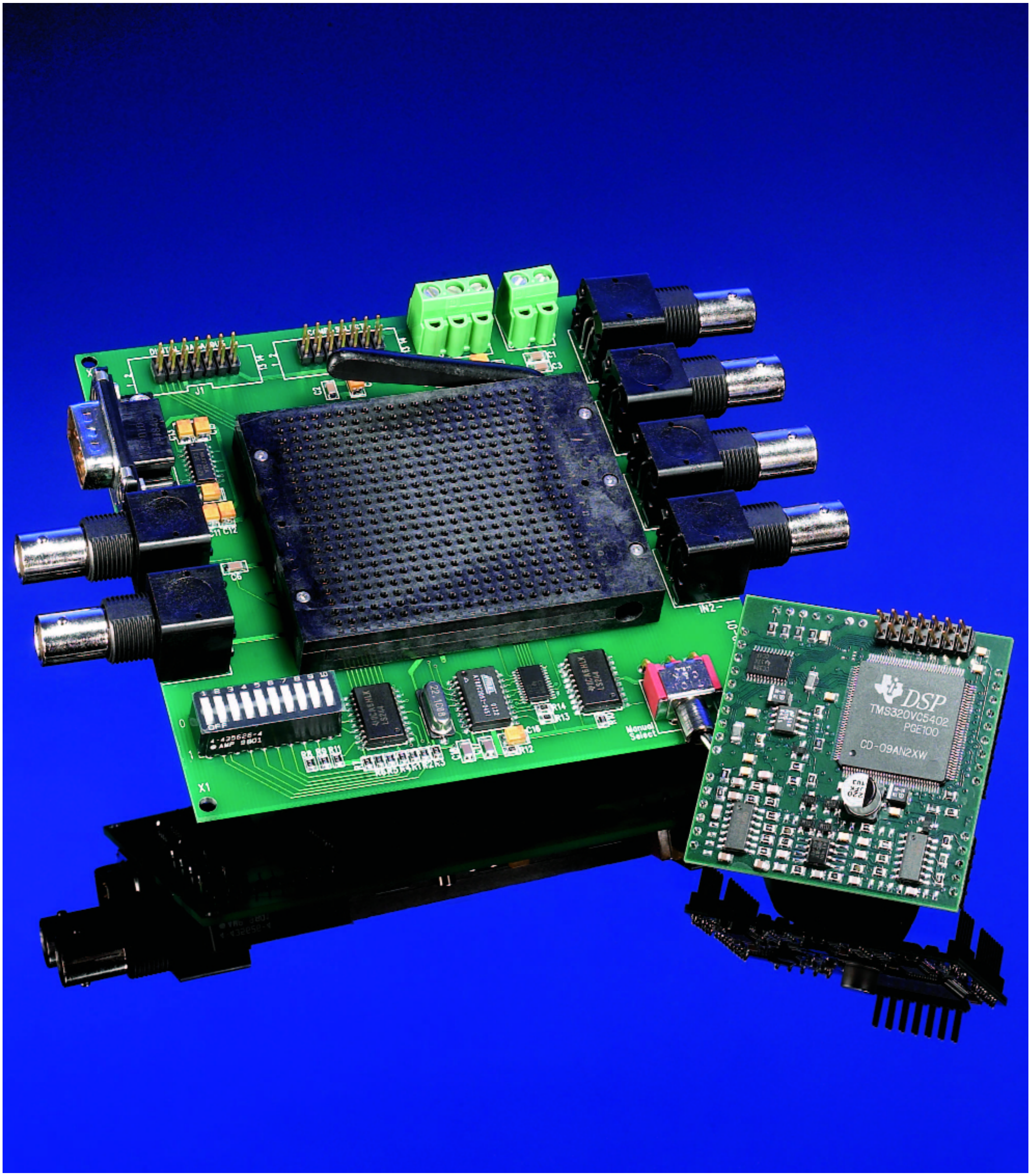
SPPDF 01 Development Suite
User's Manual

For SPPDM-01 FIR Filter Platform



SPPDF 01 Development Suite
User's Manual

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Chapter I Introduction

The **SPPDF-01** is a FIR Filter Design Suite for the SPPDM-01 dual channel, FIR filter platform with analog I/O that utilizes Frequency Devices MatLab™ GUI with MatLab™ V5.3 or MatLab™ V6.0.

The **SPPDF-01 Suite** consists of:

- An **SPPDM-01** dual channel signal processing platform containing a MatLab™ compatible FIR filter algorithm
- An **SPPDB-01** development board for the **SPPDM-01**,
- An **RS232, DB9** cable, and
- A CDRom with **CDDF-01** software containing this manual, data sheets for the SPPDF-01, SPPDM-01 and SPPDB-01, and the following utilities:
  1. **Filter Coefficient Generator (FCG) Software –** This FCG software provides coefficient data conversion for FIR filters in the frequency domain and generates sets of coefficients for single or multiple filters between 100 Hz and 20.0 kHz. From a set of specifications, FCG produces a data set that approximates the given filter characteristics in the frequency domain. The FCG software is a tool compatible with MatLab™ V5.3 or MatLab™ V6.0 and allows the user to evaluate and modify low-pass, high-pass, band-pass, and band-reject filters.
  2. **Filter Coefficient Loader (FCL) Software – FCL** software is the communication and translation interface that loads single or multiple sets of coefficients for various FIR filter types into the SPPDM-01 platform's flash memory implementing the direct application, physical realization, and usage of the FIR filters. Coefficient loading utilizes the RS232 interface on the SPPDB-01 development board to communicate with MatLab™ V5.3 or MatLab™ V6.0 FIR filter coefficient library files

Appendix C of this manual has information on how to add field programming capability. A circuit diagram is provided that may be added to the field application of the SPPDM-01 which emulates the SPPDB-01 development board and permits field loading of new filter coefficient sets.

1.1 Hardware Description

The SPPDM-01 has a double precision FIR filter algorithm programmed into its EEPROM that provides two channels of FIR filtering. Each channel is independently programmed and the FIR algorithm can be configured, shaped or altered in terms of; corner frequency, number of taps (shape factor) and filter type simply by loading different sets of coefficients. The FIR filter data comes from a dual 24-bit sigma-delta ADC on the SPPDM-01. This 24-bit data is left-shifted to automatically become a 32-bit double word. The on-board DSP reads a 32-bit coefficient set from Flash Memory for each channel according to the user's selection. Finally, the digital output of the DSP is filtered and fed sequentially into a dual 24-bit DAC for conversion of the now filtered analog signals. The 2 Megabits Flash Memory permits many coefficient sets to be stored and user addressed for maximum flexibility.

Many FIR filter types can be implemented with the DSP algorithm, provided the MatLab™ utility converges mathematically and the user stays within the 100 Hz to 20.0 kHz frequency range. The number of filter channel taps for each filter channel must be ≤ 300.

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Chapter I Introduction

See Figure 1 for SPPDF-01 hardware configuration:

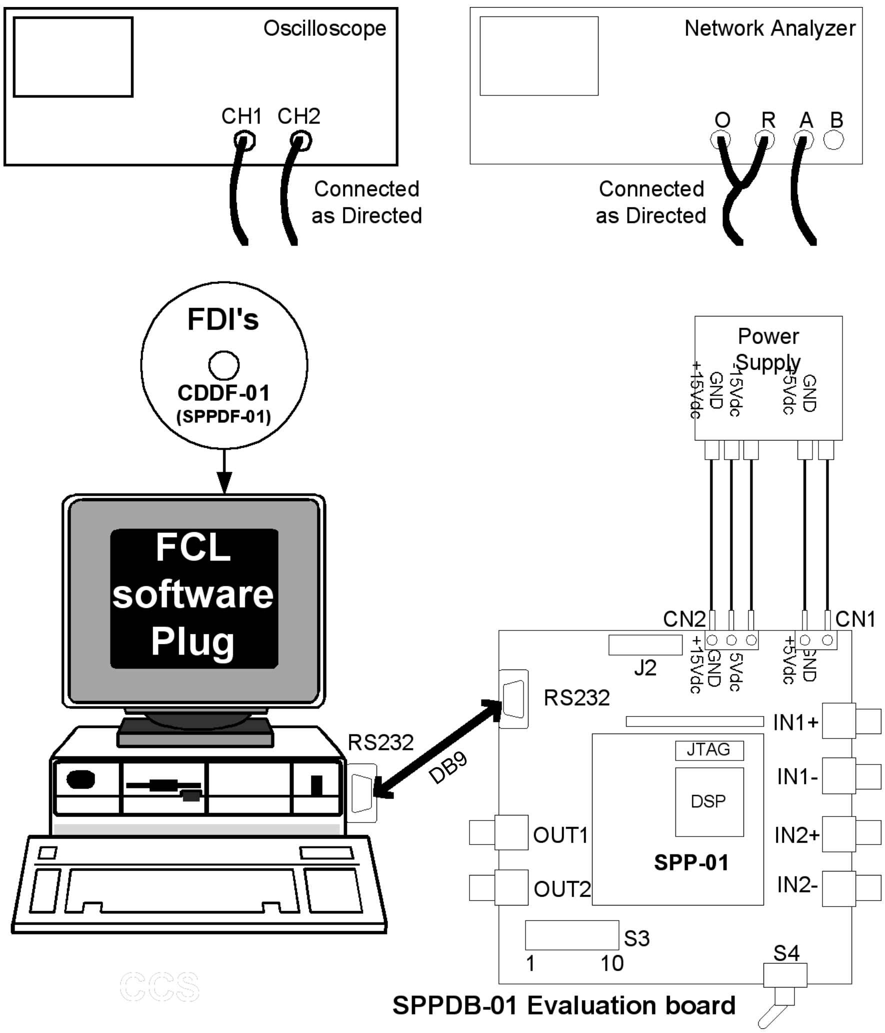

Figure 1 - SPPDF-01 Hardware Configuration

An oscilloscope is recommended for troubleshooting and a network analyzer is presented as an example of a frequency-magnitude, frequency-phase signal characteristic analyzer.

