instruction_List*

```
Opcode     Syntax                         Selection Criteria


ADC        '#' topexpr
ADC        '(' topexpr ')' ',' INDEX      DIRECT INDEXY
ADC        '(' topexpr ')'                DIRECT INSTCMOS
ADC        '(' topexpr ',' INDEX ')'      DIRECT INDEXX
ADC        topexpr ',' INDEX              DIRECT INDEXX
ADC        topexpr ',' INDEX              EXTENDED INDEXX
ADC        topexpr ',' INDEX              INDEXY
ADC        topexpr                        DIRECT
ADC        topexpr                        EXTENDED

AND        '#' topexpr
AND        '(' topexpr ')' ',' INDEX      DIRECT INDEXY
AND        '(' topexpr ')'                DIRECT INSTCMOS
AND        '(' topexpr ',' INDEX ')'      DIRECT INDEXX
AND        topexpr ',' INDEX              DIRECT INDEXX
AND        topexpr ',' INDEX              EXTENDED INDEXX
AND        topexpr ',' INDEX              INDEXY
AND        topexpr                        DIRECT
AND        topexpr                        EXTENDED

ASL        ACCUM
ASL        topexpr ',' INDEX              DIRECT INDEXX
ASL        topexpr ',' INDEX              EXTENDED INDEXX
ASL        topexpr                        DIRECT
ASL        topexpr                        EXTENDED

BBR0       topexpr ',' topexpr            INSTROCKWELL

BBR1       topexpr ',' topexpr            INSTROCKWELL

BBR2       topexpr ',' topexpr            INSTROCKWELL

BBR3       topexpr ',' topexpr            INSTROCKWELL

BBR4       topexpr ',' topexpr            INSTROCKWELL

BBR5       topexpr ',' topexpr            INSTROCKWELL

BBR6       topexpr ',' topexpr            INSTROCKWELL

BBR7       topexpr ',' topexpr            INSTROCKWELL

BBS0       topexpr ',' topexpr            INSTROCKWELL
```

```
Opcode     Syntax                          Selection Criteria

BBS1       topexpr ',' topexpr             INSTROCKWELL

BBS2       topexpr ',' topexpr             INSTROCKWELL

BBS3       topexpr ',' topexpr             INSTROCKWELL

BBS4       topexpr ',' topexpr             INSTROCKWELL

BBS5       topexpr ',' topexpr             INSTROCKWELL

BBS6       topexpr ',' topexpr             INSTROCKWELL

BBS7       topexpr ',' topexpr             INSTROCKWELL

BCC        topexpr

BCS        topexpr

BEQ        topexpr

BGE        topexpr

BIT        '#' topexpr                     INSTCMOS
BIT        topexpr ',' INDEX               DIRECT INDEXX INSTCMOS
BIT        topexpr ',' INDEX               EXTENDED INDEXX INSTCMOS
BIT        topexpr                         DIRECT
BIT        topexpr                         EXTENDED

BLT        topexpr

BMI        topexpr

BNE        topexpr

BPL        topexpr

BRA        topexpr                         INST21
BRA        topexpr                         INSTCMOS

BRK        '#' topexpr
BRK

BVC        topexpr

BVS        topexpr

CLC

CLD
```

```
Opcode    Syntax                        Selection Criteria


CLI

CLV

CMP       '#' topexpr
CMP       '(' topexpr ')' ',' INDEX   DIRECT INDEXY
CMP       '(' topexpr ')'             DIRECT INSTCMOS
CMP       '(' topexpr ',' INDEX ')'   DIRECT INDEXX
CMP       topexpr ',' INDEX           DIRECT INDEXX
CMP       topexpr ',' INDEX           EXTENDED INDEXX
CMP       topexpr ',' INDEX           INDEXY
CMP       topexpr                     DIRECT
CMP       topexpr                     EXTENDED

CPX       '#' topexpr
CPX       topexpr                     DIRECT
CPX       topexpr                     EXTENDED

CPY       '#' topexpr
CPY       topexpr                     DIRECT
CPY       topexpr                     EXTENDED

DEC       ACCUM                       INSTCMOS
DEC       topexpr ',' INDEX           DIRECT INDEXX
DEC       topexpr ',' INDEX           EXTENDED INDEXX
DEC       topexpr                     DIRECT
DEC       topexpr                     EXTENDED

DEX

DEY

EOR       '#' topexpr
EOR       '(' topexpr ')' ',' INDEX   DIRECT INDEXY
EOR       '(' topexpr ')'             DIRECT INSTCMOS
EOR       '(' topexpr ',' INDEX ')'   DIRECT INDEXX
EOR       topexpr ',' INDEX           DIRECT INDEXX
EOR       topexpr ',' INDEX           EXTENDED INDEXX
EOR       topexpr ',' INDEX           INDEXY
EOR       topexpr                     DIRECT
EOR       topexpr                     EXTENDED

INC       ACCUM                       INSTCMOS
INC       topexpr ',' INDEX           DIRECT INDEXX
INC       topexpr ',' INDEX           EXTENDED INDEXX
INC       topexpr                     DIRECT
INC       topexpr                     EXTENDED
```

```
Opcode     Syntax                       Selection Criteria

INX

INY

JMP        '(' topexpr ')'
JMP        '(' topexpr ',' INDEX ')'    INSTCMOS INDEXX
JMP        topexpr

JSR        topexpr

LDA        '#' topexpr
LDA        '(' topexpr ')' ',' INDEX    DIRECT INDEXY
LDA        '(' topexpr ')'              DIRECT INSTCMOS
LDA        '(' topexpr ',' INDEX ')'    DIRECT INDEXX
LDA        topexpr ',' INDEX            DIRECT INDEXX
LDA        topexpr ',' INDEX            EXTENDED INDEXX
