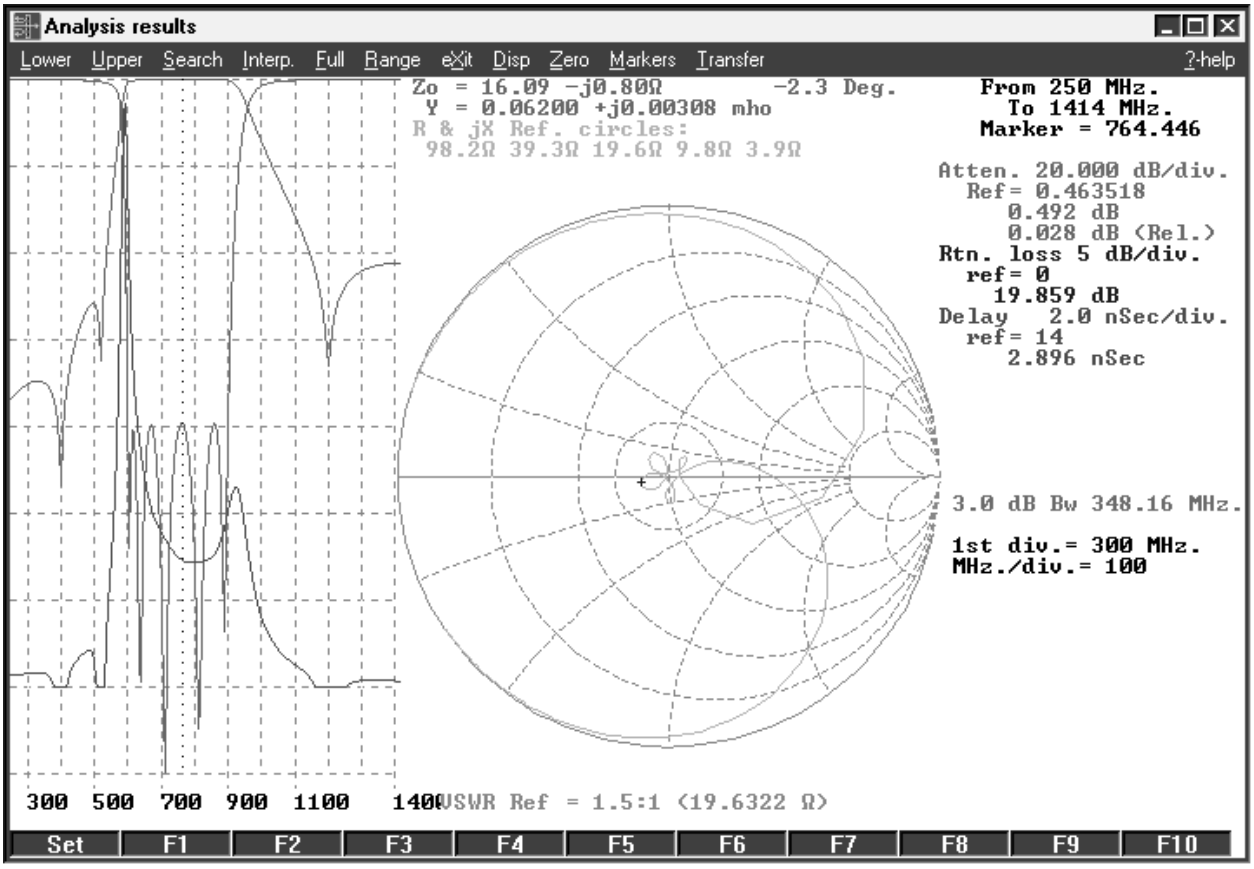
GRAPHIC PLOT



The plot module was developed to graphically display the results of an analysis run in a manner resembling a network analyzer using the full graphics features of the computer.

The vertical scale of the display is automatically selected so that the data will be displayed on a 1-2-5 units per division scale just as a it would be displayed on a real network analyzer. The scale is picked to provide no less than 3 vertical divisions of display.

A movable vertical dotted line cursor is also provided to mark one specific frequency point on the display. At the edge of the screen, to the right, is a digital readout of the information corresponding to the frequency point at the cursor. The digital display shows the vertical scale (units per division) and the reference (top) line value.