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1.2 Software Description

Users can define and configure filters using FREQUENCY DEVICES' **SPPDF-01 Filter Coefficient Generator (FCG)** software. The FCG - GUI is invoked from within the MatLab™ (User Supplied) environment and sends commands to the MatLab™ engine using the specific filter values loaded into the FCG – GUI. The MatLab™ engine responds to FCG commands and calculates coefficient sets for the indicated FIR filters. These coefficient sets are temporarily stored in the MatLab™ workspace environment. The filter response is displayed graphically within MatLab™ for verification of program convergence and acceptability. To prevent loss, the coefficients sets can be stored as files on the PC in a designated folder, before exiting MatLab™.

Note: the FCG software is provided as a convenience to the user. It is a tool to facilitate standard FIR filter design. Experienced MatLab™ users may design their own custom FIR filters for the SPPDM-01 using the appropriate MatLab™ FIR design tools, as long as SPPDF-01 design constraints are met.

Design constraints on the SPPDM-01 FIR Filter Platform are:

- Frequency Range: 100 Hz to 20 kHz
- Maximum Number of Taps: 300.

Note: Low-pass and high-pass filters are easily configured but some versions of band-pass and band-reject filters might not converge mathematically within some of the constraints. User may be required to try other parameter combinations until a converging implementation is found.

Chapter II of this document will be directed to MatLab™ users who wish to use Frequency Devices' FCG-GUI to design standard FIR filters for the SPPDM-01. The experienced MatLab™ filter designer may skip Chapter II and go right to **Chapter III**, the Filter Coefficient Loader (FCL) section.

The FCG software is a design tool for FIR filters to be used within the MatLab™ environment. The FCG software provides for the entry of specific filter parameters into the MatLab™ environment allowing the MatLab™ engine to calculate coefficients that approximate the given filter descriptions.

User must first determine filter type, followed by selection of various specification parameters. Based on the selected values, MatLab™ creates a best approximation set of coefficients. This set of coefficients corresponds to a single or multiple number of filters and may be managed in two modes: Immediate and Batch.

- **Immediate Mode** of operation relies on the MatLab™ workspace to present the set of coefficients as an ***M x N*** matrix where **M** is the number of filters and **N** is the number of coefficients for each filter. **See Appendix A - Examples 2 and 3.**
- **Batch Mode** of operation creates a text batch file where the system saves the set of coefficients uniquely identified by the various filters. **See Appendix A – Examples 4 and 5.**

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2.1. FCG Installation and Startup:

Install the FCG software by inserting the CDDF-01 disk into the PC, CDRom drive.
Select the drive in Explorer or use the RUN menu.
CLICK on the Filter Coefficient Generator folder, then
CLICK on "SETUP" and follow the instructions on the installation window.

After installation of the software, two shortcuts will be inserted on the desktop, namely FCG and FCGScript. Configure the software to run under the installed version of MatLab™ by running the FCGConfig file located under the FCG directory, Program Files in the Windows directory. The FCGConfig program will ask and set the location of your MatLab™ engine file: matlab.exe.

After configuring the environment, **DOUBLE CLICK** on the new short cut called FCG on the PC desktop to start the program.

The experienced user may skip the above steps by loading the MatLab™ environment, going to the specific directories, and making the necessary initializations and M-file calls from within MatLab™. This will automatically invoke the FCG main panel GUI.

2.2 FCG GUI Control Group Descriptions

The components of the main panel are shown in the **Figure 2** below:

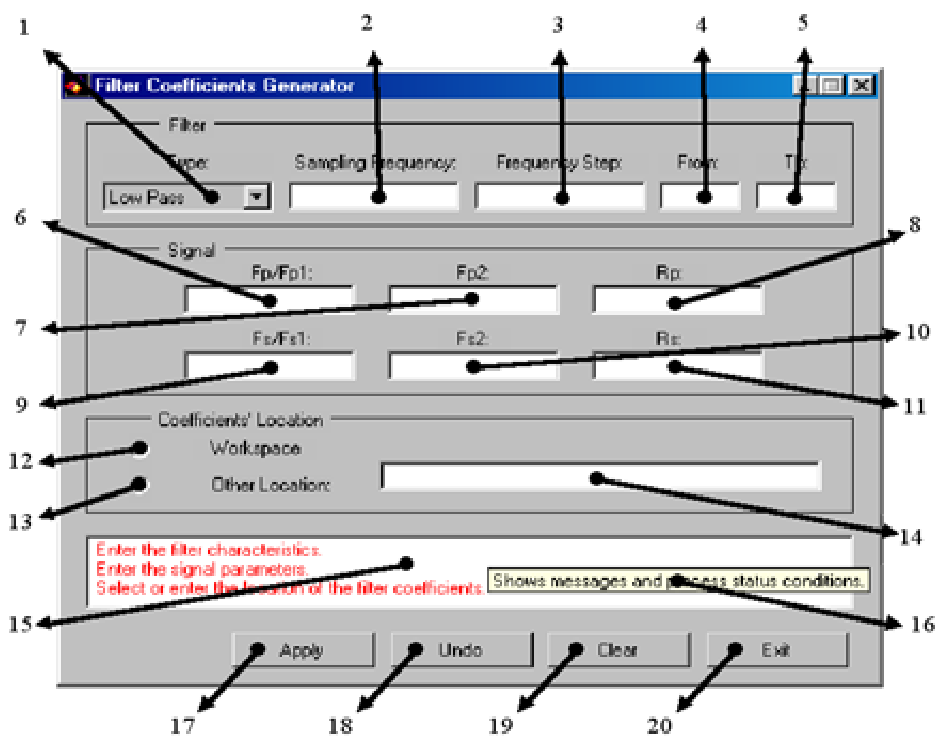

Figure 2 – Filter Coefficient Generator Main Panel

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The main panel GUI is divided into five functional groups. **Note: All entries or selections must be completed in all groups before the "Apply" command (which initiates the filter coefficient generation) is executed.**

2.2.1 Group A, Filter (Items 1 - 5) - contain the controls necessary to specify the parameters used in the generation of sets of coefficients for single or multiple filters over a predefined bandwidth.

1. **Filter Type List Control:** Is used to select filter type. Select *Low-Pass, High-Pass, Band-Pass* or *Band-Stop*. The default value shown at startup is *Low-Pass*. When selecting *Low-Pass* or *High-Pass Filter Type*, the Second Pass-band Cutoff Input Control (Fp2) and the Second Stop-band Cutoff Input Control (Fs2) will be disabled.
2. **Sampling Frequency Input Control:** Specifies the sampling frequency. Sampling frequency must be entered. **Required sampling rate for the SPPDM-01 family of products is always 48000Hz.**
3. **Frequency Step Input Control:** Enters a constant that represents the frequency steps for the generation of the sets of filter coefficients over the bandwidth for a particular filter. Since there is a limit to the maximum number of steps, small step sizes may limit bandwidth. The Frequency Step (Fstep) represents a positive number limited by SPPDM-01 family parameters such as the Maximum Bandwidth (MB) (100 to 20,000 Hz) and the Maximum Number of Filters (MNF = 512). For a specific filter, the Per Step Maximum Number of Filters (PSMNF) is calculated to be PSMNF = MB / Fstep. This value must be greater than one and less than MNF. The frequency step value is meaningless when only one set of filter coefficients is generated. **A valid Fstep must be entered.**
4. **From:** Range Input Control is used to enter a numeric value for the lowest bandwidth limit. It represents the starting point in the generation of the sets of filter coefficients. The **"To"** (Item 5) is enabled when a valid number is entered into **From**. The number must be between 1 and the MNF of 512.
5. **To:** Range Input Control enters a numeric value for the highest bandwidth limit. It represents the end point used in the generation of the sets of filter coefficients. The number must be between 1 and 512 for the frequency step. The number must be equal or greater than the **"From"** number (Item 4). This control remains disabled until a valid **From** value is entered. Then a valid **To** value can be entered.

2.2.2 Group B, Signal (Items 6 - 11) - are the controls used to input the relative specifications for the filter(s) described in Group A.

6. **Fp/Fp1: First Pass-band Cutoff Input Control** enters a numeric value interpreted as Pass-band Cutoff Frequency (Fp in Hz) for low-pass and high-pass type filters and as First Pass-band Cutoff (Fp1) frequency for band-pass and band-stop type filters.
7. **Fp2: Second Pass-band Cutoff Input Control** enters a numeric value interpreted as Second Pass-band Cutoff Frequency (Fp2 in Hz) for band-pass and band-stop type filters. This control is enabled only when the Filter Type **(Item 1, Figure 1)** selected is either *Band-Pass or Band-Stop*.

