This Application Note is pertinent to our Unidrive SP, Commander SK, Affinity, Mentor/Quantum MP and DigitAx Drive Families

Stabilizing Erratic Signals

Dealing with life's real world situations is unfortunately a reality in Engineering. The advent of digital technology certainly brings a whole new range of application possibilities but after all this is an analog world and with high energy AC & DC drives operating in close proximity it is quite easy for radiated electrical noise to become impressed on low level sensitive analog reference or transducer feedback voltage signals. Obviously, this tendency can be minimized thru the use of 4-20mA signals but not all signals are available in that more robust motif.

Sometimes the only practical solution is to apply a little filtering to a jittering signal. This is not only true for analog reference or feedback signals but also for taming signals that are targeted to be displayed on digital readouts such as HMI (Industrial Display) screens.

Our newer drive series contains a variety of useful functions in Menu 12 under Variable Selectors. One of those functions is particularly useful to help stabilize jittery signals. This application note will outline how to filter up to 2 signals using the built-in facilities that reside within our drives.

This note will use screenshots taken from CTSoft and CTScope

The screenshots illustrated in this App Note were taken from CTSoft, our free Configuration Software. To obtain your free copy click on the links below.
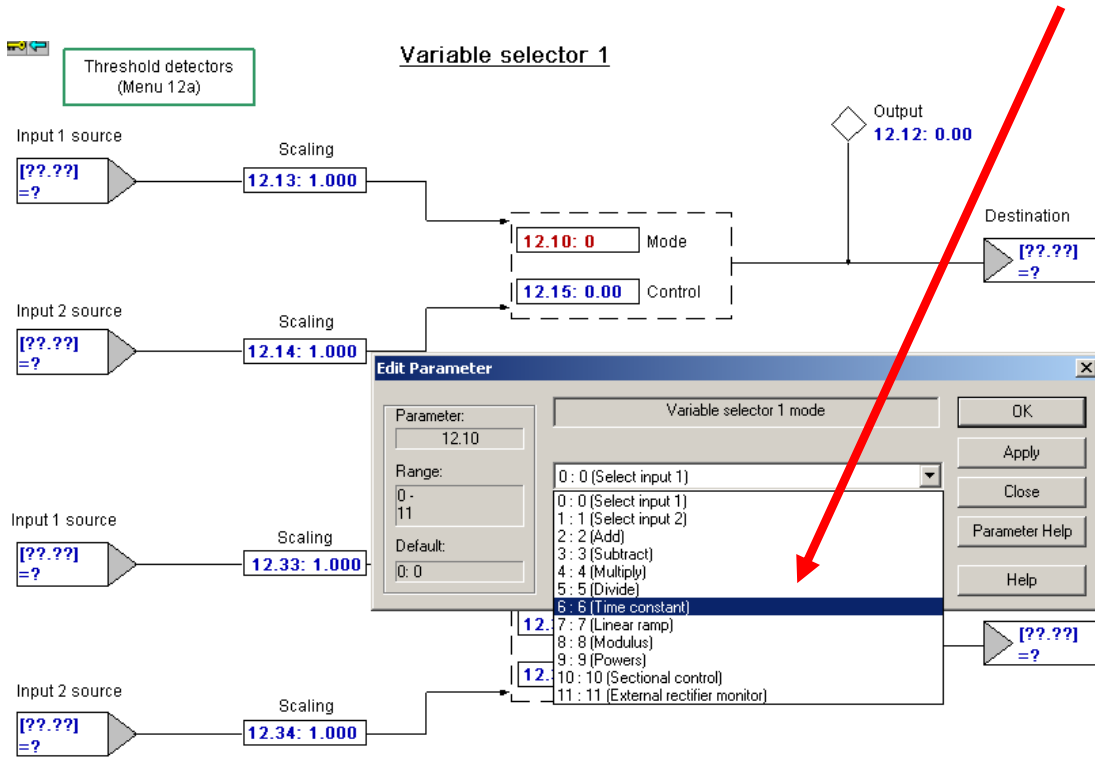
CTSoft

### Computer Cables to utilize CTSoft

CTScope

Time Constant Function

The function that can help in this regard is fairly well disguised as Time Constant.   We'll discuss this further on in this Application Note.


Time Constant Function

Mode 6 of the Variable Selector is described as Time Constant.   If one examines the action of this function carefully, they will see that it indeed applies a time constant to an input step function.   If we take the classic circuit from any introductory course in Electricity, they will recognize the circuit below as a simple RC circuit.
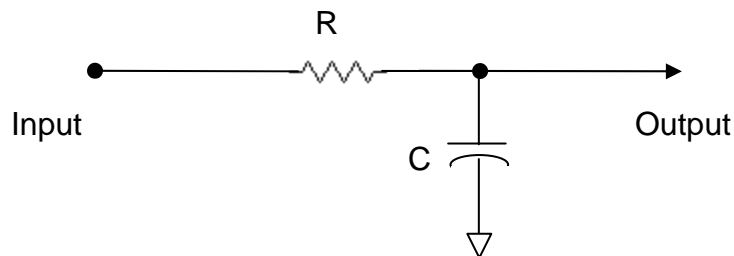
It turns out that in this configuration, should one suddenly place a step function on the input, the output voltage would rise to meet the input following the equation as shown below.