Also displayed is a close digital approximation of the bandwidth of a bandpass or notch filter determined from the analysis data displayed. The "dB down" value is defined by the passband definition parameter on the parameters menu, if it shows, otherwise the 3 dB points are assumed. The appropriate frequency points are interpolated from the data displayed, therefore two frequency points must be found on the screen to calculate bandwidth. In the event only 1 point is found (as in the case of a lowpass or highpass filter) this single frequency is displayed.

The data brought in from an analysis run is limited to 1000 frequency points or less. A linear "interpolation" mode has been included to interpolate and display information digitally for each horizontal pixel on the display regardless of the number of pixels displayed for each analysis frequency point. The frequency at the cursor is shown just above the digital data.

The dotted line marker can be moved in several ways. It can be moved by dragging it left and right using

your mouse. Pressing the mouse left button will cause the marker to jump to the mouse cursor. If you hold the left button down you can drag the marker left or right to any frequency on the plot. The marker can also be moved left and right using the keyboard arrow keys or the "<" and ">" keys. The speed of motion will be increase by a factor of 5 by pressing and holding the <Shift> key at the same time.

The Plot menu

(U)-Upper

Forces the UPPER frequency limit of the display to the frequency of the cursor by changing the frequency range. Doing this is a lot faster than using the (R)-Range command. The entire graph is redrawn. If interpolation mode is on, it will be turned off.

(L)-Lower

(S)-Search

Requests a frequency for the cursor to jump directly to. The interpolation mode will come on

Forces the LOWER frequency limit of the display to the frequency of the cursor by changing the frequency range. Doing this is a lot faster than using the (R)-Range command. The entire graph is redrawn. If interpolation mode is on, it will be turned off.

automatically if a frequency is specified that is not a direct analysis point. This frequency is retained until respecified and may be assigned to a function key as a fixed marker.

(I)-Interpolate

Turns interpolation mode on or off alternately (a toggle). When the marker frequency is an interpolation, a diamond shape will appear before the word "Marker".

(F)-Full

Causes the frequency range to expand to display all of the points analyzed. The cursor will find the nearest frequency point possible to where it was before the frequency range change even if the interpolation mode was on and showing an intermediate point.

(R)-Range

Allows the frequency range to be specified directly. The cursor will be placed at the left-most analysis point (lowest frequency). If interpolation mode is on, it will be turned off.

(X)-Exit

Leave the graphics display.

(Z)-Zero.

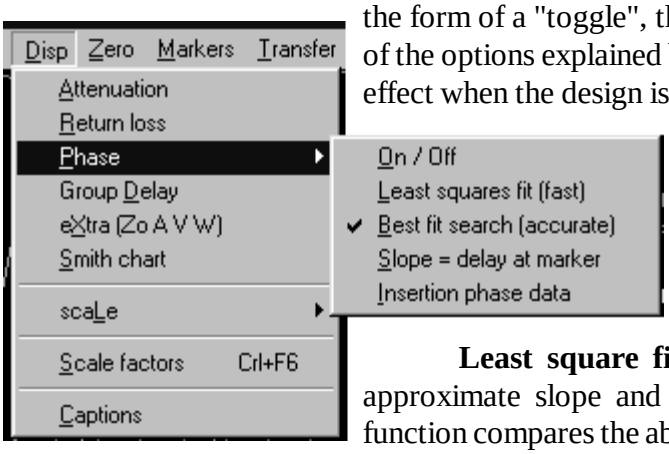
This option will bring up a digital display that will indicate the frequency difference between the point where the Zero mode was turned on and the frequency of the marker. It can be used to display the bandwidth of a bandpass filter directly by pressing the "Z" key while the marker is resting on the lower 3 dB point, then move to the upper 3 dB point. The display will then be showing the 3 dB bandwidth. The interpolation mode can be used to increase the accuracy of the procedure. Pressing the Z key twice will toggle the feature off, then back to zero. The bandwidth displayed automatically is calculated internally this way.

(?)-help

Displays a help screen.

(D)-Display

Causes a drop-down menu to appear for the selection of what data is to be displayed. The selection is in the form of a "toggle", that is, it acts like a "push-on, push-off" switch. Any or all of the options explained below may be displayed simultaneously. Any selections in effect when the design is saved to disk are recorded in the ".spk" specification file.



Attenuation.

The Display is forward attenuation. The reference line is the point of least loss.

Phase linearity

Four phase linearity display modes are provided. The mode in effect will be identified with a check mark.

