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# **HP 10391B Inverse Assembler Development Package Reference Manual**

**for the HP 16500A Logic Analysis System,  
and the HP 1650A/B and HP 1651A/B Logic Analyzers**



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# General Information

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## Introduction

The HP 10391B Inverse Assembler Development Package allows you to design a custom inverse assembler for the HP 1650A/B, HP 1651A/B, HP 16510A/B, or HP 16511B Logic Analyzers. The inverse assembler runs in the logic analyzer, and converts the "ones and zeros" captured by the analyzer into mnemonics you're familiar with.

The inverse assembler routines are written on an HP Vectra, IBM-PC, or PC compatible using Hewlett-Packard's Inverse Assembly Language. This code is assembled on the PC, then downloaded over RS-232C to the disk in the logic analyzer. The inverse assembler file can then be loaded into a state analyzer to disassemble captured data.

To be successful with this software package, you should be familiar with general programming concepts and simple microprocessor operation. In addition, a basic understanding of state analysis with Hewlett-Packard logic analyzers is assumed in this manual.

This manual is organized as follows:

- Chapter 1 lists the equipment required by this software package, and describes how to install the software on the PC. This chapter also gives a step-by-step guide to using the programs provided in this package. This chapter should be read by all users.
- Chapters 2 and 3 are a tutorial on writing an inverse assembler. These chapters can be skipped if you've used Hewlett-Packard's Inverse Assembly Language (IAL) on the HP 64000 Development System.
- Chapter 4 is the language reference for the Inverse Assembler Language (IAL).
- The appendices hold listings of sample source code, and a tutorial for advanced topics.

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## Equipment Required

The following equipment is needed to use the HP Inverse Assembler Development Package:

1. HP Vectra, IBM-PC, or PC compatible with a minimum of 256 Kbytes of memory and MS-DOS® 2.1 or above.
2. One flexible disk drive with an internal hard disk (recommended configuration) for the PC, or two flexible disk drives.
3. RS-232C port configured as COM 1 or 2 on the PC.  
Recommended card:
  - HP 24540A Serial/Parallel Card, or
  - HP 24541A Dual Serial Card.
4. RS-232C printer cable. Recommended cable:
  - For 25-pin ports: HP p/n 13242-60010 or equivalent.
  - For 9-pin ports: HP 24542G or equivalent.
5. HP 1650A/B or HP 1651A/B Logic Analyzer, or HP 16500A Logic Analysis System with an HP 16510A/B or HP 16511B State/Timing Card installed.

The Inverse Assembler Development Package will require approximately 220 Kbytes of disk space.

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## Installing the Software

The Inverse Assembler Development Package includes one 5.25 inch flexible disk which contains all of the software for this package. This section describes how to install this software on a hard disk or another flexible disk.

### What's On This Disk

The following files are included in the Inverse Assembler Development Package:

<b>Filename</b>	<b>Description</b>
INSTALL.BAT	Batch file for installing the Inverse Assembler Development Package.
ASM.EXE	Assembler for HP's Inverse Assembly Language.
AIAL	A look-up table used by the IAL assembler.
IALDOWN.EXE	Download program to put the inverse assembler on the logic analyzer disk.
I8085.S	Source code for Intel 8085 inverse assembler.
8085.BAT	Batch file for automating the assembly and download process.
8085.CMD	Input file for use with 8085.BAT
I68010.S	Source code for Motorola 68010 inverse assembler.
68010.BAT	Batch file for automating the assembly and download process.
68010.CMD	Input file for use with 68010.BAT.

## Installing the Software on a Hard Disk

Use the following steps to install the software on a hard disk:

1. Insert the 5.25 inch flexible disk containing the HP 10391B software into Drive A: of the PC.
2. At the DOS prompt, change the current drive to the hard disk. For instance, if your hard disk is Drive C:, type

**C:**

at the DOS prompt.

3. At the DOS prompt, make the subdirectory where you want the Inverse Assembler Development Package installed. For instance, if you want to put the software in the subdirectory \ IAL on the hard disk, type

**MKDIR IAL**

at the DOS prompt. If you are installing the software in the root directory or into a subdirectory that already exists, this step is not needed.

4. Change the current DOS directory to the directory where you want the software installed. For instance, if you want to install the software in subdirectory \ IAL, type

**CD\ IAL**

at the DOS prompt.

5. Type

**A:\ INSTALL**

at the DOS prompt. This will begin the installation process. When the installation is completed, you will see the message

**Installation Complete!**

on the PC screen and you will be returned to a DOS prompt in the root directory of the current drive.

## What the Installation Does

Running the INSTALL.BAT batch file does the following:

1. It copies these files from Drive A: to the current directory on the hard disk:

ASM.EXE  
IALDOWN.EXE

I8085.S  
8085.BAT  
8085.CMD

I68010.S  
68010.BAT  
68010.CMD

2. It creates the subdirectory

**\ HP64700\ TABLES**

on your hard disk.

3. It copies the file

**AIAL**

into the subdirectory \ HP64700\ TABLES on your hard disk. This file is a table used by the ASM.EXE program. It **MUST** be in this subdirectory for the ASM.EXE program to execute properly.

## Installing the Software on a Flexible Disk

Use the following steps to install the software on a flexible disk:

1. Insert the 5.25 inch flexible disk containing the HP 10391B into Drive A: of the PC.
2. Put the destination flexible disk into Drive B:. If the flexible disk in Drive B: is not formatted, format it at this time.
3. At the DOS prompt, change the current drive to Drive B: by typing

**B:**

at the DOS prompt.

4. At the DOS prompt, make the subdirectory where you want the Inverse Assembler Development Package installed. For instance, if you want to put the software in the subdirectory \ IAL on the flexible disk, type

**MKDIR IAL**

at the DOS prompt. If you are installing the software in the root directory or into a subdirectory that already exists, this step is not needed.

5. Change the current DOS directory to the directory where you want the software installed. For instance, if you want to install the software in subdirectory \ IAL, type

**CD\ IAL**

at the DOS prompt.



6. Type

**A:\INSTALL**

at the DOS prompt. This will begin the installation process. When the installation is completed, you will see the message

**Installation Complete!**

on the PC screen and you will be returned to a DOS prompt in the root directory of Drive B:.

## **What the Installation Does**

Running the INSTALL.BAT file does the following:

1. Copies these files from Drive A: to the current directory of the flexible disk in Drive B:

ASM.EXE  
IALDOWN.EXE

I8085.S  
8085.BAT  
8085.CMD

I68010.S  
68010.BAT  
68010.CMD

2. Creates the subdirectory

**\HP64700\ TABLES**

on the flexible disk in Drive B:.

3. Copies the file

**AIAL**

into the subdirectory B:\HP64700\ TABLES. This file contains a table used by the ASM.EXE program. It **MUST** be in this subdirectory for the ASM.EXE program to execute properly.

## **Advanced Installation Topics**

The installation instructions just presented assume you will be executing the ASM.EXE and IALDOWN.EXE files while in the subdirectory where these files are stored. If you want to execute these files while in a different subdirectory, or from a different drive, the following steps will be necessary:

1. Add the PATH statement to your AUTOEXEC.BAT file that points to the subdirectory where the Inverse Assembler Development Package is located. For example, if the software was installed in the subdirectory C:\IAL, you must add the following statement to your AUTOEXEC.BAT file:

**PATH= C:\IAL**

2. Add the SET statement to your AUTOEXEC.BAT file that points to the drive where subdirectory \HP64700 was created by the INSTALL.BAT file. For example, if the subdirectory \HP64700 was created on the C: drive, the following line should be added to your AUTOEXEC.BAT file:

**SET HPTABLES= C:\HP64700\TABLES**

After adding these statements to your AUTOEXEC.BAT file, reboot your PC.

These statements will allow you to execute the ASM.EXE and IALDOWN.EXE programs from any subdirectory in your PC.

---

## Setting Up the Hardware

These steps must be performed to properly set up the hardware for the Inverse Assembler Development Package:

1. Connect the logic analyzer to the COM 1 or 2 port of the PC using the RS-232C cable specified earlier in this chapter.
2. Turn on and boot up the logic analyzer.
3. Check the RS-232C configuration.
  - a. If you are using an HP 1650A or HP 1651A, press the I/O key, and select the "RS-232-C Configuration" field.
  - b. If you are using an HP 1650B or HP 1651B, press the I/O key, and select "Controller connected to RS-232C."
  - c. If you are using an HP 16500A, select the "RS-232C" field in the System Configuration Menu. Change the pop-up to read "RS-232C Connected to: Controller".
  - d. The required RS-232C configuration for all of the logic analyzers is:

Protocol:	XON/XOFF
Data Bits:	8
Stop Bits:	1
Parity:	None
Baud rate:	9600
  - e. Select the "Done" field on the display when the configuration is set up correctly.

4. Set up the logic analyzer disk drive.
  - a. Put a blank, unformatted flexible disk into the front disk drive of the logic analyzer.
  - b. If you are using an HP 1650A/B or HP 1651A/B, press the I/O key, and select the Disk Operations field.
  - c. If you are using an HP 16500A, select the "Configuration" field in the System Configuration Menu. Select the "Front Disk" field to go to the System Front Disk Menu.
  - d. Format the blank disk by changing the "Load" field to "Format Disk," then selecting "Execute."

The hardware is now set up to download an inverse assembler from the PC.

---

## **Building a Custom Inverse Assembler**

As an overview, here are the steps needed to build an inverse assembler for an HP 1650A/B, HP 1651A/B, HP 16510A/B, or HP 16511B logic analyzer:

1. Write the inverse assembly algorithm.

The procedures to disassemble the information captured by the logic analyzer are written using HP's Inverse Assembly Language (IAL). The environment, syntax, and constraints of this language are presented in chapters 2 through 4, and appendices A through C of this manual.

The software received with this product includes the source code for the Intel 8085 and Motorola 68010 inverse assemblers. These files may be helpful when first learning the Inverse Assembly Language. Listings of these files are included in appendices A and C.

This source code can be written with almost any PC text editor. For a discussion of the requirements of the text editor, see "Choosing a Text Editor" in chapter 4.

2. Assemble the source code.

The ASM.EXE program included on the software disk is used to convert the ASCII source code written in step 1 into a relocatable file that the logic analyzer can understand.

For a complete discussion of the assembler syntax and options, see "Assembling the Source Code" later in this chapter.

3. Download the relocatable file to the logic analyzer.

The IALDOWN.EXE program copies the relocatable file generated in step 2 to a file on the flexible disk of the logic analyzer. This transfer goes through the RS-232C port configured as COM 1 or 2 on the PC.

IALDOWN.EXE prompts you for the source and destination filenames, the file description, and for the "Invasm" option required. If desired, this process can be automated using a batch file. For all the details on IALDOWN.EXE, see "Downloading the Relocatable File" later in this chapter.

4. Build the logic analyzer configuration file.

The logic analyzer must now be told how to capture information from the target system. This configuration is entered from the analyzer's front panel and must specify the following:

- a. What channels of the logic analyzer are monitoring the address, data, and status information of the target system.
- b. Which clocks are used to latch data from the target system, and which clock edges are used.

If desired, the configuration file can also set up symbol tables and special trace specifications.

Once the logic analyzer configuration is completed, the inverse assembler can be loaded from the logic analyzer disk to disassemble captured states.

For more detail on this step, see "Building the Configuration File" later in this chapter.

The rest of this chapter discusses the details of steps 2, 3, and 4. Writing the source code for an inverse assembler is the topic of chapters 2 through 4, and the appendices of this manual.

---

## Assembling the Source Code

The source code for an inverse assembler must be converted into a format that the logic analyzer understands. The ASM.EXE program in this software package is an assembler that does this conversion.

To assemble source code, simply type

**ASM < filename>**

at the DOS prompt, where < filename> is the name of the file in which the source code is stored.

For example, to assemble the source code for the 8085 inverse assembler that was included with this software, type

**ASM I8085.S**

at the DOS prompt.

Here is what happens when ASM.EXE is executed:

1. The assembler reads the source code from the file you specified. If it cannot find the file you specified, it will generate the message:

**asm: Termination, Input source file not found.**

2. The assembler then gets a special look-up table from the subdirectory \ HP64700\ TABLES. If the assembler cannot find this file or its subdirectory, it will generate the message:

**asm: Termination, Unimplemented or invalid processor name**

This message indicates that the Inverse Assembler Development package was not installed correctly, or that the line:

**SET HPTABLES= < disk> \ HP64700\ TABLES**

should be added to the PC's AUTOEXEC.BAT file. See the installation section of this chapter for details.

3. The assembler then makes several passes through the source code to convert the source code into a format the logic analyzer can understand. The output of this step is called the relocatable object code, or relocatable code for short.

If the assembler encounters any errors in the source code, it will stop the assembly process and generate an error message on the PC screen. A complete list of the assembler error messages is provided in appendix D.

4. Finally, the assembler writes the relocatable code to a DOS file. The DOS filename is the original filename with ".R" appended to it.

For example, if you typed

**ASM I8085.S**

to assemble the 8085 source code, the relocatable code will be placed in the file I8085.R.

For a complete list of the assembler error messages, see appendix D.



## **Assembler Options**

Options can be specified when calling the assembler to make debugging the source code easier. These options are added to the ASM command when starting the assembly process.

The full syntax of the ASM program is:

```
ASM [-o] [-l] [-n] [-e] [-x] [-t] < file> [> list_file]
```

Items in the square brackets ([..]) are optional parameters for this program.

< file> is the name of the source file to be assembled.

## Option Definitions

ASM recognizes the following options which must be preceded by a dash (-). Options can be concatenated after a single dash (for example, -ox)

- o** Generate a listing of the assembler results. This listing includes the following:
  - a. Source statements with the associated object code,
  - b. Error messages, with a pointer to the error, and
  - c. A summary of errors with a descriptive list.
- l** Same as -o
- n** No listing of assembler results, except for errors (default).
- e** Not implemented for the IAL
- x** Adds a cross-reference to the listing generated by -o or -l. This cross-reference shows all line numbers that have text in the label field, including variable and constant declarations. It also shows which lines reference these labels.
- t** Causes assembly with no object code generation or relocatable file creation.

For example, `ASM -ox I8085.S` would assemble the `I8085.S` file and produce a listing and a cross-reference, as well as the relocatable file `I8085.R`. The cross-reference is appended to the end of the listing and would begin with:

FILE: I8085.S		CROSS REFERENCE TABLE	
LINE	SYMBOL	TYPE	REFERENCES
231	LOD_STO	D	180
40	LO_INPUT_STATUS	P	644,657,672
100	ILLEGAL_OPCODE	D	196,199,387,417,447,492
340	MOVES	D	336
675	LO_WAS_OPCODE	D	672



---

In the cross-reference table, the letter listed under the TYPE column has the following definition:

- A = Absolute
  - C = Common (COMN)
  - D = Data (DATA)
  - E = External
  - M = Multiple Defined
  - P = Program (PROG)
  - R = Predefined Register
  - S = Special
  - U = Undefined
-

The default output location for listings and the cross-references is the PC screen. The listing output can be rerouted to a file using the optional [> list\_file]. For example, the command

```
ASM -ox I8085.S > I8085.L
```

would do the following:

1. Assemble the source code in I8085.S,
2. Create a listing of the assembler results, with a cross-reference,
3. Put the relocatable code in file I8085.R, and
4. Put the listing in file I8085.L.

To dump the listing directly to the PC's printer, use

```
ASM -ox I8085.S > PRN
```

---

## Downloading the Relocatable File

Once the relocatable file has been constructed with the ASM.EXE program, the relocatable file should be downloaded to the disk in the logic analyzer. The download process is handled by the IALDOWN.EXE program.

To start the download, type IALDOWN at the DOS prompt. IALDOWN will do the following:

1. Ask you for the filename to store the relocatable file under on the logic analyzer's disk. You should type in the filename after the prompt, then press < Enter> .
2. Ask you for the file description that will be displayed in the logic analyzer disk menu. You should type in the file description after the prompt, then press < Enter> .
3. Ask you for the name of the relocatable file on the PC. You should type in the name of the relocatable file, including the .R extension, then press < Enter> .
4. Ask you which COM Port (1 or 2) you are using. You should type in 1 or 2, depending on which COM Port you are using to download to the HP 1650A/B, 1651A/B, or HP 16500A.
5. Ask you for the "Invasm" Field Option. Select the letter for the "Invasm" option that is appropriate for your inverse assembler, then press < Enter> .



The "Invasm" field is used for microprocessors with limited status information. For more information on using this field, see appendix B.

---

6. When the last question is answered, the program will read the relocatable file from the PC disk and download it through COM 1 or 2 to the front disk of the logic analyzer. It also downloads the filename and file description information. During the download, the logic analyzer will display:

#### STORING FILE TO DISK

7. When the download is complete, the PC will return you to the DOS prompt.

Here are the steps for downloading the 8085 inverse assembler included with this software package. This example assumes the relocatable file is in the same DOS subdirectory as the IALDOWN.EXE program.

C> IALDOWN

Logic Analyzer Filename = I8085

Logic Analyzer File Description \_\_\_\_\_  
(must be 32 characters or less) = INTEL 8085 INVERSE ASSEMBLER

Relocatable File on the PC = I8085.R

COM Port to use (1 or 2)

"Invasm" Field Options:

- A = No "Invasm" Field
- B = "Invasm" Field with no pop-up
- C = "Invasm" Field with pop-up. 2 choices in pop-up.
- D = "Invasm" Field with pop-up. 8 choices in pop-up.

Select the appropriate letter (A, B, C or D): A

Some notes on this process:

The logic analyzer filename can be no more than 10 characters long. Valid characters for the filename are A-Z, 0-9, and \_ (underscore). The first character of the filename must be an uppercase alpha character.

The logic analyzer file description must be 32 characters or fewer. Notice that there is a line on the PC screen directly above the file description. This line is 32 characters long and can be used as a "ruler" for your file description.

The relocatable filename must include the .R extension.

## Shortcuts When Using IALDOWN

To save time when using IALDOWN, you may enter the answers to the IALDOWN prompts when starting the program. When answering the IALDOWN questions on the DOS command line, the following rules must be followed:

1. Separate each answer by a space,
2. Enclose the file description in quotes ("..").
3. The logic analyzer filename, the length of the file description, and the relocatable filename extension must follow the guidelines shown in the step-by-step example.

For example, typing

```
IALDOWN I8085 'INTEL 8085 INVERSE ASSEMBLER'I8085.R 1 A
```

at the DOS prompt would download the 8085 inverse assembler through COM 1 to the logic analyzer disk just like the previous step-by-step example.

**Batch Files** The ASM and IALDOWN programs can be included in batch files to automate the assembly and download process. The files 8085.BAT and 68010.BAT on the software disk are simple examples of batch files for both the Intel 8085 and the Motorola 68010. The 8085.BAT file contains two lines:

```
ASM I8085.S
IALDOWN < 8085.CMD
```

The first line tells the ASM.EXE program to assemble the file I8085.S. The relocatable code will be placed in file I8085.R.

The second line of the batch file starts the IALDOWN program, with the answers to the program prompts coming from file 8085.CMD. 8085.CMD has the following five lines:

```
I8085
INTEL 8085 INVERSE ASSEMBLER
I8085.R
1
A
```

These are the answers to IALDOWN prompts.

To execute this batch file, type

```
8085
```

at the DOS prompt. The batch file will then assemble the I8085.S source code and download it to the logic analyzer disk, just like the previous step-by-step example.

---

**Note** 

If the answers to IALDOWN are placed in a separate file, as shown in this example, each line of the "answer" file must be terminated with a < CR> < LF> (carriage return, line feed).

---



---

## Building the Configuration File

The logic analyzer's configuration file stores the set-up needed by the instrument to capture the states from the target system. A few rules must be followed when configuring the logic analyzer for an inverse assembler to work properly.

- The inverse assembler can only be used in State analysis.
- The following labels **MUST** be defined in the Format Menu:

<b>Label</b>	<b>Description</b>
ADDR	Label for the logic analyzer channels connected to the target system Address Bus.
DATA	Label for the logic analyzer channels connected to the target system Data Bus.
STAT	Label for the logic analyzer channels connected to the target system Status Lines. These lines should indicate what kind of bus cycle was captured by the logic analyzer.

- For the HP 16511B, the following labels must also be defined in the Format menu:

<b>Label</b>	<b>Description</b>
ADDR_B	Label for the logic analyzer channels connected to the target system auxiliary address bus for the HP 16511B.
DATA_B	Label for the logic analyzer channels connected to the target system auxiliary data bus for the HP 16511B.

The ADDR, DATA, ADDR\_B, DATA\_B, and STAT labels are used with specific communication variables in the Inverse Assembly Language. The relationship between the ADDR, DATA, ADDR\_B, DATA\_B, and STAT labels and the communication variables is shown in the table below:

<b>Label</b>	<b>Is Linked with the Communication Variable</b>
ADDR	INITIAL_ADDRESS and INPUT_ADDRESS
DATA	INITIAL_DATA and INPUT_DATA
STAT	INPUT_STATUS
ADDR_B	INPUT_ADDR_B
DATA_B	INPUT_DATA_B

**Note** 

The ADDR\_B and DATA\_B variables are NOT used in the HP 1650A/B, HP 1651A/B, and HP 16510A/B Logic Analyzers.

Because of the link between the labels and the communication variables, the ADDR, DATA, and STAT labels must be defined in the Format menu before the inverse assembler is loaded from the logic analyzer disk.

The following steps may be used as a checklist when building the logic analyzer configuration file:

1. In the logic analyzer Configuration menu, set up one of the analyzers to be a State Analyzer.
2. Assign the pods to the State Analyzer that will capture the signals in the target system. Each pod has 16 channels; assign the number of pods necessary to acquire all of the needed signals.
3. In the State Format menu, enter the labels ADDR, DATA, and STAT, and labels ADDR\_B and DATA\_B for the HP 16511B. Assign the appropriate channels to each label.
4. Set up the clock specification to properly capture states from the target system. The signals captured on the clock edge must be set up 10 ns before the clock edge, and must hold typically 0 ns after the clock edge. Refer to the reference manual for your logic analyzer for exact specifications. Verify the timing of the state clock using timing diagrams for the target system.
5. In the logic analyzer Format menu, set the Clock Period field to correspond to how fast you are clocking in data. For more information on the Clock Period field, refer to the reference manual for your logic analyzer.
6. If desired, enter additional labels, define Symbol Tables, or set up a Trace Specification for the logic analyzer.

## **Linking the Inverse Assembler and the Configuration File**

A link can be established between the inverse assembler and the configuration file. With a link established, loading the configuration file from the disk will automatically load the inverse assembler at the same time. Here is how to link the configuration file with the inverse assembler:

1. Set up the logic analyzer to capture states from the target system. This can be done manually by entering the configuration from the front panel, or by loading a configuration file from the disk. The configuration must follow the rules listed on page 1-23.
2. Insert the inverse assembler disk into the disk drive of the logic analyzer. Load the inverse assembler file from this disk into the analyzer you have configured for state analysis.
3. Go to the State Listing.
4. Go to the field under the DATA label that contains "Hex" and select this field. A pop-up menu will appear on the logic analyzer screen.
5. The pop-up will have seven fields. Select the field labeled "Invasm" and the inverse assembler will display mnemonics in place of hex data.
6. Store the configuration file to the inverse assembler disk. This establishes a link between the configuration file and the inverse assembler. When the configuration file is loaded it will automatically load the inverse assembler.

---

## Putting It All Together

This chapter has discussed the steps needed to convert IAL source code to an inverse assembler used with a logic analyzer. This final example will put all the steps together.

In this section, you will actually assemble source code that was provided with the software package and put it on the logic analyzer disk. You will also create the configuration file for this inverse assembler and link the configuration file to inverse assembler. The example used is the inverse assembler for the Motorola 68010 microprocessor.

1. If you have not already done so, install the Inverse Assembler Development Package on your PC.
2. Connect the hardware as described in this chapter. When finished, you should have a blank, formatted disk in the logic analyzer disk drive.
3. Assemble the 68010 source code that was provided with the software package. Type

**ASM I68010.S**

at the DOS prompt. This will generate a relocatable file called I68010.R

4. Download the relocatable code to the logic analyzer. Type

**IALDOWN**

at the DOS prompt. When prompted by the IALDOWN program, answer the questions as follows:

Logic Analyzer Filename = I68010

Logic Analyzer File Description \_\_\_\_\_  
(must be 32 characters or less) = MOTOROLA 68010 INVERSE ASSEMBLER

Relocatable File on the PC = I68010.R

COM Port to use (1 or 2)

"Invasm" Field Options:

A = No "Invasm" Field

B = "Invasm" Field with no pop-up

C = "Invasm" Field with pop-up. 2 choices in pop-up.

D = "Invasm" Field with pop-up. 8 choices in pop-up.

Select the appropriate letter (A, B, C or D): B

This will download the inverse assembler to the logic analyzer disk. When completed, you will be returned to the DOS prompt on the PC.

- Manually set up the logic analyzer Configuration and Format menus as shown below.

State/Timing E Configuration Print Run

Analyzer 1  
Name: 68010  
Type: State

Analyzer 2  
Type: Off

Pod 1  
-----  
Pod 2  
-----  
Pod 3  
-----

Unassigned Pods  
Pod 4  
-----  
Pod 5  
-----

State/Timing E Format 1 Print Run

Clock Period > 60 ns Clock Jt Symbols

Pod E3 Pod E2 Pod E1

TTL TTL TTL

Clock Clock Clock

Label	Pod	15 .. 87 .. 0	15 .. 87 .. 0	15 .. 87 .. 0
ADDR	+	*****.....	*****	*****
DATA	+	.....	.....	*****
STAT	+	.....*****	.....	.....
Off				
Off				
Off				
Off				
Off				

- Go to the Front Disk Drive menu and load the inverse assembler into the State analyzer that you just set up.

7. Go to the State Listing menu and change "Hex" under the DATA label to "Invasm." You should see a screen that looks like this:

State/Timing E		Listing 1	Invasm	Print	Run
Markers Off					
Label>	ADDR	68010 Mnemonic	STAT		
Base>	Hex	hex	Hex		
 <input type="text"/>					

8. Store the configuration to the logic analyzer disk. Use the filename

**C68010**

and the description

**MOTOROLA 68010 CONFIGURATION**



If you want to test this inverse assembler, connect the logic analyzer to a 68000 or 68010 target system using the general purpose probes and grabbers. Connect the signals as follows:

<b>Signal Name</b>	<b>Logic Analyzer Pod:Bit</b>	<b>Signal Name</b>	<b>Logic Analyzer Pod:Bit</b>
A0	Pod 2:Bit 0	D0	Pod 1:Bit 0
A1	Pod 2:Bit 1	D1	Pod 1:Bit 1
A2	Pod 2:Bit 2	D2	Pod 1:Bit 2
A3	Pod 2:Bit 3	D3	Pod 1:Bit 3
A4	Pod 2:Bit 4	D4	Pod 1:Bit 4
A5	Pod 2:Bit 5	D5	Pod 1:Bit 5
A6	Pod 2:Bit 6	D6	Pod 1:Bit 6
A7	Pod 2:Bit 7	D7	Pod 1:Bit 7
A8	Pod 2:Bit 8	D8	Pod 1:Bit 8
A9	Pod 2:Bit 9	D9	Pod 1:Bit 9
A10	Pod 2:Bit 10	D10	Pod 1:Bit 10
A11	Pod 2:Bit 11	D11	Pod 1:Bit 11
A12	Pod 2:Bit 12	D12	Pod 1:Bit 12
A13	Pod 2:Bit 13	D13	Pod 1:Bit 13
A14	Pod 2:Bit 14	D14	Pod 1:Bit 14
A15	Pod 2:Bit 15	D15	Pod 1:Bit 15
A16	Pod 3:Bit 8	R/W	Pod 3:Bit 0
A17	Pod 3:Bit 9	LDS	Pod 3:Bit 1
A18	Pod 3:Bit 10	UDS	Pod 3:Bit 2
A19	Pod 3:Bit 11	VMA	Pod 3:Bit 3
A20	Pod 3:Bit 12	FC0	Pod 3:Bit 4
A21	Pod 3:Bit 13	FC1	Pod 3:Bit 5
A22	Pod 3:Bit 14	FC2	Pod 3:Bit 6
A23	Pod 3:Bit 15	BGACK	Pod 3:Bit 7
GND	Pod 2:Gnd	AS	Pod 1:J Clk
GND	Pod 3:Gnd	GND	Pod 1:Gnd

Press "RUN" on the logic analyzer to capture bus activity. Under the inverse assembler field, you will see the value of the data bus, plus the kind of bus cycle captured by the logic analyzer.

To see the 68010 mnemonics, do the following:

1. Identify a state that you know contains the first state of an opcode fetch.
2. Scroll this state to the top line of the screen.
3. Select the "Invasm" field at the top of the display.

The inverse assembler will display 68010 mnemonics for the entire screen.

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# Inverse Assembler Operation

---

## Introduction

This chapter provides an overview of the inverse assembly process. It explains how the logic analyzer captures data and builds a display, and shows how an inverse assembler fits into this process. It also walks you through the steps needed to properly inverse assemble a microprocessor instruction.

This overview discusses concepts of inverse assembly without going into detail about the actual Inverse Assembly Language syntax. Syntax details are introduced in chapter 3, and a complete language reference is provided in chapter 4.