R

Input   Output

C

V_{in} V_{out}
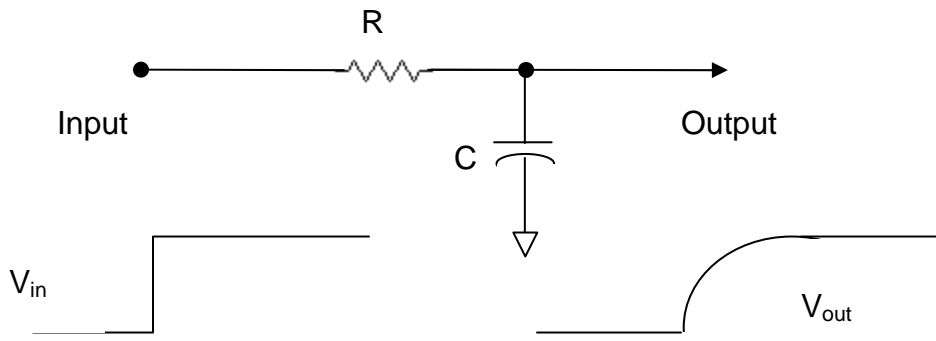
$$V_{out} = V_{in} (1 - e^{-t/RC})$$

where e is the exponential constant 2.718

Things in nature tend to follow an exponential accumulation or decay as described by the exponential constant e - which is 2.718…

From the transfer function $V_{out} = V_{in} (1 - e^{-t/RC})$ the shape of the output voltage will follow the input but after the lag per the math above. The RC in the power of e^x is known as the "*time constant*". The term **t** is simply the value of time–at any instant in time. That ratio describes the shape of the resultant output.

R

Input   Output

100K

C   10uf
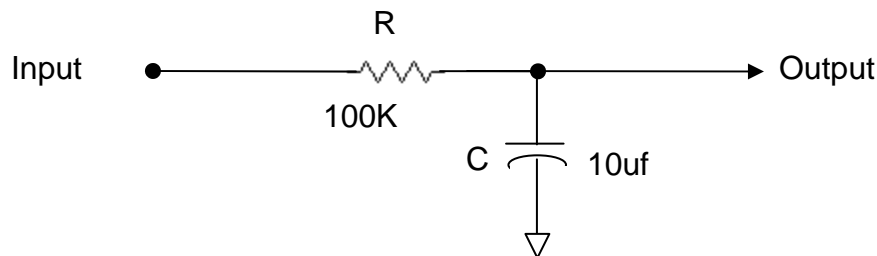
The larger value of RC, the longer the time constant. If this RC circuit consisted of a 100K resistor and 10uf capacitor, the time constant would be:

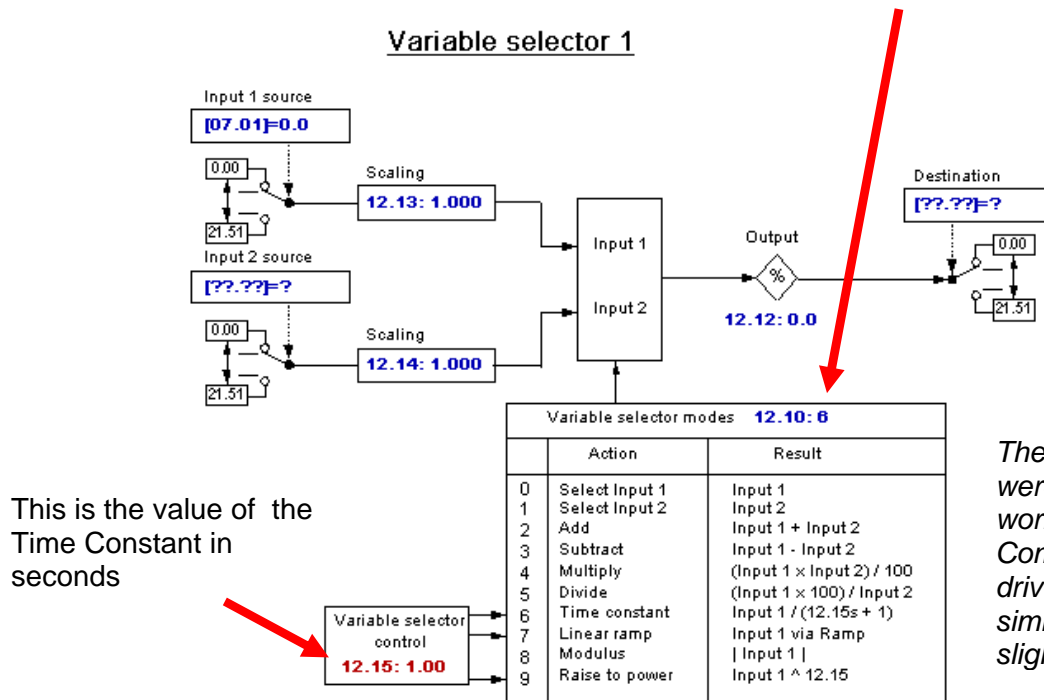$(100 \times 10^3) \times (10 \times 10^{-6}) = 1000 \times 10^{-3}$ or simply 1 second