Least square fit (fast): Uses the "least squares" method to find the approximate slope and intercept for direct phase linearity error display. This function compares the absolute phase data from the analysis run with a straight line showing actual deviation from linearity. The slope of the reference straight line is presented in units selected by the system notation. For example: Deg. / Mhz.

Best fit search (accurate): This method uses an iteration to increase the accuracy of the least squares results. It is more accurate then the least squares alone, but slightly slower. This is the default setting.

Slope = delay at marker: Uses the group delay under the marker for the slope. First, move the marker to the point on the delay curve you want to become the reference slope and then select **phase** and **"Slope = dealy at marker**" from the Disp. Menu.. This slope is referenced to the point on the plot where the selected delay is located, NOT the actual frequency. So long as you do not change the frequency range of the analysis sweep, the setting will remain. If you analyze again using a different frequency range the slope will change. If you need to change the analysis range, set up a fixed marker to store the desired frequency. After re-analyzing with the new frequency range, reset the marker frequency using the marker key, then reset the slope reference delay as before.

Insertion phase data: This displays the raw, uncorrected phase data from analysis. No straight line is superimposed. Judge linearity by eye.

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Return loss

Return loss is presented on a fixed scale of 5 dB per division below a 0 dB reference.

Group delay

Group delay is displayed. When delay data is displayed, it may have been calculated using one of two different methods. The "Fast", or the "Precise" method. If the "fast" mode was used by the analysis module, the word (Fast) is displayed next to the digital data. Fast data may be thought of as shift by one half an analysis frequency point. For more information on delay modes, see the section on the analysis module.

eXtra (Zo A V W)

This option will normally display simple impedance at the source end of the network calculated from the R +-jX data supplied by the main analysis module. The (X) option will appear as: (X)- Zo.

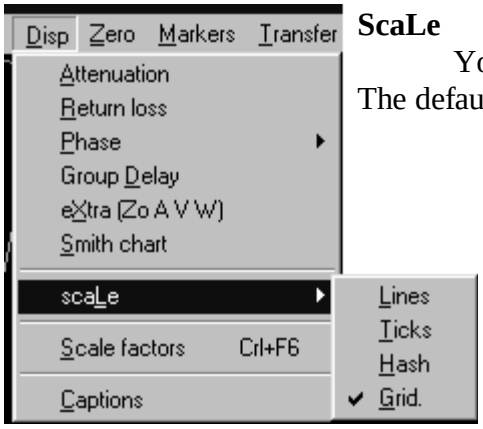
When displaying a single parameter from the power analysis module, the (X)- option will select one of the following parameters: (X)- Voltage (X)- Current or (X)- Loss

Smith chart

At any time R +-jX impedance has been included in the analysis, a Smith chart is available to display the impedance in polar form in addition to the (X) display of simple Zo.

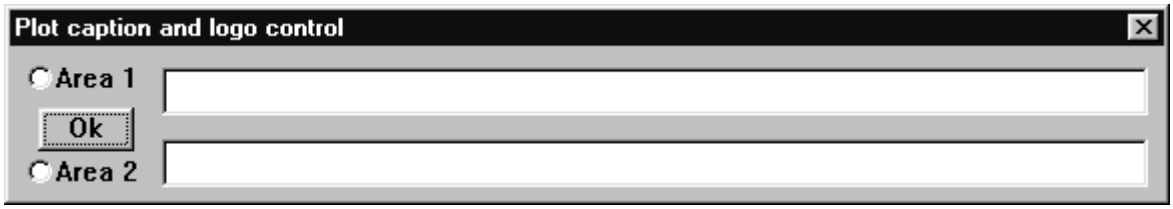
The chart is normalized to the source impedance of the network unless the network is singly terminated or the "`Report ->-`" branch was used. In this case, the chart will be normalized to the source impedance set on the parameters menu. The chart will appear in the middle of the display with the standard plot compressed to the left. The Smith chart displays all the impedance data in memory but highlights the frequency range displayed on the standard plot. All functions associated with the standard plot will still operate normally.

The impedance displayed is that of the source end of the network unless the "`Report -->-`" branch is used to request the impedance looking into some other point in the network. To use this to display the impedance looking into a specific point in a network, simply insert the "`Report --> -`" element available from the --> Lines stubs & special <-- window of the circuit editor "Insert" command (For information on the analysis of impedance AT, rather than INTO, random points in a network see the section on the analysis module).