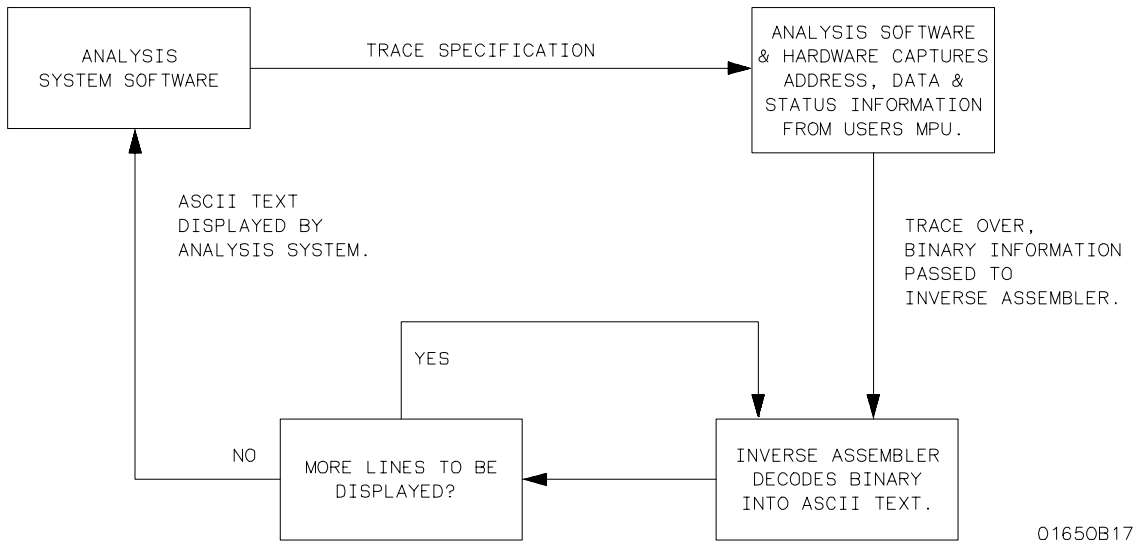
---

## **Inverse Assembler Operation**

The main function of the inverse assembler is to decode data captured by the logic analyzer. This is done as follows:

1. Using the logic analyzer system software, you specify what the logic analyzer should trigger on and what states should be stored. This information is called the "Trace Specification."
2. When the "RUN" key is pressed, the system software loads the acquisition hardware with the trace specification, and starts the acquisition. The trace will continue until the trace specification is satisfied or until you stop the acquisition.
3. Once the acquisition has stopped, the Address, Data, and Status information captured by the logic analyzer hardware is passed to the system software routines that are used to build the logic analyzer display.
4. For each line on the screen, the system software does the following:
  - a. Puts the Address information into the Display buffer.
  - b. Calls the inverse assembler to convert the captured binary Data information into text. Then it places this text into the Display buffer.
  - c. Puts additional labels, including the Status information and the Time count, into the Display buffer.
5. The system software displays the contents of the Display buffer and returns control of the instrument to the front panel.

This process is shown in Figure 2-1.



01650B17

**Figure 2-1. How an Inverse Assembler is Used**

---

## Inverse Assembly Process

To show the inverse assembly process, we will use a very simple program for the 8085 microprocessor, shown in example 1.

### Example 1:

Location	Object Code	Line	Source Line
		1	"8085"
		2	ORG 0100H
0100	32 0601	3	STA 0106H
0103	C3 0001	4	JMP 0100H
0106	00	5	NOP

During execution, the STA instruction on line 3 stores the contents of the accumulator into the memory location at address 106H. In the next instruction, program control jumps back to STA and the process repeats in a never ending loop.

If the bus cycles generated by this program were captured by a logic analyzer, the display shown in Example 2 would be expected:

### Example 2:

Line #	ADDR Hex	DATA Hex	STAT Bin	Time Rel
0000	0100	32	0011	
0001	0101	06	0010	2.00 uS
0002	0102	01	0010	1.52 uS
0003	0106	00	0001	1.48 uS
0004	0103	C3	0011	1.52 uS
0005	0104	00	0010	2.00 uS
0006	0105	01	0010	1.48 uS
0007	0100	32	0011	1.52 uS
0008	0101	06	0010	2.00 uS
0009	0102	01	0010	1.52 uS
0010	0106	00	0001	1.48 uS

etc.

If an 8085 Inverse Assembler was used to interpret the captured information, the following screen would be seen:

**Example 3:**

Line #	ADDR Hex	8085 Mnemonic Hex	STAT Bin	Time Rel
0000	0100	STA 0106	0011	
0001	0101	06 memory read	0010	2.00 uS
0002	0102	01 memory read	0010	1.52 uS
0003	0106	00 memory write	0001	1.48 uS
0004	0103	JMP 0100	0011	1.52 uS
0005	0104	00 memory read	0010	2.00 uS
0006	0105	01 memory read	0010	1.48 uS
0007	0100	STA 0106	0011	1.52 uS
0008	0101	06 memory read	0010	2.00 uS
0009	0102	01 memory read	0010	1.52 uS
0010	0106	00 memory write	0001	1.48 uS

etc.

The "8085 Mnemonic" field in Example 3 replaced the "DATA" field in Example 2.

To build the display in Example 3, the system software formats the screen and displays the "Line # " and "ADDR" information. Then the inverse assembler is called to fill in the "8085 Mnemonic" section. Next, the "STAT" and "Time" information is filled in by the system software. This process is repeated for every line on the display.

For the purposes of discussion, we will just look at the STA instruction found in line 3 of Example 1. The 8085 is an 8-bit microprocessor with a 16-bit addressing range. The STA instruction stores the value of the 8-bit accumulator into the memory location specified in the operand field. This instruction gets broken down into the following object code:

8-bit opcode	16-bit address
XX	XXXX

The analysis hardware would have captured the following information when tracing the execution of this instruction:

State	ADDR
0	Address of opcode
1	Address of low order address byte
2	Address of high order address byte
3	Address of store (states 2+ 3)
4	Address of next instruction

State	DATA	STAT
0	Opcode value	Opcode fetch
1	Low order address byte	Operand memory read
2	High order address byte	Operand memory read
3	Accumulator data	Memory write
4	Next opcode value	Opcode fetch



In our example, the actual data captured by the analysis hardware follows:

State	ADDR	DATA	STAT
0	0100	32	Opcode fetch
1	0101	06	Operand memory read
2	0102	01	Operand memory read
3	0106	00	Memory write
4	0103	C3	Opcode fetch

The first step for the inverse assembler is to check the status of the state being disassembled. If the state is an opcode fetch, the inverse assembler should decode it into the appropriate mnemonic. If the state is not an opcode fetch, it should display the captured data and the type of cycle captured.

In this example, the first state captured is an opcode fetch with 32H on the data bus. The inverse assembler should branch to an area of the code that will determine the mnemonic for this opcode. For the 8085, 32H is the object code for the STA instruction, so the inverse assembler will place the following in the output display buffer:

**STA**

The 8085 STA instruction is a multi-byte instruction. The two bytes following the opcode indicate the 16-bit address where the contents of the accumulator are to be stored in memory. The inverse assembler must be written to look forward to the next two states to properly decode the destination address of the STA instruction.

The first state following the STA instruction is the lower byte of the destination address; the second state is the upper byte. The inverse assembler will read the data in these two states, combine the results into a single 16-bit quantity and display this address after STA in the display buffer. After doing this, the output display buffer will contain:

**STA 0106**

The inverse assembler has now decoded the instruction back into its mnemonic form. Next, it returns to the system software to display the assembly instructions, as follows:

Line #	ADDR Hex	8085 Mnemonic Hex	STAT Bin	Time Rel
0000	0100	STA 0106	0011	

The inverse assembler will then be called for the next three analysis states that have been used to complete the STA instruction. It checks to see if these states are opcode fetches, and since they are not, the inverse assembler will simply display the status of these states. The first two states after the opcode represent the address of the operand. They are labeled as "read" states. The third state is the result of the STA instruction and is labeled as a "write" operation. Note that the address and mnemonic information show the actual data that was written and the location of the write operation.

Line #	ADDR Hex	8085 Mnemonic Hex	STAT Bin	Time Rel
0000	0100	STA 0106	0011	
0001	0101	06 memory read	0010	2.00 uS
0002	0102	01 memory read	0010	1.52 uS
0003	0106	00 memory write	0001	1.48 uS

This completes the task the inverse assembler would normally be expected to perform in displaying the results of the STA instruction execution. The inverse assembler would be called again for the fifth analysis state. In this example, it is the jump (JMP) instruction.

---

## Summary

The following points are the key points of this chapter:

- An inverse assembler is used to convert the data captured by the logic analyzer into text on the logic analyzer display. Often, this text is microprocessor mnemonics.
- The inverse assembler is called once for each state to be displayed on the screen.
- The first thing an inverse assembler should do when called is check the status information for that state. If the status indicates an opcode fetch, the inverse assembler should decode the state into the proper mnemonic. If the state is not an opcode fetch, the inverse assembler should display the captured data and the cycle type.
- When decoding opcode fetches, it may be necessary to look forward in the acquired data to completely decode a multi-byte instruction.

**Inverse Assembler Operation**  
**2-10**

**HP 10391B IAL Development Package**  
**Reference Manual**

## Writing Inverse Assembler Code

---

### Introduction

The previous chapter presented an overview of what an inverse assembler is, and what kind of tasks it needs to perform. This chapter will detail how to implement these tasks with Hewlett-Packard's Inverse Assembly Language (IAL).

Inverse assemblers written with the IAL will execute on HP 1650A/B, HP 1651A/B, HP 16510A/B, and HP 16511B Logic Analyzers. The first part of this chapter describes the environment inside the logic analyzer where an inverse assembler executes. The second half of this chapter will discuss some of the IAL instructions that can be used to perform specific inverse assembly tasks.

A complete description of IAL instructions and syntax is provided in chapter 4.

---

### IAL Environment

Hewlett-Packard's Inverse Assembly Language defines a simple environment where an inverse assembler is executed. The major elements of this environment are:

1. The logic analyzer acquisition memory,
2. The ACCUMULATOR,
3. Pre-defined communication variables which give the ACCUMULATOR access to the acquisition memory,
4. User-defined variables for temporary storage during inverse assembly, and
5. The output display buffer.

The logic analyzer acquisition memory is part of the logic analyzer hardware. All other parts of the IAL environment are part of the system software that build up this virtual machine. A block diagram of the environment is shown in figure 3-1 on page 3-5.

The IAL environment can be thought of as a simple pseudo-processor with a single accumulator. The inverse assembly routine runs on this pseudo-processor. The inverse assembler reads captured information from the acquisition memory, decodes this information into text (such as a microprocessor's mnemonics) and places the text into the output display buffer. As mentioned in the previous chapter, the inverse assembler will be called once for each state to be displayed.

Instructions coded in IAL are executed much like those in assembly language. The instructions are executed one at a time and in sequential order. The GOTO and CALL instructions are used to branch to another area of the inverse assembler. IF and CASE statements can be used for conditional testing.

Similar to simple microprocessor systems, the inverse assembler code is stored in a separate code space. A program counter points to the current instruction being executed by the IAL interpreter. A stack pointer and stack are used in conjunction with subroutine calls. The code space, program counter, stack pointer, and stack cannot be directly accessed by the IAL instructions.

---

## **The Logic Analyzer Acquisition Memory**

The logic analyzer's memory is an array of bits that is up to 80 channels wide (160 channels wide on the HP 16511B) and up to 1024 states deep. The channels are grouped under specific labels in the logic analyzer's Format menu: ADDR, DATA, ADDR\_B, DATA\_B, and STAT. These labels are used to identify to the inverse assembler which channels were used for capturing the Address, Data, and Status information for each state captured.

The information captured by the logic analyzer is treated as Read Only Memory by the inverse assembler.

---

## **The Accumulator**

The heart of the IAL environment is the ACCUMULATOR. The ACCUMULATOR is a single 32-bit register that can be used for the following:

- It can access the logic analyzer acquisition memory through pre-defined communication variables.

- It can read and write variables defined by the user.
- Variables read into the ACCUMULATOR can be written to the output display buffer.
- It can be operated on by arithmetic and logical operations.
- It can be tested using IF and CASE instructions.

Memory-to-memory operations are not supported by the inverse assembly language. To move contents from one variable to another, the contents must first be loaded into the ACCUMULATOR from the source location, then stored to the destination location.

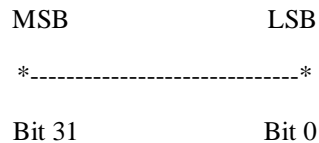
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## IAL Variables

There are two types of variables used in the inverse assembly language:

1. Communication variables provided by the IAL interpreter. Through these variables, the inverse assembler can read the address, data, and status information captured by the logic analyzer. These variables can also be used to tag states that have already been used for inverse assembly, and can also indicate which captured states contain the first byte of an instruction fetch. Table 3-3 at the end of this chapter lists the communication variables.
2. Variables declared by an inverse assembler using the "VAR" pseudo. These can be used for holding temporary values or setting flags for internal use.

All variables and the ACCUMULATOR are treated as 32-bit integers, as shown in the following diagram:



The ADD and SUBTRACT instructions perform two's complement arithmetic on all variables, which means values can be added and subtracted to get a correct positive or negative result. The highest order bit (31) will be 0 for positive and 1 for negative results. This bit can be tested to see if the value is positive or negative.

All compares done with the "IF" instruction are unsigned. Take care when comparing variables. Since negative numbers will have the most significant bit set in two's complement, the "IF" statement will treat negative numbers as greater than positive numbers. For example, -1 (FFFFFFFFH in two's complement) will be treated as larger than 1 (00000001H in two's complement).

---

## **The Output Display Buffer**

The output display buffer is a write-only memory where ASCII text and numbers are written for each state of the inverse assembly display. Each state can print up to four lines with up to 64 characters per line.

---

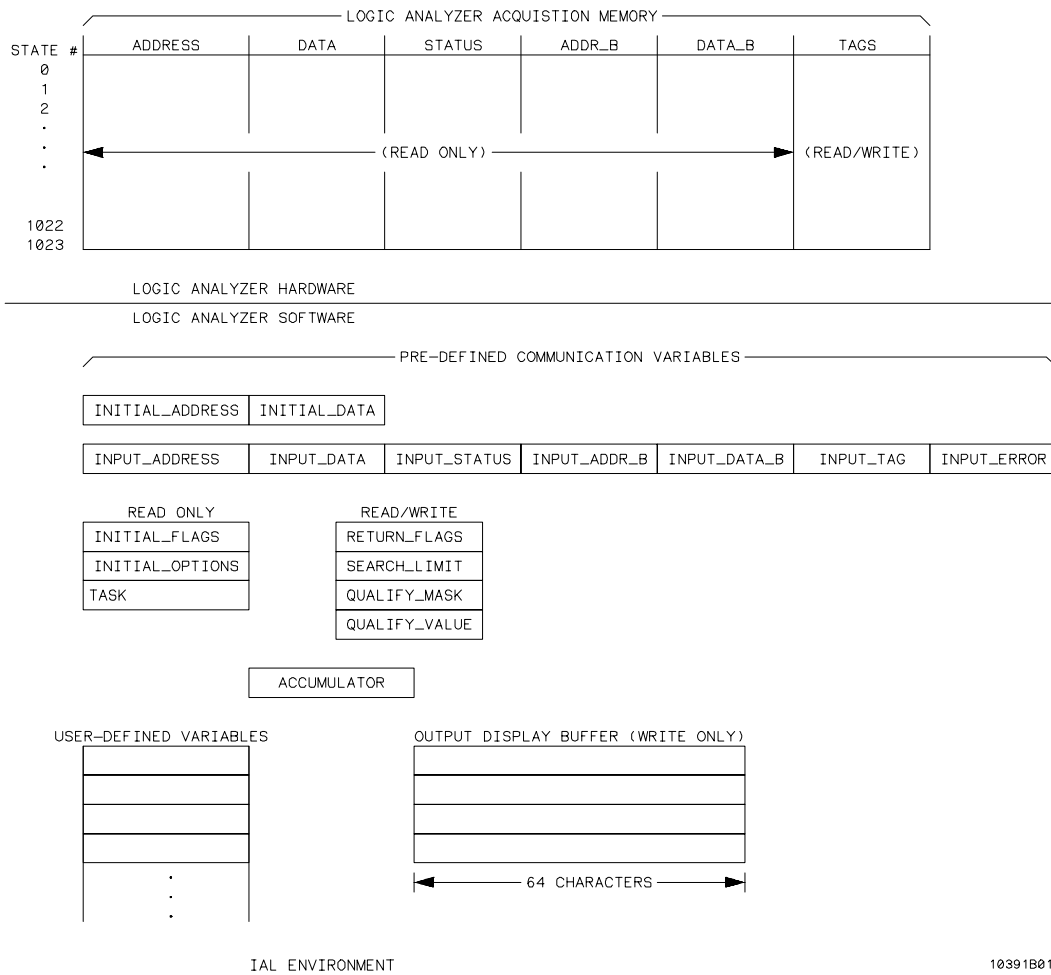
## **Developing an Inverse Assembler**

The development process for an inverse assembler uses the following steps:

1. Write the inverse assembler source code.
2. Assemble the source code into relocatable code.
3. Download the inverse assembler to a logic analyzer disk.
4. Load the inverse assembler into the logic analyzer.
5. Test and verify the inverse assembler's operation.

This section describes how to write the inverse assembler source code (Step 1 above) that can be properly assembled by the assembler. Steps 2 through 5 are discussed in other sections of this manual. The examples given in this chapter are good examples of the IAL syntax. Refer to chapter 4 for a complete definition of the IAL syntax and instructions.





**Figure 3-1. The IAL Environment**

---

## A Simple Inverse Assembler

The source code for a simple, yet complete, inverse assembler is shown below:

```
1 "IAL"  
2  
3     OUTPUT "Inverse assembler not present"  
4     RETURN
```

If this code were assembled, downloaded to a logic analyzer disk, then loaded into the logic analyzer, typical results would look like:

Label	>	ADDR	DATA	STAT	Time
Base	>	Hex	Invasm	Bin	Rel
+ 0000		0396	Inverse assembler not present	0110	
+ 0001		0397	Inverse assembler not present	0110	680 nS
+ 0002		6106	Inverse assembler not present	1100	920 nS
+ 0003		03C5	Inverse assembler not present	0110	7.24 uS
+ 0004		03C6	Inverse assembler not present	0110	680 nS
+ 0005		6008	Inverse assembler not present	1101	920 nS
+ 0006		0396	Inverse assembler not present	0110	496.6 uS
+ 0007		0397	Inverse assembler not present	0110	680 nS
+ 0008		6006	Inverse assembler not present	1100	920 nS
+ 0009		03C5	Inverse assembler not present	0110	7.24 uS
+ 0010		03C6	Inverse assembler not present	0110	640 nS
+ 0011		6008	Inverse assembler not present	1101	920 nS
+ 0012		0396	Inverse assembler not present	0110	524.8 uS
+ 0013		0397	Inverse assembler not present	0110	640 nS
+ 0014		6006	Inverse assembler not present	1100	920 nS
+ 0015		03C5	Inverse assembler not present	0110	7.28 uS

This screen was generated, starting with line number 0000, as follows:

1. The logic analyzer system software displayed the line number of the state and the information captured under the ADDR label.
2. The system software called the inverse assembler. In this case, the instruction in line 3 of the source code puts the "Inverse assembler not present" message in the output display buffer.
3. When the RETURN instruction was executed in line 4, control was passed back to the system software.
4. The system software displayed the information captured under the STAT and Time labels.

Steps 1 through 4 were repeated 16 times until the logic analyzer screen was filled.

This example illustrates some important principles:

1. The inverse assembler will be called once for every state to be displayed on the screen.
2. Executing a RETURN instruction when the inverse assembler is not in a subroutine will end the inverse assembly for the current state, and will return control back to the logic analyzer system software.

Most inverse assemblers are more complex than the previous example. The following sections will discuss how to implement additional inverse assembly tasks. To examine a complete inverse assembler, see appendix A for an Intel 8085 inverse assembler, and appendix C for a Motorola 68010 inverse assembler.

---

## Reading Acquisition Memory

An inverse assembler is used to convert the data captured by the logic analyzer into a display that is meaningful to the user. Usually, microprocessor mnemonics are displayed.

The first step, then, of an inverse assembler is to read the information captured by the logic analyzer. The inverse assembler routines can then decode this information into the appropriate text.

The following section demonstrates how an inverse assembler can read the logic analyzer's acquisition memory. As an illustration, the STA instruction for the Intel 8085 microprocessor will be decoded. An overview of the decoding process for this instruction was presented in chapter 2. If necessary, review chapter 2 at this time.

---

## Decoding the STA Instruction

When the Intel 8085 executes the STA instruction, a logic analyzer captures the following raw data:

Line #	ADDR Hex	DATA Hex	STAT Bin	Time Rel
0000	0100	32	0011	
0001	0101	06	0010	2.00 uS
0002	0102	01	0010	1.52 uS
0003	0106	00	0001	1.48 uS
0004		.		
		.		
		.		

ADDR is the label assigned to the group of logic analyzer channels probing the 8085 address bus, DATA is the label for the channels on the 8085 data bus, and STAT is the label for the logic analyzer channels probing the 8085 status and control lines. STAT will be used by the inverse assembler to determine what kind of 8085 bus cycle was captured by the logic analyzer. These labels were set up in the logic analyzer's Format menu.

Line 0000 of this acquisition contains the object code for the STA instruction. Line 0001 has the lower byte of the STA destination address. Line 0002 has the upper byte of the destination address and line 0003 holds the actual write operation of the STA instruction.

If the logic analyzer were to inverse assemble this captured information, here is what would happen:

As the logic analyzer builds the display, it will print 0000 under the "Line # " column and 0100 under the ADDR label. At this point, the system software calls the inverse assembler.

When an inverse assembler is called, the system software initializes pre-defined variables called "Communication Variables." These variables allow the inverse assembler to read the acquisition memory. The following communication variables get initialized by the system software when an inverse assembler is called:

```
INITIAL_ADDRESS  
INITIAL_DATA  
INPUT_ADDRESS  
INPUT_DATA  
INPUT_ADDR_B  
INPUT_DATA_B  
INPUT_STATUS  
INPUT_ERROR  
INPUT_TAG
```

Refer to table 3-3 on page 3-30 for a description of these communication variables.



INPUT\_ADDR\_B and INPUT\_DATA\_B are only used with the HP 16511B Logic Analyzer.

---

When decoding line 0000, the communication variables will be initialized as follows:

<u>Communication Variable</u>	<u>Initialized to:</u>
INITIAL_ADDRESS	0100H
INITIAL_DATA	32H
INPUT_ADDRESS	0100H
INPUT_DATA	32H
INPUT_STATUS	0011B
INPUT_ERROR	0
INPUT_TAG	0

Using the instruction

#### **LOAD INPUT\_STATUS**

will bring the STAT value for line 0000 (0011B) into the ACCUMULATOR. The inverse assembler can then test the ACCUMULATOR to see if this state is an opcode fetch. In this inverse assembler, 0011B is the status for an opcode fetch. The inverse assembler can now begin decoding the opcode.

The instruction

#### **LOAD INPUT\_DATA**

will bring the DATA value for line 0000 (32H) into the ACCUMULATOR. The inverse assembler can decode this into the STA instruction using a lookup table. When the opcode has been properly identified in the lookup table, the instruction

#### **OUTPUT 'STA'**

will place the string "STA" into the output display buffer.

---

## Decoding the Destination Address of the STA Instruction

As discussed in chapter 2, STA is a multi-byte instruction. The destination address for this instruction is held in the next two memory locations after the STA object code. The 8085 will fetch the object code for the STA instruction, then fetch the contents of the next two memory locations to determine the destination address. To properly inverse assemble the STA instruction, the inverse assembler must duplicate the microprocessor's operation. It will have to look ahead of the current state being inverse assembled to the states that contain the STA instruction's destination address.

The Inverse Assembly Language provides the INPUT command to allow an inverse assembler to read information from any state in the acquisition memory. The INPUT command is used to "point" to the desired state. When that state is located in the acquisition memory, the following communication variables get initialized with the contents of that state:

```
INPUT_ADDRESS
INPUT_DATA
INPUT_ADDR_B
INPUT_DATA_B
INPUT_STATUS
INPUT_ERROR
INPUT_TAG
```

Refer to table 3-3 on page 3-30 for a description of these communication variables.

The INPUT instruction can search in one of two modes, absolute or relative. In the absolute mode, an address is passed to the INPUT instruction. The INPUT instruction then searches forward through the acquisition memory until it finds a state whose ADDR sample matches the address passed to the instruction.

In the relative mode, the number of states is passed to the INPUT instruction. The INPUT instruction then goes forward or backwards through acquisition memory the specified number of states. In both cases, the INPUT search begins at the original state being disassembled. When the desired state is found, the communication variables listed on the previous page are loaded with the values in that state.

Here is how the INPUT instruction is used by the Intel 8085 inverse assembler to decode the destination address of the STA instruction:

1. The destination address of the STA instruction is in the two memory locations following the STA object code. The first step, then, is to store the address of the STA object code in a variable that can be modified later by the inverse assembler.

Since the inverse assembler is currently decoding the state with the STA object code, the following instructions will put the address of the STA object code in a variable for later use:

```
LOAD INPUT_ADDRESS      ;Load the ACCUMULATOR with the
                        ;address of the STA object code

STORE NEW_ADDRESS       ;Store the contents of the
                        ;ACCUMULATOR into the variable
                        ;NEW_ADDRESS
```

In this example, the STA instruction was fetched from address 0100H. These instructions will put the value 0100H into NEW\_ADDRESS.



2. To calculate where the low byte of the destination address is located, add one to the address of the STA object code:

```
INCREMENT NEW_ADDRESS ;Adds one to NEW_ADDRESS
```

NEW\_ADDRESS now holds the value 0101H.

3. The address calculated in step 2 can be used with the INPUT instruction to point to the state that has the low byte of the destination address, as follows:

```
INPUT ABS,NEW_ADDRESS ;Point to the state with the value of  
;NEW_ADDRESS in the ADDR column.
```

When the correct state is found, the INPUT instruction will initialize the following communication variables:

<u>Communication Variable</u>	<u>Initialized to:</u>
INPUT_ADDRESS	0101H
INPUT_DATA	06H
INPUT_STATUS	0010B
INPUT_ERROR	0
INPUT_TAG	0

4. The value of DATA for this state should be saved to calculate the destination address.

```
LOAD INPUT_DATA ;Load the ACCUMULATOR with the low  
;byte of the destination address
```

```
STORE LOW_BYTE ;Store the contents of the  
;ACCUMULATOR into the variable  
;LOW_BYTE
```

For this example, these instructions will put the value 06H into LOW\_BYTE.

- To calculate where the high byte of the destination address is located, add one more to the address of the STA object code:

```
INCREMENT NEW_ADDRESS ;Adds one to NEW_ADDRESS
```

NEW\_ADDRESS now holds the value 0102H.

- The INPUT instruction is used again. This time to point to the state that has the high byte of the destination address:

```
INPUT ABS,NEW_ADDRESS ;Point to the state with the value of
;NEW_ADDRESS in the ADDR column.
```

When this state is found, the communication variables will be initialized as follows:

<u>Communication Variable</u>	<u>Initialized to:</u>
INPUT_ADDRESS	0102H
INPUT_DATA	01H
INPUT_STATUS	0010B
INPUT_ERROR	0
INPUT_TAG	0

- The value of DATA for this state should also be saved for calculating the destination address.

```
LOAD INPUT_DATA ;Load the ACCUMULATOR with the high
;byte of the destination address
```

```
STORE HIGH_BYTE ;Store the contents of the
;ACCUMULATOR into the variable
;HIGH_BYTE
```

These instructions put the value 01H into HIGH\_BYTE.

8. The inverse assembler now has all the information needed to calculate the STA instruction's destination address. After this calculation, the output display buffer should contain:

### STA 0106

This completes the inverse assembly process for line 0000 in this example. The inverse assembler will now return control to the logic analyzer's system software. The system software will print the values under the STAT and Time label, then begin this process all over again for line 0001 on the display.



---

A complete listing of the Intel 8085 inverse assembler is given in appendix A. The basic steps presented above are the steps used by the inverse assembler in decoding the STA instruction.

The inverse assembler adds several routines to check for errors during the inverse assembly process. These routines were omitted here to add clarity.

---

---

## Additional Capabilities of the Input Instruction

The INPUT instruction can also include patterns in the STAT column when searching for a specific state. Two other communication variables are used for this task. The QUALIFY\_VALUE pseudo instruction defines the pattern in the STAT column that must also be present in order for a search to succeed. For example, the QUALIFY\_VALUE could have been set to 0010B in the previous example to help insure that the correct state had been found. In the case of step 3, the INPUT instruction would have searched for a state in the acquisition memory with 0101H in the ADDR column and 0010B in the STAT column.

The QUALIFY\_MASK pseudo instruction further modifies the QUALIFY\_VALUE. This communication variable defines which bits in QUALIFY\_VALUE should be ignored during the INPUT search. The QUALIFY\_MASK operand is considered to be a 32-bit mask where a "0" represents a "don't care" state and a "1" represents a "care" state. For example, if QUALIFY\_MASK were set to 0001B, with a QUALIFY\_VALUE of 0010B, the INPUT instruction would only look for a 0 in the LSB.

QUALIFY\_VALUE and QUALIFY\_MASK are enabled by adding the QUALIFIED option to the INPUT instruction operand.