The output of such a circuit when presented with a sudden 10v step of input, with these component values, would result in the following waveform:

RC Circuit Output from a 10v Step Input
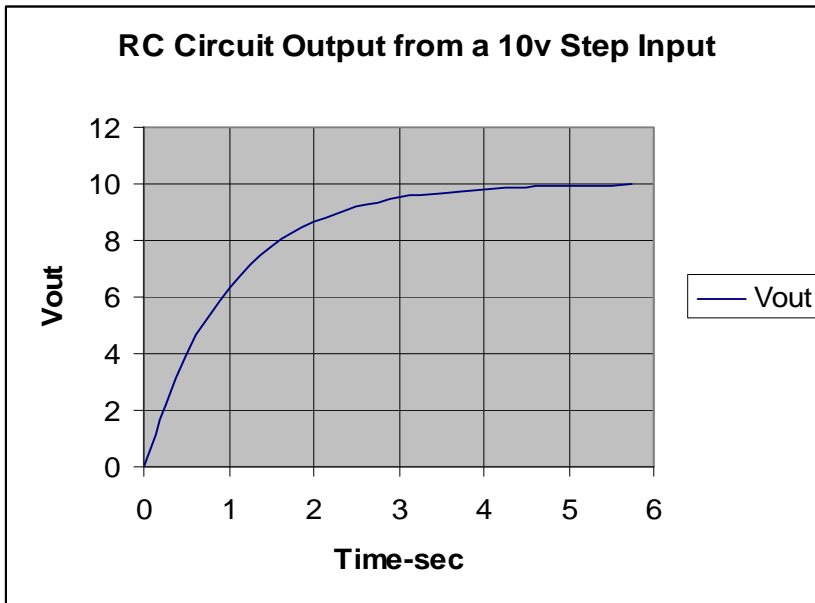
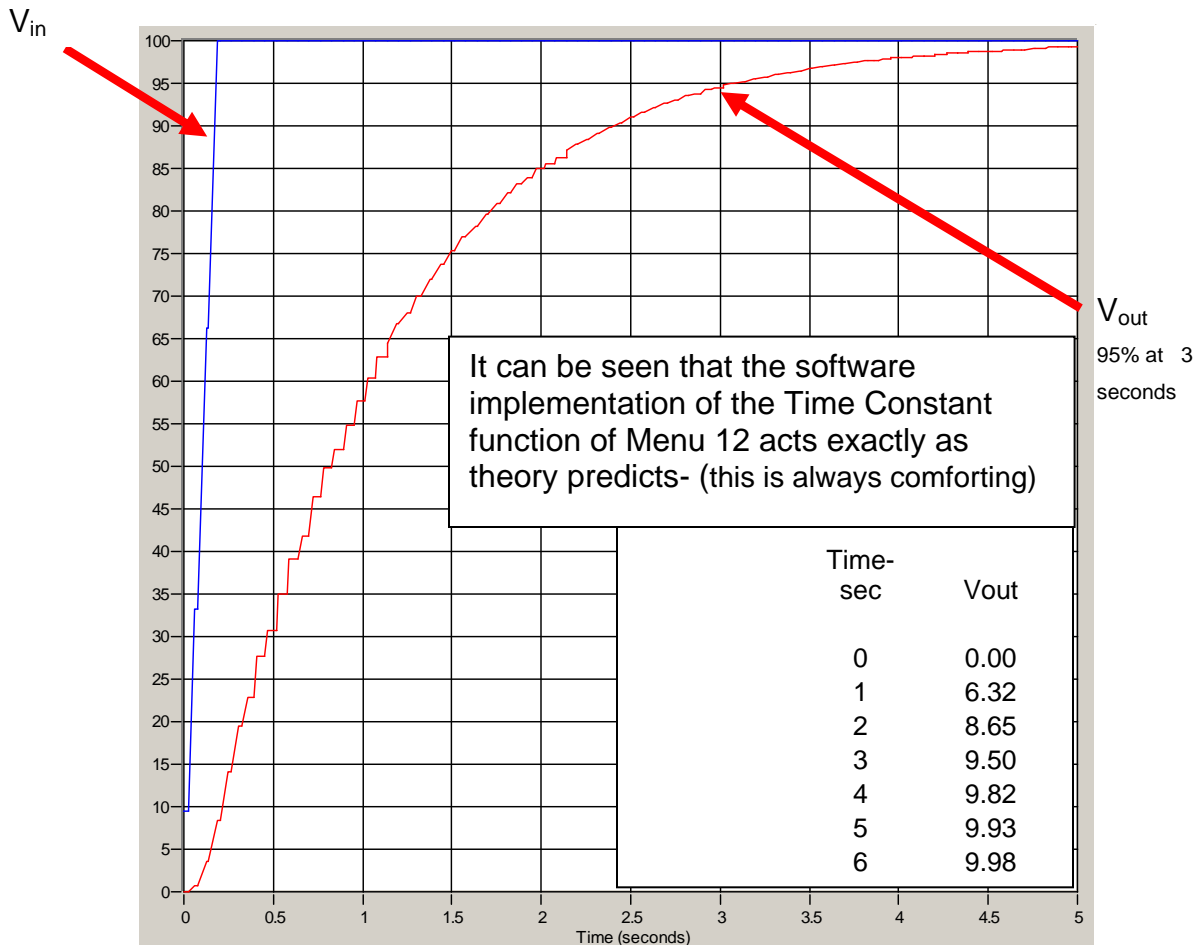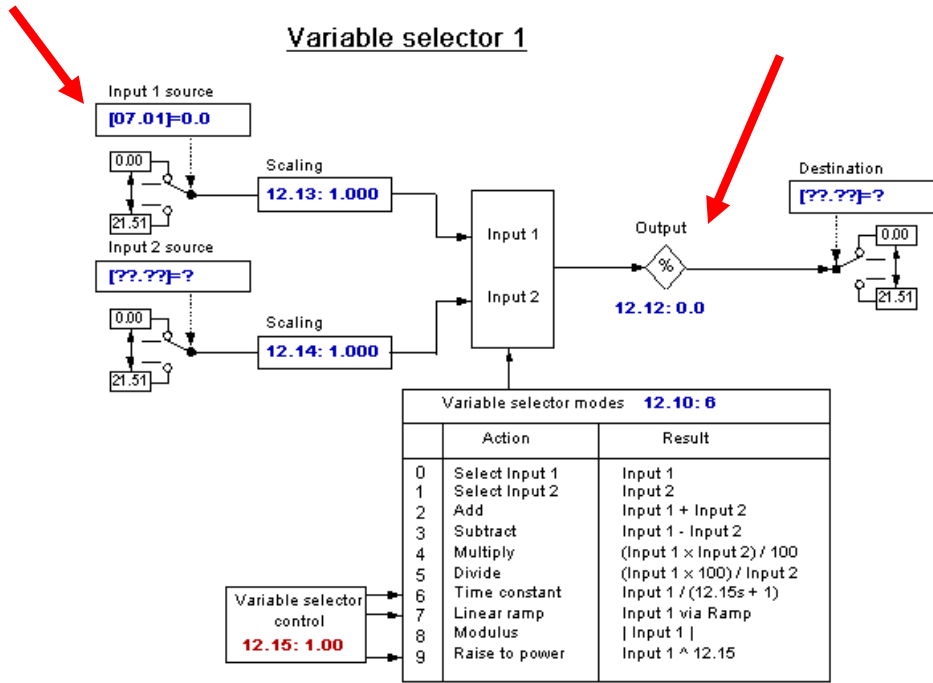| Time-sec	Vout
0	0.00
1	6.32
2	8.65
3	9.50
4	9.82
5	9.93
6	9.98