ScaLe

You are also given the option to select the style of scale marks you like best. The default setting is "Grid", but you may also select "Lines", "Ticks" or "Hash"



(*) Area 1
(*) Area 2

Use the keypad arrow keys, Home, End and Backspace keys to format a caption to be displayed below the plot for presentation hard copy purposes. Each of the two captions can be up to 60 characters long and will appear on the bottom two lines below the plot in place of the fixed marker buttons. If either caption area buttons are marked the personal logo will also appear. The logo will be described later.

Static (fixed) frequency markers

Most designs require that some frequency or frequencies be passed with some specified maximum loss while attaining a minimum rejection at another frequency. It is helpful to be able to examine the performance of the design at each of these frequencies quickly so that the specifications can be verified after each parameter change and analysis run. Fixed, setable frequency markers have been provided as a method of referencing these specific frequency points abstractly, as F1, F2, F3 etc. The keyboard function keys are used for this purpose.

To set a marker to a specific frequency, use the "S" Search feature to define the frequency, then press

<Shift> and any function key (F1-F10). It must be pointed out that the frequency is being set to that searched for, NOT the frequency where the marker falls after the search. The marker frequency is that of the nearest pixel and will be an interpolation. You can also use your mouse to press the [Set] button followed by one of the ten marker buttons [F1], [F2],....[F10].

To return the marker to that same frequency at a later time, push the same Function key again. F1 through F10 keys will remain defined until redefined (static). The F10 keyboard key is used by Windows and must be selected using the mouse.

Any marker frequency may also be assigned to a function key at any time, in the same way, without using the search feature. This will assign the marker interpolated frequency to the key rather than the search buffer frequency. This will be less accurate if some precise frequency is desired. The actual frequency assigned to the marker key will be the latest search frequency unless the marker has been moved, then it will be the interpolated frequency of the marker.