To speed up the operation of the inverse assembler, the SEARCH\_LIMIT command can be used to specify the number of states that will be searched to find the required data. This limit optimizes the processing by not allowing the entire acquisition memory to be searched for every INPUT instruction. If the QUALIFIED option is selected for the INPUT instruction, the SEARCH\_LIMIT only applies to the number of QUALIFIED states.

---

**Note** 

SEARCH\_LIMIT may not provide an effective limit when the INPUT,QUALIFIED instruction is executed. In this case, SEARCH\_LIMIT counts the number of states where the value of STAT meets the QUALIFIED condition set up using QUALIFY\_VALUE and QUALIFY\_MASK. If the logic analyzer did not capture any states meeting the QUALIFIED condition, the inverse assembler will still search the entire acquisition memory.

---

If an INPUT instruction is terminated because the SEARCH\_LIMIT is encountered, the communication variable INPUT\_ERROR will be set to a non-zero value.

---

## Putting Text into the Output Display Buffer

Each state can write up to four lines into the output display buffer, with up to 64 characters per line. The OUTPUT instruction is used to place text and numbers into the buffer.

The output display buffer does not automatically wrap text to the next line on the display when the end of a line is reached. The inverse assembler must check the position in the display buffer and generate a new line to avoid writing text off the end of a line.

The FETCH\_POSITION instruction allows the inverse assembler to read where the last character was printed in the display buffer, and NEW\_LINE allows the inverse assembler to generate a new line in the display buffer. When NEW\_LINE is executed, the next OUTPUT instruction will begin printing in column one of the new line. No commands are provided to allow the OUTPUT instruction to print to a previous line.

Other instructions associated with an OUTPUT instruction include:

DEFAULT_WIDTH	Defines the width of the output display buffer.
POSITION	Allows the inverse assembler to move to a specific column in the display buffer, or relative to where the last character was written.
FORMAT	Defines the format for displaying the contents of the ACCUMULATOR.

---

## Generating Symbolic Addresses

In the 8085 example, the destination address for the STA instruction was displayed in hexadecimal. Normally, assembly language programs are written with symbolic references to addresses. The programmer uses an assembler and linker to convert these symbolic references to absolute addresses.

An inverse assembly display with absolute addresses may be difficult to interpret if the original assembly language program was written using symbolic references.

The HP 1650A/B, HP 1651A/B, HP 16510A/B, and HP 16511B logic analyzers include symbol tables for converting the raw captured data under a label into text. If the "base" of a label is set to "symbol," the value of a state will be replaced by the symbol defined in the logic analyzer symbol tables. For example, if the ADDR symbol table defines the pattern 0C000H as the text "KBD", then KBD will be displayed in place of 0C000H under the ADDR label. (See the logic analyzer's operating manual for more detail on symbol tables).

The ADDR symbol table can also be used by the inverse assembler when the ADDR base is set to symbol. Using the ADDR symbol table with an inverse assembler will provide a display that resembles the assembly language source code.

The instruction to generate symbolic addresses using the ADDR symbol table is:

**IF\_NOT\_MAPPED THEN < result>**

This instruction will check the ADDR symbol table for a symbol with a value or range that corresponds to the value in the ACCUMULATOR. It would normally be used as follows:

**IF\_NOT\_MAPPED THEN OUTPUT ACCUMULATOR,FORMAT**

When this instruction is executed, the following three cases are possible:

**Case 1:** The value in the ACCUMULATOR matches a pattern in the ADDR symbol table.

In this case, the symbol in the ADDR symbol table will be written to the output display buffer. The OUTPUT ACCUMULATOR, FORMAT portion of this instruction will not be executed.

**Note** 

---

This case applies only to symbols that are defined using "Pattern" in the logic analyzer symbol table.

---

**Example:**

```
JMP PORT_ADDRESS
```

**Case 2:** The value in the ACCUMULATOR falls within a range defined in the ADDR symbol table.

In this case, the symbol associated with the range will be written to the output display buffer. The ACCUMULATOR will be set to the offset from the beginning of the range. The < result> part of the instruction will then be executed to display this offset.

**Note** 

---

This case applies only to symbols that are defined using "Range" in the logic analyzer symbol table.

---

**Example:**

```
JMP SUBROUTINE+ 23H
```

**Case 3:** The value in the ACCUMULATOR does not match a pattern in the ADDR symbol table and does not fall within a range defined in the symbol table. (That is, both Case 1 and Case 2 above are false).

In this case, the value of the ACCUMULATOR will be displayed using the < result> part of the instruction.

**Example:**

JMP 0FFFFH



---

The IF\_NOT\_MAPPED instruction can only access the ADDR symbol table if the base for ADDR is set to symbol.

---

---

## Hints on Parsing an Opcode

The inverse assembler can be written with the CASE\_OF or IF instructions to identify opcodes and status information for your microprocessor. Tables or other methods can also be used for parsing opcodes.

The speed and size of the inverse assembler is dependent on the structure of the inverse assembler code. The inverse assembler instruction set is designed to produce efficient code; however, there are techniques that will increase this efficiency.

First, study the instruction set for the target microprocessor thoroughly before designing the inverse assembler code. This study should reveal the natural breaks in the opcode values. A common approach is to divide the instruction set roughly in half by using the most significant bit as the breakpoint. Other approaches are to parse the opcode based on the number of operands in the instruction or to parse it based on the addressing modes. A microprocessor with multiple accumulators tends to have the same operations performed on each accumulator. This is a convenient way to further parse the opcode. These are some of the possibilities in parsing an opcode. You should study an instruction set and decide on the best approach for your needs.



---

## Using INPUT\_TAG to Mark States

While disassembling a state, it may be useful to mark states pointed to by the INPUT instruction. The mark can be used during subsequent inverse assembler calls to disassemble this state with a special routine.

For example, many microprocessors do not differentiate externally between memory reads that fetch data from memory and memory reads that fetch operands for a multi-byte instruction. The inverse assembler can mark a state as an operand when decoding the multi-byte instruction. When this marked state is called for inverse assembly, the inverse assembler can read the tag and display "operand" instead of "memory read."

To tag states:

Each state of the logic analyzer's acquisition memory has a TAG that can be written to and read by the inverse assembler. The lower 16 bits of the TAG are user-tags and can be directly accessed by the inverse assembler.

The inverse assembler writes to the TAG using the TAG\_WITH instruction. The TAG is read using the INPUT\_TAG communication variable. INPUT\_TAG is read the same way as the other INPUT communication variables discussed previously.

Bits 16 and 17 of the TAG are system tags. These tags are used to inverse assemble microprocessors with incomplete status. For a thorough discussion of the use of bits 16 and 17, see appendix B.

---

## Other Communication Variables

This chapter has discussed the following communication variables:

INPUT_ADDRESS	INITIAL_ADDRESS
INPUT_ADDR_B	INPUT_DATA_B
INPUT_DATA	INITIAL_DATA
INPUT_STATUS	SEARCH_LIMIT
INPUT_ERROR	QUALIFY_VALUE
INPUT_TAG	QUALIFY_MASK

The remaining communication variables in the IAL environment are:

INITIAL_FLAGS	INITIAL_OPTIONS
RETURN_FLAGS	TASK

INITIAL\_FLAGS and INITIAL\_OPTIONS are used when the microprocessor does not provide enough status information to uniquely determine the first byte of an opcode fetch. Their use is detailed in appendix B. The RETURN\_FLAGS and TASK variables are explained in the following sections.

---

## RETURN\_FLAGS

RETURN\_FLAGS indicate the result of the IF\_NOT\_MAPPED instruction. Two bits (Bit 16 and 17) are interpreted as follows:

Bit 16:                   0 = no mapping was done  
                          1 = mapping was successful

\*Bit 17:                   0 = mapped to a range  
                          1 = mapped to a pattern

\*Bit 17 is valid only if Bit 16 = 1

Bit 0 of RETURN\_FLAGS is also used to inverse assemble microprocessors with incomplete status. See appendix B for a complete description of using Bit 0.

---

## TASK

All of HP's current logic analyzers and emulators can inverse assemble captured data. To avoid re-writing an inverse assembler for each different instrument, Hewlett-Packard has defined an Inverse Assembly Language that is compatible among all of the following instruments at the source code level:

- HP 64XXX Emulation
- HP 64620 State Analysis
- HP 1630A/D/G Logic Analyzer
- HP 1631A/D Logic Analyzer
- HP 1650A/B and HP 1651A/B Logic Analyzer
- HP 16510A/B and HP 16511B Logic Analyzer

Inverse assembler source code written to work on one of the machines listed above can be used in another machine, often with only minor changes.

The TASK communication variable is used to identify what kind of machine the inverse assembler is operating in. By using the TASK variable to identify which machine is being used, it may be possible to write a single inverse assembler that works properly in all of the above machines.

TASK will have the following values, depending on which HP instrument the inverse assembler is running in:

<b>Value</b>	<b>Environment</b>
0	Emulation--display memory mnemonic
1	Emulation--display trace mnemonic
2	Emulation--display trace status mnemonic
3	HP 64620 State Analysis
4	HP 1630A/D and HP 1631A/D Logic Analyzers
5	HP 1630G, HP 1650A/B, HP 1651A/B, HP 16510A/B and HP 16511B Logic Analyzers

For the HP 10391B IAL Development Package, TASK will always be 5 or greater.

**Table 3-1. Inverse Assembler Executable Instruction Set****Arithmetic/Logical Instructions**

<b>Instruction</b>	<b>Operand</b>	<b>Destination</b>	<b>Description</b>
ADD	Memory/immediate	Accumulator	Accumulator + operand
SUBTRACT	Memory/immediate	Accumulator	Accumulator - operand
DECREMENT	Memory	Memory	Memory - 1
INCREMENT	Memory	Memory	Memory + 1
AND	Memory/immediate	Accumulator	Accumulator AND operand
EXCLUSIVE_OR	Memory/immediate	Accumulator	Accumulator XOR operand
INCLUSIVE_OR	Memory/immediate	Accumulator	Accumulator OR operand

**ACCUMULATOR Instructions**

<b>Instruction</b>	<b>Operand</b>	<b>Description</b>
LOAD	Memory/immediate	Copy Memory/immediate to Accumulator.
STORE	Memory	Copy Accumulator to Memory.
EXTRACT_BIT	Immediate	Extract Bit # (0= LSB, 31= MSB) and put in Accumulator.
ROTATE RIGHT/LEFT,	Immediate	Rotate Accumulator.
COMPLEMENT		Ones complement Accumulator.
TWOS_COMPLEMENT		Twos complement Accumulator.

**Memory Instructions**

<b>Instruction</b>	<b>Operand</b>	<b>Destination</b>	<b>Description</b>
SET	Memory,immediate	Memory	Memory = Immediate (-8 to + 7)

**Table 3-1. Inverse Assembler Executable Instruction Set (continued)**

**Conditional Instructions**

<b>Instruction</b>	<b>Operand</b>	<b>Description</b>
CASE_OF	Memory	Branch to one of the following statements, depending on the value of Memory.
CASE_OF	MSB,LSB	Branch to one of the following statements, depending on the value of the bit range in the Accumulator.
CASE_END		End of CASE statement.

<b>Instruction</b>	<b>Description</b>
IF Memory rel Memory THEN result	Test Memory vs. Memory.
IF Memory rel Immediate THEN result	Test Memory vs. Immediate value.
IF MSB,LSB rel Memory THEN result	Test the value of the bit range in the Accumulator vs. Memory.
IF MSB,LSB rel Immediate THEN result	Test the value of the bit range in the Accumulator vs. Immediate.

Where "rel" is

- = equal
- < > not equal
- < = less than or equal
- > = greater than or equal
- < less than
- > greater than

**Table 3-1. Inverse Assembler Executable Instruction Set (continued)****Program Control Instructions**

<b>Instruction</b>	<b>Operand</b>	<b>Description</b>
CALL	Label	Branch to Label, stack return address.
GOTO	Label	Branch to Label.
RETURN		Return from CALL, or leave inverse assembler.
ABORT		Leave inverse assembler.

**Output Display Buffer Instructions**

<b>Instruction</b>	<b>Operand</b>	<b>Description</b>
OUTPUT	String constant	Write string constant to output display buffer.
OUTPUT	string	Write string to output display buffer.
OUTPUT	ACCUMULATOR,FORMAT	Write value of Accumulator to output display buffer, using the defined FORMAT.
POSITION	ABS/REL,immediate	Move in the output display buffer to an absolute column number or a column relative to the current position.
DEFAULT_WIDTH	immediate	Defines the maximum width of the Output Display Buffer

**Table 3-1. Inverse Assembler Executable Instruction Set (continued)**

**Output Display Buffer Instructions (continued)**

<b>Instruction</b>	<b>Description</b>
FETCH_POSITION	Load Accumulator with the column number where the last character was printed.
NEW_LINE	Generate a new line in the output display buffer for the current state.
IF_NOT_MAPPED THEN result	OUTPUT the symbol in the ADDR symbol for the contents of the Accumulator. If no symbol is present, execute the result instruction.

**Miscellaneous Instructions**

<b>Instruction</b>	<b>Operand</b>	<b>Description</b>
INPUT REL/ABS,	Memory/Immediate [,QUALIFIED]	Point to the desired state in the acquisition memory and initialize communication variables.
TAG_WITH	Memory/Immediate	Tag the state in acquisition memory for future reference.
NOP		No action.

**Table 3-2. Pseudo Instructions****Symbolic Operand Definition**

<b>Label</b>	<b>Instruction</b>	<b>Operand</b>	<b>Description</b>
LABEL	ASCII/ASC	string	Defines string for OUTPUT instructions.
LABEL	CONSTANT/CONST	immediate	Defines a constant of the name LABEL and assigns the immediate value to it.
LABEL	VARIABLE/VAR	[immediate]	Declares a variable of the name LABEL and initializes it to the immediate value.
LABEL	FORMAT a,b,c[,DISPLAY_BASE]		Defines a format for the OUTPUT instruction.

**Note** 

Labels appearing on lines without instructions are assumed to be code labels for use with the GOTO and CALL instructions. Labels for ASCII, CONSTANT, VARIABLE, and FORMAT pseudo instructions must be on the same line as the rest of the pseudo to be accepted as the label for that pseudo.

**Inverse Assembler Titles**

<b>Instruction</b>	<b>Operand</b>	<b>Description</b>
LABEL_TITLE	string	Replaces the label DATA with a string.
BASE_TITLE	string	Replaces the base title Hex with a string.



**Table 3-2. Pseudo Instructions (continued)**

**Pseudo instructions used with the INPUT instruction**

<b>Instruction</b>	<b>Operand</b>	<b>Description</b>
QUALIFY_VALUE	immediate	Defines the value in INPUT_STATUS to search for.
QUALIFY_MASK	immediate	Defines which bits of QUALIFY_VALUE to use or ignore.
SEARCH_LIMIT	immediate	Defines the maximum number of states searched by the INPUT instruction. When the SEARCH_LIMIT is reached, the INPUT instruction stops with INPUT_ERROR initialized to a non-zero value.

**Debugging Aides**

<b>Instruction</b>	<b>Operand</b>	<b>Description</b>
MAX_INSTRUCTION	Immediate	Limits number of instructions executed.

**Table 3-3. Communication Variables**

<b>Variable</b>	<b>Description</b>
INITIAL_ADDRESS	Contains the value of acquisition memory for the ADDR label when the logic analyzer system software calls the inverse assembler to decode a state.
INITIAL_DATA	Contains the value of acquisition memory for the DATA label when the logic analyzer system software calls the inverse assembler to decode a state.
INPUT_ADDRESS	Contains the value of acquisition memory for the ADDR label for a specific state. INPUT_ADDRESS is initialized in two cases: <ol style="list-style-type: none"><li>1. When the logic analyzer system software calls the inverse assembler to decode a state, or</li><li>2. When the INPUT instruction is executed. In this case, INPUT_ADDRESS contains the value in the ADDR label for the state pointed to by the INPUT instruction.</li></ol>
INPUT_DATA	Contains the value of acquisition memory for the DATA label for a specific state. INPUT_DATA is initialized in the same cases as INPUT_ADDRESS.
INPUT_STATUS	Contains the value of acquisition memory for the STAT label for a specific state. INPUT_STATUS is initialized in the same cases as INPUT_ADDRESS.
INPUT_ADDR_B	Contains the value of acquisition memory for the ADDR_B label for a specific state. INPUT_ADDR_B is initialized in the same cases as INPUT_ADDRESS.
INPUT_DATA_B	Contains the value of acquisition memory for the DATA_B label for a specific state. INPUT_DATA_B is initialized in the same cases as INPUT_ADDRESS.
INPUT_TAG	Contains the value of the tag for this state. Tags can be written by the inverse assembler to mark a state for future reference. They are also used when decoding a microprocessor that generates insufficient status (See appendix B).

**Table 3-3. Communication Variables (continued)**

<b>Variable</b>	<b>Description</b>
INPUT_ERROR	Set to zero if the communication variables were successfully initialized. Set to non-zero if the initialization failed.
QUALIFY_VALUE	Defines the pattern in the STAT label that must be present during an INPUT REL/ABS,QUALIFIED instruction.
QUALIFY_MASK	Defines which bits of QUALIFY_VALUE are used in a qualified INPUT search.
SEARCH_LIMIT	Limits the number of states searched by the INPUT instruction.
RETURN_FLAGS	Indicate the results of an IF_NOT_MAPPED instruction. Also used when disassembling microprocessors with incomplete status.
INITIAL_FLAGS	Used when disassembling microprocessors with incomplete status.
INITIAL_OPTIONS	Used when disassembling microprocessors with incomplete status.
TASK	Identifies which HP machine the inverse assembler is executing in.

**Writing Inverse Assembler Code**  
**3-32**

**HP 10391B IAL Development Package**  
**Reference Manual**

# Inverse Assembler Instruction Set

---

## Introduction

This final chapter defines the syntax, explains the function of each executable and pseudo instruction, and illustrates how the instructions are used with one or more examples. For quick reference, the instructions are arranged alphabetically.

---

## Choosing a Text Editor

The inverse assembler source code can be written using any text editor on your PC that can output the file in printable U.S. ASCII characters. Source code that contains non-printable, U.S. ASCII characters may not assemble properly.

Many text editors add non-printable U.S. ASCII characters to files to represent text enhancements, such as underlining or italics. These editors may also include special instructions to allow a file to be stored as a U.S. ASCII file only. These instructions are included to allow a text file to be used by other PC programs.

If the manual for your text editor is unclear about the characters stored in files, the following test may be useful:

1. Write a few paragraphs of text using your text editor. Do not include text enhancements, such as underlining or italics.
2. Store the text to disk. Use the special storage instructions for storing ASCII text, or the editor instructions that allow a file to be used by another PC program.

3. Exit the text editor. At the DOS prompt, type:

**type < filename>**

where < filename> is the name of the file you stored from your text editor.

4. When you select the "Enter" key after typing the above command, DOS will copy your file to the PC screen. If the screen shows characters you did not type into the file, your text editor is storing non-printable ASCII characters and cannot be used with the IAL assembler. If the screen looks exactly like the text you entered in your editor, this file can probably be used with the IAL assembler.

(Non-printable U.S. ASCII characters include special national characters and characters outside the code range of 32 through 127.)

---

## **Entering Inverse Assembler Source Code**

The following syntax rules must be followed to allow IAL source code to be properly assembled by the assembler.

**The First Line** The first line of inverse assembler source code **MUST** be the following:

**'IAL'**

This string **MUST** begin in the first column of the line and should be the only text on that line. "IAL" tells the assembler what kind of source code follows.

**Line Format Rules** Each line is divided into four fields:

1. The Label Field
2. The Operation Field
3. The Operand Field
4. The Comment Field

a. Field sequence cannot be changed. The correct order of field sequence is:

<b>Label</b>	<b>Operation</b>	<b>Operand</b>	<b>Comment</b>
NEW_ADDR	VAR	0	;Defines the variable NEW_ADDR ;and initializes it to 0



It is recommended that each field in the source statement start at a fixed position (column) in the line. Presenting each line in a fixed format improves readability.

- b. One or more spaces **MUST** separate the fields in a line.
- c. A label field, if used, **MUST** begin in column one.
- d. The operation and operand fields **MUST** not begin in column one. Column one is reserved for the start of the label field or for the delimiter of the comment field.

Additional rules and conventions governing the fields in a line are given in the following paragraphs.

### **Length of Lines**

Lines may contain up to 110 characters (including spaces) and are terminated by a carriage return < CR> . A line containing more than 110 characters will be truncated to 110 characters.

Blank lines are ignored by the assembler and can be used to improve the readability of the source code.

**Label Field** The label field is used for the following:

1. To declare variables (VAR).
2. To define constants (CONST) or string constants (ASCII).
3. To define formats (FORMAT) for the OUTPUT instructions.
4. To define the destination of GOTO or CALL instructions.

The label field is required in the ASCII, VAR, CONST, and FORMAT pseudo instructions. It is optional for all other instructions and pseudo instructions. A line with only a label is a valid line.

Every label **MUST** be unique. The instructions, pseudo instructions, and communication variables listed in Tables 3-1, 3-2, and 3-3 are reserved words and cannot be used for label names.

The label field starts in column one of the line and **MUST** be terminated by a space or a colon (:).

A label can consist of the letters A through Z (upper and lower case), the numeric digits 0 through 9, and the underline symbol (\_). The label may contain any number of characters, as long as the first character is a letter.

**Valid Labels:**

ab\_cd  
AB\_CD  
A5rHi

**Invalid Labels:**

ab.cd?  
\$BCDEF  
4UVWXY



If more than 15 characters are entered in the label field, the assembler will print all characters in the output listing; however, it will only use the first 15 characters for label identification. The assembler will recognize:

**STATEMENT\_LABEL1**

and

**STATEMENT\_LABEL2**

as identical labels and will issue a "DUPLICATE SYMBOL" error message. The assembler does check the case of characters in a label. It will treat:

**Name**

and

**name**

as two separate labels.

**Operation Field** The operation field contains an IAL instruction or pseudo instruction. The operation field follows the optional label field and is separated from it by at least one space, a tab, or a colon (:). If there is no label, the instruction may begin in any column position after column one.

An instruction in the operation field **MUST** be all upper-case letters, exactly as listed in the "Language Reference" section of this manual.

An operation field that requires an operand is terminated by one or more spaces or by a tab. If no operand is required, the operation field can also be terminated by a carriage return, or by a semicolon (;). Termination of this type of operation field indicates the start of the comment field.

**Operand Field** The operand field specifies values or variables required by the IAL instruction. The operand field, if present, follows the operation field and **MUST** be separated from it by at least one space or tab. The following table shows the different types of operands that may be expected by an IAL instruction:

<b>Operand</b>	<b>Description</b>
memory	Name of a variable defined using the VAR instruction.
immediate	An immediate numeric value, or the name of a constant defined using the CONST declaration.
string	An ASCII string, enclosed in quotation marks (").
LABEL	The line label to branch to in a CALL or GOTO instruction.
MSB,LSB	A subrange of the ACCUMULATOR used in IF and CASE instructions. MSB specifies the most significant bit of the ACCUMULATOR to be used in the test; LSB specifies the least significant bit.
result	The IAL instruction to be executed if an IF or an IF_NOT_MAPPED instruction tests true.

**Comment Field** The optional comment field may contain any information that you feel is necessary to identify portions of the program. The delimiter for the comment field is the semicolon (;), a tab, or a space following the operand field. A semicolon in any column of the line will start the comment field (except when used in an ASCII string).


In addition, an asterisk (\*) in column one of a line indicates that the entire line is a comment.

**Delimiters** Certain characters are used to indicate the end of fields or labels, and the beginning of others. These characters, referred to as delimiters, should not be used as ordinary characters. For example, a space cannot be used as part of a label name. A list of delimiters is shown in the following table:

<b>Delimiter</b>	<b>Use</b>
Space	Separates fields or operands; ends a label
Tab	Separates fields; ends a label
Semicolon (;)	Indicates the start of a comment field
Asterisk (*)	When used in column one, indicates the start of a comment field.
Colon (:)	Indicates the end of a label field
Apostrophes ('..')	Indicates a character string
Quotation Marks ("..")	Indicates a character string
Carets (^ ..^ )	Indicates a character string

**Numeric Terms** A numeric term may be binary, octal, decimal, or hexadecimal. A binary term **MUST** have the suffix "B" (for example: 101101B). Octal values **MUST** have either an "O" or a "Q" suffix (for example: 26O, 26Q). A hexadecimal term **MUST** have the suffix "H" (for example: 0BBH, 2CDH, 36H). When no suffix is assigned, the decimal value is always assumed.

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**Note**  You must start a hexadecimal term with a decimal digit. The assembler will identify a term that starts with an alphabetic character as a label or an expression.

---

## **String Constants**

String constants are defined by the ASC or ASCII pseudo instruction to be used by the OUTPUT instruction. String constants are enclosed by apostrophes ('..'), quotation marks (".."), or carets (^ ..^ ).

String constants do not have a numerical value and cannot be operated on by IF or CASE statements.

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## **Language Reference**

The following pages list the executable and pseudo instructions for Hewlett-Packard's Inverse Assembler Language. For quick reference, these instructions are arranged alphabetically.

# ABORT

---

## ABORT

## Leave Inverse Assembler

SYNTAX			
Label	Operation	Operand	Comment
	ABORT		

The ABORT instruction will pass control back to the logic analyzer system software even if the program is currently in a subroutine.

### Example:

```
ABORT          ;Return to  
               ;System Software.
```

**ADD****Add to Accumulator**

SYNTAX			
Label	Operation	Operand	Comment
	ADD	memory/immediate	

The contents of the operand field are added to the value in the accumulator. The operand can be either a memory reference or an immediate value. The value of immediate data can range from 0 to 0FFFFFFFFH (32 bit value).

**Example:**

```

ADD          1          ;Increment
                ;accumulator.

ADD          NAME       ;Add variable to
                ;accumulator.

```

# AND

---

## AND

## Logical AND with Accumulator

SYNTAX			
Label	Operation	Operand	Comment
	AND	memory/immediate	

This instruction performs a logical "AND" of the value of the operand and the value in the accumulator. The operand can be either a memory reference or an immediate value. The value of immediate data can range from 0 to 0FFFFFFFH (32 bit value).

### Examples:

```
AND          1          ;AND lower bit.  
AND          MASK      ;AND with MASK  
                ;variable.
```

## Pseudo ASCII/ASC

## Define ASCII String

SYNTAX			
Label	Operation	Operand	Comment
LABEL	ASCII/ASC	string	

The ASCII pseudo instruction is used to define an ASCII string to be used with an OUTPUT instruction. This is recommended for strings that are used more than once to minimize the size of the inverse assembler.

**Examples:**

```
LOAD_STG      ASCII      "LOAD"      ;Define text for
                                     ;OUTPUT instruction.
STORE_STG     ASC        "STORE"
```



## Pseudo BASE\_TITLE

---

### Pseudo BASE\_TITLE

### Define BASE Title

SYNTAX			
Label	Operation	Operand	Comment
	BASE_TITLE	string	

The BASE\_TITLE pseudo instruction is used to place text in the BASE portion of the inverse assembler field. The string defined in BASE\_TITLE will replace the default "Hex."

#### Examples:

```
BASE_TITLE      "Mnemonic"          ;Places the text Mnemonic  
                ;in the base of the  
                ;inverse assembler field.
```

#### Note



The BASE\_TITLE text does not effect the way data is processed by the logic analyzer.

---

**CALL****Transfer Program Control to Label**

SYNTAX			
Label	Operation	Operand	Comment
	CALL	LABEL	

The CALL instruction transfers program control to the label specified. A RETURN instruction will transfer control to the statement following the CALL. The maximum subroutine nest level is 16.

**Example:**

```
CALL          SUBROUTIN          ;Control is
                                     ;transferred to
                                     ;SUBROUTIN.
```

# CASE\_OF

---

## CASE\_OF

## Conditional Testing of Variable or Accumulator

SYNTAX			
Label	Operation	Operand	Comment
	CASE_OF	memory/MSB,LSB	

The CASE\_OF instruction allows conditional testing of either a user variable or the accumulator. Program control will branch to one of the instructions following the case depending on the value of the variable or accumulator. If the operand is a memory reference, then the value of the memory location becomes an index added to the current program counter to fetch the next instruction. Otherwise, the bit range specified is the index.

CASE\_OF rules:

1. The CASE\_OF statement must be followed by a CASE\_END statement.
2. If the value of the operand falls into the range of the CASE, the corresponding instruction will be executed. Otherwise, the statement following CASE\_END will be executed.
3. Any instruction may occur in the CASE except:
  - a. IF,
  - b. IF\_NOT\_MAPPED, or
  - c. another CASE.

4. If a CALL is executed, the return from the subroutine will execute the instruction following the CASE\_END.
5. GOTO and RETURN instructions are unconditional branches out of the CASE.

**Example 1:**

```

CASE_OF      NAME      ;Test memory NAME.
  OUTPUT     "LDA"     ;Execute this if NAME = 0.
  CALL       SUB       ;Execute this if NAME = 1.
CASE_END
< next instruction>   ;Execute next instruction
                       ;if NAME < > 0,1. Execution
                       ;will also take place
                       ;after either statement
                       ;in the body of CASE
                       ;is executed.