One should see that in 1 Time Constant (1TC) the output reaches about 63% of full value and that after 5T (five Time Constants which is 5 seconds in our case) the output reaches 99% of the full 10v input.

This Time Constant is what the Mode 6 is describing for Variable Selector modes.

Variable selector 1

Input 1 source
[07.01]=0.0

Scaling
12.13: 1.000

Input 2 source
[??.??]=?

Scaling
12.14: 1.000

Input 1

Input 2

Output
%
12.12: 0.0

Destination
[??.??]=?

This is the value of the Time Constant in seconds

Variable selector control
12.15: 1.00

Variable selector modes   12.10: 6

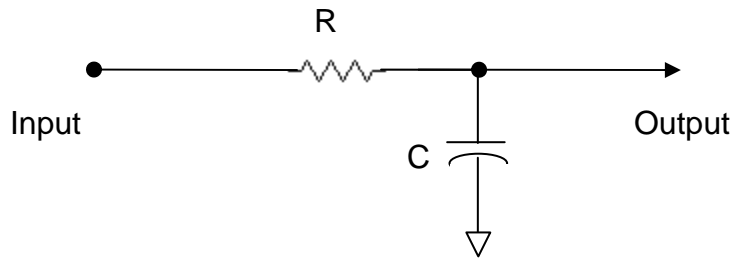|	Action	Result
0	Select Input 1	Input 1
1	Select Input 2	Input 2
2	Add	Input 1 + Input 2
3	Subtract	Input 1 - Input 2
4	Multiply	(Input 1 × Input 2) / 100
5	Divide	(Input 1 × 100) / Input 2
6	Time constant	Input 1 / (12.15s + 1)
7	Linear ramp	Input 1 via Ramp
8	Modulus		Input 1	
9	Raise to power	Input 1 ^ 12.15

These screenshots were from CTSoft working with a Commander SK. Other drive types are very similar but may appear slightly different.

The following is a screenshot from CTScope looking at #7.01 (an analog input that was set to 100%) and #12.12 (the output of the Time Constant function).

Variable selector 1

Input 1 source

[07.01]=0.0

0.00

21.51

Scaling

12.13: 1.000

Input 2 source

[??.??]=?