NOTE: The data for all the markers may be displayed on the screen simultaneously. This feature is turned on / off by pressing <Ctrl> F8 or by the menu option “Markers” Tabulate.

```
To set up a marker for 97 MHz on F2 key, for example:
        Press <S>
        key in: 97 <Enter>
         (marker will jump as close to that frequency as it can)
        Press <Shift> [F2]
To find 97 later (maybe after a redesign and another analysis run)
        Press [F2]
         (marker will again find 97 Mhz)
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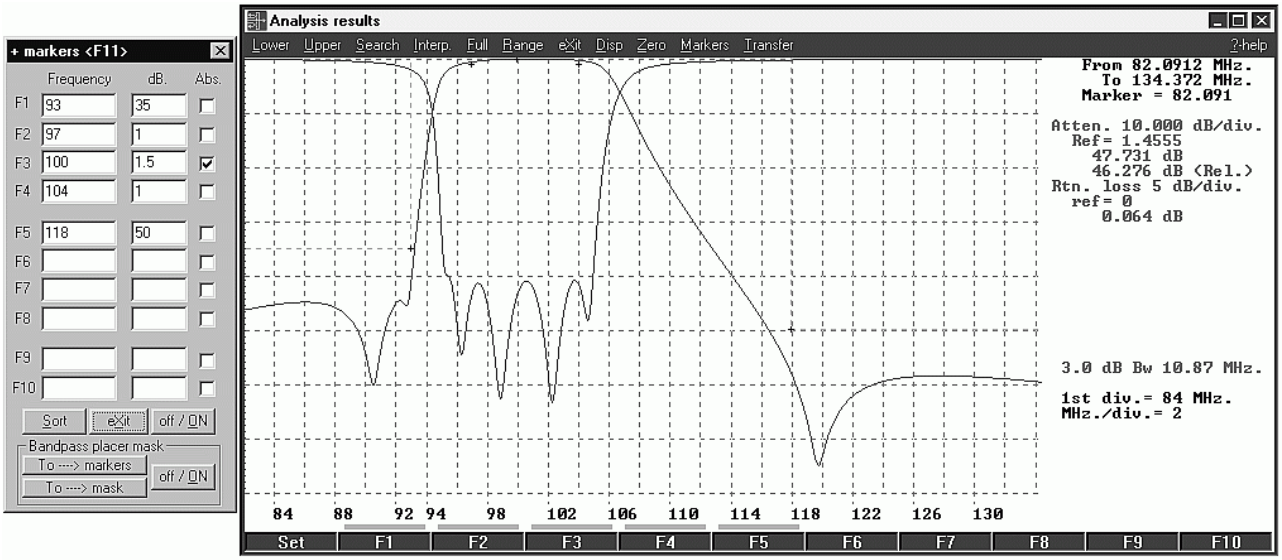
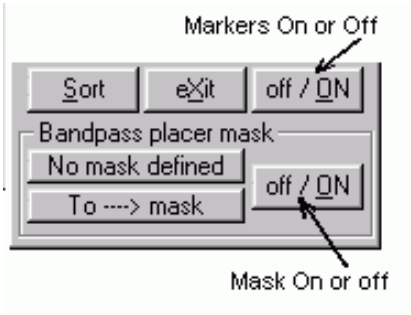
Each of the fixed markers may have an attenuation level associated with it. The level will be relative to



the insertion loss unless the associated “Abs” box is checked. Then it is absolute. A dialog box is used to define the attenuation for each frequency marker in the right column of edit boxes. The dialog box can be called from the Marker menu or by pressing the [F11] key. Any marker that has an attenuation assigned to it will display as a “+” mark at the correct position on the plot. These markers can be used as a specification mask. Any frequency defined with attenuation equal to zero will not be displayed. The “+” markers can be turned on or off using the [on / off] button. The button text will change to indicate the status. A [Sort] button

is provided to put all the frequencies in ascending order. The sort function will also compress all the marks together removing any markers defined a zero frequency. The sort function on the dialog box is identical with the sort option on the plot marker menu.



Either the markers or the bandpass mask my be turned on or off. The two other buttons are used to copy the markers or mask to the other. The button text will change to indicate if copying is possible at the time.

The plot markers may be used to generate specification masks for both the bandpass and the lowpass placer modules. The markers can also be defined from bandpass masks that were keyed into the mask edit boxes of the bandpass placer earlier. The bandpass pole placer requires mask specifications in absolute frequency and attenuation units. The lowpass placer requires its frequency points be in normalized units. This is because it can be used to scale any type of filter including bandpass and band reject filters. Both of these can be defined from the markers. This represents three different operations.

* Using an existing bandpass placer mask to define markers.

Any bandpass mask displayed on the plot can be converted to markers by pressing the **[to ---> markers]** button on the markers dialog box. Markers to show the passband corners are NOT generated. If no bandpass mask is defined the button text will say so.

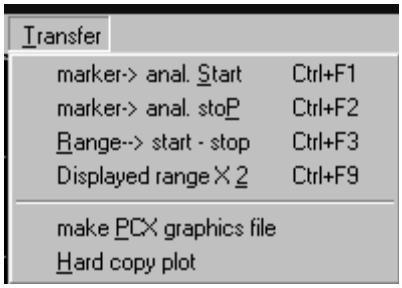
* Using markers to define a bandpass mask.

Markers displayed on the plot may be converted to a bandpass placer mask using the **[to ---> Mask]** button on the markers dialog box <F11>. Any marker defined as 6 dB or more is assumed to be a stopband specification. Any marker defined as less then 6 dB is assumed to be a passband specification and is ignored. A marker is determined to be above or below the passband by its location above or below the passband defined on the parameters dialog box menu center frequency and bandwidth parameters. This requires that the center frequency and bandwidth be set BEFORE making the mask. You should select the bandpass placer before making the mask to check or set the passband parameters. This is especially important if the network has several passbands and markers are defined for stopbands related to each. This would be the case if a multiplexer is being evaluated. If a filter type other than a bandpass is selected the button text will say so. Note that a bandpass mask can be made when any bandpass filter is selected but only the bandpass placer can actually use it. Other types of bandpass filters require a lowpass mask.

* Using markers to define a lowpass reference mask.

