This Application Note is pertinent to the Unidrive SP, Mentor MP, Commander SK
Affinity and Commander GP20 using SyPT Lite

Practical Comparators

Introduction

Quite often a common function that is required when completing a customer application is the use of a magnitude comparator or numerical comparator. A numerical comparator is a math function that determines when one value is <, <=, =, >=, > and <> another value. (Those symbols are read as: Less than, less than or equal to, equal to, greater than or equal to, greater than and not equal to respectively). SyPT Lite and our professional version SyPT Pro both support function blocks for these common mathematic functions. These functions are quite useful and are commonly used in solving application programs. However, when we review customer programs during troubleshooting sessions, all too often , we see instances of Comparator usage oversights. These programming oversights can cause erratic system behavior and can in certain instances actual damage. This application note will attempt to illustrate the pitfall and corrective actions that can be taken in order to make a numerical comparator practical for reliable operation.

This application note will use the free PLC software toolkit called SyPT Lite that can be utilized by our Unidrive SP, Commander SK , Mentor MP, Affinity and GP20 drives.

To obtain your free copy of SyPT Lite simply click here→ **SyPT Lite**

Free

Review of SyPT Lite Comparator Functions

Below is an example of a Greater than function in SyPT. Value A is typically a varying signal or amount. Value B is typically either a constant value or a customer setting that is constant during execution. However, Value B could be a variable as well (a constantly changing value).

| Name	Comment
<	LT (<)
<=	LE (<=)
<>	NE (<>)
=	EQ (=)
>	GT (>)
>=	GE (>=)
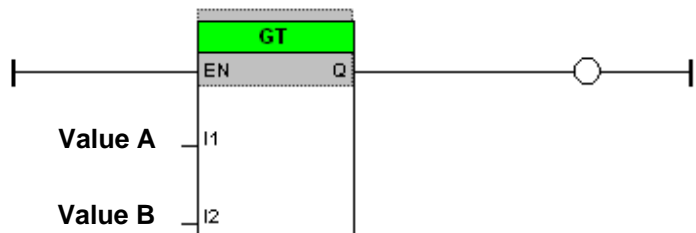
If Value A exceeds Value B, output Q becomes active

Getting Familiar with Function Blocks

There's an older song with the lyrics "*Getting to know you, getting to know all about you*" – I'm personally not too fond of it but it does describe what one needs to do to gain a full understanding of how a function block acts under various conditions. I would encourage all Users of SyPT or any programming language for that matter, to create small test programs using functions they are either trying to understand or examine.