LDA        topexpr ',' INDEX            INDEXY
LDA        topexpr                      DIRECT
LDA        topexpr                      EXTENDED

LDX        '#' topexpr
LDX        topexpr ',' INDEX            DIRECT INDEXY
LDX        topexpr ',' INDEX            EXTENDED INDEXY
LDX        topexpr                      DIRECT
LDX        topexpr                      EXTENDED

LDY        '#' topexpr
LDY        topexpr ',' INDEX            DIRECT INDEXX
LDY        topexpr ',' INDEX            EXTENDED INDEXX
LDY        topexpr                      DIRECT
LDY        topexpr                      EXTENDED

LSR        ACCUM
LSR        topexpr ',' INDEX            DIRECT INDEXX
LSR        topexpr ',' INDEX            EXTENDED INDEXX
LSR        topexpr                      DIRECT
LSR        topexpr                      EXTENDED

MUL                                     INST21

NOP

ORA        '#' topexpr
ORA        '(' topexpr ')' ',' INDEX    DIRECT INDEXY
ORA        '(' topexpr ')'              DIRECT INSTCMOS
ORA        '(' topexpr ',' INDEX ')'    DIRECT INDEXX
ORA        topexpr ',' INDEX            DIRECT INDEXX
ORA        topexpr ',' INDEX            EXTENDED INDEXX
ORA        topexpr ',' INDEX            INDEXY
```

```
Opcode     Syntax                          Selection Criteria

ORA        topexpr                         DIRECT
ORA        topexpr                         EXTENDED

PHA

PHP

PHX                                        INST21
PHX                                        INSTCMOS

PHY                                        INST21
PHY                                        INSTCMOS

PLA

PLP

PLX                                        INST21
PLX                                        INSTCMOS

PLY                                        INST21
PLY                                        INSTCMOS

RMB0       topexpr                         INSTROCKWELL

RMB1       topexpr                         INSTROCKWELL

RMB2       topexpr                         INSTROCKWELL

RMB3       topexpr                         INSTROCKWELL

RMB4       topexpr                         INSTROCKWELL

RMB5       topexpr                         INSTROCKWELL

RMB6       topexpr                         INSTROCKWELL

RMB7       topexpr                         INSTROCKWELL

ROL        ACCUM
ROL        topexpr ',' INDEX               DIRECT INDEXX
ROL        topexpr ',' INDEX               EXTENDED INDEXX
ROL        topexpr                         DIRECT
ROL        topexpr                         EXTENDED

ROR        ACCUM
ROR        topexpr ',' INDEX               DIRECT INDEXX
ROR        topexpr ',' INDEX               EXTENDED INDEXX
ROR        topexpr                         DIRECT
```

```
Opcode     Syntax                      Selection Criteria

ROR        topexpr                     EXTENDED

RTI

RTS

SBC        '#' topexpr
SBC        '(' topexpr ')' ',' INDEX   DIRECT INDEXY
SBC        '(' topexpr ')'             DIRECT INSTCMOS
SBC        '(' topexpr ',' INDEX ')'   DIRECT INDEXX
SBC        topexpr ',' INDEX           DIRECT INDEXX
SBC        topexpr ',' INDEX           EXTENDED INDEXX
SBC        topexpr ',' INDEX           INDEXY
SBC        topexpr                     DIRECT
SBC        topexpr                     EXTENDED

SEC

SED

SEI

SMB0       topexpr                     INSTROCKWELL

SMB1       topexpr                     INSTROCKWELL

SMB2       topexpr                     INSTROCKWELL

SMB3       topexpr                     INSTROCKWELL

SMB4       topexpr                     INSTROCKWELL

SMB5       topexpr                     INSTROCKWELL

SMB6       topexpr                     INSTROCKWELL

SMB7       topexpr                     INSTROCKWELL

STA        '(' topexpr ')' ',' INDEX   DIRECT INDEXY
STA        '(' topexpr ')'             DIRECT INSTCMOS
STA        '(' topexpr ',' INDEX ')'   DIRECT INDEXX
STA        topexpr ',' INDEX           DIRECT INDEXX
STA        topexpr ',' INDEX           EXTENDED INDEXX
STA        topexpr ',' INDEX           INDEXY
STA        topexpr                     DIRECT
STA        topexpr                     EXTENDED

STX        topexpr ',' INDEX           DIRECT INDEXY
STX        topexpr                     DIRECT
```

```
Opcode     Syntax                      Selection Criteria

STX        topexpr                     EXTENDED

STY        topexpr ',' INDEX           DIRECT INDEXX
STY        topexpr                     DIRECT
STY        topexpr                     EXTENDED

STZ        topexpr ',' INDEX           DIRECT INDEXX INSTCMOS
STZ        topexpr ',' INDEX           EXTENDED INDEXX INSTCMOS
STZ        topexpr                     DIRECT INSTCMOS
STZ        topexpr                     EXTENDED INSTCMOS

TAX

TAY

TRB        topexpr                     DIRECT INSTCMOS
TRB        topexpr                     EXTENDED INSTCMOS

TSB        topexpr                     DIRECT INSTCMOS
TSB        topexpr                     EXTENDED INSTCMOS

TSX

TXA

TXS

TYA
```