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8. **Rp: Pass-band Ripple Input Control** enters a numeric value interpreted as the Pass-band Ripple (Rp in dB) for every type of filter selected. When entering values, a good ripple value is one that produces convergence in the FIR coefficient generation algorithms when combined with the other relative specifications. Common values of ripple for convergence are from 0.01 to 0.1 dB.
9. **Fs/Fs1: First Stop-band Cutoff Input Control** enters a numeric value interpreted as Stop-band Cutoff Frequency (Fs in Hz) for low-pass and high-pass type filters and as First Stop-band Cutoff Frequency (Fs1) for band-pass and band-stop type of filters.
10. **Fs2: Second Stop-band Cutoff Input Control** enters a numeric value interpreted as Second Stop-band Cutoff Frequency (Fs2 in Hz) for band-pass and band-stop type of filters. This control is enabled only when the Filter Type (**Item 1, Figure 1**) selected is either *Band Pass* or *Band Stop*.
11. **Rs: Stop-band Attenuation Input Control** enters a numeric value interpreted as the Stop-band Attenuation (Rs in dB) for every type of filter selected. The stop-band attenuation must be less than or equal to the maximum bandwidth. **Valid stop-band attenuation must be entered.**

2.2.3 Group C, Coefficient Location (Items 12 - 14) - manages the two available modes of operation: Immediate mode and Batch mode.

12. **Workspace: CLICK** this button whenever the set/sets of filter coefficients are to be dumped into the MatLab™ Workspace. This provides immediate access of the coefficients through a matrix data structure in the workspace. User may want to initialize an **M x N** matrix variable that will contain the coefficient data where **M** is the number of filters and **N** is the number of coefficients per filter. **Note: data will be lost if the workspace is cleared, or in quitting the MatLab™ environment without saving the variable contents.**
13. **Other Location: CLICK** this button whenever the set/sets of filter coefficients are to be down loaded to a specific text file. This provides access to the coefficients at a later time. For example, the file may be accessed and its contents read into a matrix structure in the workspace. The inexperienced user should use this mode of operation when attempting to use the FCG - FGL setup. The experienced user may accomplish every task from within MatLab™, allowing the use of the systems in immediate mode. Selecting this control enables the **Batch Mode Input Control Window** next to the **Other Location** button.
14. **Batch Mode Input Control Window:** This window is enabled whenever the **Other Location** button is selected. This window allows entry of files from any other location different from the MatLab™ workspace. Complete pathname must be entered for the file destination. **The name of the file must have the "*.coe*" suffix, otherwise it will not be validated.** The file created will identify each set of coefficients using the following format: filt1 tab-character coefficient1 tab-character coefficient2 tab-character … coefficientN newline filt2 …

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2.2.4 Group D, Message (Items 15 - 16) - contains an indicator that shows system status, and generation process information at specific instances. This group also presents controls' (tooltips) about functional characteristics.

15. **Message Text Box Window:** This window continuously shows messages and process status conditions. It provides next step usage indications to help user/system interaction. It serves as a tool to obtain information about the system status and the coefficients generation process.
16. **Tooltip Indicator:** Placing the cursor over any message or status line in the window, will produce a drop down text with an explanation. To obtain next step; process instructions, controls, indicator purpose, functions, or descriptions, place cursor over any control or indicator in the FCG panel. This tool is used to learn about a control or indicator function before its use.

2.2.5 Group E, Command (Items 17 - 20) - allows the user to initiate certain process/system commands.

17. **Apply:** Using this command button starts the filter generation process using the entered group of parameters. It also initiates plots of filter amplitude and phase for each set of coefficients generated. The command enables execution only after appropriate parameters have been entered and validated. After completion, it sends the coefficients to the location specified in the **Coefficients' Location Group (Group C, Items 12, 13 and 14).**
18. **"Undo" & 19. "Clear" Command Buttons:** These command buttons are "dummy" buttons. They are for features yet to be implemented. They are provided as tools for an experienced programmer who wishes to add commands to start a specific sequence of instructions. Their default function is to present a message to the user.
20. **Exit:** Use this command button to exit the software. It closes any open windows and quits the FCG system. The MatLab™ environment may continue to be used after exiting the FCG software.

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Chapter III Filter Coefficient Loader

The Filter Coefficients Loader (FCL) Software is a tool that performs the interface, communication, translation, and formatting functions for single or multiple sets of coefficients and different filter types for loading into an SPPDM-01 platform using the SPPDB-01 development board. The FCL also reformats and initiates the translation of FIR filter coefficient data into a format that is recognized by the SPPDM-01 hardware as coefficients that influence the imbedded FIR filter algorithm.

FCL allows the user to issue a single command to select and load mode of operation, serial communication parameters, and filter addresses in memory space. The user starts the process that implements the SPPDB-01, RS232 serial communication port, using a translation-formatter to transform the "raw" coefficient data into FIR specifications recognized by the SPPDM-01 FIR filter algorithm. For this to occur, the FCL uses a "software plug" **(see Appendix B)** that groups a set of dynamically linked subroutines for translation formatting of coefficient data into a recognizable pattern of information. It also uses a graphical user interface that implements a serial communication protocol for the loading of coefficients into the SPPDM-01.

The FCL's role in FIR design and application is to provide the means for the filter coefficients generated, from relative specifications, to be interpreted as valid frequency-magnitude/frequency-phase characteristics by the SPPDM-01. This allows performance of real time analysis, experiments, decision-making, etc. in an easy, fast, reliable and repeatable way.

3.1 Equipment Required:

Provided by Frequency Devices

3.1.1 SPPDF-01 FIR Filter Development Suite
- SPPDM-01 FIR filter platform
- SPPDB-01 Design/Development Board

3.1.2 Filter Coefficients Generator and Loader Software Installation Disk, CDDF-01

3.1.3 RS232 cable and connectors, provided with SPPDF-01

Provided by Customer

3.1.4 PC Test Station (Windows 9x or more) MatLab™ V5.3 or higher

3.1.5 ±15Vdc, +5Vdc Power Supply

3.2 Installation and Startup:

To install the FCL software, insert the CDDF-01 disk provided with the Development Suite in the appropriate CDRom drive.
- Select the Filter Coefficient Loader folder
- RUN setup and follow instructions on the installation window.

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Chapter III Filter Coefficient Loader

After installation of the software, two shortcuts are inserted on the desktop, namely FCL and FCLScript. The software must be configured to run under the installed version of MatLab™ by running the FCLConfig file located under the FCG directory Program Files in the Windows directory. The FCLConfig program will ask and set the location of the MatLab™ engine file: matlab.exe. After configuring the environment, DOUBLE CLICK on the new short cut called FCL on the PC desktop to start the program.

The experienced user may skip the above steps by loading the MatLab™ environment, going to the specific directories, and making the necessary initializations and M-file calls from within MatLab™. This will automatically invoke the FCL main panel GUI.

3.3 FCL GUI Main Panel:

The components of the FCL, GUI Main Panel are shown in the **Figure 3** below:

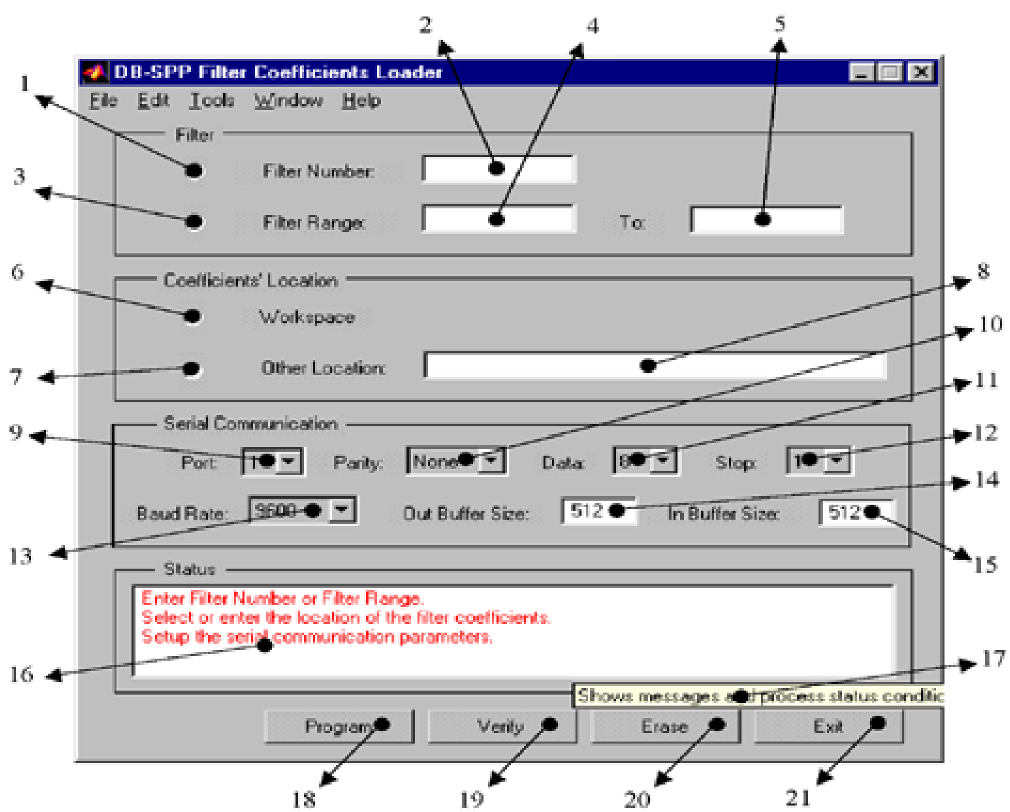

Figure 3 - Filter Coefficient Loader GUI Main Panel

The main panel is divided into five functional groups. **Note: All entries or selections must be completed in all groups before the "Program" command (Item 18) is executed.**

3.3.1 Group A, Filter (Items 1 - 5) - contains the controls necessary to specify the parameters used for loading sets of coefficients for single or multiple filters over a predefined bandwidth.