Below is one such SyPT Lite program where a numerical comparator is being used to simply determine when an analog voltage value being presented to a Commander SK terminal T2 exceeds 5v. The analog input on terminal T2 of the Commander SK can be configured for Voltage or mA signals. In my case I selected voltage and simply wired a potentiometer to that input. The voltage range for T2 is 0 to +10v which will result in a value at #7.01 to span 0-100.0%. Parameter #7.01 can be monitored in real-time at Pr94 on the SK keypad.
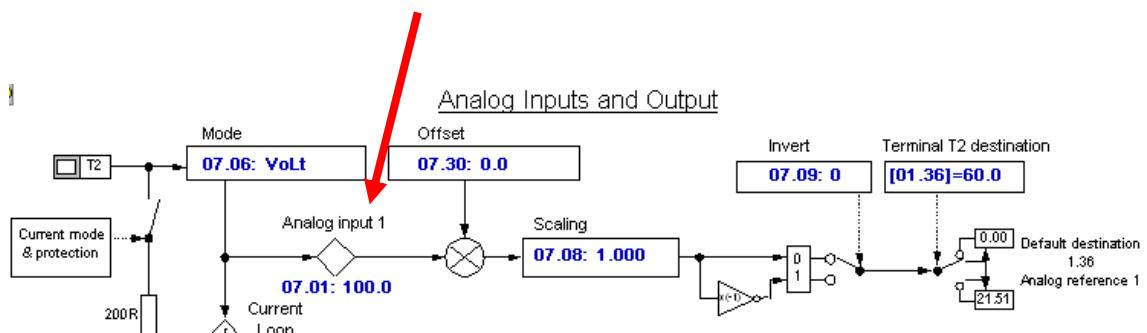
The SyPT Lite program below is comparing #7.01 values to a constant value of 50%.
One thing noticed right off the bat is that the value read at #7.01 does not contain decimal points and is x100 of what appears in #7.01 or Pr94. When Pr94 read 100.0, the value in SyPT Lite #7.01 reads 100000. So if we want to know when the input voltage exceeds 5v or 50.0% we would need to set the comparator for 50000.
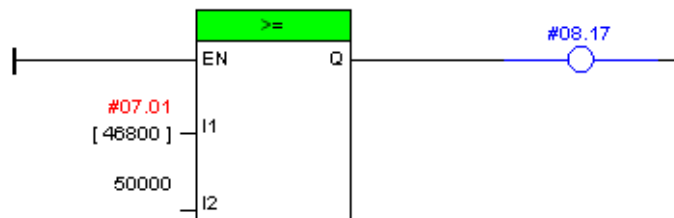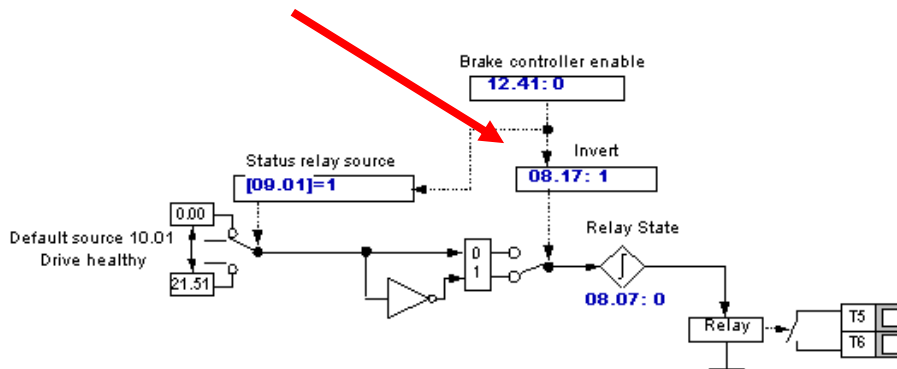

I would encourage you to create this program yourself, compile, download and run it in your test drive.

For easy audible testing and verification, I set the Comparator output to activate the Commander SK's relay inverter.

The Pitfall

Ok, so it looks real straight forward and it appears to work just fine as you turn the pot from 0 to maximum you hear the relay click around ½ rotation of the pot. But look more closely. Set your pot just at the edge of comparison. Observe Pr94 and adjust the pot for just the very edge of 49.9-50.0%. Listen to that relay !!! Sounds like a Geiger counter going off near Uranium 238 !

Just imagine what would happen if this was being used to monitor a varying signal in order to control a large contactor being piloted by the T5/ T6 relay !! It would be very embarrassing when this condition presented itself in the real world - and it would eventually. Instead of the annoying Geiger counter like sound, it would be more like a .50 caliber machine gun firing away.

Ok – so you're convinced. What can be done about it ?

The comparator is doing exactly what it is supposed to. It turns on the output when the input is greater than 50.0% in our case- and off when the signal falls below 50.0%. Any analog noise or analog dither will cause the comparison to possibly result in different outcome with each scan thru the program.

In order to make a numerical comparator practical when monitoring varying signals, one needs to introduce hysteresis. Hysteresis implies memory. Hysteresis will provide a deadband around the point of comparison to prevent such erratic results.

If we analyze what needs to be accomplished it will help us to create a solution. If we to set the comparator to trip at 51% and remain set even if the signal reduces to 50% but should the signal fall to 49%, the output would be reset. This would create a hysteresis band of 2%. This might be just fine or perhaps a little excessive but one can always set the upper point at 50.5% and the lower at 49.5% just to cover the expected amount of input variation. Testing should be proof that your hysteresis amount is adequate.