0.00

21.51

Scaling

12.14: 1.000

Input 1

Input 2

Output

%

12.12: 0.0

Destination

[??.??]=?

0.00

21.51

	Variable selector modes	12.10: 6	
	Action	Result
0	Select Input 1	Input 1
1	Select Input 2	Input 2
2	Add	Input 1 + Input 2
3	Subtract	Input 1 - Input 2
4	Multiply	(Input 1 × Input 2) / 100
5	Divide	(Input 1 × 100) / Input 2
6	Time constant	Input 1 / (12.15s + 1)
7	Linear ramp	Input 1 via Ramp
8	Modulus		Input 1	
9	Raise to power	Input 1 ^ 12.15

Variable selector
control

12.15: 1.00

V$_{in}$

V$_{out}$

95% at   3
seconds

It can be seen that the software implementation of the Time Constant function of Menu 12 acts exactly as theory predicts- (this is always comforting)

Time-sec	Vout
0	0.00
1	6.32
2	8.65
3	9.50
4	9.82
5	9.93
6	9.98

Time (seconds)

Carrying this idea a bit further.

So as shown, if were to apply a DC steady state voltage to the input of this circuit, the circuit tends to pass the DC voltage value from the input to the output as was demonstrated in the previous discussion….. but it does so after a time as described by the equation $V_{out} = V_{in} (1- e^{-t/RC})$.

For AC signals however, the output would become less and less as the input frequency rises as one should remember that the capacitors impedance becomes less with higher AC frequencies as described by:

$$X_C = \frac{1}{2\pi f C} \text{ in Ohm's}$$

By observation, as the denominator becomes greater the value of Xc become smaller. Therefore one can see how the output of the RC circuit tends to "attenuate" the output as frequencies increase.

This action is describing the action of a Low Pass Filter – LPF. In fact, this configuration is a simple single pole Low Pass Filter. Such a filter is said to have a cutoff frequency (where the output level is -3db below the input or about 70.7% of the input and has a phase shift of -45 degrees … lagging).
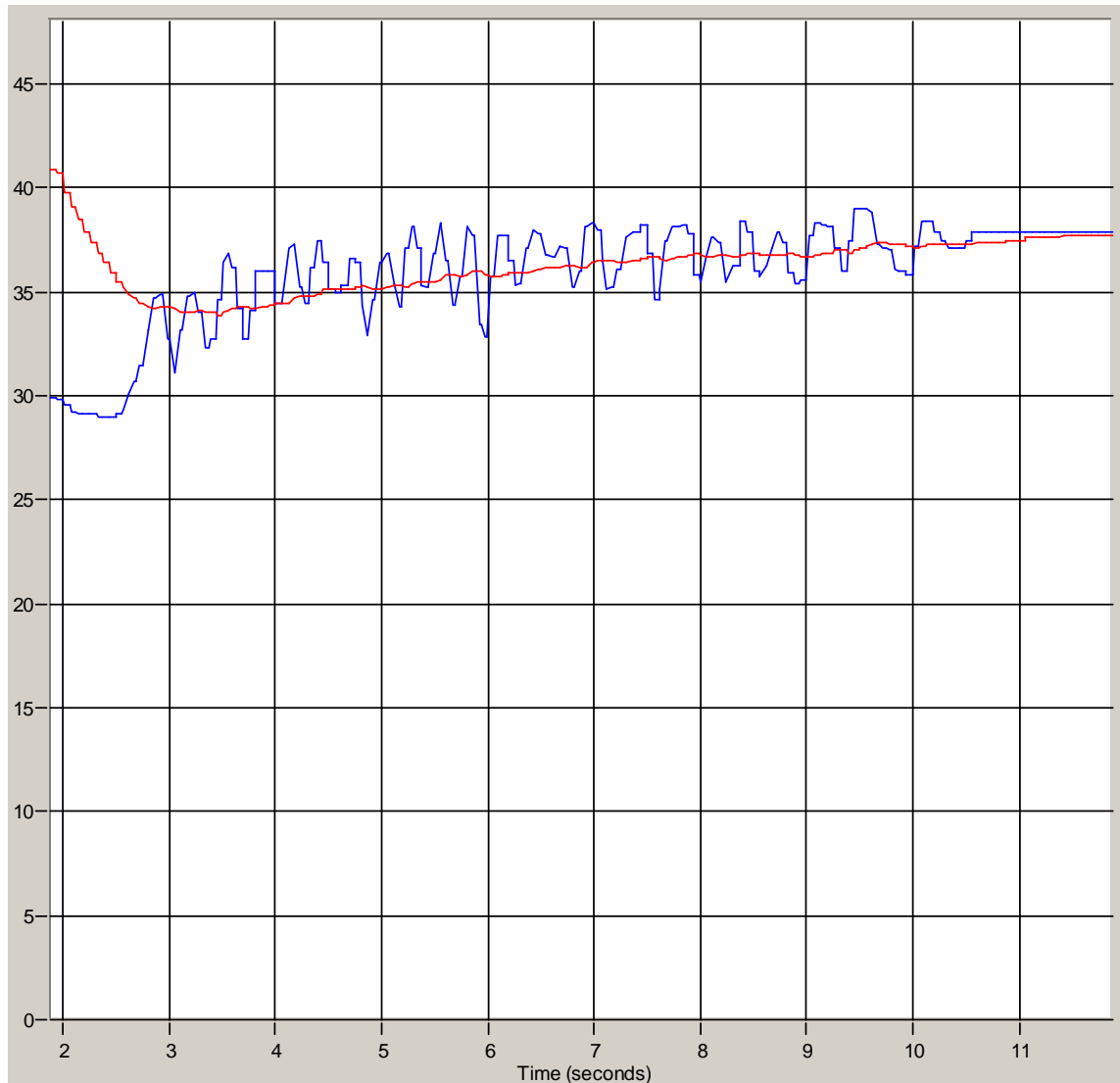
This cutoff frequency for the Low Pass Filter is : $fc = \frac{1}{2\pi RC}$