As this type of mask can relate to any type of filter they must be generated in normalized units. This is done by the parameters dialog box **[order N]** function NOT on the graphics plot. When the lowpass pole placer has been selected as the lowpass reference, pressing the **[order N]** button will bring up a prompt asking if you would like to generate a lowpass mask or not. If you respond with NO, each marker will be displayed in turn showing its normalized frequency location instead of actually making the mask. If a lowpass reference is selected OTHER then the placer, such as Chebyshev or elliptic function, the markers are simply used, each in turn, to determine and set the filter order. As with the bandpass mask, the passband corners are determine by the parameters that are set and only markers defined as 6 dB or more are considered stopband specifications. Bandpass mask are displayed in red. Lowpass reference masks are shown in magenta (purple).

Transfer



marker-> anal Start
marker-> anal stoP
Range-> start - stop
Displayed range X 2

It is often desirable to "magnify" a small area of an analysis frequency range by actually doing another analysis run across that frequency range rather than just by respecifying the upper and lower frequency limits of the graph. This new frequency range may be taken from the graph vertical dotted line marker by the use of the function keys. By pressing <Ctrl> F1 the lower limit of the range may be set to that of the marker. The upper limit can be set using the <Ctrl> F2 key in the same way. These do not interfere with the fixed marker frequencies assigned to F1 or F2. Unlike the fixed markers, the range limit frequencies are set to that of the marker itself, the search frequency is not involved. The new range will be transferred directly to the network analysis module the next time analysis is called. Any of the frequency transfer keys can be used to transfer frequency range limits to the optimization module in the same way. <Ctrl> F3 will transfer the entire range displayed by the plot rather then one at a time. The <Ctrl> F9 key will double the width of the displayed sweep.

Make BMP graphics file

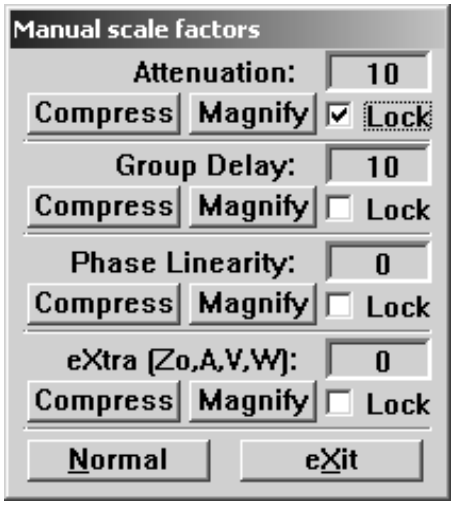
This will copy the plot and data areas to a BMP format graphics file that can be merged into documents. The fixed marker function keys are not included in the file but area 1 and area 2 captions and the personal logo will be.

Hard copy plot

Will make a color copy to your printer of the same area as the BMP screen dump. The plot will be at the top of the paper and centered horizontally.

Manual scale factors

It is occasionally desirable to enhance the appearance of an individual set of curves for a screen copy by magnifying or compressing a single curve to a different scale factor than the automatic scaling feature would normally choose. This might be done to show more detail on one curve while showing another curve over a wider frequency spread, or to display a flatness specification over a narrow frequency range without it being magnified.



A mechanism is provided to magnify or compress the curves temporarily or lock in the selected setting. The manual scale factor dialog box is activated by pressing <Ctrl> F6:

This adjustment can be thought of as moving a switch on a network analyzer having settings in a 1-2-5 sequence. All scale factors will continue to be automatic and in the usual 1-2-5 sequence after then next analysis run unless the [ ] Lock button is checked which will lock in the displayed scale factor.

The scale factors can be restored to normal (x 1.00) by pressing the **Normal** button.

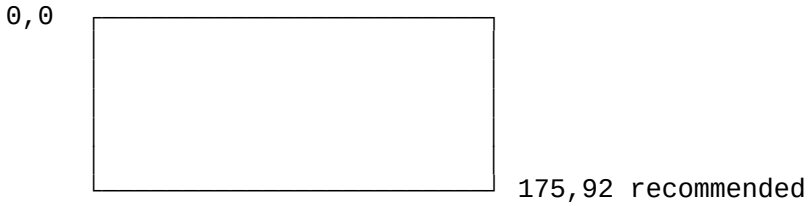
Custom company logo

PCFILT has the ability to read in and display a custom logo at the lower right corner of the graphics display when either of the bottom line captions are displayed. The logo file must be in the default directory (C:\PCFILT for must users) and must have the file name LOGO.BMP. The user can make this logo file himself as it is a standard Windows bitmap file generated by the Paint program as well as many other graphics programs.

The maximum horizontal size of the logo area is 175 pixels. The height is limited only by the size of the plot window. If the logo is any wider than 175 pixels it will not be displayed.

The file must have 4 bit or 16 colors. The colors should use fully saturated red, green and blue components to be accurately reproduced on a printer on in screen copies to BMP files.

To remove the logo entirely, simply delete the LOGO.BMP file.



Plot colors

The colors displayed on the plot may be set to your taste. The settings are recorded with the design file and once recorded with the default file will remain until you change them.

The plot colors dialog box is available from the Display - Colors - K menu.

The color Yellow will revert to brown when printed or when the screen is inverted.