Notice the Action

(* Comparator with Hystersis *)
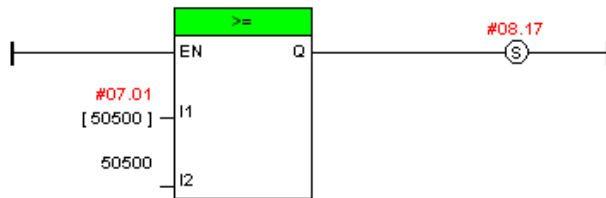
Case where the input signal rises to 50.5%

Note that it Sets the #8.17 bit   RED

(* *)
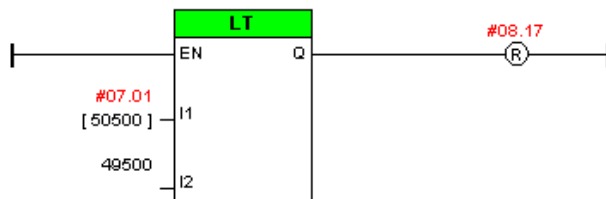
(* Comparator with Hystersis *)
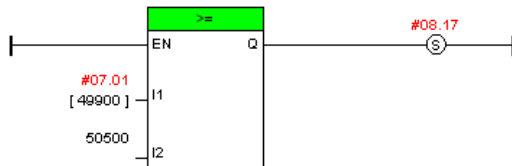
Case where the input signal falls to 49.9%

Note that #8.17 bit remains Set   RED

(* *)
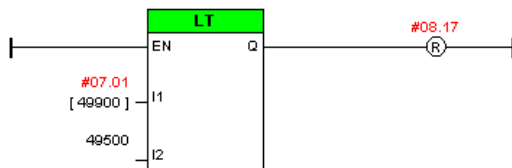
(* Comparator with Hystersis *)

Case where the input signal falls to 49.4%

Note that #8.17 bit is Reset   BLUE

(* *)
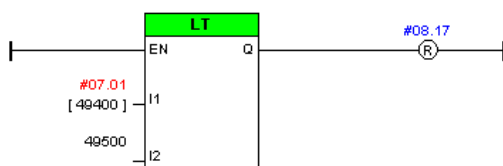
Closer Examination under the Microscope

Below is a screenshot of a CTScope captured session.   The blue trace is our analog signal hovering around the 50% trip point.   The red trace is the bit #8.17 magnified 25x so that it is more visible.   Note the action of the comparator.   Slight movement above 50.5 causes the output (red) to be high and below 49.5 it is low.
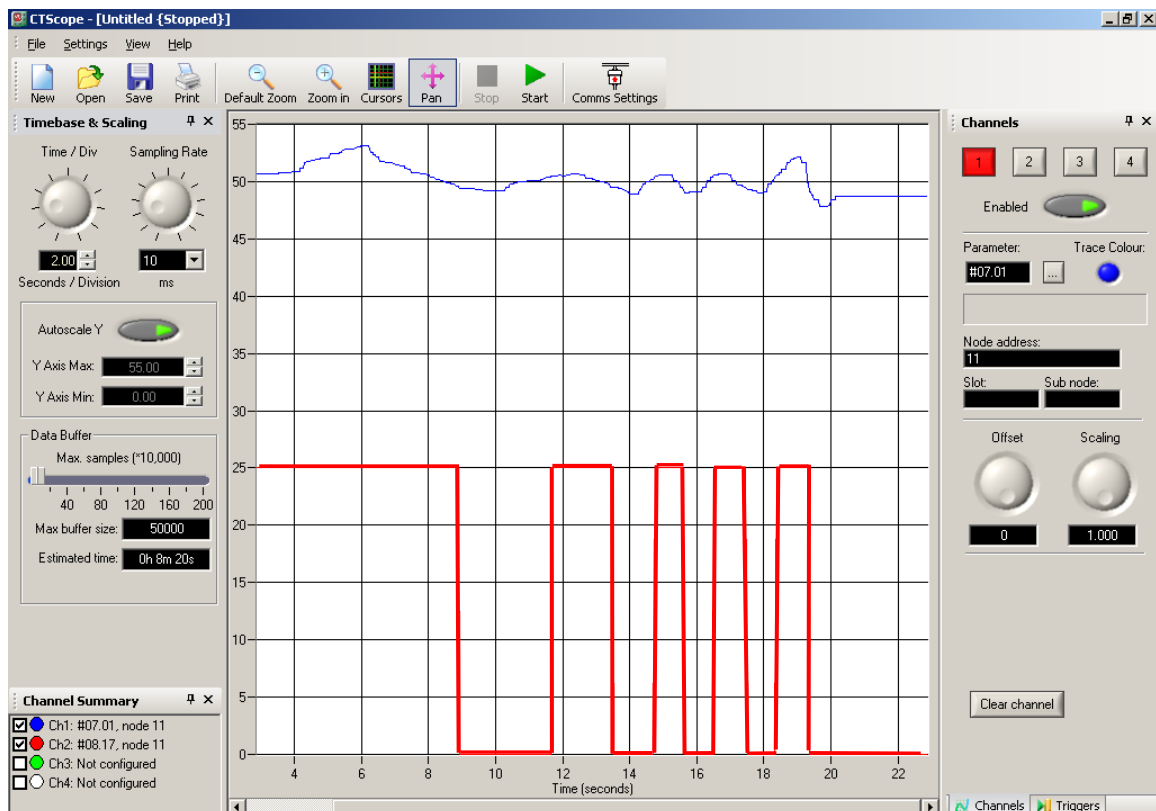
CTScope is also a complimentary software tool free for your use with Control Techniques Drives.