```

**Example 2:**

```

CASE_OF      28,27     ;Decode add/subtract group.
  OUTPUT     "addu"    ;Execute if accumulator
                       ;bit 28,27 = 0
  OUTPUT     "subu"    ;Execute if accumulator
                       ;bit 28,27 = 1
  OUTPUT     "adds"    ;Execute if accumulator
                       ;bit 28,27 = 2
  OUTPUT     "subs"    ;Execute if accumulator
                       ;bit 28,27 = 3
CASE_END

```

# COMPLEMENT

---

## COMPLEMENT

## One's Complement on Accumulator

SYNTAX			
Label	Operation	Operand	Comment
	COMPLEMENT		

A one's complement is performed on the contents of the accumulator. Bits that are 1 change to 0 and those that are 0 change to 1.

**Example:**

COMPLEMENT

;One's complement  
;on accumulator.

**CONSTANT/ CONST  
Pseudo**

**Define Constant**

SYNTAX			
Label	Operation	Operand	Comment
NAME	CONST	constant	

This instruction allows commonly used constants to be defined and referenced by the label specified. Normally, immediate constants are handled automatically by the assembler, but the assembler will not optimize the use of constants that are identical. To avoid wasting data space, commonly used constants can be defined and referenced by symbolic names. All constants are 32-bit quantities.

**Example:**

```
ML24          CONST    0FFFFFFH    ;Mask lower 24-bit
                                   ;constant.
```

# DECREMENT

---

## DECREMENT

## Decrement Memory Location

SYNTAX			
Label	Operation	Operand	Comment
	DECREMENT	memory	

This instruction decrements the memory location specified by the operand by one. The operand must be defined using the VARIABLE pseudo instruction.

**Example:**

```
DECREMENT      SAM           ;Decrement the  
                ;variable SAM.
```

---

**Pseudo  
DEFAULT\_WIDTH**

Default width of display field

SYNTAX			
Label	Operation	Operand	Comment
	DEFAULT_WIDTH	immediate	

This instruction defines the maximum DEFAULT\_WIDTH of the display field. Operands can range from 1 to 64. The logic analyzer can display a maximum of 59 characters. When a DEFAULT\_WIDTH larger than 59 is specified, the extra characters can be scrolled onto the screen.

If no default width is specified, the default width is 32.

**Example:**

```
DEFAULT_WIDTH 40 ;The default
;width is 40.
```



# EXCLUSIVE\_OR

---

## EXCLUSIVE\_OR

## Exclusive OR with Accumulator

SYNTAX			
Label	Operation	Operand	Comment
	EXCLUSIVE_OR	memory/immediate	

This instruction performs a logical "EXCLUSIVE OR" of the operand value and the accumulator value. The operand can be either a memory reference or an immediate value. The value of immediate data can range from 0 to 0FFFFFFFH (32-bit value).

### Example:

```
EXCLUSIVE_OR    1                ;Toggle lower bit
EXCLUSIVE_OR    MASK             ;OR variable MASK.
```

---

**EXTRACT\_BIT****Extract from Accumulator**

SYNTAX			
Label	Operation	Operand	Comment
	EXTRACT_BIT	immediate	

The operand for this instruction is a bit number in the accumulator with a range from 0 to 31. This bit will be extracted and the value of the accumulator set to its value (either 0 or 1).

**Example:**

```
EXTRACT_BIT    10                ;Set accumulator  
                                   ;to value of bit  
                                   ;10 in accumulator.
```

# FETCH\_POSITION

---

## FETCH\_POSITION      Determine Current Position in the Output Buffer

SYNTAX			
Label	Operation	Operand	Comment
	FETCH_POSITION		

The FETCH\_POSITION instruction sets the accumulator to the column number of the display output buffer where the next OUTPUT instruction will write characters. The instruction is particularly useful in determining whether or not an output string will fit on the current output line.

**Example:**

```

OUTPUT STRING1                                ;output a string
FETCH_POSITION                                ;determine next column
                                                ;number to write

;
;the accumulator now contains the next column
;number. If the second string to be output is 25
;characters, adding 25-1 to the accumulator will
;give the column number of the last character
;in STRING2
;
ADD 24                                         ;calculate column number of last

;
;Now see if the last column number to be used is
;greater than the maximum line length. If it is,
;issue a NEW_LINE instruction, then output the
;second string.
;
IF 31,0> 64 THEN NEW_LINE                    ;start a new line if > 64

OUTPUT STRING2                                ;output the second string

```

# Pseudo FORMAT

---

## Pseudo FORMAT

## Format Accumulator

SYNTAX			
Label	Operation	Operand	Comment
NAME	FORMAT	a,b,c [,DISPLAY_BASE]	

FORMAT is used to define how the accumulator should be converted when used in conjunction with the OUTPUT instruction. The operands are defined as follows:

<u>Operand</u>	<u>Description</u>
a	Defines how many bits of the accumulator will be converted. It can range from 1 to 32; if a subrange is specified, then the most significant bits will be ANDed with 0.
b	Specifies the base of the conversion. It can be BIN, OCT, DEC, or HEX
c	Specifies the number of characters to be displayed by the OUTPUT instruction. Leading zeros will be supplied if the number is smaller than the converted field. If c= LEFT_JUSTIFIED, a zero suppressed number will be generated, displaying as many digits as necessary.
DISPLAY_BASE	This optional operand can be used to append a B, O, D, or H on the end of the constant converted, depending on the numeric base of the number.

All operands in the accumulator can be displayed as one ASCII character by using the keyword ASCII instead of the number-of-bits operand.

**Examples:**

HEX_FMT	FORMAT	16,HEX,4,DISPLAY_BASE	;Four digit ;hex format.
REG_FMT	FORMAT	3,DEC,LEFT_JUSTIFIED	;Left-justified ;decimal.
ASC_FMT	FORMAT	ASCII	;ASCII format.

# GOTO

---

## GOTO

## Transfer Program Control

SYNTAX			
Label	Operation	Operand	Comment
	GOTO	LABEL	

The GOTO instruction transfers program control to the label specified.

**Example:**

```
GOTO          OPCODE_STATUS    ;Branch to  
                                     ;status routine.
```

SYNTAX			
Label	Operation	Operand	Comment
	IF	memory rel memory/ immediate	THEN result
	or		
	IF	MSB,LSB rel memory/ immediate	THEN result
Where rel is			
	=	equal	
	< >	not equal	
	< =	less or equal	
	> =	greater or equal	
	<	less than	
	>	greater than	



# IF

---

The IF instruction allows operands to be compared and decisions made based on the results of the comparison. The first form of the IF instruction allows memory to be compared to other memory locations or to immediate data. Immediate data can range from 0 to 0FFFFFFFFH (32 bits). The operand to the THEN part can be any instruction except another IF, a CASE, or IF\_NOT\_MAPPED.

The second form of the IF instruction allows a bit range of the accumulator to be tested. Here the first operand specifies the most significant bit (MSB) and the second operand specifies the least significant bit (LSB). This allows all or part of the accumulator to be tested against an immediate value or memory.

### Examples:

```
IF NAME < 101 THEN GOTO LABEL      ;Test value of
                                   ;NAME

IF 6,3 = 1001B THEN CALL SUBROUTIN ;Test accumulator
                                   ;bit range 6-3
                                   ;inclusive.
```

**IF\_NOT\_MAPPED****Check for Symbol in ADDR Symbol Table**

SYNTAX			
Label	Operation	Operand	Comment
	IF_NOT_MAPPED THEN	result	

The IF\_NOT\_MAPPED instruction is used to put symbols from the ADDR symbol table into the inverse assembled listing. A listing that uses the ADDR symbol table may be easier to interpret because the logic analyzer's display will more closely resemble the original microprocessor source code.

The most common usage of the IF\_NOT\_MAPPED instruction is:

**IF\_NOT\_MAPPED THEN OUTPUT ACCUMULATOR,FORMAT**

When the IF\_NOT\_MAPPED instruction is executed, the contents of the ACCUMULATOR are compared to the ADDR symbol table.

Three conditions are possible:

1. If the address in the ACCUMULATOR matches a symbol defined as a pattern, i.e., not included in a range, the symbol associated with the address is displayed. The "result" part of the instruction, in this case the "OUTPUT" instruction, is not executed. This means the value passed corresponds exactly with a particular symbol.

**Example:**

**JMP PORT\_ADDRESS**

## IF\_NOT\_MAPPED

---

2. If the address is not found as a single valued address, but is part of a range, the symbol associated with the range will be displayed. The ACCUMULATOR will be set to the offset from the beginning of the range. The "result" part of the instruction will be executed to display this offset.

**Example:**

**JMP SUBROUTIN+ 023H**

3. If the address in the ACCUMULATOR is not found as a single valued address or as part of a range, i.e., not in the symbol table, no symbolic information will be displayed. Here, the value in the accumulator will contain the absolute address and will be displayed using the "result" part of the function.

**Example:**

**JMP 0FFFFH**

The RETURN\_FLAGS variable has two flags in the upper 16 bits. These flags indicate the result of the IF\_NOT\_MAPPED instruction. They are interpreted as follows:

Bit 16:	0 = no mapping was done 1 = mapping was successful
*Bit 17:	0 = mapped to a range 1 = mapped to a single value symbol

\* Bit 17 is valid only if bit 16 = 1.

**INCLUSIVE\_OR**

**Logical OR with Accumulator**

SYNTAX			
Label	Operation	Operand	Comment
	INCLUSIVE_OR	memory/immediate	

This instruction performs a "logical or" of the operand value and the accumulator value. The operand can be either a memory reference or an immediate value. The value of immediate data can range from 0 to 0FFFFFFFFH (32-bit value).

**Example:**

```
INCLUSIVE_OR 1                ;Set bit 1.
INCLUSIVE_OR MASK            ;OR with MASK.
```

# INCREMENT

---

## INCREMENT

## Increment Memory Location

SYNTAX			
Label	Operation	Operand	Comment
	INCREMENT	memory	

This instruction increments the memory location specified by the operand by one. The operand must be defined by the VARIABLE pseudo.

**Example:**

```
INCREMENT      NAME          ;Increment  
                ;variable NAME.
```

**INPUT**

**Input Data**

SYNTAX			
Label	Operation	Operand	Comment
	INPUT	ABS/REL,memory/immediate [,QUALIFIED]	

The INPUT instruction to allows an inverse assembler to read information from any state in the acquisition memory. This may be necessary in order to completely decode a multibyte instruction, or to display the results of an executed instruction.

The INPUT instruction is used to "point" to the desired state. When that state is located in the acquisition memory, the following communication variables get initialized with the contents of that state:

INPUT_ADDRESS	Contains the value of acquisition memory in the ADDR column of the state being pointed to.
INPUT_DATA	Contains the value of acquisition memory in the DATA column of the state being pointed to.
INPUT_ADDR_B	Contains the value of acquisition memory in the ADDR_B column of the state being pointed to.
INPUT_DATA_B	Contains the value of acquisition memory in the DATA_B column of the state being pointed to.
INPUT_STATUS	Contains the value of acquisition memory in the STAT column of the state being pointed to.
INPUT_ERROR	Set to zero if the specified state was found and the communication variables were successfully initialized. Set to non-zero if the state was not found or if the variable could not be initialized.

# INPUT

---

## INPUT\_TAG

Contains the value of the tag for this state. Tags can be written by the inverse assembler to mark a state for future reference. They are also used when decoding a microprocessor that generates insufficient status (see appendix B).

INPUT can point relative to the current state being processed by the inverse assembler, or the acquisition memory can be searched to find a state containing a specific value in the ADDR column.

If the QUALIFIED option is specified, the INPUT instruction will also look for a specific pattern in the STAT column. This qualifier is set by the values in the QUALIFY\_VALUE and QUALIFY\_MASK pseudo instructions.

### **INPUT REL,operand:**

This option points to a state before or after the current state being processed by the inverse assembler. The operand indicates how far from the current state to point and which direction (before or after the current state). If the operand is a positive number, the INPUT instruction is pointing to a state after the current state. A negative operand points to a state before the current state.



---

INPUT REL, operand does not change the current state.

---

If the inverse assembler is currently decoding line 1 on the logic analyzer display, the statement

**INPUT REL,2**

would cause the inverse assembler to skip over line 2 on the display and point to the acquired data in line 3.

The operand can be either an immediate value or a user-defined variable. To read data after the current line, use a user-defined variable or an immediate value that is positive. To read data before the current line, use an immediate value that is negative.

**INPUT ABS, operand:**

This option will search forward through the acquisition memory to find a state with a specific value in the ADDR column, and will point to the acquired data in the line containing that address.

The operand specifies the absolute address. The operand must be a user-defined variable or a communications variable (see table 3-3 in chapter 3).

The SEARCH\_LIMIT variable limits the number of states to be searched by the INPUT routine. If QUALIFIED is specified, then the search count applies to the number of states that are satisfied by the status qualification check.

**Examples:**

INPUT	ABS,DATA_ADDRESS,QUALIFIED	;Qualified on ;status.
INPUT	ABS,DATA_ADDRESS	;Not qualified.
INPUT	REL,2	;Point two states ;ahead.
INPUT	REL,COUNT	;Relative with ;count.



## Pseudo LABEL\_TITLE

---

### Pseudo LABEL\_TITLE

### Define Inverse Assembler Title

SYNTAX			
Label	Operation	Operand	Comment
	LABEL_TITLE	string	

The LABEL\_TITLE pseudo instruction is used to define the title of the inverse assembler field. The string defined in LABEL\_TITLE will replace the default "DATA."

#### Examples:

```
LABEL_TITLE      ^ 8085 Mnemonic^
```

**LOAD****Load Accumulator**

SYNTAX			
Label	Operation	Operand	Comment
	LOAD	memory/immediate	

This instruction loads the accumulator with the value specified by the operand field. The operand can be either a memory reference or an immediate value. The value of immediate data can range from 0 to 0FFFFFFFFH (32-bit value).

**Examples:**

```
LOAD          1          ;Set accumulator
                ;to 1.

LOAD          SAM       ;Load value of SAM.
```

## MAX\_INSTRUCTION Pseudo

---

### MAX\_INSTRUCTION Pseudo

### Limit Number of Instructions Executed

SYNTAX			
Label	Operation	Operand	Comment
	MAX_INSTRUCTION	immediate	

Since the programmer has the ability to control program flow, it is possible to program an infinite loop that will never return to the calling program. To avoid this problem, a maximum number of instructions variable is used to limit the number of instructions that can be executed each time the inverse assembler is called. This number is initialized to a large number and should never interfere with the inverse assembler. However, this number can be used to set a low limit on the instruction limit to see which calls to the inverse assembler take the most time. This can be used to optimize sections or stop near-infinite loops. The value of MAX\_INSTRUCTION, initialized by this pseudo, cannot be changed during the inverse assembly. If the instruction count exceeds this value, the inverse assembler is aborted. In addition, an instruction overflow message is placed in the output buffer and displayed.

The default value for MAX\_INSTRUCTION is 10000.

**Example:**

```
MAX_INSTRUCTION 50                ;Check for execution
                                   ;of more than 50
                                   ;instructions.

MAX_INSTRUCTION 10000             ;This sets a large
                                   ;limit so only infinite
                                   ;loops will abort the IAL.
```

## NEW\_LINE

---

### NEW\_LINE

### Begin Generating a New Output Line

SYNTAX			
Label	Operation	Operand	Comment
	NEW_LINE		

The NEW\_LINE instruction is used when more than one line of information is to be output by the inverse assembler for a single captured analysis state. Following the execution of the NEW\_LINE instruction, subsequent OUTPUT and POSITION instructions refer to the new line of inverse assembler output. The NEW\_LINE instruction can be used to generate up to four inverse assembler output lines. Exceeding this limit will cause the inverse assembler to abort.

#### Example:

```
OUTPUT "This is line 1"  
NEW_LINE  
OUTPUT "****This is line 2"
```

This series of instructions will produce the output shown below:

```
This is line 1  
****This is line 2
```

---

**NOP****No Operation**

SYNTAX			
Label	Operation	Operand	Comment
	NOP		

The NOP instruction has no effect on the execution of the inverse assembler. The instruction following NOP will be executed next.

**Example:**

```
CASE_OF          0,0
                OUTPUT      "F"
                NOP
CASE_END
```

# OUTPUT

---

## OUTPUT

## Output to Output Buffer

SYNTAX			
Label	Operation	Operand	Comment
	OUTPUT	string/ACCUMULATOR ,FORMAT	

The OUTPUT instruction expects an operand defined by the ASCII pseudo, an immediate string, or the key word ACCUMULATOR followed by a conversion format defined by the FORMAT pseudo. The first two operands will copy ASCII text to the output buffer. The third operand will convert the accumulator using the specified format to a number in the output buffer.

### Example:

```
LOAD_STG    ASCII    "LOAD"
            OUTPUT   LOAD_STG          ;Output LOAD
            ;text.
            OUTPUT   "LOAD"           ;Output immediate
            ;text.
            OUTPUT   ACCUMULATOR,HEX_FMT ;Convert
            ;accumulator
            ;to hex.
```

**POSITION**

**Position Column Pointer**

SYNTAX			
Label	Operation	Operand	Comment
	POSITION	ABS/REL,column number	

The POSITION instruction allows the current column pointer to be moved to an absolute or relative position in the output buffer. The column number can range from 1 to 64 for absolute positioning or -32 to 31 for relative positioning. In the relative mode, negative numbers move the column position to the left of the current location and positive numbers move it to the right.

**Example:**

```

POSITION          ABS,10          ;Move to column
                                ;10.
POSITION          REL,-2         ;Move to the left
                                ;2 columns.
    
```



## QUALIFY\_MASK & QUALIFY\_VALUE Pseudos

### QUALIFY\_MASK & QUALIFY\_VALUE Pseudos

### Set Qualify Specifications

SYNTAX			
Label	Operation	Operand	Comment
	QUALIFY_MASK	immediate	
	or		
	QUALIFY_VALUE	immediate	

QUALIFY\_MASK and QUALIFY\_VALUE are used to set qualify specifications for the INPUT instruction. When INPUT ABS,operand,QUALIFIED or INPUT REL,operand,QUALIFIED is executed, both the address and status must be satisfied before data is returned. The mask operand is considered to be a 32-bit mask where a 0 represents a "don't care" state and a 1 represents a "care" state. The status in the analysis buffer is first masked (ANDed) with the value of QUALIFIED\_MASK to obtain the value of "care" bits. Then this value is compared to QUALIFY\_VALUE to see if the status is satisfied.



QUALIFY\_MASK and QUALIFY\_VALUE are also the names of communication variables and should be treated as communication variables if the mask or the value needs to vary dynamically. Use the pseudo-ops if qualify specifications are constants that do not vary.

## QUALIFY\_MASK & QUALIFY\_VALUE Pseudos

---

### Examples:

```
QUALIFY_MASK      00101B      ;Only care about  
                  ;bits 0 and 2  
  
QUALIFY_VALUE     00001B      ;Value must  
                  ;be 001B.
```

# RETURN

---

## RETURN

Return

SYNTAX			
Label	Operation	Operand	Comment
	RETURN		

The RETURN instruction can be used to return to the instruction following a CALL or to leave the inverse assembler if a RETURN is executed without any subroutine nesting.

**Example:**

```
RETURN                                ;Return to calling routine
                                       ;or leave inverse assembler
                                       ;if not in a subroutine.
```

**ROTATE**

**Rotate Accumulator Contents**

SYNTAX			
Label	Operation	Operand	Comment
	ROTATE	RIGHT,immediate or LEFT,immediate	

This instruction rotates the accumulator contents either right or left the number of bits specified. The operand can range from 1 to 32. Bits that are shifted off the left side (on left shifts) are rotated back on the right side, and vice versa (circular shift).

**Examples:**

```

ROTATE          LEFT,10          ;Shift left 10
                                   ;bits and rotate
                                   ;in on right.

ROTATE          RIGHT,20         ;Shift right 20
                                   ;bits and rotate
                                   ;in on left.
    
```

# SEARCH\_LIMIT Pseudo

## SEARCH\_LIMIT Pseudo

## Limit Analysis Search

SYNTAX	Operation	Operand	Comment
	SEARCH_LIMIT	immediate	

The SEARCH\_LIMIT instruction applies to the INPUT instruction and to reading data from the analysis buffer after a trace. The operand specifies how many analysis states should be searched in order to find the required data. The limit optimizes processing by not allowing the entire buffer to be searched each time.

The search limit should be set to the maximum number of memory or I/O references made between opcode fetches. For example, if the inverse assembler was searching for a memory read state and that state was not captured by the analysis hardware, SEARCH\_LIMIT would be used to limit the number of states scanned. The variables QUALIFY\_MASK and QUALIFY\_VALUE may be used to qualify the search. Every time the condition is satisfied, the search count is incremented. QUALIFY\_MASK and QUALIFY\_VALUE can be changed to search for other conditions and SEARCH\_LIMIT can be defined to reflect the number of states that are expected to be found.

The default for SEARCH\_LIMIT is 16.

### Examples:

```
SEARCH_LIMIT      7                ;Search limited to 7
                                   ;analysis states.
```

---

**SET****Set Memory**

SYNTAX			
Label	Operation	Operand	Comment
	SET	memory,immediate	

The memory location specified is set to the value in the immediate operand. The operand can range from -8 to + 7.

**Example:**

```
SET          NAME,2          ;Set value of  
                                ;NAME to 2.
```

# STORE

---

## STORE

## Store Value in Accumulator

SYNTAX			
Label	Operation	Operand	Comment
	STORE	memory	

This instruction stores the value in the accumulator in the location defined by the operand. The operand label must be defined by the VAR pseudo, or be one of the communication variables (see table 3-3 in chapter 3).

### Example:

```
STORE          NAME          ;Store accumulator value  
                ;in variable NAME.
```

## SUBTRACT

## Subtract from Accumulator

SYNTAX			
Label	Operation	Operand	Comment
	SUBTRACT	memory/immediate	

The value specified by the operand is subtracted from the value in the accumulator. The operand can be either a memory reference or an immediate value. The value of immediate data can range from 0 to 0FFFFFFFH (32-bit value). Negative numbers are expressed in two's complement form.

### Example:

```
SUBTRACT      1           ;Decrement
                ;accumulator.

SUBTRACT      NAME       ;Subtract value of
                ;NAME from
                ;accumulator.
```



# TAG\_WITH

---

## TAG\_WITH

## Tag Analysis States

SYNTAX			
Label	Operation	Operand	Comment
	TAG_WITH	memory/immediate	

The TAG\_WITH instruction provides a convenient method to "mark" a state. This mark can then be used during subsequent inverse assembly calls.

TAG\_WITH is used most often when disassembling a multibyte instruction. When the first state of a multibyte instruction is disassembled, the inverse assembler will look ahead with the INPUT instruction to get all of the bytes of the instruction. The TAG\_WITH instruction can be used to mark the bytes as "already decoded." When this "tagged" line is disassembled later, the inverse assembler can display only the status of the line, instead of attempting to decode it.

The tag operand is the value of the tag to be associated with this "tagged" state. The operand may be an immediate value, or a user-defined variable. The tag has a 16-bit value; the non-tagged value is zero. When the INPUT instruction is executed, the variable INPUT\_TAG will be initialized with the tag value of that state. For more details on using TAG\_WITH, refer to appendix B.

### Example:

```
TAG_WITH      TAG_VALUE      ;Tag current  
              ;analysis state.
```

---

## TWOS\_COMPLEMENT

## Two's Complement on Accumulator

SYNTAX		
Label	Operation	Comment
	TWOS_COMPLEMENT	

A two's complement is performed on the accumulator, changing all 1 bits to 0 and 0 bits to 1, then adding 1 to the result.

**Example:**

TWOS\_COMPLEMENT

;Negate accumulator.

## Pseudo VARIABLE/VAR

---

### Pseudo VARIABLE/VAR

### Initialize and Reserve Memory

SYNTAX			
Label	Operation	Operand	Comment
NAME	VARIABLE	immediate	

The VARIABLE instruction defines a storage location that can be used on arithmetic and conditional statements. It can be initialized to a specific value with the optional operand field.

#### Example:

```
NAME          VARIABLE          0FFH      ;Define variable
                                     ;storage and assign
                                     ;an initial value
                                     ;of 0FFH.
```



## 8085 Inverse Assembler

---

```
^IAL^
*****
*
* INVERSE ASSEMBLER FOR THE 8085 MICROPROCESSOR
*
* This source code can be used with the HP 64620S, HP 1630A/D/G
* HP 1631A/D, HP 1650A, HP 1651A, or HP 16510A logic analyzers.
*
* INPUT_STATUS consists of the following 8085 signals:
*
*      BIT 3      IO/M
*      BIT 2      HLDA
*      BIT 1      S1
*      BIT 0      S0
*
* These signals are clocked in at the end of the bus cycle by the
* OR'd combination of RD, WR and INTA.
*
*****
*
*              INITIALIZE
*
*****
SEARCH_LIMIT    5
DEFAULT_WIDTH   20
MAPPED_WIDTH    20
LABEL_TITLE     ^8085 Mnemonic^
BASE_TITLE      ^  hex^
*
*      Variables used by the inverse assembler
*
```

```

NEW_ADDRESS    VARIABLE    0    ; ADDRESS TO FETCH
LOW_BYTE       VARIABLE
HIGH_BYTE      VARIABLE
LO_INPUT_ERROR VARIABLE
LO_INPUT_STATUS VARIABLE
MAP_FLAG       VARIABLE
ADDRESS        VARIABLE
INPUT_MODE     VARIABLE
OPCODE_TEMP    VARIABLE
*
*           Constants used by the inverse assembler
*
ML16           CONSTANT 0000FFFFH
INPUT_ABS      CONSTANT 0
INPUT_REL      CONSTANT 1
STATUS_MASK    CONSTANT 1011B
OPCODE_STATUS  CONSTANT 0011B
UNKNOWN        ASCII "unknown"
MEM_WRITE      ASCII "memory write"
MEM_READ       ASCII "memory read"
IO_WRITE       ASCII "i/o write"
IO_READ        ASCII "i/o read"
INT_ACK        ASCII "interrupt ack"
HALT           ASCII "halt"
*
*  DISPLAY FORMATS
*
HEX4_FMT       FORMAT 16,HEX,4    16 BITS, IN HEX, DISPLAY 4 DIGITS
HEX2_FMT       FORMAT 8,HEX,2     8 BITS, IN HEX, DISPLAY 2 DIGITS

```

```

*****
*
* Entry Point of Inverse Assembler
*
*****
      SET INPUT_MODE,INPUT_ABS           NORMALLY, ABSOLUTE READ
      SET RETURN_FLAGS,0                INITIALIZE FLAG TO NOT INSTR. LINE
      LOAD INITIAL_ADDRESS               GET ADDRESS TO DISSASSEMBLE
      STORE NEW_ADDRESS
      IF INPUT_ERROR <> 0 THEN GOTO DATA_ERROR      BRANCH IF ERROR
      IF TASK = 3 THEN GOTO ANALYSIS      HP 64620S
      IF TASK = 4 THEN GOTO ANALYSIS      HP 1630A/D & 1631A/D
      IF TASK = 5 THEN GOTO ANALYSIS      HP 1630G, 1650A/B, 1651A/B, 16510A/B, & 16511B

ILLG_TASK
      OUTPUT "Illegal Task Request"
      ABORT

DATA_ERROR
      OUTPUT "Data error"
      ABORT

ILLEGAL_OPCODE
      OUTPUT "Illegal Opcode"
      ABORT

ANALYSIS
      LOAD INPUT_STATUS                 GET STATUS OF WHAT WAS READ
      AND STATUS_MASK                   MASK OUT HLDA
      IF 3,0 = OPCODE_STATUS THEN GOTO OPCODE_DECODE

*
* IF ITS NOT AN OPCODE, JUST SHOW THE DATA, FOLLOWED BY THE STATUS
*
      POSITION REL,2
      LOAD INPUT_DATA
      OUTPUT ACCUMULATOR,HEX2_FMT

```

```

MNE_STATUS
*
* DISPLAY THE STATUS OF THE MNEMONIC
*
*
* NOTE, THE STATUS TABLE BELOW IS CONSTRUCTED WITH THE S2 BIT (HLDA)
* AS A DONT CARE.  ACTUALLY, BECAUSE OF THE STATE CLOCKING
* ARRANGEMENT (INTA or RD or WR), WE WILL NEVER SEE THE CONDITION
* WHERE HLDA IS HIGH.

    POSITION REL,1
    LOAD INPUT_STATUS
    AND STATUS_MASK           MASK OUT HLDA
    CASE_OF 3,0
        OUTPUT UNKNOWN        STATUS = 0000B
        OUTPUT MEM_WRITE      STATUS = 0001B
        OUTPUT MEM_READ        STATUS = 0010B
        OUTPUT UNKNOWN        STATUS = 0011B
        OUTPUT UNKNOWN        STATUS = 0100B
        OUTPUT MEM_WRITE      STATUS = 0101B
        OUTPUT MEM_READ        STATUS = 0110B
        OUTPUT UNKNOWN        STATUS = 0111B
        OUTPUT HALT            STATUS = 1000B
        OUTPUT IO_WRITE        STATUS = 1001B
        OUTPUT IO_READ         STATUS = 1010B
        OUTPUT INT_ACK         STATUS = 1011B
        OUTPUT HALT            STATUS = 1100B
        OUTPUT IO_WRITE        STATUS = 1101B
        OUTPUT IO_READ         STATUS = 1110B
        OUTPUT INT_ACK         STATUS = 1111B
    CASE_END
    RETURN
OPCODE_DECODE
    SET RETURN_FLAGS,1      FLAG AN INSTRUCTION LINE (AS OPPOSED TO DATA)
    LOAD INPUT_DATA
    CASE_OF 7,6
        GOTO GROUP_1         ;B7-B6=0
        GOTO GROUP_2         1
        GOTO GROUP_3         2
        GOTO GROUP_4         3
    CASE_END