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1. **Filter Number:** CLICK on this control whenever a *single* set of coefficients is to be loaded into the SPPDM-01 external memory. Selecting this control enables the **Filter Number Input Control Window (Item 2).**
2. **Filter Number Input Control Window:** This control is enabled whenever the Filter Number Selector is used. This control allows entry of the numeric value that identifies a single set of coefficients as the taps for a specific filter. The number must be between 1 and 512, the maximum number of filters (MNF) allowed.
3. **Filter Range:** CLICK on this control whenever *multiple* sets of coefficients need to be loaded into the SPPDM-01 external memory. Selecting this control enables the **Filter Range (From) Input Control (Item 4).**
4. **Filter Range (From) Input Control:** This control is enabled whenever the **Filter Range** is selected. With this control the user enters a numeric value representing the lowest filter identification number to load. It represents the starting point identifying the multiple sets of coefficients as the taps for a specific group of sequentially positioned filters. The number must be between 1 and 512, the MNF allowed.
5. **Filter Range (To) Indicator:** This indicator shows a numeric value representing the highest filter identification number LOADED. It represents the end point, identifying the multiple sets of coefficients as the taps for a specific group of sequentially positioned filters. **The number must be between 1 and 512, the MNF allowed.** The **Filter Range (To)** number must be equal or greater than the **Filter Range (From)** number.

3.3.2 Group B, Coefficients' Location (Items 6 - 7): Manages the immediate and batch modes of operation.

6. **Workspace:** CLICK on the "Workspace" button to enable the **Immediate Mode.** This allows the set or sets of filter coefficients to be loaded from the MatLab™ Workspace and immediately accesses the coefficients through a matrix data structure (See Chapter II, Item 12). The FCG software may produce the matrix data. **Note: Data is lost 1) if the workspace is cleared, or 2) quitting the MatLab™ environment without saving the variable contents.**
7. **Other Location:** CLICK the "Other Location" button to enable the **Batch Mode** window. This will allow a set or sets of filter coefficients to be loaded from a specific text file into the SPPDM-01. Selecting this control enables the **Batch Mode Input Control Window (Item 8).**
8. **Batch Mode Input Control:** This control window becomes active whenever the **Batch Mode Selector** "Other Location" is selected. Use this window to enter any other location different from the MatLab™ workspace. The complete path-name for the file destination must be entered. **The name of the file must have the "*.coe*" suffix, otherwise it will not be validated.** The workspace variable created specifies the set of coefficients as an **M x N** matrix. Variable **M** is the number of filters and **N** is the number of coefficients per filter.

3.3.3 Group C, Serial Communication (Items 9 – 15): presents the controls used to set and enter the parameters that control the serial communication protocol.

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9. **Port:** Use this control to select the communication port through which data will flow. Select a number starting from 1 for the communication port one up to 32 for the communication port thirty-two. The selection must be made before the loading of coefficients is started. The default value shown at startup is 1. See the operating system's manuals for the PC for instructions on how to configure higher number ports.
10. **Parity:** Use this control to select the parity mode for the selected communication port. **For the SPPDF-01 parity must be "*None*".** Select None for no parity,
11. **Data:** Use this control to select the number of data bits for the selected communication port. **For the SPPDF-01 the data (bits) must be set to "8".**
12. **Stop:** Use this control to select the number of stop bits for the selected communication port. **For the SPP environment the stop (bits) must be "1".**
13. **Baud Rate:** Use this control to select the baud rate for the selected communication port. **For the SPPDF-01 environment the baud rate must be set to "9600".**
14. **Out Buffer Size:** Use this control to enter a numeric value that specifies the size of the output queue for the selected communication port. This number is not limited to a specific range of values. **A valid output buffer size value must be entered before the loading of coefficients.** Default is 512 bytes.
15. **In Buffer Size:** This control enters a numeric value that specifies the size of the input queue for the selected communication port. This number is not limited to a specific range of values. A valid input buffer size value must be entered before the loading of coefficients. Default is 512 bytes.

3.3.4 Group D, Message Group (Items 16 – 18): contains an indicator that shows system status, and generation process information for specific cases. This group also presents controls' (tooltips) about functional characteristics and a progress bar for relative process completion at specific instances.

16. **Message Text Box:** This window continuously shows messages and process status conditions. It presents next step usage messages to aid with user-system interaction. It serves as a tool to obtain sequential information about the system status and coefficient loading process.
17. **Tooltip Indicator:** Position the cursor on top of a status line or message in the status window to obtain next step process instructions in a drop down text box. Putting the cursor over any control or indicator in the FCL, GUI panel provides a short description of that control. Use this tool to learn about the control or indicator function before it is used.

3.3.5 Group E, Command Group (Items 18 – 21): allows the user to initiate certain process/system commands.

18. **Program Command Button:** This command button starts the filter set/sets of coefficient loading process utilizing the selected parameters. This starts the translation, formatting and loading process through the **"*software plug (Appendix B)*".** After successful completion, the coefficients will reside in the SPPDM-01 external memory. This command will only execute after all required parameters have been entered and validated.

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19. **"Verify" & 20. "Erase":** These command buttons are "dummy" buttons. They are for features yet to be implemented. They are provided as tools for the experienced programmer who wishes to add commands to start a specific sequence of instructions. Their default function is to present a message to the user.
21. **Exit:** Use this command button to exit the software. It closes any open panels and quits the FCL system. The MatLab™ environment may continue to be used after exiting.

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Appendix A - Example 1

SPPDB-01 Manual FIR Filter Selection

For **Manual FIR Filter Selection** a 10-bit DIP-switch on the SPPDB-01 is used to select a filter to run for each SPPDM-01 channel. It is designated as D_0 to D_9, where D_9 is the most significant bit (MSB), while D_0 is the least significant bit (LSB). In the SPPDF-01 Suite, D_9 is used as a channel selection bit (Channel 1 (0) and Channel 2 (1)). D_0 to D_8 are used as frequency selection bits. The DSP checks the switch status at the rate of 48 kHz. If the status has changed, the DSP follows these steps:

- Check D_9 bit. If D_9 is '0', the filter number selection is set for channel one (1), if D_9 is '1', the filter number selection is set for channel two (2).
- Extract bits D_0 to D_8 and get the filter setting number.
- According to the filter number, calculate the coefficient set address in flash memory.
- Copy the coefficient set into the DSP internal memory.
- Run with new coefficients.

With 9-bit tuning (D_0 thru D_8), up to 512 different filter numbers (coefficients) can be selected for each channel on SPPDM-01. Although the FCG can create 1 to 682 sets of filter coefficients at one time, only the first 512 sets are accessible. To select a filter number, set D_0 to D_8 according to the following formula.
$FN=1+D_0+D_1*2+D_2*4+D_3*8+D_4*16+D_5*32+D_6*64+D_7*128+D_8*256$. Where **FN** means Filter Number.

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Appendix A - Example 2

FCG Immediate Mode Operation Single Set Coefficient

1. Open MatLab™ and initialize a global variable in the MatLab™ workspace called coefficients. Set the format to ***long*** for better representation of the results.

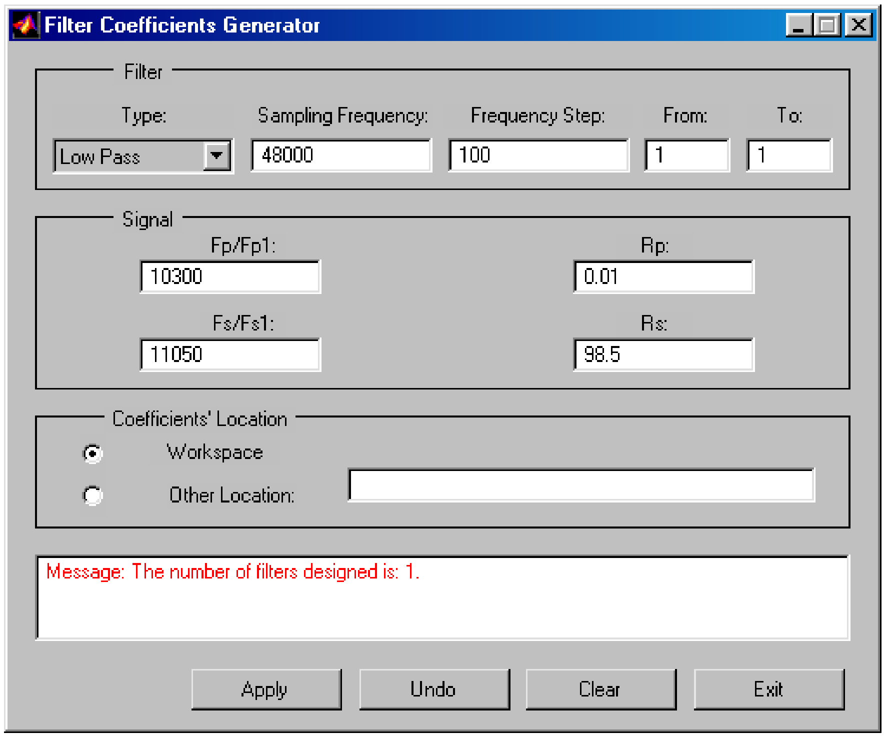

Figure 4 – Filter Coefficient Generator Display,
Immediate Mode Operation - Single Coefficient Set