To obtain your Free Copy

Simply click here→   CTScope

An Even Closer Examination

Another feature of CTScope is the ability to make rather precise measurements using the Cursor placement function.
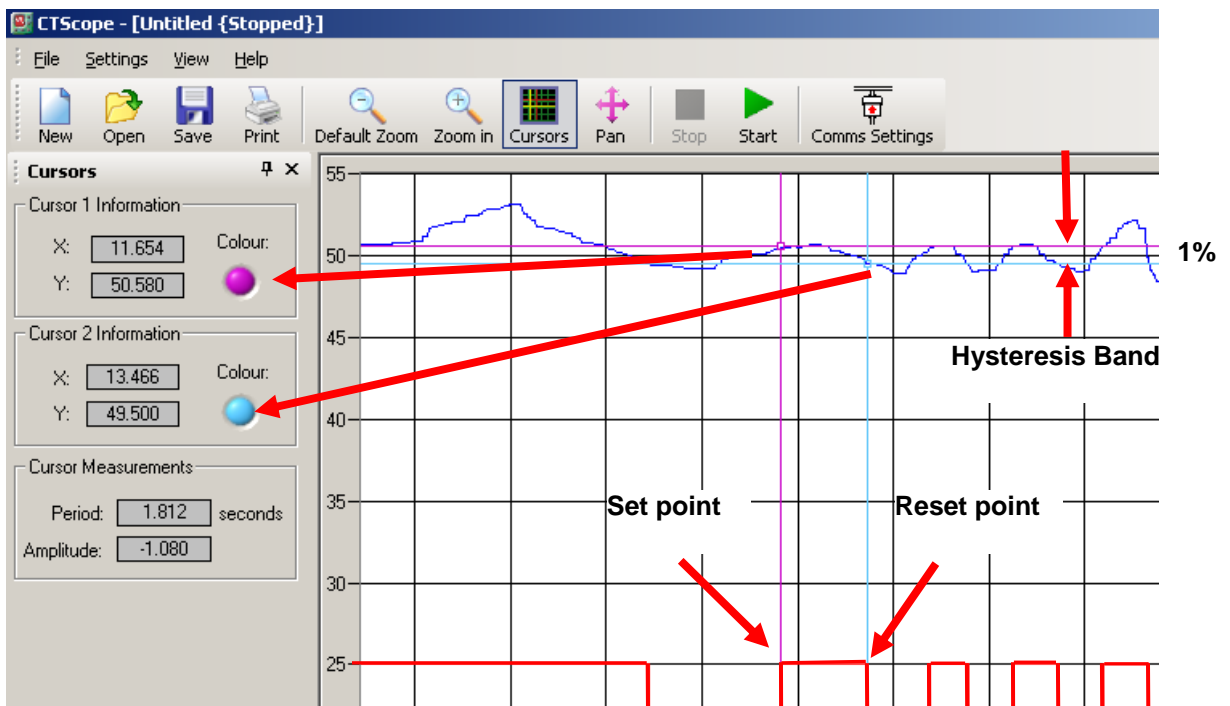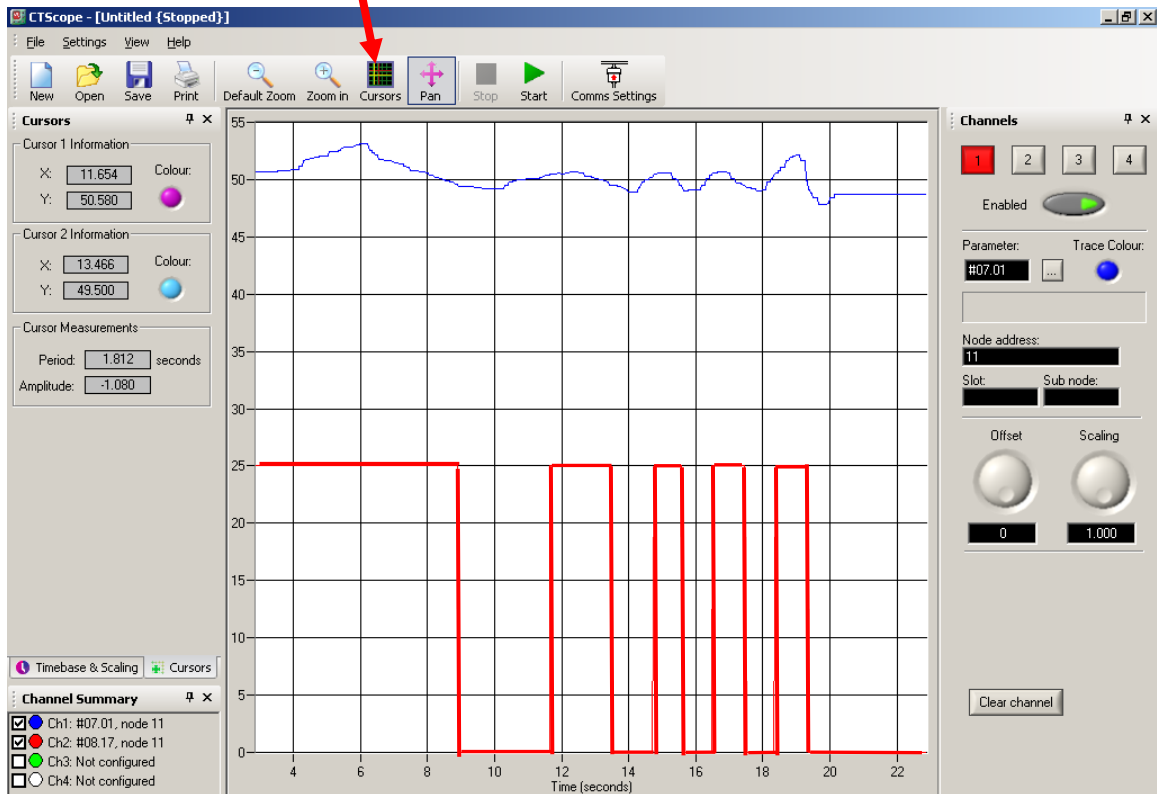
Practical Implementation

So as one can see, by using 2 comparators with an upper and lower trip point, one can create a hysteresis band which solves the problem when using a numerical comparator on time varying signals. But what if you want to make the trip points User adjustable. You would like to simply have a Comparator trip point value and possibly an adjustable hysteresis amount. If you could settle on just using a fixed hysteresis amount then that would eliminate the need for another input variable to deal with.