```



\*\*\*\*\*

\*  
\* Group 1  
\* MVI r,exp  
\* LXI dr,exp DAD dr  
\* STAX LDAX STA LDA SHLD LHLD  
\* INR DCR INX DCX  
\* RLC RRC RAL RAR CMA STC CMC DAA  
\* NOP RIM SIM  
\*

\*\*\*\*\*

GROUP\_1  
CASE\_OF 2,0  
GOTO SPECIAL\_1 00XX X000  
GOTO DAD\_LXI 00XX X001  
GOTO LOD\_STO 00XX X010  
GOTO INX\_DCX 00XX X011  
GOTO INR 00XX X100  
GOTO DCR 00XX X101  
GOTO MVI 00XX X110  
GOTO LOGICAL\_1 00XX X111  
CASE\_END

\*\*\*\*\*

\*  
\* SPECIAL\_1 - SPECIAL SYMBOLS  
\*

\*\*\*\*\*

SPECIAL\_1  
IF 3,3 = 1 THEN GOTO ILLEGAL\_OPCODE 00XX 1000  
CASE\_OF 5,4  
OUTPUT "NOP" 0000 0000  
GOTO ILLEGAL\_OPCODE 0001 0000  
OUTPUT "RIM" 0010 0000  
OUTPUT "SIM" 0011 0000  
CASE\_END  
RETURN

```

*****
*
* DAD_LXI
*
*****
DAD_LXI
    IF 3,3 = 0 THEN GOTO LXI          00XX 0001
    OUTPUT "DAD "                     00XX 1001
    CALL LONG_REG
    RETURN

LXI
    OUTPUT "LXI "
    CALL LONG_REG
    OUTPUT ", "
    CALL LEXPR_NO_MAP          DONT MAP 16 BIT DATA QUANTITY
    RETURN
*****
*
* LOD_STO
*
*****
LOD_STO
    IF 5,5 = 0 THEN GOTO LDAX_STAX    000X X010
    CASE_OF 4,3
        OUTPUT "SHLD"                0010 0010
        OUTPUT "LHLD"                0010 1010
        OUTPUT "STA "                 0011 0010
        OUTPUT "LDA "                 0011 1010
    CASE_END
    STORE OPCODE_TEMP          SAVE THE OPCODE ACROSS LEXPR
    POSITION REL,1
    CALL LEXPR
    RETURN

```

```
LDAX_STAX
  CASE_OF 3,3
    OUTPUT "STAX"           000X 0010
    OUTPUT "LDAX"          000X 1010
  CASE_END
  POSITION REL,1
  CALL LONG_REG
  RETURN
```

\*\*\*\*\*

\*

\* INX\_DCX

\*

\*\*\*\*\*

```
INX_DCX
  CASE_OF 3,3
    OUTPUT "INX"           00XX 0011
    OUTPUT "DCX"          00XX 1011
  CASE_END
  POSITION REL,2
  CALL LONG_REG
  RETURN
```

\*\*\*\*\*

\*

\* INR

\*

\*\*\*\*\*

```
INR
  OUTPUT "INR  "
  CALL DREG_NAME
  RETURN
```

```

*****
*
* DCR
*
*****

DCR
    OUTPUT "DCR "
    CALL DREG_NAME
    RETURN

*****
*
* MVI
*
*****

MVI
    OUTPUT "MVI "
    CALL DREG_NAME
    OUTPUT ", "
    CALL EXPR
    RETURN

*****
*
* LOGICAL_1
*
*****

LOGICAL_1
    CASE_OF 5,3
        OUTPUT "RLC"           0000 0111
        OUTPUT "RRC"           0000 1111
        OUTPUT "RAL"           0001 0111
        OUTPUT "RAR"           0001 1111
        OUTPUT "DAA"           0010 0111
        OUTPUT "CMA"           0010 1111
        OUTPUT "STC"           0011 0111
        OUTPUT "CMC"           0011 1111
    CASE_END
    POSITION REL,2
    RETURN

```

```

*****
*
* Group 2
*
*****
GROUP_2
    IF 7,0 <> 01110110B THEN GOTO MOVES      BRANCH IF NOT HALT INSTR
        OUTPUT "HLT"
        RETURN

MOVES
    OUTPUT "MOV "
    CALL DREG_NAME
    OUTPUT ", "
    CALL SREG_NAME
    RETURN

*****
*
* Group 3
*
*****
GROUP_3
    CASE_OF 5,3
        OUTPUT "ADD"           1000 0XXX
        OUTPUT "ADC"           1000 1XXX
        OUTPUT "SUB"           1001 0XXX
        OUTPUT "SBB"           1001 1XXX
        OUTPUT "ANA"           1010 0XXX
        OUTPUT "XRA"           1010 1XXX
        OUTPUT "ORA"           1011 0XXX
        OUTPUT "CMP"           1011 1XXX
    CASE_END
    POSITION REL,2

```

```

CALL SREG_NAME
RETURN
*****
*
* Group 4
*
*****
GROUP_4
CASE_OF 2,0
GOTO Rcc                11XX X000
GOTO POP_RET            11XX X001
GOTO Jcc                11XX X010
GOTO JMP_IO             11XX X011
GOTO Ccc                11XX X100
GOTO PUSH_CALL         11XX X101
GOTO Immediate         11XX X110
GOTO RST                11XX X111
CASE_END
GOTO ILLEGAL_OPCODE
*****
*
* Rcc
*
*****
Rcc
OUTPUT "R"
CALL COND_CODES
RETURN
*****
*
* POP_RET Etc.
*
*****

```

```

POP_RET
  IF 3,3 = 1 THEN GOTO RET_PCHL_SPHL      11XX 1001
  OUTPUT "POP "                            11XX 0001
  CALL LONG_REG
  RETURN

```

```

RET_PCHL_SPHL
  CASE_OF 5,4
    OUTPUT "RET "                          1100 1001
    GOTO ILLEGAL_OPCODE                   1101 1001
    OUTPUT "PCHL "                         1110 1001
    OUTPUT "SPHL "                         1111 1001
  CASE_END
  RETURN

```

\*\*\*\*\*

\*

\* Jcc

\*

\*\*\*\*\*

```

Jcc
  OUTPUT "J"
  CALL COND_CODES
  POSITION REL,2
  CALL LEXPR          GET 2 BYTES
  RETURN

```

\*\*\*\*\*

\*

\* JMP\_IO Etc.

\*

\*\*\*\*\*

```

JMP_IO
  CASE_OF 5,3
    GOTO JMP          1100 0011
    GOTO ILLEGAL_OPCODE 1100 1011
    GOTO OUT_IN      1101 0011
    GOTO OUT_IN      1101 1011

```

```

        OUTPUT "XTHL "           1110 0011
        OUTPUT "XCHG "           1110 1011
        OUTPUT "DI  "           1111 0011
        OUTPUT "EI  "           1111 1011
CASE_END
RETURN
JMP    OUTPUT "JMP  "
        CALL LEXPR
        RETURN

OUT_IN
CASE_OF 3,3
        OUTPUT "OUT "           1101 0011
        OUTPUT "IN  "           1101 1011
CASE_END
CALL LEXPR
RETURN

*****
*
* Ccc
*
*****

Ccc
        OUTPUT "C"
        CALL COND_CODES
        POSITION REL,2
        CALL LEXPR
        RETURN

*****
*
* PUSH_CALL
*
*****

PUSH_CALL
        IF 3,3 = 0 THEN GOTO PUSH           11XX 0101

```



```

        IF 5,3 <> 001 THEN GOTO ILLEGAL_OPCODE
        OUTPUT "CALL "          1100 1101
        CALL LEXPR
        RETURN
PUSH   OUTPUT "PUSH "
        CALL LONG_REG
        RETURN

```

\*\*\*\*\*

\*

\* Immediate

\*

\*\*\*\*\*

Immediate

```

        CASE_OF 5,3
        OUTPUT "AD"            1100 0110
        OUTPUT "AC"            1100 1110
        OUTPUT "SU"            1101 0110
        OUTPUT "SB"            1101 1110
        OUTPUT "AN"            1110 0110
        OUTPUT "XR"            1110 1110
        OUTPUT "OR"            1111 0110
        OUTPUT "CP"            1111 1110
        CASE_END
        OUTPUT "I "
        CALL EXPR
        RETURN

```

\*\*\*\*\*

\*

\* RST

\*

\*\*\*\*\*

RST

```

        OUTPUT "RST "
        CASE_OF 5,3
        OUTPUT "0"             1100 0111
        OUTPUT "1"             1100 1111

```

```

        OUTPUT "2"           1101 0111
        OUTPUT "3"           1101 1111
        OUTPUT "4"           1110 0111
        OUTPUT "5"           1110 1111
        OUTPUT "6"           1111 0111
        OUTPUT "7"           1111 1111
CASE_END
RETURN

```

\*\*\*\*\*

\*

\* COND\_CODES - OUTPUT CONDITION CODES

\*

\*\*\*\*\*

COND\_CODES

```

CASE_OF 5,3
        OUTPUT "NZ"         XX00 0XXX
        OUTPUT "Z "         XX00 1XXX
        OUTPUT "NC"         XX01 0XXX
        OUTPUT "C "         XX01 1XXX
        OUTPUT "PO"         XX10 0XXX
        OUTPUT "PE"         XX10 1XXX
        OUTPUT "P "         XX11 0XXX
        OUTPUT "M "         XX11 1XXX
CASE_END
RETURN

```

\*\*\*\*\*

\*

\* DREG\_NAME - OUTPUT DESTINATION REGISTER NAME

\*

\*\*\*\*\*

DREG\_NAME

```

CASE_OF 5,3
        OUTPUT "B"         XX00 0XXX
        OUTPUT "C"         XX00 1XXX
        OUTPUT "D"         XX01 0XXX
        OUTPUT "E"         XX01 1XXX
        OUTPUT "H"         XX10 0XXX

```

```

        OUTPUT "L"           XX10 1XXX
        OUTPUT "M"           XX11 0XXX
        OUTPUT "A"           XX11 1XXX
CASE_END
RETURN

```

\*\*\*\*\*

\*

\* SREG\_NAME - OUTPUT SOURCE REGISTER NAME

\*

\*\*\*\*\*

SREG\_NAME

```

CASE_OF 2,0
  OUTPUT "B"           XXXX X000
  OUTPUT "C"           XXXX X001
  OUTPUT "D"           XXXX X010
  OUTPUT "E"           XXXX X011
  OUTPUT "H"           XXXX X100
  OUTPUT "L"           XXXX X101
  OUTPUT "M"           XXXX X110
  OUTPUT "A"           XXXX X111
CASE_END
RETURN

```

\*\*\*\*\*

\*

\* LONG\_REG OUTPUT LONG REGISTER NAME

\*

\*\*\*\*\*

LONG\_REG

```

CASE_OF 5,4
  OUTPUT "B"           XX00 XXXX
  OUTPUT "D"           XX01 XXXX
  OUTPUT "H"           XX10 XXXX
  OUTPUT "SP"          POSSIBLY OVERWRITTEN BY PSW CONDITION
CASE_END
IF 7,4 <> OFH THEN RETURN      1111 XXXX
POSITION REL,-2
OUTPUT "PSW"
RETURN

```

\*\*\*\*\*

\*

\* LEXPR OUTPUT 16-BIT HEX VALUE IN NEXT TWO BYTES

\*

\*\*\*\*\*

LEXPR

SET MAP\_FLAG,0            PRESET TO DO ADDRESS MAPPING  
GOTO MAP\_SET

LEXPR\_NO\_MAP

SET MAP\_FLAG,1            PRESET FOR NO MAPPING

MAP\_SET

CALL NEXT\_BYTE            GET LOW BYTE OF DATA  
STORE LOW\_BYTE            SAVE THE LOW ORDER BYTE  
LOAD INPUT\_ERROR          GET ERROR FLAG  
STORE LO\_INPUT\_ERROR      SAVE ERROR FLAG IN TEMPORARY  
LOAD INPUT\_STATUS  
AND STATUS\_MASK           MASK OUT HLDA  
STORE LO\_INPUT\_STATUS  
  
CALL NEXT\_BYTE            GET HIGH BYTE OF DATA  
STORE HIGH\_BYTE           SAVE THE HIGH ORDER BYTE  
ROTATE LEFT,8            MOVE HIGH BYTE TO UPPER 8 BITS  
INCLUSIVE\_OR LOW\_BYTE     PUT THE 2 BYTES TOGETHER  
AND ML16                  ONLY LOWER 16 BITS ARE VALID ADDRESS  
STORE ADDRESS             SAVE THE 16 BIT ADDRESS  
  
LOAD INPUT\_STATUS  
AND STATUS\_MASK           MASK OUT HLDA  
IF 3,0 = OPCODE\_STATUS THEN GOTO HI\_WAS\_OPCODE  
IF LO\_INPUT\_STATUS = OPCODE\_STATUS THEN GOTO NOT\_ASSOCIATED  
IF INPUT\_ERROR = 0 THEN GOTO SHOW\_CHECK    BRANCH IF NO DATA READ ERROR

HI\_WAS\_OPCODE

NOT\_ASSOCIATED

OUTPUT "\*\*\*"            NO HIGH BYTE FOUND  
SET MAP\_FLAG,1           SET TO SKIP ADDRESS MAPPING  
GOTO CHECK\_LOW           CHECK FOR THE LOW ORDER BYTE

```

SHOW_CHECK
    IF MAP_FLAG = 0 THEN GOTO CHECK_LOW      BRANCH IF STILL MAPPING
    LOAD HIGH_BYTE                          GET UPPER BYTE
    OUTPUT ACCUMULATOR,HEX2_FMT            DISPLAY THE HIGH BYTE

CHECK_LOW
    IF LO_INPUT_STATUS = OPCODE_STATUS THEN GOTO LO_WAS_OPCODE
    IF LO_INPUT_ERROR = 0 THEN GOTO SHOW_LOW BRIF NO DATA READ ERROR

LO_WAS_OPCODE
    OUTPUT "***"                            NO LOW BYTE FOUND
    RETURN                                  NO MAPPING, WE ARE FINISHED

SHOW_LOW
    IF MAP_FLAG = 0 THEN GOTO MAPPER        BRANCH IF MAPPING ALLOWED
    LOAD LOW_BYTE                          GET THE LOW ORDER BYTE
    OUTPUT ACCUMULATOR,HEX2_FMT          DISPLAY THE LOWER BYTE
    RETURN                                  LEAVE

MAPPER
    LOAD ADDRESS                            GET THE 16 BIT ADDRESS
    IF_NOT_MAPPED THEN OUTPUT ACCUMULATOR,HEX4_FMT
    RETURN

*****
*
*  EXPR  OUTPUT 8-BIT HEX VALUE IN NEXT BYTE
*
*****

EXPR
    CALL NEXT_BYTE                          GET THE BYTE AFTER THE OPCODE
    LOAD INPUT_STATUS                       destroys data in accumulator from NEXT_BYTE
    AND STATUS_MASK                         MASK OUT HLDA
    IF 3,0 <> OPCODE_STATUS THEN GOTO EXPR_HEX2  BRANCH IF DATA FOUND
    OUTPUT "***"                            FLAG THE BYTE AS NOT FOUND
    RETURN

EXPR_HEX2
    LOAD INPUT_DATA                         RELOAD DATA

```

```

        OUTPUT ACCUMULATOR,HEX2_FMT
        RETURN
*****
*
* GET NEXT BYTE FROM ANALYSIS DATA
* INCREMENTS INPUT_ADDRESS, NEW_ADDRESS AND RETURN_COUNT
*
*****
NEXT_BYTE
        INCREMENT NEW_ADDRESS          MOVE AHEAD TO NEXT ADDRESS
GET_BYTE
*
* ENTRY POINT TO READ THE DESIRED BYTE WITHOUT INCREMENTING NEW_ADDRESS
*
        LOAD INPUT_MODE                SEE WHICH INPUT MODE WE'RE IN
        CASE_OF 0,0
            INPUT ABS,NEW_ADDRESS        READ THE DATA
            INPUT REL,NEW_ADDRESS
        CASE_END
        LOAD INPUT_DATA                SET ACCUMULATOR TO DATA READ
        RETURN

```

# Microprocessors with Incomplete Status

---

## Introduction

The Intel 8085 instructions decoded in chapters 2 and 3 were easy to disassemble because of the status information provided by the microprocessor. In the 8085, the value 0011B under the STAT label indicates that this state is the first state of an opcode fetch. Any other kind of bus cycle has a different status.

When disassembling 8085 operations, the inverse assembler goes through the following steps:

1. Load INPUT\_STATUS for the state to be disassembled.
2. If the value of INPUT\_STATUS represents an opcode fetch, go to the routine for decoding opcode fetches.
3. If the value of INPUT\_STATUS indicates any other kind of bus cycle, display only the value in INPUT\_DATA and the cycle type.

Not all microprocessors provide a unique value under the STAT label for the first byte of an opcode fetch. This appendix explains how to deal with this problem.

---

**Note**

This section uses examples based on the Motorola 68010. A complete listing of the 68010 inverse assembler is provided in appendix C.

---

---

## Using INPUT\_TAG to Mark States

The Motorola 68010 microprocessor does not uniquely identify which bus cycle contains the first word of an instruction fetch. For example, the 68010 instruction:

### **JMP 00255A**

would be captured as follows by the logic analyzer:

Label	>	ADDR	DATA	68010 Mnemonic	STAT
Base	>	Hex	Hex	Hex	Symbol
+ 0000		00201E	4EF9	JMP 00255A	SUPR PRGM READ
+ 0001		002020	0000	0000 supr program read	SUPR PRGM READ
+ 0002		002022	255A	255A supr program read	SUPR PRGM READ
+ 0003		00255A		(Next 68010 instruction)	
			.		
			.		
			.		

State 0000 above contains the opcode for the JMP instruction under the DATA label. States 0001 and 0002 contain the destination address of the JMP opcode. Note that all three of these states have the same value under the STAT label. (In this example, the STAT value has been interpreted by the STAT symbol table to make it easier to read. Also, the raw data captured by the logic analyzer is displayed under the data label next to the mnemonic field.)

If the inverse assembler follows the same procedure as the 8085, here is what will happen, beginning with line 0000:

1. Load INPUT\_STATUS for state 0000. Since this value represents a program read, go to the routine that decodes opcode fetches.
2. Decode the 4EF9H in INPUT\_DATA. This will put the ASCII string

### **JMP**

into the output display buffer.



3. Look forward into states 0001 and 0002 to get the destination address for JMP. This is done using the INPUT,ABS instruction.
4. Calculate the destination address for the JMP instruction and put it into the output display buffer. At this point, the disassembly process for state 0000 is complete. The following is in the output display buffer:

**JMP 00255A**

Using the same process for state 0001:

1. Load INPUT\_STATUS for state 0001. Since this value represents a program read, go to the routine that decodes opcode fetches.
2. Decode the 0000H in INPUT\_DATA. This will put the ASCII string

**ORIB**

into the output display buffer.

Step 2 is incorrect for state 0001. State 0001 is not the ORIB opcode. It is part of the operand for the opcode in state 0000. This confusion is a direct result of the limited status information generated by the 68010. The information in STAT must be supplemented to differentiate between a state that contains an opcode fetch and a state that contains operands.

The communication variable INPUT\_TAG can be used to supplement the information provided by INPUT\_STATUS. Each state has a tag associated with it. The inverse assembler can use the lower 16 bits of the tag to mark a state for later reference. In the case of the 68010, the tags are used to mark a state as an operand that has already been decoded.

To mark the tags for a state, use the TAG\_WITH instruction. The tags are read through the INPUT\_TAG communication variable.

Here is how the 68010 disassembly process would operate when using the tag bits to supplement the INPUT\_STATUS information:

1. Load INPUT\_STATUS for state 0000. Since this value represents a program read, go to the routine that decodes opcode fetches.
2. Load INPUT\_TAG for state 0000. Check if this state was tagged to supplement the INPUT\_STATUS information. Since this state is the first state of an opcode fetch, the tag value of bits 0 through 5 will be 0.
3. Decode the 4EF9H in INPUT\_DATA. This will put the ASCII string

**JMP**

into the output display buffer.

4. Look forward into states 0001 and 0002 to get the destination address for JMP. This is done using the INPUT\_ABS instruction. Tag states 0001 and 0002 with the TAG\_WITH instruction to indicate that they have already been used as an operand for decoding state 0000.
5. Calculate the destination address for the JMP instruction and put it into the output display buffer. At this point, the disassembly process for state 0000 is complete. The following is in the output display buffer:

**JMP 00255A**

These same steps are used for decoding state 0001.

1. Load INPUT\_STATUS for state 0001. Since this value represents a program read, go to the routine that decodes opcode fetches.
2. Load INPUT\_TAG for state 0001. Check if this state was tagged to supplement the INPUT\_STATUS information. In this case, state 0001 was tagged as an operand when state 0000 was disassembled. Branch to a routine that will display only the value of INPUT\_DATA and the type of bus cycle.
3. Read INPUT\_DATA and put its value in the output display buffer. Read INPUT\_STATUS and decode its value into the cycle type. Put the cycle type into the output display buffer to finish disassembling state 0001. At this time the output display buffer will hold:

**0000 supr program read**

Using the tags associated with each state allows the inverse assembler to supplement the status provided by the 68010. This supplement allows the inverse assembler to correctly decode the operands of an instruction.

---

## **Software Compatibility with other Logic Analyzers**

As mentioned in chapter 3, Hewlett-Packard's Inverse Assembly Language is compatible with several different logic analyzers and emulators. The TASK communication variable is used to identify which environment the inverse assembler is running in.

The HP 1630 and HP 1631 logic analyzers do not use bits 2 through 15 of the INPUT\_TAG. User-tags in those instruments are limited to bits 0 and 1. If the source code will be used for more than one family of logic analyzers, the inverse assembler should only use bits 0 and 1 of the INPUT\_TAG to insure compatibility.

---

## Synchronizing the Inverse Assembler to the Captured Data

In the previous section, tag bits 0 through 5 were used to help differentiate between the first state of an opcode fetch and the operands for that fetch. Unfortunately, this solution only solves some of the problems caused by microprocessors with incomplete status.

In the previous example, line 0000 was assumed to be the first state of an opcode fetch. This was an arbitrary assumption; in general there is no way to determine which state contains the first line of an opcode fetch when inverse assembling 68010 bus cycles. As previously shown, once the inverse assembler is synchronized to the information captured by the logic analyzer, the inverse assembler can work properly, using the tag bits.

The problem, then, is to find some way of synchronizing the inverse assembler to captured data. Once synchronized, the tag bits can be used to supplement the status provided by the microprocessor to insure correct inverse assembly.

---

## The "Invasm" Field

The HP 1650A/B, HP 1651A/B, HP 16510A/B, and HP 16511B Logic Analyzers provide a field to allow you to manually synchronize the inverse assembler to the captured data. This field is called "Invasm" and is located in the middle of the first line of the Display menu.

### Note



The "Invasm" field is not normally displayed in the Display menu. When an inverse assembler is downloaded to the logic analyzer disk, you can specify if this field is needed. If the field is needed by the inverse assembler, it will be turned on when the inverse assembler is loaded into the logic analyzer.

---

The following steps explain how to use the "Invasm" field to synchronize the inverse assembler to the captured data:

1. Identify a state on the logic analyzer screen that is the first state of an instruction fetch. This can often be determined from the address and status captured in the state.
2. Roll this state up to the top line on the state listing.
3. Select the "Invasm" field. This tells the inverse assembler that the top line on the state listing is the first state of an opcode fetch. The inverse assembler is now synchronized to the captured data.

The "Invasm" field is an inverse assembler control feature used to synchronize the inverse assembler to the captured data. It uses INPUT\_TAG bits 16 and 17 to communicate with the inverse assembler.



---

INPUT\_TAG bits 0 through 15 are user tags. As previously discussed, the inverse assembler can read and write these tags to mark states. INPUT\_TAG bits 16 and 17 are system tags and are completely under the control of the logic analyzer. The inverse assembler has READ ONLY access to bits 16 and 17 of INPUT\_TAG.

Inverse assemblers that do not require the "Invasm" field to synchronize to captured data can completely ignore bits 16 and 17.

---

---

## **INPUT\_TAG Values and How They Change**

INPUT\_TAG bits 16 and 17 are interpreted as shown in the following table:

<b>Bit 17</b>	<b>Bit 16</b>	<b>Description</b>
0	0	Not disassembled and is <b>ILLEGAL</b> for the inverse assembler to do so. The "Invasm" field has not been selected.
0	1	Not disassembled and is legal for the inverse assembler to do so. The "Invasm" field has been selected.
1	0	Disassembled and is not the first state of an opcode fetch.
1	1	Disassembled and is the first state of an opcode fetch.

After the logic analyzer has made a measurement, INPUT\_TAG bits 16 and 17 start with a value of 0. At this point, the "Invasm" field has not been selected to synchronize the inverse assembler. None of the lines on the screen have been disassembled. In fact, it is illegal for the inverse assembler to disassemble a state when bits 16 and 17 are 0. Instead, the inverse assembler should be written to display only the value in INPUT\_DATA and the kind of bus cycle indicated by the value in INPUT\_STATUS.

For the 68010 example, here is what should be on the logic analyzer display before the "Invasm" field is selected:

Label	>	ADDR	DATA	68010 Mnemonic	STAT
Base	>	Hex	Hex	Hex	Symbol
+ 0000		00201E	4EF9	4EF9 supr program read	SUPR PRGM READ
+ 0001		002020	0000	0000 supr program read	SUPR PRGM READ
+ 0002		002022	255A	255A supr program read	SUPR PRGM READ
+ 0003		00255A	(Next 68010 instruction)		
			.		
			.		
			.		

When the "Invasm" field is selected, the analyzer sets INPUT\_TAG bit 17 to 0 and bit 16 to 1 for the first state on the display. This indicates to the inverse assembler that it can disassemble this state. After doing so, the inverse assembler returns control to the analyzer. At this time, the analyzer tags the NEXT state with bit 17 equal to 0 and bit 16 equal to 1 (legal to disassemble). With this method, the remainder of the trace list can be disassembled using a single selection of the "Invasm" field. Rolling forward will disassemble the last line on the screen as it scrolls onto the display.

**Note** 

The logic analyzer only disassembles states on the instrument screen. Jumping to a different area of the trace memory will cause the inverse assembler to lose synchronization with the captured data. Also, rolling the screen backwards to display lines before the first state that was disassembled will cause previous lines to not be disassembled.

In both of these cases, you must re-synchronize the inverse assembler by repeating the process shown on page B-7.

In the 68010 inverse assembler, the first communication variable checked is INPUT\_TAG bits 16 and 17. If the value in bits 16 and 17 is 0, the inverse assembler will only display the value of INPUT\_DATA and the cycle type. For any other value, the inverse assembler will try to disassemble the state.

Here are the steps executed on state 0000 in the previous example if the "Invasm" field has not been selected:

1. Load INPUT\_TAG for state 0000. Check the value in bits 16 and 17. Since "Invasm" has not been selected, the value here will be 0 (Not safe to inverse assemble). Branch to a routine that will display only the value of INPUT\_DATA and the type of bus cycle.
2. Load INPUT\_DATA and put its value in the output display buffer. Read INPUT\_STATUS and decode its value into the cycle type. Put the cycle type into the output display buffer to finish disassembling state 0000. At this time the output display buffer will hold:

#### **4EF9 supr program read**

To synchronize the inverse assembler to the acquired information, you should scroll state 0000 to the top of the listing. When "Invasm" is selected, the inverse assembler does the following for this state:

1. Load INPUT\_TAG for state 0000. Check the value in bits 16 and 17. Since "Invasm" has been selected, the value here will be 01B (Safe to inverse assemble). Branch to the routine that decodes opcodes.
2. Check bits 0 through 15 of INPUT\_TAG to see if this state was tagged to supplement the INPUT\_STATUS information. Since this state is the first state of an opcode fetch, the tag value of bits 0 through 15 will be 0.
3. Load INPUT\_STATUS for state 0000. Since this value represents a program read, continue to decode this state as an opcode fetch.



4. Decode the 4EF9H in INPUT\_DATA. This will put the ASCII string

**JMP**

into the output display buffer.

5. Look forward into states 0001 and 0002 to get the destination address for JMP. This is done using the INPUT,ABS instruction. Tag states 0001 and 0002 with the TAG\_WITH instruction to indicate that they have already been used as an operand for decoding state 0000.
6. Calculate the destination address for the JMP instruction and put it into the output display buffer. At this point, the disassembly process for state 0000 is complete. The following is in the output display buffer:

**JMP 00255A**

7. When the inverse assembler returns control to the logic analyzer, tag bits 16 and 17 of the next state (state 0001) will be set to 01B.

The logic analyzer now calls the inverse assembler to decode the next state. The disassembler will go through the following steps for state 0001:

1. Load INPUT\_TAG for state 0001. Check the value in bits 16 and 17. Since "Invasm" has been selected, the value here will be 01B (Safe to inverse assemble). Branch to the routine that decodes opcodes.
2. Load INPUT\_TAG for state 0001. Check if this state was tagged to supplement the INPUT\_STATUS information. In this case, state 0001 was tagged as an operand when state 0000 was disassembled. Branch to a routine that will display only the value of INPUT\_DATA and the type of bus cycle.