2. **Initiate the FCG by clicking on the desktop icon.** On the GUI, under **"Filter Type"** select ***Low Pass*** as the filter. Notice that the Second Pass-band Cutoff Input Control and the Second Stop-band Cutoff Input Control are disabled and no longer visible.
3. **Sampling Frequency:** Enter ***48000 (Hertz)*** as the sampling frequency. This value is constant for the SPPDM-01 family of products. Remember to **drop units (Hertz)** when entering this and the following parameters
4. **Frequency Step:** Enter ***100*** as the frequency increment between sets of coefficients.
5. **From: - Enter the (Range) From Value:** Enter ***1*** as the lowest filter number.
6. **To: - Enter the (Range) To Value:** Enter ***1*** as the highest filter number. This will generate only one set of filter coefficients for the type selected. This also makes the Frequency Step value meaningless.
7. **Fp/Fp1 - Enter the Pass-band Cutoff Frequency:** Enter ***10300*** (Hertz) as the pass-band cutoff frequency.
8. **Rp - Enter the Pass-band Ripple:** Enter ***0.01*** (dB) as the pass-band ripple.

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9. **Fs/Fs1 - Enter the Stop-band Cutoff Frequency:** Enter ***11050*** (Hertz) as the stop-band cutoff frequency.
10. **Rs - Enter the Stop-band Attenuation:** Enter ***98.5*** (dB) as the Stop band Attenuation. Drop the negative sign when entering this parameter.
11. **Select MatLab™ Workspace:** CLICK on the workspace location control for immediate mode of coefficients generation.
12. **Generate the Coefficients:** CLICK on ***Apply*** to start the immediate mode of coefficients generation process and send the set of coefficients to the MatLab™ workspace. This also starts the Amplitude/Phase Plot shown in **Figure 5** below:

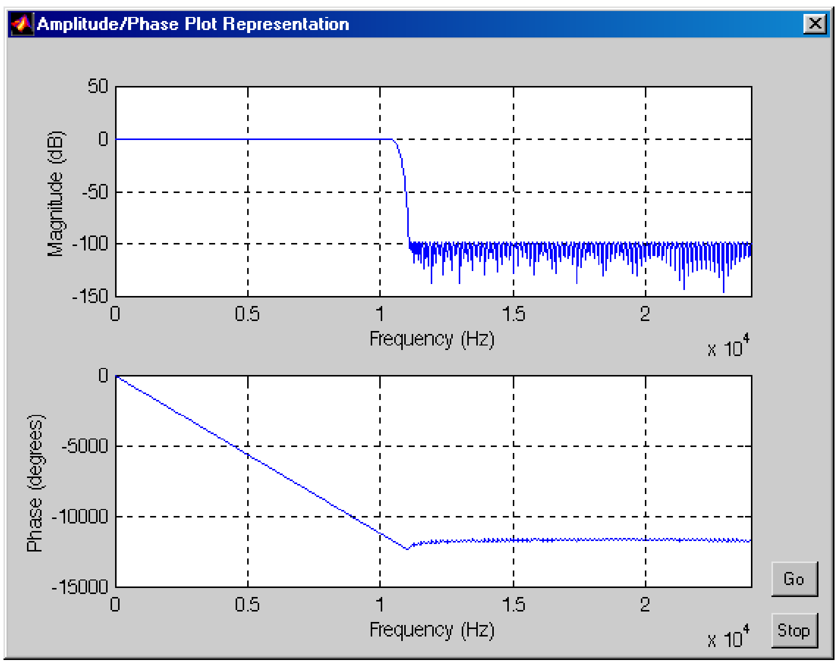

Figure 5 - Amplitude/Phase Plot – Immediate Mode Operation, Single

12.1. **Frequency-Magnitude (Hz-dB) Characteristics Plot:** Shows the frequency-magnitude characteristics graph for the set of coefficients generated for the filter and allows design decisions to be made for actual FIR filters designed from the set of entered parameters.

12.2. **Frequency-Phase (Hz-degrees) Characteristics Plot:** Presents the frequency-phase characteristics plot representation for the entered set of filter coefficients. The graph shows the user the ideal frequency-phase representation.

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12.3. Go Command Button: CLICK ***Go*** and the plot panel window will close and execution will return to the main panel.

12.4. Stop Command Button: CLICKING **Stop** will close the plot panel window and return user to the main panel.

13. **Note:** CLICK ***Go*** command button after inspecting the amplitude/phase characteristics representations to close the plot panel window and return to the main panel. You may also CLICK the **Stop** command button to get to the main panel. The Message indicator shows the number of filters designed. For this example it is one (1).
14. **Inspect results:** At the MatLab™ environment prompt type: ***whos***. The system will respond with the information for the ***coefficients*** variable:

Name	Size	Bytes	Class
coefficients	**1x299**	**2392**	**double array (global)**

Grand total is 299 elements using 2392 bytes

IMPORTANT

Remember: When clearing or quitting the workspace, the coefficients data will be lost unless the variables are saved to the workspace. After saving them, the coefficients may be used as desired: i.e. loading into the SPPDM-01 platform, mathematical transformation, inspection, etc. Follow MatLab™'s and the FCL's instructions for performing these tasks.

References:

1.1. The Mathworks, Using MatLab™ Graphics
1.2. The Mathworks, Building GUI's with MatLab™
1.3. The Mathworks, Using MatLab™
1.4. The Mathworks, MatLab™ Function Reference
1.5. The Mathworks, Application Program Interface (API) Guide
1.6. The Mathworks, Application Program Interface (API) Reference
1.7. SPPDF-01 Operation/User Manual
SPPDB-01 Specifications Sheets

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1. Open MatLab™ and load into the initialize a global variable in the MatLab™ workspace called coefficients. Set the format to ***long*** for better representation of the results. Initialize this variable by loading the values obtained from the FCG software or any other coefficient generating software. The experienced user may find it easier to work within the MatLab™ environment with both, FCG and FCL, without quitting MatLab™.

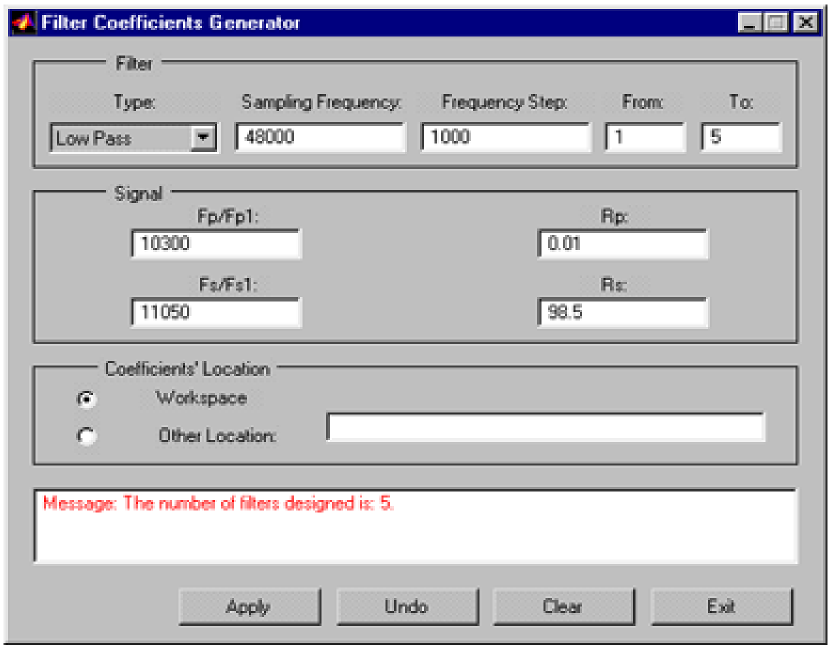

Figure 6 – Filter Coefficient Generator Display, Immediate Mode Operation – Multiple Coefficient Sets

2. **Initiate the FCL by clicking on the desktop icon.** On the GUI, under "**Filter Type**" select ***Low Pass*** as the filter. Notice that the Second Pass-band Cutoff Input Control and the Second Stop-band Cutoff Input Control are disabled and no longer visible. An experienced user may continue to use MatLab™ if already opened, by starting the M-file that initialized the FCL-GUI.
3. **Sampling Frequency:** Enter ***48000 (Hertz)*** as the sampling frequency. This value is constant for the SPPDM-01 family of products. Remember to drop units (Hertz) when entering this and the following parameters
4. **Frequency Step:** Enter ***1000*** as the frequency increment between sets of coefficients.
5. **From: - Enter the (Range) From Value:** Enter ***1*** as the lowest filter number.
6. **To: - Enter the (Range) To Value:** Enter ***5*** as the highest filter number. This will generate five (5) sets of filter coefficients for the type selected. The sets are created in steps specified in the Frequency Step control.
7. **Fp/Fp1 - Enter the Pass-band Cutoff Frequency:** Enter ***10300*** (Hertz) as the pass-band cutoff frequency. 8. Rp - Enter the Pass-band Ripple: Enter 0.01 (dB) as the pass-band ripple.