Example

A common application of a Comparator might be used to determine when a machines speed has exceeded a certain value. Suppose we wanted to turn on InfraRed heating elements to preheat a plastic sheet so that a Thermoformer properly makes plastic cups. When the line speed is up to production speed the IR Heating elements do a fine job but occasionally the line speed needs to be reduced to clear out a jam or something. The line never really stops as the plastic sheet production is a continuous process. In this case the Heat Lamps will scorch the sheet and cause it to wrinkle and sag. The Process Engineer would like you to create a relay output to turn off the lamps at point that he can adjust if need be to accommodate different plastic sheet thicknesses etc. Line Speed is adjusted with a Speed Pot that has a minimum setting. The Commander SK is controlling the Line Speed of the plastic line.

Stamping Thermoformer

IR Lamps
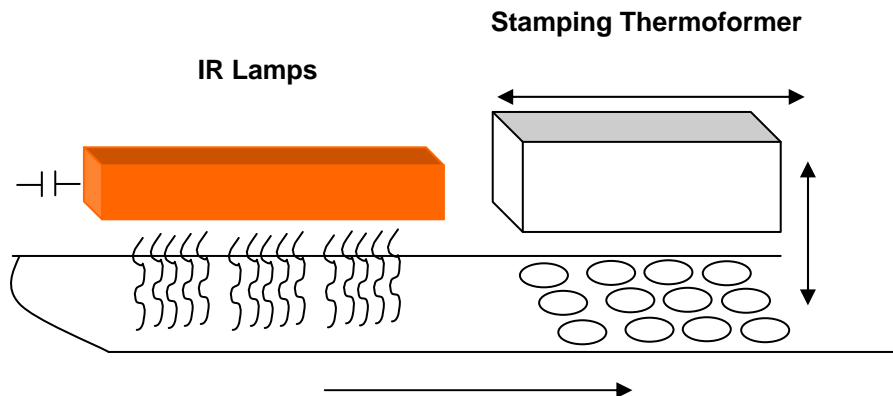
You realize that this just requires a simple analog comparator. You are using SyPT Lite for other application requirements and plan on adding a bit to your program to solve this additional request. But knowing what you know about varying signals you are cognizant of the problems associated with such comparisons. You need a comparator scheme that employs Hysteresis. For your application you decide on a fixed 1% of hysteresis. Additionally to make things as simple as possible you plan on creating a trip point that is adjustable from 1-99% with no decimals required.

(* User Adjustable Trip Point Max Limit *)

```
                    ┌───────────┐                      ┌───────────┐
                    │    GT     │                      │   Move    │
                    ├───────────┤                      ├───────────┤
        ────────────┤EN       Q ├──────────────────────┤EN     ENO ├────────────────○────
                    │           │                      │           │
            #18.11  │           │                  99  │           │  #18.11
              50 ───┤I1         │                     ─┤IN       Q ├─ 50
                    │           │                      │           │
                    │           │                      └───────────┘
              99 ───┤I2         │
                    │           │
                    └───────────┘
```
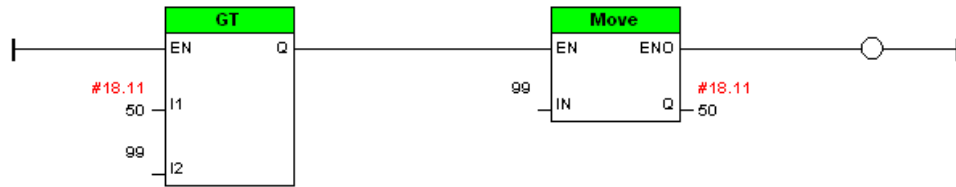
Limiting User adjustment of setpoint from 1-99%