A.2.2 *Operands*

ACCUM   The a or (A) reserved symbol

INDEX   The x or y (or X or Y) reserved
                      symbols

A.2.3 *Selection_Criteria_Keywords*

DIRECT   The instruction can use the direct
                      addressing mode. The expression
                      must have a value between 0 and 255
                      that is defined when the
                      instruction is processed in the
                      input pass.

EXTENDED   The instruction can use the
                      extended (16 bit address) mode.

```
INDEXX              The instruction can use the X
                    index.

INDEXY              The instruction can use the Y
                    index.

INSTCMOS            The instruction is in the CMOS and
                    ROCKWELL CMOS instruction sets.

INSTROCKWELL        The instruction is in the ROCKWELL,
                    ROCKWELL CMOS, and R65c00/21
                    instruction sets.

INST21              The instruction is in the R65c00/21
                    instruction set.
```

A.2.4 **Apostrophes** The apostrophes in the syntax field are a notation used for the parser generator and are not put in the assembler source statement.

A.3 **Notes**

A.3.1 **Top_Expressions** The syntax of some of the instructions combined with the standard expression syntax resulted in confusion whether an operand was an expression surrounded by parenthesis, or a indexed reference. To get around this, the expressions in these ambiguous cases were restricted to those forms of expression that don't have surrounding parenthesis at the top level. Subexpressions may be parenthesized, but only if an operator seperates or precedes the subexpression.

```
    Example

    lda 47h,y        ; load absolute, y
    lda +(47h),y     ; load absolute, y
    lda (47h),y      ; load (indirect), y
    lda ((47h)),y    ; error
```

A.3.2 **Reserved_Symbols**

A.3.2.1 **Machine_Dependent_Reserved_Symbols** A X Y a x y

A.3.2.2 **Standard_Reserved_Symbols** AND DEFINED EQ GE GT HIGH LE LOW LT MOD NE NOT OR SHL SHR XOR and defined eq ge gt high le low lt mod ne not or shl shr xor

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