Remember- RC is the **Time Constant**

If we use the value of Time Constant that we did earlier of 1 second, our Filter cutoff frequency would be :

$$f_c = \frac{1}{2pi\,(1\,)} = \frac{1}{6.28} = 0.16Hz \text{ a fairly lower frequency}$$

To filter noisy temperature or pressure transducer signals a Time Constant this large may be ok.

For Pressure, Level or Temperature Control systems, feedback is usually rather slow and filtering time constants of 0.5 – 1 seconds may be tolerable.

For Dancer or Load Cell feedback on a Tension systems however, this would be a bit too long – perhaps a Time Constant of 0.1 or less would be more in order for these types of systems that require higher overall response.

Basically, when filtering a signal to remove extraneous noise, one should select a Time Constant as large as possible without creating too much of a time lag-(phase shift). The Time Constant can be determined via mathematical means if one has a reasonable model of the physical system but with a free tool like **CTScope**, one can merely adjust the time constant until the appropriate results can be observed.

Actually using this knowledge

Ok, so enough on the theory of operation- (actually there is much more to say on the topic but I just went over what I needed to substantiate how the Time Constant description of this mode becomes a Filter). We can see that one can pick up a signal by either of the two Variable Selectors in Menu 12, set it for Mode 6 (Time Constant), set the Time Constant in the Variable Selector Control and the filtered signal will be available as a 0 to -/-100% value.
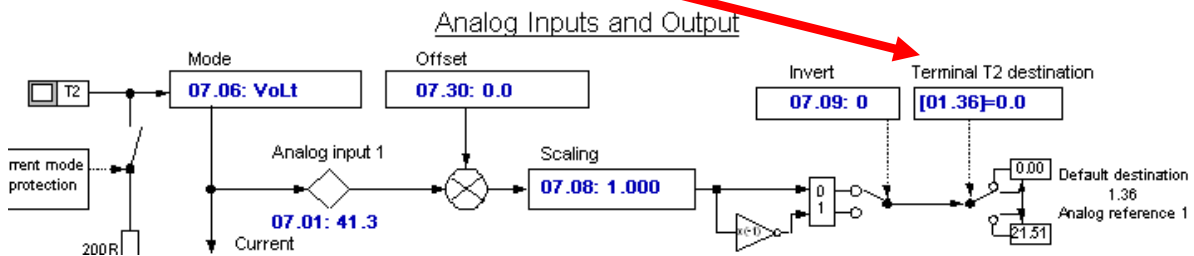
At this point, one could pick this filtered signal up at the Output
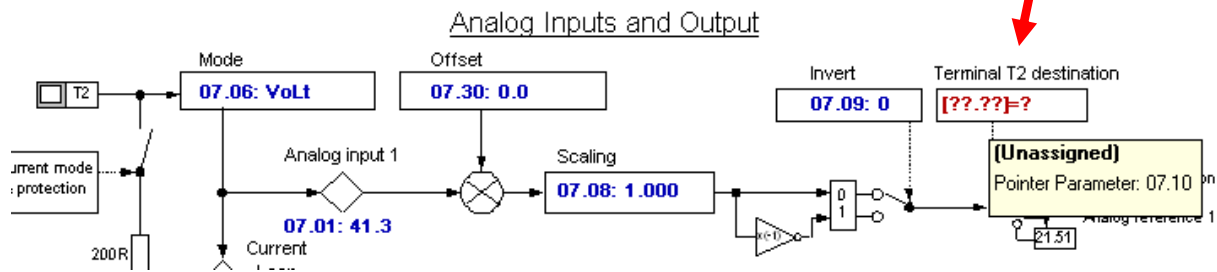
or send it to a destination
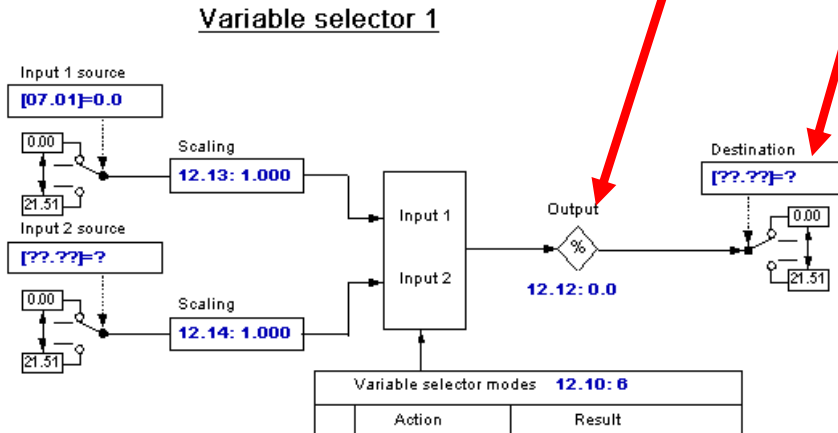
Filter an Analog Reference Command Signal