3. Read INPUT\_DATA and put its value in the output display buffer. Read INPUT\_STATUS and decode its value into the cycle type. Put the cycle type into the output display buffer to finish disassembling state 0001. At this time the output display buffer will hold:

**0000 supr program read**

4. When the inverse assembler returns control to the logic analyzer, tag bits 16 and 17 of state 0002 will be set to 01B.

---

## Using RETURN\_FLAGS

In chapter 3, bits 16 and 17 of the RETURN\_FLAGS communication variable were used to indicate the results of an IF\_NOT\_MAPPED instruction. RETURN\_FLAGS can also be used to mark states that are the first state in an opcode fetch.

Executing the

**SET RETURN\_FLAGS,0**

instruction in the inverse assembler indicates to the logic analyzer that the current state being decoded DOES NOT CONTAIN the first state of an instruction fetch. Executing

**SET RETURN\_FLAGS,1**

indicates that the current state DOES CONTAIN the first state of an instruction fetch.

**Note**



---

The commands above are setting RETURN\_FLAGS, bit 0 to a 0 or a 1.

---

Setting bit 0 of RETURN\_FLAGS also affects bits 16 and 17 of INPUT\_TAG. When bit 0 of RETURN\_FLAGS is set by using the set RETURN\_FLAGS statement, bit 17 of INPUT\_TAG is set to 1. Bit 16 of INPUT\_TAG is set to the value of RETURN\_FLAGS bit 0.

When bits 16 and 17 of INPUT\_TAG are set to a 10B or 11B, it indicates the state has already been disassembled. In most cases, the inverse assembler should not try to inverse assemble a line that has already been decoded.

To complete the 68010 example, then, steps must be added to mark bit 0 of RETURN\_FLAGS to insure a line will not be inverse assembled twice. For state 0000, the following steps would be performed:

1. Load INPUT\_TAG for state 0000. Check the value in bits 16 and 17. Since "Invasm" has been selected, the value here will be 01B (Safe to inverse assemble). Branch to the routine that decodes opcodes.
2. Check bits 0 through 15 of INPUT\_TAG to see if this state was tagged to supplement the INPUT\_STATUS information. Since this state is the first state of an opcode fetch, the tag value of bits 0 through 15 will be 0.
3. Load INPUT\_STATUS for state 0000. Since this value represents a program read, continue to decode this state as an opcode fetch.
4. Set RETURN\_FLAGS bit 0 to 1, to indicate that this state is the first state of an instruction fetch.
5. Decode the 4EF9H in INPUT\_DATA. This will put the ASCII string

#### **JMP**

into the output display buffer.

6. Look forward into states 0001 and 0002 to get the destination address for JMP. This is done using the INPUT\_ABS instruction. If bits 16 and 17 of INPUT\_TAG for states 0001 and 0002 are marked as "already disassembled", do not complete the inverse assembly for state 0000. In this case, these tag bits are still set to 0.

7. Tag states 0001 and 0002 with the TAG\_WITH instruction to indicate that they have already been used as an operand for decoding state 0000. This statement is operating on bits 0 through 15 of the INPUT\_TAG.
8. Calculate the destination address for the JMP instruction and put it into the output display buffer. At this point, the disassembly process for state 0000 is complete. The following is in the output display buffer:

**JMP 00255A**

9. When the inverse assembler returns control to the logic analyzer, tag bits 16 and 17 of the next state (state 0001) will be set to 01B. Tag bits 16 and 17 of this state (state 0000) are set to 11B.

The steps for state 0001 are similar:

1. Load INPUT\_TAG for state 0001. Check if this state was tagged to supplement the INPUT\_STATUS information. In this case, state 0001 was tagged as an operand when state 0000 was disassembled. Branch to a routine that will display only the value of INPUT\_DATA and the type of bus cycle.
2. Set RETURN\_FLAGS bit 0 to 0, to indicate that this state is not the first state of an instruction fetch.
3. Read INPUT\_DATA and put its value in the output display buffer. Read INPUT\_STATUS and decode its value into the cycle type. Put the cycle type into the output display buffer to finish disassembling state 0001. At this time the output display buffer will hold:

**0000 supr program read**

4. When the inverse assembler returns control to the logic analyzer, tag bits 16 and 17 of state 0002 will be set to 01B. Tag bits 16 and 17 of this state (state 0001) are set to 10B.

---

## Summary of INPUT\_TAGS Bits 16 and 17

In summary, INPUT\_TAG bits 16 and 17 are used with the "Invasm" field in the logic analyzer Display menu to allow you to "point" to the line that contains the first state of an opcode fetch. This allows the inverse assembler to synchronize to the captured data on microprocessors that provide incomplete status.

Bits 16 and 17 are interpreted as follows:

Bit 17	Bit 16	Description
0	0	Not disassembled and is ILLEGAL for the inverse assembler to do so. The "Invasm" field has not been selected.
0	1	Not disassembled and is legal for the inverse assembler to do so. The "Invasm" field has been selected.
1	0	Disassembled and is not the first state of an opcode fetch. This value was generated when the SET RETURN_FLAGS,0 instruction was executed.
1	1	Disassembled and is the first state of an opcode fetch. This value was generated when the SET RETURN_FLAGS,1 instruction was executed.

The "Invasm" field with no options, as discussed here, is enabled by selecting "B" for the final input of the IALDOWN program. See chapter 1 for additional information.

---

## States Containing Multiple Opcodes

In the 68010 example, the start of an opcode fetch could be identified by pointing to a specific state. For some microprocessors, simply pointing to a state may not be sufficient to uniquely identify where an opcode starts.

For example, the Motorola 68020 is a 32-bit microprocessor. Opcodes can start in the high or low 16-bit word contained in a 68020 32-bit fetch. In this case you need to point to the high or low word of a specific state.

As another example, the Intel 80386 is a 32-bit microprocessor where an opcode can start in any of the four byte positions of the 32-bit fetch. In addition, the 80386 can run two kinds of object code: object code originally designed for Intel's 16-bit microprocessors (such as the 8086) or object code designed specifically for the 80386 32-bit instruction set. So, when pointing to a state that holds the start of an instruction fetch, you must point to one of four bytes in the 32-bit word. Also, you must indicate if the instructions are from Intel's 16- or 32-bit instruction set.

The following section will describe how to handle both of the situations described above.

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## The "Invasm" Field Revisited

When discussing the 68010 inverse assembler, the "Invasm" field was used to synchronize the inverse assembler to the captured information. In the case discussed, selecting the "Invasm" field set INPUT\_TAGS bits 16 and 17 to 01B.

As previously noted, the "Invasm" field is normally not displayed in the Display Menu. When an inverse assembler is downloaded to the logic analyzer disk, you can specify if this field is needed. If the field is needed by the inverse assembler, it will be turned on when the inverse assembler is loaded into the logic analyzer.

The download program, IALDOWN, provides four options related to the "Invasm" field. When downloading the inverse assembler, IALDOWN will ask which option is required for the "Invasm" field. The options available are:

Option	Description
A	No "Invasm" field needed. Do not display. This was the option selected for the 8085 inverse assembler.
B	"Invasm" field needed. No other options required. This was the option selected for the 68010 inverse assembler.
C	"Invasm" field needed. When "Invasm" is selected, provide a pop-up on the logic analyzer screen that provides the following two choices:  <div style="text-align: center;">           High            Low         </div>
D	"Invasm" field needed. When "Invasm" is selected, provide a pop-up on the logic analyzer screen that provides the following eight choices:  <div style="text-align: center;">           Size 16, Byte 0            Size 16, Byte 1            Size 16, Byte 2            Size 16, Byte 3            Size 32, Byte 0            Size 32, Byte 1            Size 32, Byte 2            Size 32, Byte 3         </div>

For options B, C, and D, bits 16 and 17 of INPUT\_TAG are interpreted as follows:

<b>Bit 17</b>	<b>Bit 16</b>	<b>Description</b>
0	0	Not disassembled and is ILLEGAL for the inverse assembler to do so. The "Invasm" field has not been selected.
0	1	Not disassembled and is legal for the inverse assembler to do so. The "Invasm" field has been selected.
1	0	Disassembled and is not the first state of an opcode fetch. This value was generated when the SET RETURN_FLAGS,0 instruction was executed.
1	1	Disassembled and is the first state of an opcode fetch. This value was generated when the SET RETURN_FLAGS,1 instruction was executed.

For options C and D, the communication variables INITIAL\_FLAGS and INITIAL\_OPTIONS are used to tell the inverse assembler which field was selected in the pop-up.

For both options C and D, bit 1 of INITIAL\_FLAGS is set to 1 if a field has been selected.



For option C, INITIAL\_OPTIONS bit 0 is set as follows:

<b>Bit 0</b>	<b>Field selected in pop-up</b>
0	High
1	Low

For option D, INITIAL\_OPTIONS bits 0 through 3 are set as follows:

<b>Bit 3</b>	<b>Bit 2</b>	<b>Bit 1</b>	<b>Bit 0</b>	<b>Field selected in pop-up</b>
0	1	0	0	Size 16, Byte 0
0	1	0	1	Size 16, Byte 1
0	1	1	0	Size 16, Byte 2
0	1	1	1	Size 16, Byte 3
1	0	0	0	Size 32, Byte 0
1	0	0	1	Size 32, Byte 1
1	0	1	0	Size 32, Byte 2
1	0	1	1	Size 32, Byte 3

All other combinations of bits 0 through 3 in INITIAL\_OPTIONS are unimplemented.

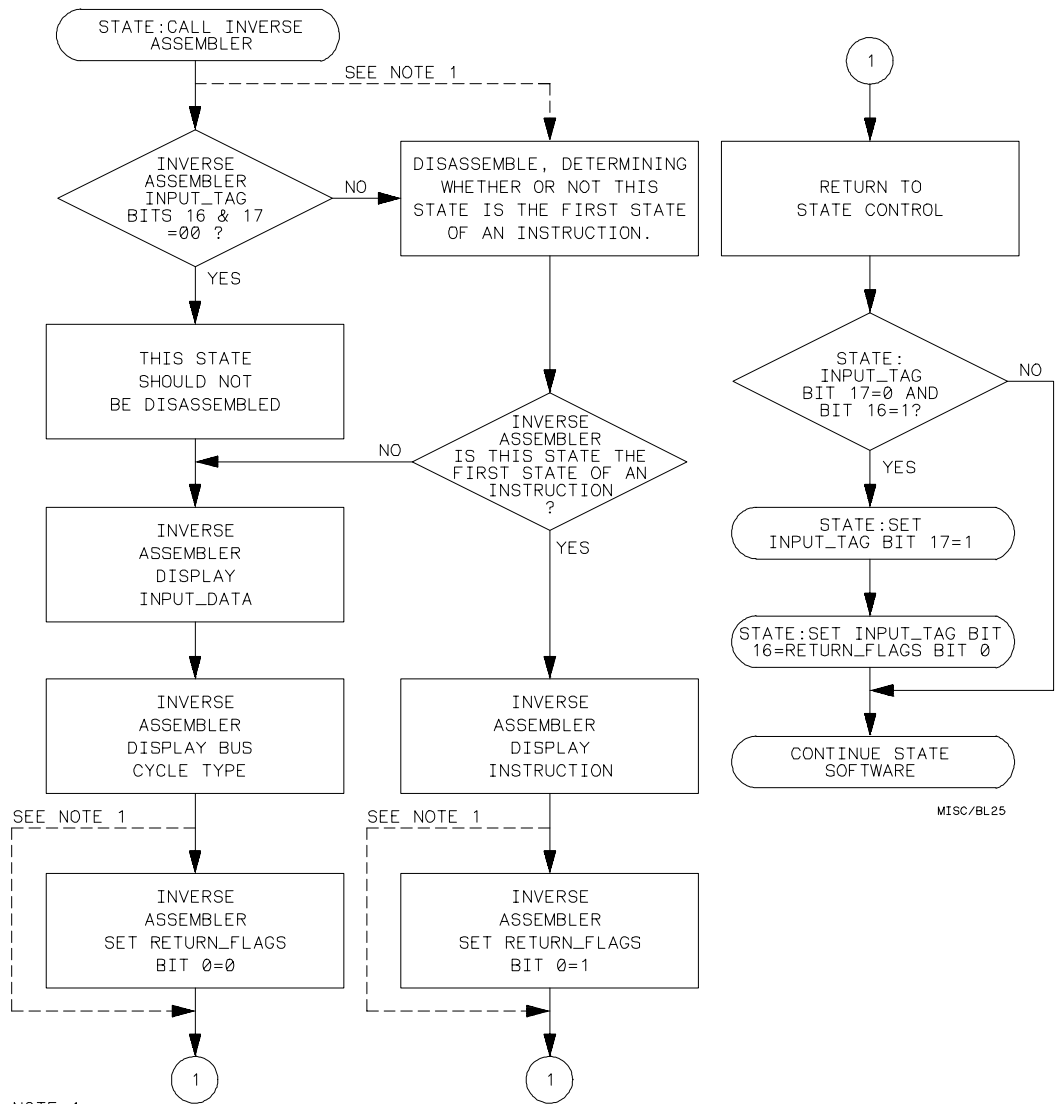
The inverse assembler can use this additional information when parsing through an opcode. For instance, when disassembling the Motorola 68020, option C is used. If the Low field is selected in the "Invasm" pop-up, the inverse assembler will ignore the high word of INPUT\_DATA and begin inverse assembly with the low word of INPUT\_DATA.

Figure B-1 is an overview of the "Invasm" field.

---

## **Code Synchronization with the HP 1630/31 Logic Analyzers**

The HP 1630 family of logic analyzers do not support options C and D of the download program IALDOWN. Only the simple synchronization using option B is available with these instruments. If the source code will also be used for the HP 1630A/D/G or HP 1631A/D, do not use the INITIAL\_FLAGS or INITIAL\_OPTIONS communication variables.



NOTE 1:  
AN INVERSE ASSEMBLER NOT REQUIRING THE USE OF THE "INVASM" FIELD MECHANISM CAN IGNORE INPUT\_TAG BITS 16 AND 17 BY TAKING THIS PATH.

**Figure B-1. Invasm Field Mechanism**

# 68010 Inverse Assembler

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"IAL"

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\*

\* INVERSE ASSEMBLER FOR THE 68010 MICROPROCESSOR

\*

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\*

\* THE LOGIC ANALYZER CAPTURES 24 ADDRESS LINES, 16 DATA LINES AND  
\* 8 STATUS LINES ON THE RISING EDGE OF LAS.

\*

\* THE 8 STATUS LINES FOR THIS INVERSE ASSEMBLER ARE:

\*

\*           BIT 0 --- R/LW (CPU PIN 9)  
\*           BIT 1 --- LLDS (CPU PIN 8)  
\*           BIT 2 --- LUDS (CPU PIN 7)  
\*           BIT 3 --- LVMA (CPU PIN 19)  
\*           BIT 4 --- FCO (CPU PIN 28)  
\*           BIT 5 --- FC1 (CPU PIN 27)  
\*           BIT 6 --- FC2 (CPU PIN 26)  
\*           BIT 7 --- LBGACK (CPU PIN 12)

\*

\*\*\*\*\*

EA_TYPE	VARIABLE	0	; TYPE OF EA REQUESTED
REG_FIELD	VARIABLE	0	; VALUE OF THE REGISTER FIELD
MODE_FIELD	VARIABLE	0	; VALUE OF THE MODE FIELD
SIZE_FIELD	VARIABLE	0	; VALUE OF THE SIZE FIELD
DISASSEMBLY_BLOCK	VARIABLE	0	; TRUE/FALSE - IS BLOCK ENCOUNTERED?

RD_STATUS	VARIABLE	0	; HIGH/LOW BYTE READ FAILURES
HIGH_BYTE	VARIABLE	0	; HIGH ORDER 32 BIT ADDRESS BYTE
LOW_BYTE	VARIABLE	0	; LOW ORDER 32 BIT ADDRESS BYTE
INT	VARIABLE	0	; TRUE = INTERRUPT ACK
SR_ACCESS	VARIABLE	0	; TRUE = SR ACCESS OK, FALSE OTHERWISE
TEMP1	VARIABLE	0	; GENERAL PURPOSE TEMPORARY
REG_MASK	VARIABLE	0	; MOVEM REGISTER MASK
PREFETCH_LOC	VARIABLE	0	; TELLS WHERE PREFETCH IS EXPECTED
REQUESTED_ADDRESS	VARIABLE	0	; ADDRESS WE ARE LOOKING FOR
TEMP_DATA	VARIABLE	0	; STORES UPPER BYTE OF 68008 INSTRUCTION
ABSOLUTE	VARIABLE	0	; VARIABLE THAT TELLS IF THE ADDRESS IS ; OFFSET OR ABSOLUTE DUE TO OVERFLOW
INT_VAL	VARIABLE	OFFFFFH	; VARIABLE FOR INT VS CPU SPACE OPERATIONS

\*\*\*\*\*

ML2	CONSTANT	03H	2 LSB MASK
ML3	CONSTANT	07H	3 LSB MASK
ML4	CONSTANT	0FH	4 LSB MASK
ML8	CONSTANT	0FFH	8 LSB MASK
ML20	CONSTANT	0FFFFFFH	20 LSB MASK
ML24	CONSTANT	0FFFFFFFH	24 LSB MASK
INSTR_LINE	CONSTANT	1	FLAG FOR INSTR LINE
NOT_INSTR_LINE	CONSTANT	0	FLAG FOR NON-INSTR LINE
UNUSED_PREFETCH	CONSTANT	1	TAG FOR PREFETCHED INSTR
OPERAND_USED	CONSTANT	2	TAG FOR USED OPERANDS
FALSE	CONSTANT	0	
TRUE	CONSTANT	1	
BYTE	CONSTANT	00B	BYTE TRANSFER INDICATOR
WORD	CONSTANT	01B	WORD TRANSFER INDICATOR
LONG	CONSTANT	10B	LONG TRANSFER INDICATOR
TAG_COLUMN	CONSTANT	9	COLUMN FOR TAG DISPLAY

STATUS_MASK	CONSTANT	10111111B	MASK 68010
STATUS_VALUE	CONSTANT	10101001B	VALUE 68010
SUPR_DATA	ASCII	"supr data"	
SUPR_PROG	ASCII	"supr program"	
USER_DATA	ASCII	"user data"	
USER_PROG	ASCII	"user program"	
READ	ASCII	"read"	
WRITE	ASCII	"write"	
TYPE_6800	ASCII	" (6800)"	
DMA	ASCII	"DMA"	
FOUR_STAR	ASCII	"****"	
COMMA	ASCII	","	
D	ASCII	"D"	
A	ASCII	"A"	
B	ASCII	"B"	
W	ASCII	"W"	
L	ASCII	"L"	
NUM_SIGN	ASCII	"#"	
OR_OP	ASCII	"OR"	
AND_OP	ASCII	"AND"	
SUB_OP	ASCII	"SUB"	
EOR_OP	ASCII	"EOR"	
ADD_OP	ASCII	"ADD"	
CLR_OP	ASCII	"CLR"	
MOVE_OP	ASCII	"MOVE"	
SR	ASCII	"SR"	
CCR	ASCII	"CCR"	
USP	ASCII	"USP"	
TWO_STAR	ASCII	"**"	
S	ASCII	"S"	
RIGHT_BRACKET	ASCII	"]"	
R	ASCII	"R"	
PERIOD	ASCII	."	
ILLEGAL	ASCII	"Illegal"	
	SEARCH_LIMIT	34	

\*\*\*\*\*

BIN3_FMT	FORMAT	3,BIN,3	3 BITS, BIN, 3 DIGITS
DEC1_FMT_3	FORMAT	3,DEC,1	3 BITS, DEC, 1 DIGIT
HEX1_FMT	FORMAT	4,HEX,1	4 BITS, HEX, 1 DIGIT

HEX1_FMT_3	FORMAT	3,HEX,1	3 BITS, HEX, 1 DIGIT
HEX2_FMT	FORMAT	8,HEX,2	8 BITS, HEX, 2 DIGITS
HEX2_FMT_5	FORMAT	5,HEX,2	5 BITS, HEX, 2 DIGITS
HEX4_FMT	FORMAT	16,HEX,4	16 BITS, HEX, 4 DIGITS
HEX6_FMT	FORMAT	24,HEX,6	24 BITS, HEX, 6 DIGITS
HEX8_FMT	FORMAT	32,HEX,8	32 BITS, HEX, 8 DIGITS

\*\*\*\*\*

```

LABEL_TITLE ^68010 Mnemonic^
BASE_TITLE ^      hex^
DEFAULT_WIDTH 31

```

```

LOAD ML20
STORE INT_VAL

```

INITIALIZE

```

SET RETURN_FLAGS,INSTR_LINE  PRESET TO INSTRUCTION LINE
SET SR_ACCESS,FALSE          INITIAL CONDITION, DONT ALLOW SR ACCESS
SET DISASSEMBLY_BLOCK,FALSE  INITIALLY NO INVERSE ASSEMBLY BLOCK

LOAD INPUT_ADDRESS           GET ADDRESS OF FIRST STATE PASSED
STORE REQUESTED_ADDRESS      SAVE THIS AS THE ADDRESS WE'RE LOOKING AT
IF INPUT_ERROR <> 0 THEN GOTO DATA_ERROR

LOAD  STATUS_MASK           ; GET PROGRAM READ STATUS MASK
STORE QUALIFY_MASK         ... AND SAVE AS INPUT QUALIFIER MASK
LOAD  STATUS_VALUE          ; GET PROGRAM READ STATUS VALUE
STORE QUALIFY_VALUE        ... AND SAVE AS INPUT QUALIFIER VALUE

```

CHECK\_INPUT\_TAG

```

LOAD INPUT_TAG              GET THE CURRENT TAG VALUE
IF 17,16 <> 0 THEN GOTO OPCODE_DECODE  OK TO DISASSEMBLE

```

\* ELSE ONLY DISPLAY STATUS INFORMATION

```

LOAD INPUT_STATUS
AND QUALIFY_MASK
IF 7,0 = QUALIFY_VALUE THEN GOTO FLAGGED_AS_INSTR

```

\*\*\*\*\*

```

DISPLAY_STATUS
    SET RETURN_FLAGS,NOT_INSTR_LINE          DONT FLAG THIS LINE
FLAGGED_AS_INSTR
    POSITION ABS,3
    LOAD INPUT_DATA
    OUTPUT ACCUMULATOR,HEX4_FMT             DISPLAY THE INPUT DATA
    POSITION REL,1
    LOAD INPUT_TAG
    IF 1,0 <> UNUSED_PREFETCH THEN GOTO NOT_PREFETCH
        OUTPUT "unused prefetch"
        RETURN
NOT_PREFETCH
    LOAD INPUT_STATUS
    IF 7,7 = 1 THEN GOTO NOT_DMA
        OUTPUT DMA
        RETURN
NOT_DMA
    CASE_OF 6,4
        CALL UNKNOWN
        OUTPUT USER_DATA
        OUTPUT USER_PROG
        CALL UNKNOWN
        CALL UNKNOWN
        OUTPUT SUPR_DATA
        OUTPUT SUPR_PROG
        CALL INT_ACK
    CASE_END
    IF INT = TRUE THEN GOTO NO_R_W_DISP       INTERRUPT ACK IS ALWAYS READ
    POSITION REL,1
    CASE_OF 0,0
        OUTPUT WRITE
        OUTPUT READ
    CASE_END
NO_R_W_DISP
    CASE_OF 3,3
        OUTPUT TYPE_6800           INDICATE A 6800 CYCLE

```

```

NOP                                NOTHING FOR NORMAL 68000 CYCLE
CASE_END

* IF THE TRANSFER IS A BYTE TRANSFER THE UNDEFINED BYTE IS xxed OUT.
* UPPER AND LOWER DATA STROBE TELL WHICH BYTE OR BYTES ARE VALID.
* UPPER DATA STROBE IS INPUT ON STATUS BIT 2 AND LOWER DATA
* STROBE IS INPUT ON STATUS BIT 1.

CASE_OF 2,1
RETURN                               WORD XFER, NO DONT CARES
POSITION ABS,5                       POSITION TO xx THE LOWER BYTE
POSITION ABS,3                       POSITION TO xx THE UPPER BYTE
RETURN                               UNDEFINED TRANSFER
CASE_END
OUTPUT "xx"                          OUTPUT THE DON'T CARES
RETURN                               EXIT INVERSE ASSEMBLER

```

\*\*\*\*\*

```

OPCODE_DECODE
LOAD INPUT_TAG                      GET THE TAG FOR THIS STATE
IF 1,0 = OPERAND_USED THEN GOTO DISPLAY_STATUS
IF 1,0 = UNUSED_PREFETCH THEN GOTO DISPLAY_STATUS

LOAD INPUT_STATUS                   GET THE STATUS OF THE INPUT
AND QUALIFY_MASK                   GET ONLY THE DESIRED BITS FOR PROGRAM READ
IF 7,0 <> QUALIFY_VALUE THEN GOTO DISPLAY_STATUS    BRIF NOT OPCODE

LOAD INPUT_DATA                     GET THE DATA THAT WAS READ

MEM_OPC_DEC
LOAD INPUT_DATA                     GET THE DATA THAT WAS READ
CASE_OF 15,12
GOTO Bit_MOVEP_Imm
GOTO MOVE_B_L_W
GOTO MOVE_B_L_W
GOTO MOVE_B_L_W
GOTO Misc
GOTO ADDQ_SUBQ_Scc_DBcc

```



```

GOTO Bcc
GOTO MOVEQ
GOTO OR_DIV_BCD_AND_MUL_EXG
GOTO Math_Extended
GOTO UNIMPLEMENTED
GOTO CMP_EOR
GOTO OR_DIV_BCD_AND_MUL_EXG
GOTO Math_Extended
GOTO Shift_Rotate
GOTO UNIMPLEMENTED
CASE_END

```

\*\*\*\*\*

```

Bit_MOVEP_Imm
IF 8,8 = 1 THEN GOTO Dynamic_MOVEP
CASE_OF 11,9
  OUTPUT OR_OP           0000 0000 XXXX XXXX
  OUTPUT AND_OP          0000 0010 XXXX XXXX
  OUTPUT SUB_OP           0000 0100 XXXX XXXX
  OUTPUT ADD_OP           0000 0110 XXXX XXXX
  GOTO Static             0000 1000 XXXX XXXX
  OUTPUT EOR_OP           0000 1010 XXXX XXXX
  OUTPUT "CMP"           0000 1100 XXXX XXXX
  GOTO MOVES              0000 1110 XXXX XXXX
CASE_END
OUTPUT "I"               ALL OF THE ABOVE ARE IMMEDIATE
CALL SHOW_SIZE            DISPLAY THE SIZE INDICATOR
CALL IMMEDIATE           DISPLAY THE IMMEDIATE DATA
OUTPUT COMMA             SEPARATE OPERAND FIELDS
* NOW SET THE VARIABLE THAT ALLOWS/DISALLOWS EFFECTIVE ADDRESS ACCESS
* TO THE STATUS REGISTER
LOAD INITIAL_DATA        GET THE ORIGINAL OPCODE BACK
CASE_OF 11,9
  SET SR_ACCESS,TRUE     ORI CAN ACCESS STATUS REGISTER
  SET SR_ACCESS,TRUE     ANDI CAN ACCESS STATUS REGISTER
  SET SR_ACCESS,FALSE    SUBI CANNOT ACCESS STATUS REGISTER
  SET SR_ACCESS,FALSE    ADDI CANNOT ACCESS STATUS REGISTER
  NOP                    CANT GET HERE (BIT STATIC INSTR)
  SET SR_ACCESS,TRUE     EORI CAN ACCESS STATUS REGISTER

```

```

        SET SR_ACCESS,FALSE      CMPI CANNOT ACCESS STATUS REGISTER
        NOP                      CANT GET HERE (ILLEGAL OPCODE)
CASE_END
CALL EA_DISP                    DISPLAY THE EFFECTIVE ADDRESS
IF SR_ACCESS = FALSE THEN RETURN      CANNOT ACCESS SR/CCR
LOAD INITIAL_DATA              GET THE ORIGINAL OPCODE
IF 5,0 <> 111100B THEN RETURN      COULD, BUT DIDNT ACCESS SR/CCR
RETURN

*****
MOVES
    OUTPUT MOVE_OP
    OUTPUT S
    CALL SHOW_SIZE
    CALL READ_NEXT_OPERAND
    IF INPUT_ERROR <>0 THEN GOTO INCOMPLETE_OPCODE
    LOAD INPUT_DATA
    STORE TEMP_DATA
    CASE_OF 11,11
        CALL EA_DISP
        CALL REG_DISP
    CASE_END
    OUTPUT COMMA
    LOAD TEMP_DATA
    CASE_OF 11,11
        CALL REG_DISP
        CALL EA_DISP
    CASE_END
    RETURN

REG_DISP
    LOAD TEMP_DATA
    CASE_OF 15,15
        OUTPUT D
        OUTPUT A
    CASE_END
    AND 07000H
    ROTATE RIGHT,12
    OUTPUT ACCUMULATOR,DEC1_FMT_3
    RETURN

*****

```

```

Dynamic_MOVEP
  IF 5,3 = 001B THEN GOTO MOVEP
  CALL BIT_MNEMONIC          DISPLAY THE BIT MANIPULATION INSTR
  POSITION ABS,TAG_COLUMN     MOVE OVER TO OPERAND FIELD
  CALL DATA_REG_11_9       DISPLAY THE REG NUMBER (BITS 11 - 9)
  OUTPUT COMMA
  GOTO EA_DISP              DISPLAY THE EFFECTIVE ADDRESS