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8. **Rp - Enter the Pass-band Ripple:** Enter ***0.01*** (dB) as the pass-band ripple.
9. **Fs/Fs1 - Enter the Stop-band Cutoff Frequency:** Enter ***11050*** (Hertz) as the stop-band cutoff frequency.
10. **Rs - Enter the Stop-band Attenuation:** Enter ***98.5*** (dB) as the Stop-band Attenuation. Drop the negative sign when entering this parameter.
11. **Select MatLab™ Workspace:** CLICK on the workspace location control for immediate mode of coefficients generation.
12. **Generate the Coefficients:** CLICK on ***Apply*** to start the immediate mode of coefficients generation process and send the set of coefficients to the MatLab™ workspace. This also starts the Amplitude/Phase Plot shown in **Figure 7** below:

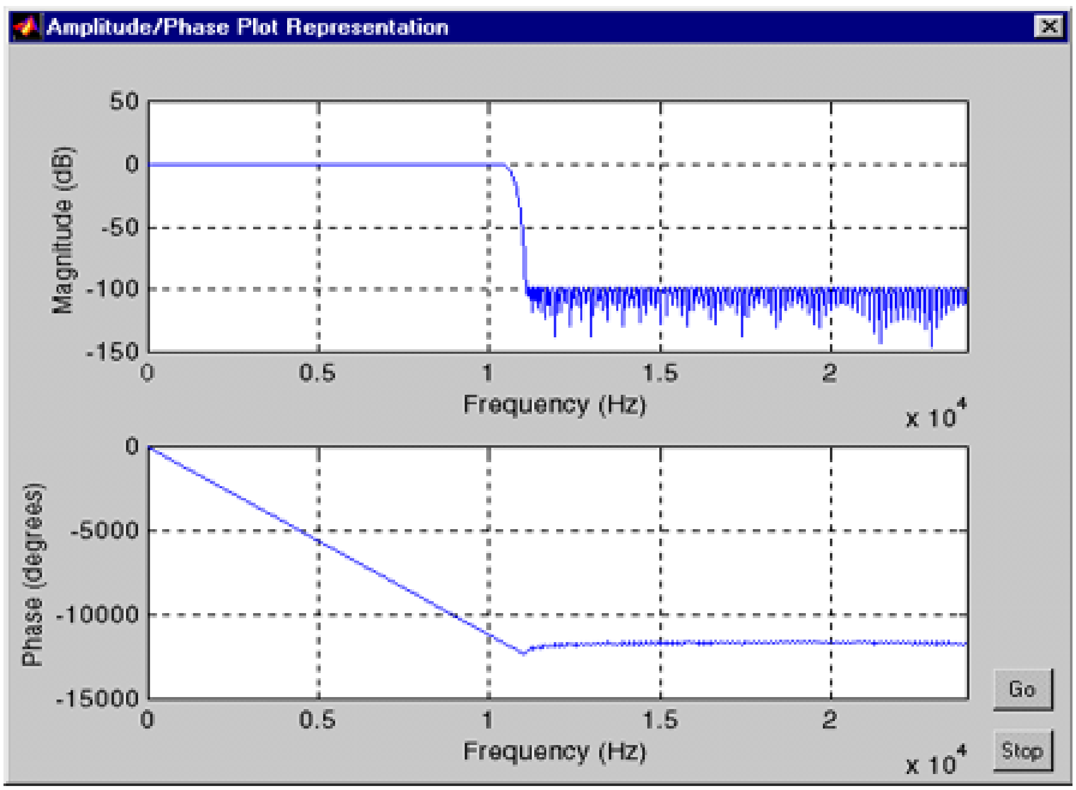

Figure 7 - Amplitude/Phase Plot – Immediate Mode Operation
(First plot in a multiple number of plots)

13. **Go:** CLICK the ***Go*** command button after inspecting the amplitude/phase characteristics, to close the plot panel window and return to the main panel. The ***Stop*** command button may also be clicked to return to the main panel. The Message indicator shows the number of filters designed.

14. **Inspect results:** At the MatLab™ environment prompt, type: ***whos***. The system will respond with the information for the ***coefficients*** variable:

Name	Size	Bytes	Class
coefficients	**5x299**	**11960**	**double array (global)**

Grand total is 1495 elements using 11960 bytes

IMPORTANT

Remember that, when clearing or quitting the workspace, the coefficients data will be lost unless the variables are saved to the workspace. After saving them, the coefficients may be used as desired: i.e. loading into the SPPDM-01 platform, mathematical transformation, inspection, etc. Follow MatLab™'s and the FCL's instructions for performing these tasks.

References:

1.1. The Mathworks, Using MatLab™ Graphics
1.2. The Mathworks, Building GUI's with MatLab™
1.3. The Mathworks, Using MatLab™
1.4. The Mathworks, MatLabTM Function Reference
1.5. The Mathworks, Application Program Interface (API) Guide
1.6. The Mathworks, Application Program Interface (API) Reference
1.7. SPPDF-01 Operation/User Manual
1.8. SPPDB-01 Specifications Sheets

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Appendix A - Example 4

FCL Batch Mode Operation Single Set Coefficient

1. Initialize a global variable in the MatLab™ workspace called ***coefficients***. Set the format to ***long*** for better representation of the results.

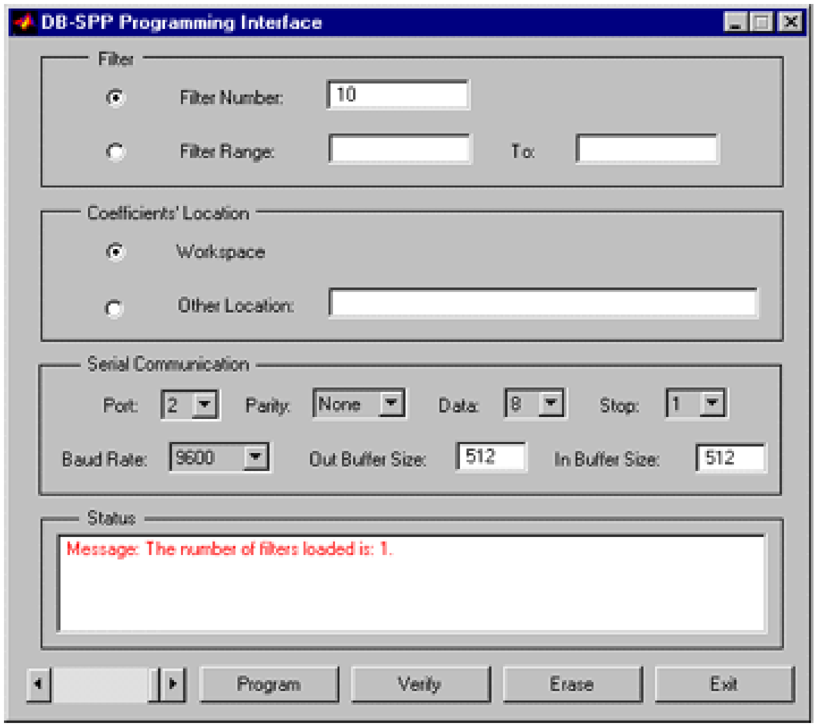

Figure 8 – FCL Display, Single Set Coefficient, Batch Mode Operation

2. **Select Filter Number:** CLICK on the ***Filter Number*** control for loading of a single set of coefficients.
3. **Enter the Filter Number:** Enter ***10*** to identify the filter and specify its location in memory as the tenth one.
4. **Select MatLab™ Workspace:** CLICK on the workspace location control to load the coefficients directly from the workspace.
5. **Select the communication port:** Select ***2*** as the communication port.
6. **Select the Parity:** Select ***None*** as the parity for the selected communication port. This value is constant for the SPPDM-01 family of products.
7. **Select the Data (Bits) Number:** Select ***8*** as the number of data bits for the selected communication port. This value is constant for the SPPDM-01 family of products.
8. **Select the Stop (Bits) Number:** Select ***1*** as the number of stop bits for the selected communication port. This value is constant for the SPPDM-01 family of products.
9. **Select the Baud Rate:** Select ***9600*** as the baud rate for the selected communication port. This value is constant for the SPPDM-01 family of products.
10. **Enter the Out(put) Buffer Size:** Enter ***512*** (bytes) as the size of the output buffer for the selected communication port. Remember to drop the units when entering this parameter.

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11. **Enter the In(put) Buffer Size:** Enter ***512*** (bytes) as the size of the input buffer for the selected communication port. Remember to drop the units when entering this parameter.
12. **Load the single set of Coefficients:** CLICK ***Program*** to start the loading process of the single set of coefficients from the workspace into the SPPDM-01's external memory location. A popup window with a bar will indicate an active system condition. After a few seconds of data translating and formatting, the **Software Plug (Appendix B)** takes over and starts the communication protocol.
    Wait for the communication protocol process to finish. After successful completion of the loading process, the workspace will show successful memory verification. The ***Message*** indicator will show the number of filters loaded. For this example it is one (1).
13. **Inspect results:** At the MatLab™ environment prompt type: ***whos.*** The system will respond with the information for the ***coefficients*** variable:

Name	Size	Bytes	Class
coefficients	**1x320**	**2560**	**double array (global)**

Grand total is 320 elements using 2560bytes

14. User can work with the coefficients as desired. For example: Load them into an SPPDM-01, mathematically transform them, inspect them, etc. Remember - If the workspace is cleared or exited, the coefficient data is lost unless the variables or the workspace are saved. Follow MatLab™ instructions for performing these tasks.
15. **Reboot the SPPDM-01 unit:** Turn the power to the SPPDB-01 evaluation board OFF. When the unit is turned ON, the last entered set of coefficients is loaded from the SPPDM-01's external memory into the DSP internal memory where it is interpreted as valid FIR filter characteristics in the frequency domain.
16. **Inspect or work with the SPPDM-01's FIR filter:** The filter may now be selected in **Manual Mode Operation, Appendix A** - Example 1 (with DIP switches), or automatically (with a computer program). Select the filter by setting the selection code to the desired filter location (number). This will set the SPPDB-01 evaluation board and the SPPDM-01 to work as a FIR filter possessing the frequency domain characteristics derived from the initial relative specifications.