If this signal was a reference signal that came in via Analog Input #1, it is typically sent to #1.36 as seen below
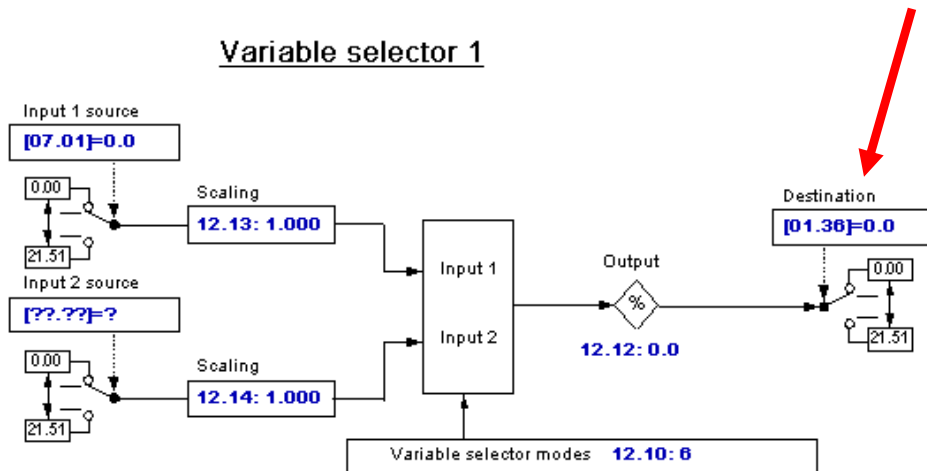

You would need to de-select that as the destination as you wish to send the filtered value to #1.36 instead.

To do this you would set the destination register (#7.10 in this case) to 0. This will de-select this destination director register.
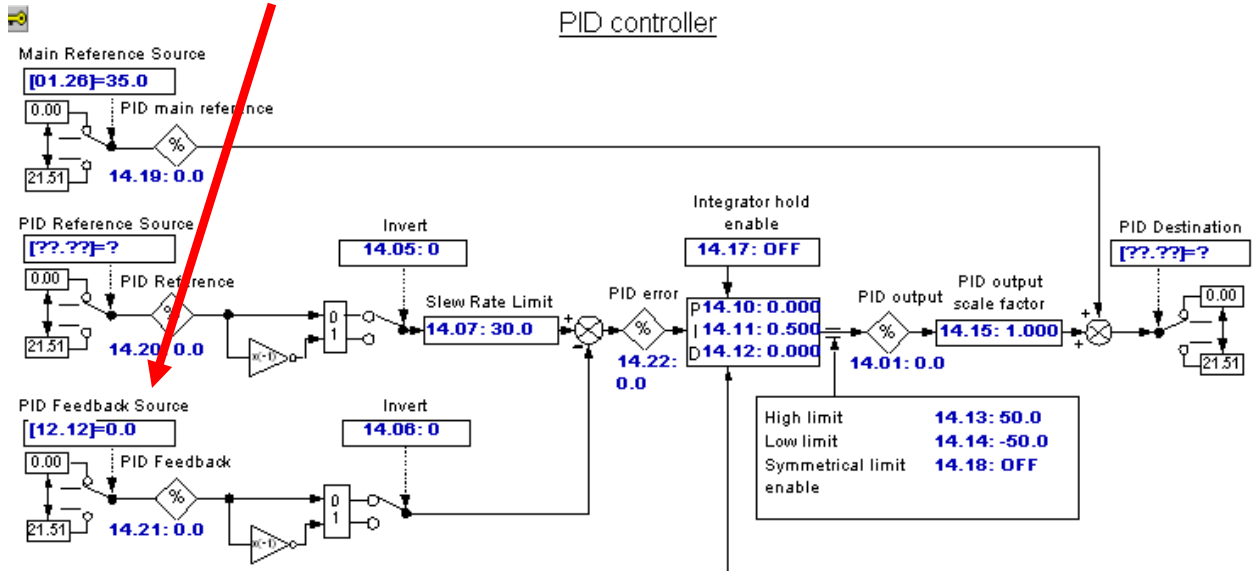
Analog Inputs and Output

Mode	Offset		Invert	Terminal T2 destination
07.06: VoLt	07.30: 0.0		07.09: 0	[??.??]=?