```

\*\*\*\*\*

```

BIT_MNEMONIC
* DISPLAY THE BIT MANIPULATION INSTRUCTION (DYNAMIC/STATIC)
  OUTPUT B
  CASE_OF 7,6
    OUTPUT "TST"
    OUTPUT "CHG"
    OUTPUT CLR_OP
    OUTPUT "SET"
  CASE_END
  OUTPUT PERIOD
  IF 5,3 = 000B THEN GOTO LONG_BIT          BRIF DYNAMIC BIT
  OUTPUT B
  SET SIZE_FIELD,BYTE          INDICATE BYTE SIZE TRANSFER
  RETURN
LONG_BIT
  OUTPUT L
  SET SIZE_FIELD,LONG         INDICATE LONG SIZE TRANSFER
  RETURN

```

\*\*\*\*\*

```

MOVEP
  OUTPUT MOVE_OP
  OUTPUT "P."          DISPLAY THE MNEMONIC
  CASE_OF 6,6
    OUTPUT W          SIZE = WORD
    OUTPUT L          SIZE = LONG
  CASE_END

```

```

CASE_OF 6,6
    SET SIZE_FIELD,WORD    SIZE = WORD
    SET SIZE_FIELD,LONG    SIZE = LONG
CASE_END
SET MODE_FIELD,101B      SET TO ADDR INDIRECT + OFFSET MODE
POSITION ABS,TAG_COLUMN  MOVE OVER TO THE OPERAND FIELD
CASE_OF 7,7
    CALL EA_DISP_MODE_SET  DISPLAY THE MEMORY SOURCE LOCATION
    CALL DATA_REG_11_9    DISPLAY THE DATA REG SOURCE
CASE_END
LOAD INITIAL_DATA        GET BACK THE ORIGINAL OPCODE
OUTPUT COMMA
CASE_OF 7,7
    CALL DATA_REG_11_9    DISPLAY THE DATA REG DESTINATION
    CALL EA_DISP_MODE_SET  DISPLAY THE MEMORY DESTINATION
CASE_END
RETURN
*****

Static
CALL BIT_MNEMONIC        DISPLAY THE BIT MANIPULATION INSTR
POSITION ABS,TAG_COLUMN  MOVE OVER TO THE OPERAND FIELD
OUTPUT NUM_SIGN          INDICATE IMMEDIATE DATA
CALL READ_NEXT_OPERAND   GET THE BIT NUMBER OPERAND
IF INPUT_ERROR = 0 THEN GOTO Static_OK
LOAD SIZE_FIELD          GET THE SIZE INDICATOR
CASE_OF 1,1
    OUTPUT "*"            OX = BYTE ie MODULO 8 BIT NUMBER
    OUTPUT TWO_STAR      1X = LONG ie MODULO 32 BIT NUMBER
CASE_END
GOTO SNODEA              Static Not Ok Display Effective Address

Static_OK
LOAD INPUT_DATA          GET THE BIT NUMBER SPECIFIER
CASE_OF SIZE_FIELD
    OUTPUT ACCUMULATOR,HEX1_FMT_3  DISPLAY THE 3 BIT VALUE
    NOP                               SHOULDN'T EVER GET HERE
    OUTPUT ACCUMULATOR,HEX2_FMT_5  DISPLAY THE 5 BIT VALUE
    NOP
CASE_END
SNODEA

```

```

OUTPUT COMMA
GOTO EA_DISP                DISPLAY THE EFFECTIVE ADDRESS
*****
MOVE_B_L_W
OUTPUT MOVE_OP
IF 8,6 = 001B THEN OUTPUT A
OUTPUT PERIOD
* THE CONVENTIONAL SIZE ROUTINE (SHOW_SIZE) CANNOT BE USED BECAUSE
* THE MOVE INSTRUCTION USES A DIFFERENT SIZE ENCODING
CASE_OF 13,12              SIZE FIELD
NOP                        SHOULDNT EVER GET HERE
OUTPUT B                   BYTE TRANSFER
OUTPUT L                   LONG TRANSFER
OUTPUT W                   WORD TRANSFER
CASE_END
CASE_OF 13,12              SIZE FIELD
NOP                        SHOULDNT EVER GET HERE
SET SIZE_FIELD,BYTE       BYTE TRANSFER
SET SIZE_FIELD,LONG      LONG TRANSFER
SET SIZE_FIELD,WORD      WORD TRANSFER
CASE_END
POSITION ABS,TAG_COLUMN    POSITION AT THE TAG DISPLAY POSITION
CALL SOURCE_EA            DISPLAY THE DESTINATION EFFECTIVE ADDR
OUTPUT COMMA
LOAD INITIAL_DATA         GET THE OPCODE BACK AGAIN
GOTO DESTINATION_EA       DISPLAY THE SOURCE EFFECTIVE ADDRESS
*****
Misc
IF 8,7 = 10B THEN GOTO ILLEGAL_OPCODE
IF 8,8 = 1 THEN GOTO CHK_LEA
IF 11,11 = 0 THEN GOTO NEGX_CLR_NOT_MOVE
CASE_OF 10,9
GOTO NBCD_AND_MIX         0100 1000 XXXX XXXX
GOTO TST_TAS              0100 1010 XXXX XXXX
GOTO MOVEM_TO_REG         0100 1100 XXXX XXXX

```

```

        GOTO MISC_JSR_JMP      0100 1110 XXXX XXXX
CASE_END
RETURN      THIS RETURN CANT HAPPEN

NBCD_AND_MIX
CASE_OF 7,6
    OUTPUT "NBCD.B"          0100 1000 00XX XXXX
    GOTO PEA_SWAP            0100 1000 01XX XXXX
    GOTO MOVEM_EXT           0100 1000 10XX XXXX
    GOTO MOVEM_EXT           0100 1000 11XX XXXX
CASE_END
POSITION ABS,TAG_COLUMN     MOVE OVER TO TAG FIELD
GOTO EA_DISP                DISPLAY THE EFFECTIVE ADDRESS

PEA_SWAP
SET TEMP1,0                 PRESET TO SWAP INSTRUCTION
IF 5,3 <> 000B THEN SET TEMP1,1     SET TO PEA INSTRUCTION
CASE_OF TEMP1
    OUTPUT "SWAP.W"
    OUTPUT "PEA.L"
CASE_END
POSITION ABS,TAG_COLUMN
CASE_OF TEMP1
    CALL DATA_REG_2_0      SWAP INSTRUCTION
    CALL EA_DISP            PEA INSTRUCTION
CASE_END
RETURN

CHK_LEA
CASE_OF 6,6
    OUTPUT "CHK.W"          0100 XXX1 10XX XXXX
    OUTPUT "LEA.L"         0100 XXX1 11XX XXXX
CASE_END
POSITION ABS,TAG_COLUMN     MOVE OVER TO OPERAND FIELD
CALL EA_DISP                DISPLAY THE EFFECTIVE ADDRESS
LOAD INITIAL_DATA          RECOVER THE ORIGINAL OPCODE
OUTPUT COMMA
CASE_OF 6,6
    CALL DATA_REG_11_9     BOUND IS IN DATA REGISTER
    CALL ADDR_REG_11_9     EFFECTIVE ADDRESS GOES TO ADDR REG
CASE_END
RETURN

```

```

NEGX_CLR_NOT_MOVE
  IF 7,6 = 11B THEN GOTO MOVE_SR_CCR          0100 0XX0 11XX XXXX
CASE_OF 10,9
  OUTPUT "NEGX"
  OUTPUT CLR_OP
  OUTPUT "NEG"
  OUTPUT "NOT"
CASE_END
CALL SHOW_SIZE          DISPLAY THE OPERATION SIZE
CALL EA_DISP           DISPLAY THE EFFECTIVE ADDRESS
RETURN

MOVE_SR_CCR
OUTPUT MOVE_OP
OUTPUT PERIOD
CASE_OF 10,9
  OUTPUT W
  OUTPUT W
  OUTPUT B
  OUTPUT W
CASE_END
CASE_OF 10,9
  SET SIZE_FIELD,WORD
  SET SIZE_FIELD,WORD          CANT GET HERE FOR 68000/08
  SET SIZE_FIELD,BYTE
  SET SIZE_FIELD,WORD
CASE_END
POSITION ABS,TAG_COLUMN
CASE_OF 10,9
  OUTPUT SR
  OUTPUT CCR          ILLEGAL INSTRUCTION, CANT GET HERE FOR 68000/08
  CALL EA_DISP        DISPLAY THE SOURCE ADDRESS
  CALL EA_DISP        DISPLAY THE SOURCE ADDRESS
CASE_END
OUTPUT COMMA
LOAD INITIAL_DATA      GET THE ORIGINAL OPCODE BACK
CASE_OF 10,9
  CALL EA_DISP        DISPLAY THE DESTINATION ADDRESS
  CALL EA_DISP        ILLEGAL INSTRUCTION, CANT GET HERE FOR 68000/08
  OUTPUT CCR
  OUTPUT SR
CASE_END

```

```

LOAD_INITIAL_DATA      GET THE ORIGINAL OPCODE BACK
IF 10,9 < 2 THEN RETURN NO UNUSED PREFETCH TO MARK

*
* NOW, LOOK AT THE EFFECTIVE ADDRESS MODE FIELD TO DETERMINE THE NUMBER
* OF PROGRAM READ STATES REQUIRED FOR THIS INSTRUCTION. THIS VALUE PLUS
* ONE WILL THEN POINT TO THE PROPER LOCATION FOR THE UNUSED PREFETCH
* STATE.
*
CASE_OF 5,3
  SET PREFETCH_LOC,+1  DATA REGISTER DIRECT
  NOP                  ADDRESS REGISTER DIRECT (**ILLEGAL**)
  SET PREFETCH_LOC,+1  ADDRESS REGISTER INDIRECT
  SET PREFETCH_LOC,+1  ADDRESS REGISTER INDIRECT POST-INCREMENT
  SET PREFETCH_LOC,+1  ADDRESS REGISTER INDIRECT PRE-DECREMENT
  SET PREFETCH_LOC,+2  ADDRESS REGISTER INDIRECT W/DISPLACEMENT
  SET PREFETCH_LOC,+2  ADDR REG IND W/DISPLACEMENT AND INDEX
  CALL LOOK_AT_REG_FIELD FOR MODE = 7, REG FIELD MUST BE EXAMINED
CASE_END
GOTO MARK_PREFETCH    MARK THE PREFETCH

LOOK_AT_REG_FIELD
CASE_OF 2,0            LOOKING NOW AT THE REG FIELD
  SET PREFETCH_LOC,+2 ABSOLUTE ADDRESS (SHORT)
  SET PREFETCH_LOC,+3 ABSOLUTE ADDRESS (LONG)
  SET PREFETCH_LOC,+2 PC RELATIVE W/DISPLACEMENT
  SET PREFETCH_LOC,+2 PC RELATIVE W/DISPLACEMENT AND INDEX
  SET PREFETCH_LOC,+2 IMMEDIATE DATA
CASE_END
RETURN

MOVEM_EXT
IF 5,3 = 000B THEN GOTO EXT
MOVEM
  OUTPUT MOVE_OP
  OUTPUT "M."
CASE_OF 6,6
  OUTPUT W
  OUTPUT L
CASE_END
CALL READ_NEXT_OPERAND READ THE MASK WORD
STORE REG_MASK         SAVE THE MASK WORD
IF INPUT_ERROR <> 0 THEN SET REG_MASK,0

```



```

POSITION ABS,TAG_COLUMN
LOAD INITIAL_DATA          GET THE ORIGINAL OPCODE BACK
CASE_OF 10,10
  CALL MOVEM_MASK
  CALL EA_DISP
CASE_END
OUTPUT COMMA
LOAD INITIAL_DATA          GET BACK THE ORIGINAL OPCODE
CASE_OF 10,10
  CALL EA_DISP
  CALL MOVEM_MASK
CASE_END
RETURN

MOVEM_MASK
OUTPUT "rm="
LOAD REG_MASK
IF 15,0 <> 0 THEN GOTO MASK_FOUND
  OUTPUT FOUR_STAR          IF NO MASK WAS FOUND
  RETURN
MASK_FOUND
OUTPUT ACCUMULATOR,HEX4_FMT
RETURN

EXT
OUTPUT "EXT."
CASE_OF 6,6
  OUTPUT W
  OUTPUT L
CASE_END
POSITION ABS,TAG_COLUMN
GOTO DATA_REG_2_0

TST_TAS
IF 7,6 <> 11B THEN GOTO TST
  OUTPUT "TAS.B"
  GOTO MNEMONIC_DISPLAYED

TST
OUTPUT "TST"
CALL SHOW_SIZE

```

```

Mnemonic_Displayed
  POSITION ABS,TAG_COLUMN      MOVE OVER TO THE OPERAND FIELD
  GOTO EA_DISP                DISPLAY THE EFFECTIVE ADDRESS

MOVEM_TO_REG
  IF 7,7 = 0 THEN GOTO ILLEGAL_OPCODE
  GOTO MOVEM

MISC_JSR_JMP
  CASE_OF 8,6
    GOTO ILLEGAL_OPCODE
    GOTO TRAP_MIX
    OUTPUT "JSR"
    OUTPUT "JMP"
  CASE_END
  POSITION ABS,TAG_COLUMN
  GOTO EA_DISP
* CALL MARK_PREFETCH          DUMP THE UNUSED PREFETCH

TRAP_MIX
  CASE_OF 5,4
    GOTO TRAP
    GOTO LINK_UNLK
    GOTO MOVE_USP
    NOP
  CASE_END
  IF 5,3 = 111B THEN GOTO MOVEC
  CASE_OF 2,0
    OUTPUT "RESET"
    OUTPUT "NOP"
    OUTPUT "STOP"
    OUTPUT "RTE"
    GOTO RTD
    OUTPUT "RTS"
    OUTPUT "TRAPV"
    OUTPUT "RTR"
  CASE_END
  IF 2,0 <> 2 THEN GOTO NO_OPERAND
  POSITION ABS,TAG_COLUMN
  OUTPUT NUM_SIGN
  CALL READ_NEXT_OPERAND
  IF INPUT_ERROR <> 0 THEN GOTO WORD_ERROR

```

```

STOP_OK
  OUTPUT ACCUMULATOR,HEX4_FMT
  RETURN

RTD
  OUTPUT "RTD"
  POSITION ABS,TAG_COLUMN
  OUTPUT NUM_SIGN
  CALL READ_NEXT_OPERAND
  IF INPUT_ERROR <>0 THEN GOTO WORD_ERROR
  LOAD INPUT_DATA
  OUTPUT ACCUMULATOR,HEX4_FMT
  RETURN

MOVEC
  OUTPUT MOVE_OP
  OUTPUT "C.L"
  POSITION ABS,TAG_COLUMN
  CALL READ_NEXT_OPERAND
  IF INPUT_ERROR <>0 THEN GOTO INCOMPLETE_OPCODE
  LOAD INPUT_DATA
  STORE TEMP_DATA
  LOAD INITIAL_DATA
  CASE_OF 0,0
    CALL DISP_CONTROL_REG
    CALL REG_DISP
  CASE_END
  OUTPUT COMMA
  LOAD INITIAL_DATA
  CASE_OF 0,0
    CALL REG_DISP
    CALL DISP_CONTROL_REG
  CASE_END
  RETURN

DISP_CONTROL_REG
  LOAD TEMP_DATA
  IF 11,0=0 THEN OUTPUT "SFC"
  IF 11,0=1 THEN OUTPUT "DFC"
  IF 11,0=800H THEN OUTPUT USP
  IF 11,0=801H THEN OUTPUT "VBR"
  IF 10,1<> 0 THEN GOTO ILLEGAL_OPERAND
  RETURN

```

```

NO_OPERAND
  IF 2,0 < 3 THEN RETURN      NO PREFETCH TO BE MARKED
  IF 2,0 = 6 THEN RETURN      CANT MARK PREFETCH FOR TRAPV
  SET PREFETCH_LOC,+1
  GOTO MARK_PREFETCH

TRAP
  OUTPUT "TRAP"
  POSITION ABS,TAG_COLUMN
  OUTPUT NUM_SIGN
  AND ML4                     VECTOR NUMBER IN LOWER 4 BITS ONLY
  OUTPUT ACCUMULATOR,HEX1_FMT
  SET PREFETCH_LOC,+1
  GOTO MARK_PREFETCH          DUMP UNUSED PREFETCH

LINK_UNLK
  CASE_OF 3,3
    OUTPUT "LINK"
    OUTPUT "UNLK"
  CASE_END
  POSITION ABS,TAG_COLUMN
  CALL ADDR_REG_2_0
  IF 3,3 = 1 THEN RETURN
  OUTPUT ",#/"
  CALL READ_NEXT_OPERAND
  IF INPUT_ERROR <> 0 THEN GOTO WORD_ERROR
LINK_UNLK_OK
  OUTPUT ACCUMULATOR,HEX4_FMT  DISPLAY THE 16 BIT DISPLACEMENT
  RETURN

MOVE_USP
  OUTPUT MOVE_OP
  OUTPUT ".L"
  POSITION ABS,TAG_COLUMN
  CASE_OF 3,3
    CALL ADDR_REG_2_0
    OUTPUT USP
  CASE_END
  OUTPUT COMMA

```

```

CASE_OF 3,3
  OUTPUT USP
  CALL ADDR_REG_2_0
CASE_END
RETURN

```

\*\*\*\*\*

```

ADDQ_SUBQ_Scc_DBcc
  IF 7,6 <> 11B THEN GOTO ADDQ_SUBQ          ADDQ & SUBQ INSTRUCTIONS
  IF 5,3 = 001B THEN GOTO DBcc
  OUTPUT S
  GOTO Scc_DBcc

```

```

DBcc
  OUTPUT "DB"

```

```

Scc_DBcc
  CALL CONDITION_CODE          DISPLAY THE CONDITION CODE
  IF 5,3 = 001B THEN GOTO DBcc_2
  OUTPUT ".B"
  POSITION ABS,TAG_COLUMN      MOVE OVER TO THE TAG LOCATION
  GOTO EA_DISP

```

```

DBcc_2
  POSITION ABS,TAG_COLUMN      MOVE OVER TO THE TAG LOCATION
  OUTPUT D                    A DATA REGISTER IS BEING USED
  OUTPUT ACCUMULATOR,DEC1_FMT_3  DISPLAY THE REGISTER NUMBER
  OUTPUT COMMA
  CALL READ_NEXT_OPERAND
  IF INPUT_ERROR <> 0 THEN GOTO WORD_ERROR

```

```

DBcc_DISP_OK
  IF 15,15 = 1 THEN INCLUSIVE_OR OFF0000H  SIGN EXTENSION
  ADD INPUT_ADDRESS          ADD PC OF DISPLACEMENT WORD TO DISPLACEMENT
ADDRESS_OUTPUT
  AND ML24                   ONLY INTERESTED IN LOWER 24 BITS
  IF_NOT_MAPPED THEN OUTPUT ACCUMULATOR,HEX6_FMT
  RETURN

```

\*\*\*\*\*

```

ADDQ_SUBQ
  CASE_OF 8,8

```

```

        OUTPUT "ADDQ"
        OUTPUT "SUBQ"
CASE_END
CALL SHOW_SIZE          DISPLAY THE SIZE OF THE OPERATION
CALL IMM_DATA_11_9    DISPLAY THE 3 BIT IMMEDIATE DATA
OUTPUT COMMA
GOTO EA_DISP          DISPLAY THE EFFECTIVE ADDRESS
*****

Bcc
OUTPUT B
CALL CONDITION_CODE    DISPLAY THE APPLICABLE CONDITION
IF 7,0 <> 0 THEN GOTO EIGHT_BIT    BRIF AN 8 BIT DISPLACEMENT VALUE
OUTPUT ".W"            DISPLACEMENT WAS 16 BIT WORD
SET SIZE_FIELD,WORD    OPERATION SIZE = WORD
CALL READ_NEXT_OPERAND    GET THE 16 BIT DISPLACEMENT VALUE
IF 15,15 = 1 THEN INCLUSIVE_OR OFF0000H    SIGN EXTENSION
IF INPUT_ERROR = 0 THEN GOTO DISP_OK
OUTPUT "*****"
RETURN

EIGHT_BIT
OUTPUT ".B"            DISPLACEMENT WAS 8 BIT BYTE
SET SIZE_FIELD,BYTE    OPERATION SIZE = BYTE
AND ML8                INTERESTED IN LOWER 8 BITS ONLY
IF 7,7 = 1 THEN INCLUSIVE_OR OFFFF00H    EXTEND THE SIGN

DISP_OK
POSITION ABS,TAG_COLUMN    MOVE OVER TO THE OPERAND FIELD
ADD INPUT_ADDRESS        ADD ADDRESS OF DISPLACEMENT WORD
AND ML24                ONLY INTERESTED IN LOWER 24 BITS
IF SIZE_FIELD = BYTE THEN ADD 2    PC POINTING AHEAD 2 LOCATIONS
CALL ADDRESS_OUTPUT
LOAD INITIAL_DATA        RELOAD THE INITIAL OPCODE
IF 15,9 <> 0110000B THEN RETURN    BRIF NOT BRA OR BSR
IF 7,0 = 0 THEN RETURN    NO PREFETCH IF BSR.W OR BRA.W
SET PREFETCH_LOC,+1
GOTO MARK_PREFETCH

*****

```

```

MOVEQ
  OUTPUT MOVE_OP
  OUTPUT "Q.L"
  POSITION ABS,TAG_COLUMN      MOVE OVER TO TAG COLUMN
  AND ML8                    GET THE 8 BIT DATA FIELD
  IF 7,7 = 1 THEN INCLUSIVE_OR 0FFFFFF0H      SIGN EXTEND TO 32 BITS
  OUTPUT NUM_SIGN            IMMEDIATE DATA INDICATOR
  OUTPUT ACCUMULATOR,HEX8_FMT  DISPLAY THE 32 BIT IMMEDIATE VALUE
  OUTPUT COMMA
  GOTO DATA_REG_11_9        DISPLAY THE DATA REGISTER IN 11 THRU 9

```

\*\*\*\*\*

```

Math_Extended
  CASE_OF 14,14
    OUTPUT SUB_OP
    OUTPUT ADD_OP
  CASE_END
  IF 7,6 = 11B THEN GOTO SUBA_ADDA
  IF 8,8 <> 1 THEN GOTO NOT_EXTENDED
  IF 5,4 = 00B THEN GOTO EXTENDED_MATH

NOT_EXTENDED
  CALL SHOW_SIZE              DISPLAY THE SIZE OF THE OPERATION
  POSITION ABS,TAG_COLUMN      MOVE OVER TO THE OPERAND FIELD
  CASE_OF 8,8
    CALL EA_DISP              DISPLAY THE SOURCE EFFECTIVE ADDRESS
    CALL DATA_REG_11_9       DISPLAY THE SOURCE DATA REGISTER
  CASE_END
  OUTPUT COMMA
  LOAD INITIAL_DATA          GET BACK THE ORIGINAL OPCODE
  CASE_OF 8,8
    CALL DATA_REG_11_9       DISPLAY THE DESTINATION DATA REGISTER
    CALL EA_DISP              DISPLAY THE DESTINATION EFFECTIVE ADDR
  CASE_END
  RETURN

SUBA_ADDA
  OUTPUT "A."

A_ADDRESSING
  CASE_OF 8,8
    OUTPUT W

```

```

        OUTPUT L
CASE_END
CASE_OF 8,8
        SET SIZE_FIELD,WORD      WORD OPERAND
        SET SIZE_FIELD,LONG     LONG OPERAND
CASE_END
POSITION ABS,TAG_COLUMN        MOVE OVER TO THE OPERAND FIELD
CALL EA_DISP                   DISPLAY THE SOURCE ADDRESS
OUTPUT COMMA
LOAD INITIAL_DATA             GET THE ORIGINAL OPCODE
GOTO ADDR_REG_11_9           DISPLAY THE ADDRESS DESTINATION ADDR

```

\*\*\*\*\*

```

CMP_EOR
  IF 7,6 = 11B THEN GOTO CMPA
  IF 8,8 = 1 THEN GOTO CMPM_EOR
  OUTPUT "CMP"
  CALL SHOW_SIZE               DISPLAY THE OPERATION SIZE
  CALL EA_DISP                 DISPLAY THE EA SOURCE LOCATION
  OUTPUT COMMA
  GOTO DATA_REG_11_9         DISPLAY THE DATA REGISTER NAME
CMPA
  OUTPUT "CMPA."
  GOTO A_ADDRESSING
CMPM_EOR
  IF 5,3 <> 001B THEN GOTO EOR
  OUTPUT "CMPM"
  CALL SHOW_SIZE               DISPLAY THE OPERATION SIZE
  POSITION ABS,TAG_COLUMN        MOVE OVER TO THE OPERAND DISPLAY FIELD
  OUTPUT "[xx]+,[xx]+"         DISPLAY OPERAND (xx WILL BE BACKFILLED)
  POSITION REL,-10               MOVE BACK OVER TO SRC REG # FIELD
  CALL ADDR_REG_2_0            DISPLAY THE 3 BIT REGISTER NUMBER
  POSITION REL,+4                MOVE OVER TO THE DEST REG FIELD
  CALL ADDR_REG_11_9           DISPLAY THE 3 BIT ADDRESS REGISTER NAME
  POSITION REL,+2                MOVE TO THE END OF THE OPERAND
  RETURN
EOR
  OUTPUT EOR_OP
  CALL SHOW_SIZE               DISPLAY THE OPERATION SIZE

```



```

CALL DATA_REG_11_9      DISPLAY THE SOURCE DATA REGISTER
OUTPUT COMMA
GOTO EA_DISP             DISPLAY THE DESTINATION EFFECTIVE ADDR

```

\*\*\*\*\*

```

OR_DIV_BCD_AND_MUL_EXG
  IF 7,6 = 11B THEN GOTO DIV_MUL_U_S
  IF 14,14 = 0 THEN GOTO NOT_EXG
    IF 8,4 = 10100B THEN GOTO EXG
    IF 8,4 = 11000B THEN GOTO EXG
NOT_EXG
  IF 8,4 = 10000B THEN GOTO SBCD_ABCD
  CASE_OF 14,14
    OUTPUT OR_OP
    OUTPUT AND_OP
  CASE_END
  GOTO NOT_EXTENDED
DIV_MUL_U_S
  CASE_OF 14,14
    OUTPUT "DIV"
    OUTPUT "MUL"
  CASE_END
  CASE_OF 8,8
    OUTPUT "U"           UNSIGNED DIVIDE
    OUTPUT S           SIGNED DIVIDE
  CASE_END
  OUTPUT ".W"
  POSITION ABS,TAG_COLUMN  MOVE OVER TO TAG FIELD
  CALL EA_DISP           DISPLAY THE EFFECTIVE ADDRESS
  OUTPUT COMMA
  GOTO DATA_REG_11_9   DISPLAY THE DATA REGISTER IN BITS 11-9
SBCD_ABCD
  CASE_OF 14,14
    OUTPUT S
    OUTPUT A
  CASE_END
  OUTPUT "BCD.B"
  POSITION ABS,TAG_COLUMN  MOVE OVER TO THE OPERAND FIELD

```

```

IF 3,3 = 0 THEN GOTO REG_TO_REG
  OUTPUT "-["
  CALL ADDR_REG_2_0          DISPLAY THE SOURCE ADDR REGISTER
  OUTPUT "],-["
  CALL ADDR_REG_11_9        DISPLAY THE DESTINATION ADDR REGISTER
  OUTPUT RIGHT_BRACKET
  RETURN
REG_TO_REG
  CALL DATA_REG_2_0        DISPLAY THE SOURCE DATA REGISTER
  OUTPUT COMMA
  GOTO DATA_REG_11_9      DISPLAY THE DESTINATION REGISTER
EXG
  OUTPUT "EXG.L"
  POSITION ABS,TAG_COLUMN
  IF 7,3 = 01000B THEN SET TEMP1,0          DATA REGISTER EXG
  IF 7,3 = 01001B THEN SET TEMP1,1          ADDR REGISTER EXG
  IF 7,3 = 10001B THEN SET TEMP1,2          ADDR/DATA REGISTER EXG
  CASE_OF TEMP1
    CALL DATA_REG_11_9        DISPLAY THE FIRST DATA REGISTER
    CALL ADDR_REG_11_9        DISPLAY THE FIRST ADDR REGISTER
    CALL DATA_REG_11_9        DISPLAY THE DATA REGISTER
    NOP                        CANT GET HERE
  CASE_END
  OUTPUT COMMA
  LOAD INITIAL_DATA          GET THE ORIGINAL OPCODE BACK
  CASE_OF TEMP1
    CALL DATA_REG_2_0        DISPLAY THE SECOND DATA REGISTER
    CALL ADDR_REG_2_0        DISPLAY THE SECOND ADDR REGISTER
    CALL ADDR_REG_2_0        DISPLAY THE ADDRESS REGISTER
    NOP                        CANT GET HERE
  CASE_END
  RETURN

```

\*\*\*\*\*

```

Shift_Rotate
  IF 7,6 = 11B THEN GOTO Memory_Shift
  CASE_OF 4,3                DISPLAY THE TYPE OF SHIFT
    OUTPUT "AS"
    OUTPUT "LS"