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Appendix A - Example 5

FCL Batch Mode Operation Single Set Coefficient

1. Initialize a global variable in the MatLab™ workspace called ***coefficients***. Set the format to ***long*** for better representation of the results.

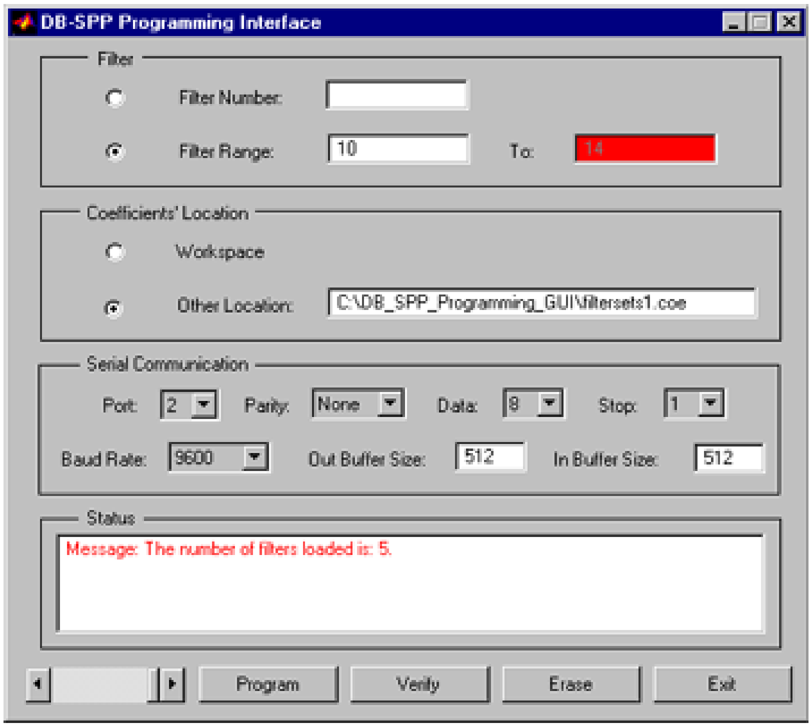

Figure 9 -
FCL Display – Batch Mode Operation, Multiple Set Coefficients

2. **Select Filter Range:** CLICK on the ***Filter Range*** control. This will allow you to load a multiple set of coefficients.
3. **Enter the Filter Range (From) Value:** Enter ***10*** as the lowest filter number. After the loading process is finished, the "**Filter Range To**" will contain a value that will reflect the number of sets loaded from Coefficients Location.
4. **Select Coefficients' Location:** CLICK "***Other Location***" button to load the coefficients from a text file. This will enable the **Batch Mode Input Control**. Enter the complete valid pathname for the file that will contain the sets of filter coefficients. The system will not continue execution if programming is attempted without a valid **pathname**. In the example the pathname is:

C:\RS232MEX\DB_SPP_Programming_GUI\filtersets1.coe.

Remember to use the .coe suffix in the filename.

5. **Select the communication port:** Select ***2*** as the communication port.
6. **Select the Parity:** Select ***None*** as the parity for the selected communication port. This value is constant for the SPPDM-01 family of products.
7. **Select the Data (Bits) Number:** Select ***8*** as the number of data bits for the selected communication port. This value is constant for the SPPDM-01 family of products.

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8. **Select the Stop (Bits) Number:** Select ***1*** as the number of stop bits for the selected communication port. This value is constant for the SPPDM-01 family of products.
9. **Select the Baud Rate:** Select ***9600*** as the baud rate for the selected communication port. This value is constant for the SPPDM-01 family of products.
10. **Enter the Out(put) Buffer Size:** Enter ***512*** (bytes) as the size of the output buffer for the selected communication port. Remember to drop the units when entering this parameter.
11. **Enter the In(put) Buffer Size:** Enter ***512*** (bytes) as the size of the input buffer for the selected communication port. Remember to drop the units when entering this parameter.
12. **Load the multiple set of Coefficients:** CLICK on ***Program*** to start the loading process of the multiple sets of coefficients from the workspace into the SPPDM-01's external memory locations. The popup window with a bar will indicate an active system condition. After a few seconds of data translating and formatting, the **software plug (Appendix B)** takes over and starts the communication protocol. **This process is repeated, as many times as there are sets to be loaded.** Wait for the communication protocol process to finish. After successful completion of the loading process, the workspace will show successful memory verification. The ***Message*** **indicator** will show the number of filters loaded. For this example it is five (5). Based on the **Filter Range (From) Control** value, the **Filter Range To Indicator** shows the upper limit number for the filter sets just loaded. Use this number so that future loadings into the SPPDM-01 do not overlap.
13. **Reboot the SPPDM-01:** Turn the power to the SPPDB-01 evaluation board OFF. When power is reapplied, the last entered set of coefficients is loaded from the SPPDM-01 external memory into the DSP internal memory where it is interpreted as a valid FIR filter characteristics in the frequency domain.
14. **Inspect or work with the SPPDM-01's FIR filter:** The filter may now be selected in **Manual Mode Operation, Appendix A** - Example 1 (with DIP switches), or automatically (with a computer program) by setting the selection code to the desired filter location (number). This will set the SPPDM-01 to work as a FIR filter possessing the frequency domain characteristics derived from the initial relative specifications.
15. **Exit:** CLICK the ***Exit*** command to stop execution and close the program. It will close any opened panels and quit the FCL system. The MatLab™ environment may continue to be used after exiting.

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Appendix B Software Plug

A tool is provided to interact with data and programs external to the MatLab™ environment by taking advantage of the MatLab™ Application Program Interface (API). By utilizing MEX-files (MatLab™ executable files), there is a library of functions that provide a communication link between MatLab™ and an external environment. The MEX-files (Dynamic Link Libraries DLL) as they are called in the Microsoft Windows environment, are linked subroutines that may be loaded and executed in the workspace.

The MEX-files behave just like M-files and built-in functions in MatLab™. The difference is that M-files have a platform-independent extension, ".m", whereas MatLab™ identifies MEX-files by platform-specific extensions. This system was developed under the Windows Platform, hence, the dll suffix. The MEX-files may be called exactly into the workspace as any M-function is called.

In the SPPDF-01 and in the Windows Platform, if there is a MEX-file called LINK.DLL, it is invoked from MatLab™ as *LINK* if no arguments are required. The call can be made from either the workspace or another M-file.

The "software plug", MEX-file or DLL using the FCL implements serial communication routines that provide the protocol link for the loading of coefficients into the SPPDM-01 filter platform.

The Software "Plug" syntax: The "software plug" may be called using the following syntax:
[data, status] = RS232MEX (command, parameters)

The *command* input is a character string. With this input, an action is performed using the *parameters* input. The actions performed are specified as follows:

Character Code	*Action*
'O' or 'o'	: open and configure a communication port
'C' or 'c'	: close communication port
'WF' or 'wf'	: write from file to output buffer
'WB' or 'wb'	: write to output buffer
'FI' or 'fi'	: flush input queue
'FO' or 'fo'	: flush output queue
'RF' or 'rf'	: read to file from input buffer
'RB' or 'rb'	: read from input buffer
'RY' or 'ry'	: read byte from input buffer
'WY' or 'wy'	: write byte to output buffer

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OutFlushCommPort:

Purpose: Removes all data from the output queue.
Algorithm: Removes all characters from the output queue of the specified port.
Syntax: [data, status] = RS232MEX(action, [*CommPort*])
Parameters: *int CommPort* - communication port to flush
Examples:

[result, condition] = RS232MEX('FO', [2])
[result, condition] = RS232MEX('fo', [2])

9.1.1. InFlushCommPort:

Purpose: Removes all data from the input queue.
Algorithm: Removes all characters from the input queue of the specified port.
Syntax: [data, status] = RS232MEX(action, [*CommPort*])
Parameters: *int CommPort* - communication port to flush
Example:

[result, condition] = RS232MEX('FI', [2])
[result, condition] = RS232MEX('fi', [2])

9.1.2. CloseCommPort:

Purpose: Closes the specified communication port, restores the associated interrupt vectors, and frees the input and output queues.
Algorithm: Closes a communication port.
Syntax: [data, status] = RS232MEX(action, [*CommPort*])
Parameters: *int CommPort* - communication port to close
Example:

[result, condition] = RS232MEX('C', [2])
[result, condition] = RS232MEX('c', [2])

9.1.3. ReadBytePort:

Purpose: To read the specified byte from the input queue.
Algorithm: Reads a byte from the input queue of the specified port. Returns an integer whose low-order byte contains the byte read. If an error occurs, the returned value is a negative error code.
Syntax: [data, status] = RS232MEX(action, [*CommPort*])
Parameters: *int CommPort* - communication port to operate on
Example:

[result, condition] = RS232MEX('RY', [1]);
[result, condition] = RS232MEX('ry', [1]);
Byte = uint8(result); % example on how to use the returned value

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9.1.4. ReadCommPort:

Purpose: To read the specified number of bytes from the input queue.