T2

urrent mode : protection

200R

Analog input 1

07.01: 41.3

Current

Scaling

07.08: 1.000

0
1

(Unassigned)
Pointer Parameter: 07.10

21.51

Then you would simply direct the filtered signal result to #1.36 as shown below.

Variable selector 1

Input 1 source

[07.01]=0.0

0.00

21.51

Input 2 source

[??.??]=?

0.00

21.51

Scaling

12.13: 1.000

Scaling

12.14: 1.000

Input 1

Input 2

Output

%

12.12: 0.0

Destination

[01.36]=0.0

0.00

21.51

Variable selector modes   12.10: 6

Remember – that a Reset is required to make destination register re-assignments to become affective

Filter a Transducer Feedback Signal

In this instance you would set the feedback source register for the PID controller (Menu 14) to pick up the filtered value at the Variable Selector Output- in this example it is #12.12.


For Pressure, Level or Temperature Control systems, feedback is usually rather slow and filtering time constants of 0.5 – 1 seconds may be tolerable.

For Dancer or Load Cell feedback on a Tension systems however, this would be a bit too long – perhaps a Time Constant of 0.1 or less would be more in order for these types of systems that require higher overall response.

Basically, when filtering a signal to remove extraneous noise, one should select a Time Constant as large as possible without creating too much of a time lag- (phase shift). The Time Constant can be determined via mathematical means if one has a reasonable model of the physical system but with a free tool like **CTScope**, one can merely adjust the time constant until the appropriate results can be observed.

Filtering a Speed or Current Signal for Display on an HMI

In this instance you would merely pick up the signal of interest, filter it, and then set the HMI to refer to the filtered value in either #12.12 or #12.32 for Variable Selector Output #1 or #2 respectively.   So for example, let's say you wish to display %Load for a certain motor but found that #4.20 was dancing around a bit more than you would like on the HMI display. Keep in mind that the %Load is proportional to motor current. The drive is producing motor current amounts in order to keep the speed steady as the load demand varies. These current amounts will tend to appear jittery. If you wish however to calm them down a bit – at least for display monitoring purposes, you could utilize the Filters of Menu 12.

Register quantity desired to be filtered

Filtered Register that would be picked up by the HMI
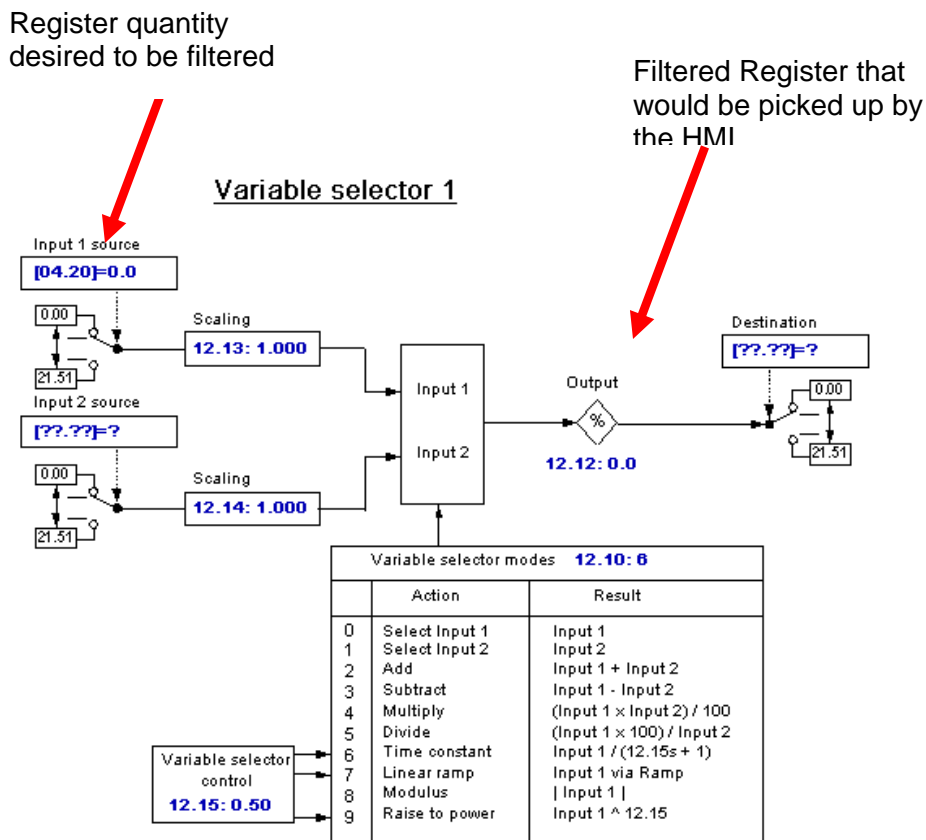
Note that the Output register #12.12 and #12.32 will be 100% at the full value of the input register. For instance, in this example #4.20 (% Load) is %Load of the motor which could be 165% possibly. Hence, the output register will be 100% at this value- the HMI displayed register would need to be scaled accordingly.

Questions ??   Ask the Author:

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