```

```

    OUTPUT "ROX"
    OUTPUT "RO"
CASE_END
CASE_OF 8,8           DISPLAY THE DIRECTION OF THE SHIFT
    OUTPUT R
    OUTPUT L
CASE_END
CALL SHOW_SIZE        DISPLAY THE OPERATION SIZE (B,L,W)
IF 5,5 = 1 THEN GOTO REG_COUNT
    CALL IMM_DATA_11_9  DISPLAY THE IMMEDIATE DATA
    GOTO COUNT_DISPLAYED
REG_COUNT
    CALL DATA_REG_11_9  DISPLAY THE DATA REG IN BITS 11-9
COUNT_DISPLAYED
    OUTPUT COMMA
    GOTO DATA_REG_2_0   DISPLAY THE SELECTED DATA REGISTER

```

\*\*\*\*\*

```

Memory_Shift
CASE_OF 10,9          DISPLAY THE TYPE OF SHIFT
    OUTPUT "AS"
    OUTPUT "LS"
    OUTPUT "ROX"
    OUTPUT "RO"
CASE_END
CASE_OF 8,8           DISPLAY THE DIRECTION OF THE SHIFT
    OUTPUT R
    OUTPUT L
CASE_END
OUTPUT ".W"           WORD OPERATIONS ONLY
SET SIZE_FIELD,WORD   SET OPERATION SIZE TO WORD
POSITION ABS,TAG_COLUMN MOVE OVER TO THE TAG DISPLAY FIELD
GOTO EA_DISP          DISPLAY THE EFFECTIVE ADDRESS

```

\*\*\*\*\*

```

UNIMPLEMENTED
    OUTPUT "Unimplemented Instruction:"

```

```

OUTPUT ACCUMULATOR,HEX4_FMT
SET PREFETCH_LOC,+1      RELATIVE POSITION OF EXPECTED PREFETCH
GOTO MARK_PREFETCH      DUMP THE UNUSED PREFETCH

```

```

*****
* 68000 INVERSE ASSEMBLER UTILITY ROUTINES
*****

```

EA\_DISP

\* DISPLAY AN EFFECTIVE ADDRESS

SOURCE\_EA

```

SET EA_TYPE,1           INDICATE A "NORMAL" LOCATION EA
GOTO EA_TYPE_SET

```

DESTINATION\_EA

```

SET EA_TYPE,0           INDICATE A "SPECIAL" LOCATION EA

```

EA\_TYPE\_SET

```

LOAD INITIAL_DATA      GET THE ORIGINAL OPCODE
CASE_OF EA_TYPE

```

```

ROTATE RIGHT,6         MOVE MODE FIELD TO LSB (SPECIAL)
ROTATE RIGHT,3         MOVE MODE FIELD TO LSB (NORMAL)

```

CASE\_END

```

AND ML3                GET THE LOWER THREE BITS

```

```

STORE MODE_FIELD       SAVE THE MODE FIELD

```

```

LOAD INITIAL_DATA      GET THE ORIGINALLY INPUT OPCODE
CASE_OF EA_TYPE

```

```

ROTATE RIGHT,9         MOVE REGISTER FIELD TO LSB (SPECIAL)
NOP                    NO MOVE REQUIRED (NORMAL)

```

CASE\_END

EA\_DISP\_MODE\_SET

\* ENTER HERE IF THE MODE HAS BEEN PRESET. THIS ASSUMES THE REGISTER  
\* NUMBER TO BE IN THE LOWER 3 BITS.

```

AND ML3                GET THE LOWER 3 BITS
STORE REG_FIELD        SAVE THE REGISTER FIELD

CASE_OF MODE_FIELD
  OUTPUT D              DATA REGISTER DIRECT
  OUTPUT A              ADDR REGISTER DIRECT
  OUTPUT "[A"          ADDR REGISTER INDIRECT
  OUTPUT "[A"          ADDR REGISTER INDIRECT W/POSTINCREMENT
  OUTPUT "-[A"         ADDR REGISTER INDIRECT W/PREDECREMENT
  GOTO DISP16          ADDR REGISTER INDIRECT W/DISPLACEMENT
  GOTO DISP8_INDEX     ADDR REG INDIRECT W/DISPLACEMENT&INDEX
  GOTO SPECIAL         SPECIAL ADDRESSING MODES
CASE_END

LOAD REG_FIELD         GET THE REGISTER FIELD
OUTPUT ACCUMULATOR,DEC1_FMT_3  DISPLAY THE SELECTED REGISTER NUMBER

LOAD INITIAL_DATA     GET THE ORIGINAL OPCODE BACK
CASE_OF MODE_FIELD
  RETURN              DATA REGISTER DIRECT
  RETURN              ADDRESS REGISTER DIRECT
  OUTPUT RIGHT_BRACKET  ADDRESS REGISTER INDIRECT
  OUTPUT "]"+"        ADDR REGISTER INDIRECT W/POSTINCREMENT
  OUTPUT RIGHT_BRACKET  ADDR REGISTER INDIRECT W/PREDECREMENT
  NOP                 SHOULDNT EVER GET HERE
  NOP                 SHOULDNT EVER GET HERE
  NOP                 SHOULDNT EVER GET HERE
CASE_END
RETURN

```

\*\*\*\*\*

```

DISP16
* 16 BIT DISPLACEMENT MODE
CALL DISP_NEXT_WORD    DISPLAY THE 16 BIT OFFSET VALUE
OUTPUT "[A"
LOAD REG_FIELD         GET THE REGISTER INDICATED
OUTPUT ACCUMULATOR,DEC1_FMT_3  DISPLAY THE SELECTED REGISTER
OUTPUT RIGHT_BRACKET

```

```
LOAD INITIAL_DATA      GET THE ORIGINAL OPCODE BACK
RETURN
```

\*\*\*\*\*

DISP8\_INDEX

\* 8 BIT DISPLACEMENT AND INDEX MODE

```
CALL READ_NEXT_OPERAND    GET THE EXTENSION WORD
IF INPUT_ERROR = 0 THEN GOTO DISP8_OK
  OUTPUT "**[A"            ADDRESS REG WILL BE BACKFILLED
  LOAD REG_FIELD          GET THE ADDRESS REGISTER NUMBER
  OUTPUT ACCUMULATOR,DEC1_FMT_3    DISPLAY REG #
  OUTPUT ",**.*]"
  RETURN
```

DISP8\_OK

```
AND ML8                  GET THE 8 BIT DISPLACEMENT
OUTPUT ACCUMULATOR,HEX2_FMT    DISPLAY THE 8 BIT DISPLACEMENT
OUTPUT "["
LOAD INPUT_DATA          GET THE ORIGINAL INPUT DATA BACK
OUTPUT A
LOAD REG_FIELD           GET THE ADDRESS REGISTER NUMBER
OUTPUT ACCUMULATOR,DEC1_FMT_3    DISPLAY THE ADDRESS REGISTER NUMBER
OUTPUT COMMA
CASE_OF 15,15
  OUTPUT D                DATA REGISTER IS INDEX
  OUTPUT A                ADDRESS REGISTER IS INDEX
CASE_END
LOAD INPUT_DATA          GET THE EXTENSION WORD
ROTATE RIGHT,12         MOVE REGISTER NUMBER TO LSB
OUTPUT ACCUMULATOR,DEC1_FMT_3    DISPLAY THE REGISTER NUMBER
OUTPUT PERIOD
LOAD INPUT_DATA          GET THE EXTENSION WORD
CASE_OF 11,11
  OUTPUT W
  OUTPUT L
CASE_END
OUTPUT RIGHT_BRACKET
```

```
LOAD INITIAL_DATA      RESTORE THE ORIGINAL OPCODE
RETURN
```

\*\*\*\*\*

#### SPECIAL

```
CASE_OF REG_FIELD
  GOTO ABS_SHORT      ABSOLUTE SHORT ADDRESS
  GOTO ABS_LONG       ABSOLUTE LONG ADDRESS
  GOTO PC_DISPLACEMENT PC WITH DISPLACEMENT
  GOTO PC_INDEX       PC WITH DISPLACEMENT & INDEX
  GOTO IMMEDIATE_SR   IMMEDIATE/ SR CCR MODIFY
CASE_END
GOTO ILLEGAL_OPERAND  ILLEGAL ADDRESSING MODES
```

\*\*\*\*\*

#### ABS\_SHORT

```
CALL READ_NEXT_OPERAND  GET THE EXTENSION WORD
IF INPUT_ERROR = 0 THEN GOTO ABS_SHORT_OK
  OUTPUT "*****"
  RETURN
```

#### ABS\_SHORT\_OK

```
IF 15,15 = 1 THEN INCLUSIVE_OR OFF0000H
GOTO ADDRESS_OUTPUT
```

\*\*\*\*\*

#### ABS\_LONG

```
CALL READ_NEXT_OPERAND  GET THE HIGH ORDER BYTE
STORE HIGH_BYTE        ... AND SAVE IT
SET RD_STATUS,00B      INITIAL STATUS...NO ERRORS
IF INPUT_ERROR <> 0 THEN SET RD_STATUS,01B  HIGH BYTE FAILURE
CALL READ_NEXT_OPERAND  GET THE LOW ORDER BYTE
STORE LOW_BYTE         ... AND SAVE IT
LOAD RD_STATUS         GET THE CURRENT READ STATUS
IF INPUT_ERROR <> 0 THEN INCLUSIVE_OR 10B  LOW BYTE FAILURE
STORE RD_STATUS        SAVE THE READ STATUS

IF RD_STATUS = 00B THEN GOTO MAP_32        BRIF MAPPING IS OK
LOAD HIGH_BYTE         GET THE UPPER 16 BIT BYTE
CASE_OF RD_STATUS
```

```

        NOP                                CANT GET HERE
        OUTPUT FOUR_STAR                   01 = HIGH BYTE FAILURE
        OUTPUT ACCUMULATOR,HEX4_FMT      10 = HIGH BYTE OK
        OUTPUT FOUR_STAR                   11 = BOTH BYTE FAILURE
CASE_END
LOAD LOW_BYTE                            GET THE LOWER 16 BIT BYTE
CASE_OF_RD_STATUS
        NOP                                CANT GET HERE
        OUTPUT ACCUMULATOR,HEX4_FMT      01 = LOW BYTE OK
        OUTPUT FOUR_STAR                   10 = LOW BYTE FAILURE
        OUTPUT FOUR_STAR                   11 = BOTH BYTE FAILURE
CASE_END
RETURN

MAP_32
LOAD HIGH_BYTE                           GET THE UPPER 16 BITS
AND OFFH                                 MASK TO LOWER 2 HIGH BYTE DIGITS
ROTATE LEFT,16                           MOVE TO THE UPPER 8 BITS
INCLUSIVE_OR LOW_BYTE                     OR IN THE LOWER 16 BITS
GOTO ADDRESS_OUTPUT

```

\*\*\*\*\*

```

PC_DISPLACEMENT
CALL READ_NEXT_OPERAND                   GET THE 16 BIT DISPLACEMENT
IF INPUT_ERROR <> 0 THEN GOTO WORD_ERROR
PC_DISP_OK
IF 15,15 = 1 THEN INCLUSIVE_OR OFF0000H SIGN EXTEND DISPLACEMENT
ADD INPUT_ADDRESS                        ADD DISPLACEMENT TO THE CURRENT PC
CALL ADDRESS_OUTPUT
OUTPUT "[PC]"
RETURN

```

\*\*\*\*\*

```

PC_INDEX
CALL READ_NEXT_OPERAND                   GET THE EXTENSION WORD
IF INPUT_ERROR = 0 THEN GOTO PC_INDEX_OK
OUTPUT "***[PC,*,*]"
RETURN
PC_INDEX_OK
AND OFFH                                 IGNORE UPPER BYTE

```



```

IF 7,7 = 1 THEN INCLUSIVE_OR OFFFOOH    SIGN EXTEND DISPLACEMENT
ADD INPUT_ADDRESS          ADD DISPLACEMENT TO THE CURRENT PC
CALL ADDRESS_OUTPUT
LOAD INPUT_DATA
OUTPUT "[PC,"
CASE_OF 15,15
    OUTPUT D
    OUTPUT A
CASE_END
ROTATE RIGHT,12           MOVE INDEX REGISTER TO LSB
OUTPUT ACCUMULATOR,DEC1_FMT_3    DISPLAY REG NUMBER
OUTPUT PERIOD
LOAD INPUT_DATA          GET THE EXTENSION WORD BACK
CASE_OF 11,11           DISPLAY THE SIZE OF THE INDEX
    OUTPUT W
    OUTPUT L
CASE_END
OUTPUT RIGHT_BRACKET
RETURN

```

\*\*\*\*\*

```

IMMEDIATE_SR
IF SR_ACCESS = FALSE THEN GOTO IMMEDIATE
CASE_OF SIZE_FIELD
    OUTPUT CCR          BYTE TRANSFER TO CCR
    OUTPUT SR          WORD TRANSFER EFFECTES ENTIRE SR
    GOTO ILLEGAL_OPERAND
    GOTO ILLEGAL_OPERAND
CASE_END
RETURN
IMMEDIATE
OUTPUT NUM_SIGN
CALL READ_NEXT_OPERAND    GET THE NEXT OPERAND WORD
IF INPUT_ERROR = 0 THEN GOTO EXT1_OK
CASE_OF SIZE_FIELD
    OUTPUT TWO_STAR    NO BYTE FOUND
    OUTPUT FOUR_STAR   NO WORD FOUND
    OUTPUT FOUR_STAR   HIGH ORDER WORD NOT FOUND
    GOTO ILLEGAL_OPCODE    ILLEGAL SIZE SPECIFICATION
CASE_END
GOTO CHECK_FOR_LONG

```

```

EXT1_OK
  CASE_OF SIZE_FIELD
    OUTPUT ACCUMULATOR,HEX2_FMT          DISPLAY 8 BIT DATA
    OUTPUT ACCUMULATOR,HEX4_FMT          DISPLAY 16 BIT DATA
    OUTPUT ACCUMULATOR,HEX4_FMT          DISP HIGH ORDER 16 BITS
    GOTO ILLEGAL_OPCODE                   SHOULDNT EVER GET HERE
  CASE_END
CHECK_FOR_LONG
*
* NOW, SEE IF WE ARE DEALING WITH LONG IMMEDIATE VALUES.  IF NOT,
* THERE IS NO NEED TO READ A SECOND EXTENSION WORD.
*
  IF SIZE_FIELD <> 10B THEN RETURN          BRIF NOT LONG DATA
*
* AT THIS POINT, WE ARE LOOKING AT "LONG" IMMEDIATE VALUES ONLY
*
  CALL READ_NEXT_OPERAND          GET THE 2ND EXTENSION WORD
  IF INPUT_ERROR <> 0 THEN GOTO WORD_ERROR
EXT2_OK
  OUTPUT ACCUMULATOR,HEX4_FMT
  RETURN

```

\*\*\*\*\*

```

DISP_NEXT_WORD
* DISPLAY THE NEXT WORD (16 BIT QUANTITY) FROM THE ANALYZER MEMORY
  CALL READ_NEXT_OPERAND          GET THE NEXT STATE
  IF INPUT_ERROR <> 0 THEN GOTO WORD_ERROR
WORD_READ_OK
  OUTPUT ACCUMULATOR,HEX4_FMT
  RETURN

```

\*\*\*\*\*

```

READ_NEXT_OPERAND
  INCREMENT REQUESTED_ADDRESS
  INCREMENT REQUESTED_ADDRESS
  CALL EXMODE_PW

```

```
CALL CHECK_FOR_BLOCK          DONT ALLOW IT TO CROSS BLOCK BOUNDARIES
IF INPUT_ERROR = 0 THEN TAG_WITH_OPERAND_USED    MARK THIS AS A USED STATE
SKIP_RET
LOAD INPUT_DATA
RETURN
```

EXMODE\_PW

BCMODE\_PW

```
INPUT ABS,REQUESTED_ADDRESS,QUALIFIED    READ THE NEXT STATE
RETURN
```

READ\_MEMORY\_OPERAND

\*\*\*\*\*

CHECK\_FOR\_BLOCK

```
IF TASK = 3 THEN RETURN    DISABLE FOR STATE (TEMPORARY)
```

```
* THIS ROUTINE CHECKS TO BE SURE THAT AN INVERSE ASSEMBLY BLOCK WILL
* NOT BE CROSSED INTO BY AN INSTRUCTION BEING DECODED IN A PREVIOUS
* BLOCK.  FOR MORE INFORMATION ON THIS PROCEDURE, SEE STEVE WILLIAMS.
```

\*

```
* THE OPERATION OF THIS ROUTINE:
```

\*

```
* 1. IF A DISASSEMBLY BLOCK HAS BEEN PREVIOUSLY ENCOUNTERED
* DURING THE DECODING OF THE CURRENT INSTRUCTION, THIS
* ROUTINE ASSUMES THAT WE ARE STILL IN THAT BLOCK, AND
* SETS "INPUT_ERROR" TO MAKE THE INVERSE ASSEMBLER THINK
* THAT A READ ERROR DID OCCUR.
```

\*

```
* 2. IF THERE WAS A NORMAL ERROR IN READING THIS STATE, NO
* DISASSEMBLY BLOCK IS ASSUMED, BUT "INPUT_ERROR" DOES
* REFLECT THAT AN ERROR OCCURRED.
```

\*

```
* 3. IF THE CONTROL TAG (BITS 17 AND 16 OF INPUT_TAG) INDICATES
* THIS STATE TO HAVE BEEN PREVIOUSLY USED AS A FIRST INSTRUCTION,
* THEN A DISASSEMBLY BLOCK BOUNDARY IS SAID TO HAVE
```

```

*      ENCOUNTERED.  THE DISASSEMBLY_BLOCK FLAG IS SET, AND
*      AN INPUT ERROR IS FLAGGED SO THAT THE INVERSE ASSEMBLER
*      CAN DO THE PROPER THINGS WITH THE ERROR FLAG.
IF DISASSEMBLY_BLOCK = TRUE THEN SET INPUT_ERROR,1
IF INPUT_ERROR <> 0 THEN RETURN          LEAVE IF READ ERROR
LOAD INPUT_TAG          GET THE TAG ASSOCIATED WITH THE NEW STATE
IF 17,16 <> 11B THEN RETURN  11B CONTROL TAG IS ONLY TAG NOT OK TO USE.
SET DISASSEMBLY_BLOCK,TRUE          A DISASSEMBLY BLOCK IS PRESENT
SET INPUT_ERROR,1          MAKE IT LOOK LIKE THE READ FAILED
RETURN

```

\*\*\*\*\*

#### SHOW\_SIZE

```

*  DISPLAY THE SIZE OF THE OPERATION (BYTE, WORD, LONG)
  OUTPUT PERIOD
  CASE_OF 7,6
    OUTPUT B
    OUTPUT W
    OUTPUT L
    GOTO ILLEGAL_OPERAND
  CASE_END
  ROTATE RIGHT,6          MOVE SIZE TO LSB
  AND ML2                ONLY LOWER 2 BITS ARE THE SIZE FIELD
  STORE SIZE_FIELD       SAVE THE SIZE FIELD
  LOAD INITIAL_DATA      RESTORE THE ORIGINAL OPCODE
  POSITION ABS,TAG_COLUMN  MOVE OVER TO OPERAND FIELD
  RETURN

```

\*\*\*\*\*

#### IMM\_DATA\_11\_9

```

*  DISPLAY THE 3 BIT IMMEDIATE DATA
*  VALUES 1-7 ARE INTERPRETED AS 1-7, VALUE 0 IS INTERPRETED AS 8

```

```

OUTPUT NUM_SIGN          IMMEDIATE DATA
IF 11,9 <> 0 THEN GOTO IMM_NOT_0
  OUTPUT "8"
  RETURN
IMM_NOT_0
  ROTATE RIGHT,9        MOVE DATA TO LOWER 3 BITS
  OUTPUT ACCUMULATOR,DEC1_FMT_3  DISPLAY THE 3 BIT #
  LOAD INITIAL_DATA     RESTORE THE INITIAL OPCODE
  RETURN

```

\*\*\*\*\*

CONDITION\_CODE

\* DISPLAY THE APPLICABLE CONDITION CODES FOR Scc, DBcc AND Bcc INSTR

```

CASE_OF 11,8
  GOTO COND_T_RA        RA FOR Bcc, T FOR Scc AND DBcc
  GOTO COND_F_BSR      BSR, F FOR Scc AND DBcc
  OUTPUT "HI"
  OUTPUT "LS"
  OUTPUT "CC"
  OUTPUT "CS"
  OUTPUT "NE"
  OUTPUT "EQ"
  OUTPUT "VC"
  OUTPUT "VS"
  OUTPUT "PL"
  OUTPUT "MI"
  OUTPUT "GE"
  OUTPUT "LT"
  OUTPUT "GT"
  OUTPUT "LE"
CASE_END
RETURN

```

COND\_T\_RA

\* DISPLAY A "T" (TRUE) FOR Scc AND DBcc. "RA" FOR Bcc INSTR

```

CASE_OF 12,12
  OUTPUT "RA"          BRA INSTRUCTION

```

```

        OUTPUT "T"
        CASE_END
        RETURN
COND_F_BSR
* DISPLAY AN "F" (FALSE) FOR Scc AND DBcc, OR BSR
        CASE_OF 12,12
        OUTPUT SR
        OUTPUT "F"
        CASE_END
        RETURN

```

ST AND DBT INSTRUCTIONS

BSR INSTRUCTION  
SF AND DBF INSTRUCTIONS

\*\*\*\*\*

```

ILLEGAL_OPERAND
        POSITION ABS,TAG_COLUMN
        OUTPUT ILLEGAL
        OUTPUT " Operand   "
        ABORT

```

\*\*\*\*\*

```

DATA_ERROR
        OUTPUT "Data Error"
        ABORT

```

\*\*\*\*\*

```

ILLEGAL_OPCODE
        OUTPUT ILLEGAL
        OUTPUT " Opcode"
        ABORT

```

\*\*\*\*\*

```

WORD_ERROR
        OUTPUT FOUR_STAR
        RETURN

```

\*\*\*\*\*

```
INCOMPLETE_OPCODE
  OUTPUT "incomplete opcode"
  ABORT
```

\*\*\*\*\*

ADDR\_REG\_11\_9

```
* DISPLAY THE ADDRESS REGISTER FOUND IN BITS 11 THRU 9
  LOAD INITIAL_DATA          BE SURE THE INITIAL OPCODE IS LOADED
  ROTATE RIGHT,9            MOVE THE REGISTER FIELD TO 3 LSB
```

ADDR\_REG\_2\_0

```
  OUTPUT A
  GOTO REG_TYPE_SHOWN
```

DATA\_REG\_11\_9

```
* DISPLAY THE DATA REGISTER FOUND IN BITS 11 THRU 9
  LOAD INITIAL_DATA          BE SURE THE INITIAL OPCODE IS LOADED
  ROTATE RIGHT,9            MOVE THE REGISTER FIELD TO 3 LSB
```

DATA\_REG\_2\_0

```
  OUTPUT D
```

REG\_TYPE\_SHOWN

```
* DISPLAY THE REGISTER NUMBER FOUND IN THE REG FIELD (BITS 11 THRU 9)
  OUTPUT ACCUMULATOR,DEC1_FMT_3  DISPLAY THE REGISTER NUMBER
  LOAD INITIAL_DATA              RESTORE THE ORIGINAL OPCODE
  RETURN
```

\*\*\*\*\*

EXTENDED\_MATH

```
* DISPLAY "X", SIZE AND OPERANDS FOR ADDX AND SUBX INSTRUCTIONS
```

```

OUTPUT "X"
CALL SHOW_SIZE          DISPLAY THE OPERATION SIZE
CASE_OF 3,3
  SET MODE_FIELD,000B   SRC & DEST ARE DATA REG DIRECT MODE
  SET MODE_FIELD,100B   SRC & DEST ARE PREDEC ADDR IND MODE
CASE_END
CALL EA_DISP_MODE_SET   DISPLAY THE SOURCE OPERAND
ROTATE RIGHT,9         MOVE DESTINATION TO LOWER 3 BITS
OUTPUT COMMA
GOTO EA_DISP_MODE_SET   DISPLAY THE DESTINATION OPERAND

```

\*\*\*\*\*

#### MARK\_PREFETCH

```

*
* FOR INSTRUCTIONS THAT HAVE KNOWN, UNUSED PREFETCH STATES, FIND THE
* NEXT OPCODE STATE, THEN SEE IF ITS ADDRESS IS THE ADDRESS IMMEDIATELY
* FOLLOWING THE CURRENT INSTRUCTION. IF SO, THEN ITS UNUSED PREFETCH.
*
INPUT REL,PREFETCH_LOC,QUALIFIED  LOOK FOR THE NEXT PROGRAM READ STATE
CALL CHECK_FOR_BLOCK              DONT CROSS INVERSE ASSEMBLY BLOCK
IF INPUT_ERROR <> 0 THEN RETURN    NO MORE PROG READ STATUS STATES
LOAD REQUESTED_ADDRESS            ADDR OF STATE SUSPECTED TO HAVE UNUSED PREFETCH
ADD 2                             MOVE AHEAD TO POINT AT UNUSED PREFETCH
SUBTRACT INPUT_ADDRESS            SUBTRACT OFF THE CURRENT ADDRESS
IF 31,0 <> 0 THEN RETURN
TAG WITH UNUSED_PREFETCH
RETURN

```

\*\*\*\*\*

#### UNKNOWN

```

*
* THIS IS TO DISPLAY THE FUNCTION CODES OF UNKNOWN MEMORY CYCLES
*
OUTPUT "unknown ("
AND 01110000B
ROTATE RIGHT,4

```



```
OUTPUT ACCUMULATOR,BIN3_FMT
OUTPUT ")")
LOAD INPUT_STATUS
RETURN
```

\*\*\*\*\*

```
INT_ACK
```

```
*
```

```
* THIS ROUTINE CHECKS FOR INT_ACK OR CPU SPACE OPERATION
```

```
*
```

```
LOAD INPUT_ADDRESS
SET INT,TRUE
IF 23,4 <> INT_VAL THEN GOTO CPU
OUTPUT "int_ack"
LOAD INPUT_STATUS
RETURN
```

```
CPU
```

```
SET INT,FALSE
OUTPUT "cpu space"
LOAD INPUT_STATUS
RETURN
```

\*\*\*\*\*

**68010 Inverse Assembler**  
**C-40**

**HP 10391B IAL Development Package**  
**Reference Manual**

# Assembler Error Messages

## Detection and Listing

The assembler (ASM.EXE) detects and lists all errors noted in the source program. The program errors are indicated in the source program listing by a two-letter code following each source statement that contains an error.

### Note

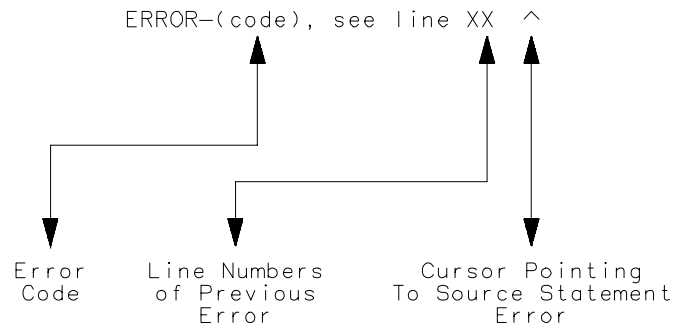


If multiple errors occur in the same source statement, generally only the first error noted will be reported.

Each error message contains an error code, a cursor (^ ^) that points to the error location in the source statement, and a statement that indicates the line number of the previous source statement that was in error to facilitate error tracing.

A summary of the number of errors within the program, along with a brief description of all error codes noted, is given at the end of the program listing.

The error message format is as follows:



10391M01

---

## Error Codes

A list of the error codes (in alphabetical order) along with a description of their meaning is shown below:

<b>Code</b>	<b>Error Definition</b>
AS	ASCII STRING - The ASCII string was terminated improperly.
DE	DEFINITION ERROR - Indicated symbol must be defined prior to it being referenced. Symbol may be defined later in the program sequence.
DS	DUPLICATE SYMBOL - Indicates that the defined symbol noted has been previously defined in the program assembly sequence.
ET	EXPRESSION TYPE - The resulting type of expression is invalid. Absolute expression was expected and not found.
IC	ILLEGAL CONSTANT - Indicates that the assembler encountered a constant that is not valid.  For example: 109B (9 is invalid)
IE	ILLEGAL EXPRESSION - Specified expression is either incomplete or an invalid term was found within the expression.
IO	INVALID OPERAND - Specified operand is either incomplete and inaccurately used for this operation. This occurs when an unexpected operand is encountered or the operand is missing. If the required operand is an expression, the error indicates that the first item in the operand field is illegal.

<b>Code</b>	<b>Error Definition</b>
IS	ILLEGAL SYMBOL - Syntax expected an identifier and encountered an illegal character or token.
MO	MISSING OPERATOR - An arithmetic operator was expected, but was not found.
MP	MISMATCHED PARENTHESIS - Missing right or left parenthesis.
SE	STACK ERROR - Indicates that a statement or expression does not conform to the required syntax.
TR	TEXT REPLACEMENT - Indicates that the specified text replacement string is invalid.
UC	UNDEFINED CONDITIONAL - Conditional operation code is invalid.
UO	UNDEFINED OPERATION CODE - Operation code encountered is not defined or the assembler does not allow the operation to be processed in its current context. This occurs when the operation code is misspelled or an invalid delimiter follows the label field.
US	UNDEFINED SYMBOL - The indicated symbol is not defined as a label.



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---

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