Algorithm: Reads desired number of bytes from input queue of the specified port and stores them in Buffer. Returns either on timeout or when Count bytes have been read. Returns an integer value indicating the number of bytes read from queue.

Syntax: [data, status] = RS232MEX(action, [*CommPort, Buffer, Count*])

Parameters: *int CommPort* - communication port to operate on

char Buffer – variable in which to store the data that was read from the selected port

int Count – number of bytes to read from the selected port

Example:

```
% assign values to the structure element
dataelement = hex2dec(' ');
parameter4.port = 2;
parameter4.data = uint8(dataelement);
parameter4.count = 2;
[result, condition] = RS232MEX('RB', parameter4)
[result, condition] = RS232MEX('rb', parameter4)
```

9.1.5. WriteBytePort:

Purpose: To write the specified byte to the output queue.

Algorithm: Writes a byte to output queue of specified port. The byte written is the low-order byte of the integer. Returns an integer whose value is 1 or 0, indicating the number of bytes placed in queue.

Syntax: [data, status] = RS232MEX(action, [*CommPort, Byte*])

Parameters: *int CommPort* - communication port to operate on

int Byte – specifies the value of the byte to be written to the selected port.

Example:

```
%assign value to the structure element
dataelement = uint8(hex2dec('85'));
parameter2.port = 1;
parameter2.byte = dataelement;
[result, condition] = RS232MEX('WY', [parameter2])
[result, condition] = RS232MEX(‘wy’, [parameter2]);
```


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9.1.6. WriteCommPort:

Purpose: To write the specified number of bytes to the output queue.

Algorithm: Writes Count bytes to output queue of specified port. Returns an integer indicating number of bytes placed in queue.

Syntax: [data, status] = RS232MEX(action, [*CommPort, Buffer, Count*])

Parameters: *int CommPort* - communication port to operate on
char Buffer – variable in which the data to be written to the selected port is stored
int Count – number of bytes to write

Example:

```
% assign values to the structure element
dataelement = [hex2dec('85') hex2dec('84')];
parameter2.port = 2;
parameter2.data = uint8(dataelement );
parameter2.count = 2;
[result, condition] = RS232MEX('WB', parameter2)
[result, condition] = RS232MEX('wb', parameter2)
```

9.1.7. ReadToFile:

Purpose: To read from the input queue until either the requested number of bytes is satisfied or the termination byte is encountered, and to store them in a file.

Algorithm: Reads from input queue of specified COM port and writes data to file specified by FileHandle. Bytes are read from input queue until Count is satisfied, Termination Byte is encountered, or an error occurs. Returns number of bytes successfully written or an error code if an error occurs.

Syntax: [data, status] = RS232MEX(action, [CommPort, *FileHandle, Count, TerminationByte*])

Parameters: *int CommPort* - communication port to operate on
int FileHandle – handle of the file to which the data is written
int Count – number of bytes to read from the selected port
int TerminationByte – byte value used to terminate the read

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Example:

```
% assign values to structure element
parameter3.port = 2;
parameter3.file = 'c:\RS232MEX\TextFileToWriteTo.txt';
parameter3.position = 0;
parameter3.count = 24;
parameter3.temination = -1;
[result, condition] = RS232MEX('RF', parameter3)
[result, condition] = RS232MEX('rf', parameter3)
```

9.1.8. WriteFromFile:

Purpose: To read from the specified file and write to output queue of the specified COM port.

Algorithm: Reads bytes from a file and writes them to the output queue until EOF is encountered, the byte count is met, or the termination byte is encountered.

Syntax: [data, status] = RS232MEX(action, [*CommPort, FileHandle, Count, TerminationByte*])

Parameters:
int CommPort - communication port to operate on
int FileHandle – pointer to the file containing the data to be written to the output queue
int Count – number of bytes to write
int TerminationByte – byte value used to terminate the write

Example:

```
% assign values to structure element
parameter1.port = 2;
parameter1.position = 0;
parameter1.count = 0;
parameter1.temination = -1;
[result, condition] = RS232MEX('WF', parameter1)
[result, condition] = RS232MEX('wf', parameter1)
```


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9.1.9. OpenCommPort:

Purpose: To open the specified COM port and configure its hardware settings.
Algorithm: Opens a COM port, and sets the port parameters as specified.
Syntax: [data, status] = RS232MEX(action, [CommPort, BaudRate, Parity, DataBitsNum, StopBitsNum, InQSize, OutQSize])
Parameters: *int CommPort* - communication port to operate on
long BaudRate – baud rate for the specific port
int Parity - parity mode for the port
int DataBitsNum - number of data bits
int StopBitsNum - number of stop bits
int InQSize - input queue size
int OutQSize - output queue size

Examples:

[result, condition] = RS232MEX('O', [1, 9600, 0, 8, 1, 512, 512])
[result, condition] = RS232MEX('o', [1, 9600, 0, 8, 1, 512, 512])

Operational Overview of the SPPDF-01 Suite

- Run MatLab.
- Run Filter Coefficients Generator (FCG) software to create a set of filter coefficients.
- Run Filter Coefficients Loader (FCL) software to download the coefficients into the SPPDM-01 via the RS232 port on the SPPDB-01 development board.
- Remove and re-apply power to reset the SPPDM-01
- Enter a coefficient or filter address via the computer port or the Manual DIP-switch on the SPPDB-01 board to select a filter to run.

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Appendix C

Field Programmable Coefficient Memory Access

Incorporation of the following circuit schematic into the OEM subassembly permits reprogramming and modification of the SPPDM-01 with the SPPDF-01 Filter Coefficient Loader (FCL) software utilizing MatLab™ V5.3 or V6.0 and an RS232 interface. Essentially, the circuit below mimics the SPPDB-01.

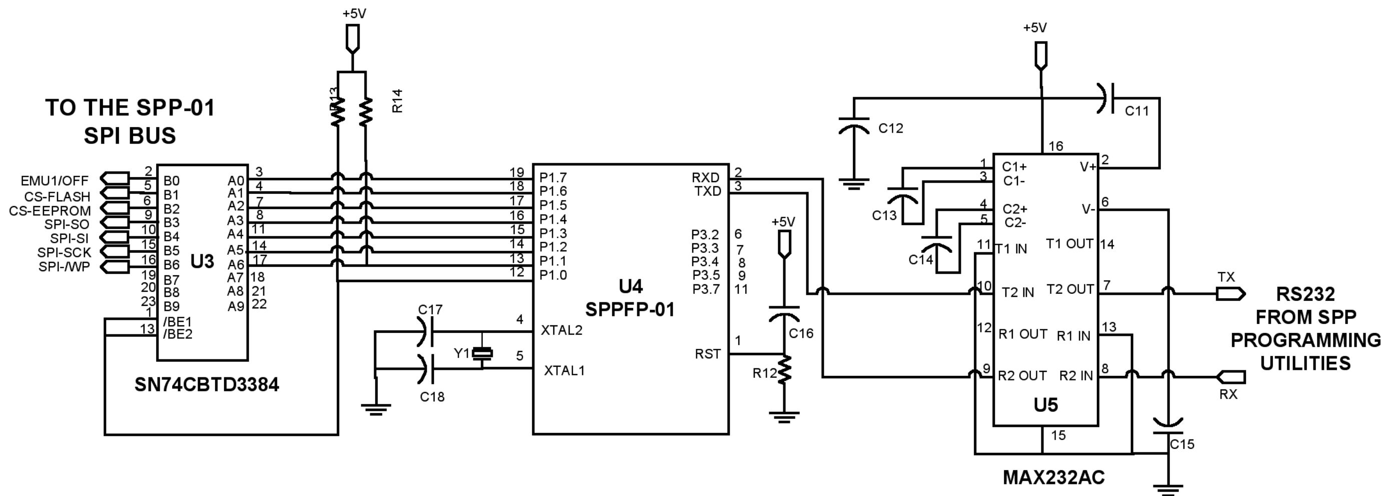

Figure 10
Required circuit to provide coefficient memory access for the SPPDM-01 family of products

The customer is responsible for obtaining manufacturer's data sheets and listed components for layout purposes. The only item that must be obtained from FDI is the **SPPFP-01, 8-bit, 2k byte preprogrammed micro-controller (U4).** Contact factory for pricing and delivery.

Note: See Figure 10 for component location.

U4	**SPPFP-01** - A™EL AT89C2051 8-BIT, 2K byte preprogrammed micro-controller
U3	TI SN74CBTD3384 10 Bit Bus FET Switch
U5	MAXIM # MAX232AC - RS232 12 to 5 Volt Level Shifter (May not be required along with its associated capacitors if U4 is connected to 5 volt logic.)
C11-16	4.7UF 20V 20% Tantalum
C17-18	33PF 50-100V 5 % (1206)
R12	8.25k 1/10W 1%
R13-14	4.75k 1/10W 1%
Y1	22.1184 MHz SMT Crystal ~18PF

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