(* User Adjustable Trip Point Min Limit *)

```
                    ┌───────────┐                      ┌───────────┐
                    │    LT     │                      │   Move    │
                    ├───────────┤                      ├───────────┤
        ────────────┤EN       Q ├──────────────────────┤EN     ENO ├────────────────○────
                    │           │                      │           │
            #18.11  │           │                   1  │           │  #18.11
              50 ───┤I1         │                     ─┤IN       Q ├─ 50
                    │           │                      │           │
                    │           │                      └───────────┘
               1 ───┤I2         │
                    │           │
                    └───────────┘
```
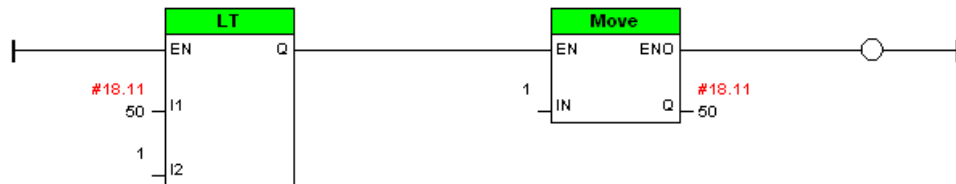
(* Calculate band (1%) off of the User trip point *)

1% band is +/-0.5% and Scale x1000

```
                    ┌───────────┐                      ┌───────────┐
                    │ multiply  │                      │ multiply  │
                    ├───────────┤                      ├───────────┤
        ────────────┤EN     ENO ├──────────            ┤EN     ENO ├────────────────○────
                    │           │                      │           │
            #18.11  │           │  #18.03      #18.11   │           │  #20.21
              50 ───┤I1       Q ├─ 250           50 ───┤I1       Q ├─ 50000
                    │           │                      │           │
               5 ───┤I2         │            1000 ────┤I2         │
                    │           │                      │           │
                    └───────────┘                      └───────────┘
```

                              Upper Trip Pt   **Lower Trip Pt**
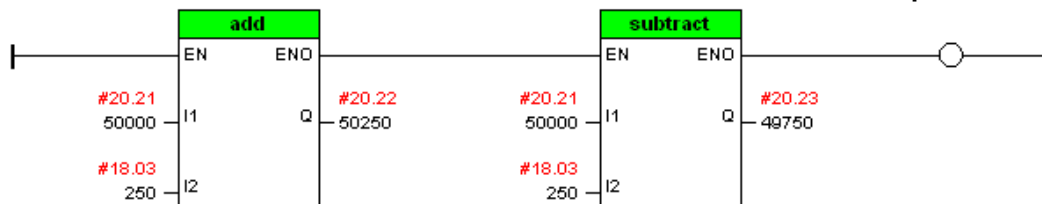
(* Create scaled Hystersis Bands *)

```
                    ┌───────────┐                      ┌───────────┐
                    │    add    │                      │ subtract  │
                    ├───────────┤                      ├───────────┤
        ────────────┤EN     ENO ├──────────            ┤EN     ENO ├────────────────○────
                    │           │                      │           │
            #20.21  │           │  #20.22      #20.21   │           │  #20.23
           50000 ───┤I1       Q ├─ 50250      50000 ───┤I1       Q ├─ 49750
                    │           │                      │           │
            #18.03  │           │              #18.03   │           │
             250 ───┤I2         │               250 ───┤I2         │
                    │           │                      │           │
                    └───────────┘                      └───────────┘
```
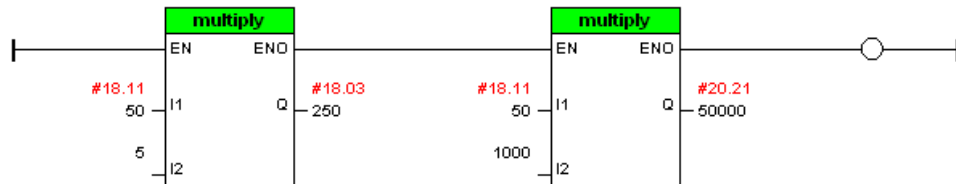
(* Comparator with Hysteresis -Upper Trip Pt *)

```
                    ┌───────────┐
                    │    >=     │              #08.17
                    ├───────────┤              ┌─┐
        ────────────┤EN       Q ├──────────────┤S├────────────
                    │           │              └─┘
            #07.01  │           │
          [ 49500 ]─┤I1         │
                    │           │
            #20.22  │           │
           50250 ───┤I2         │
                    │           │
                    └───────────┘
```

(* Comparator with Hysteresis -Lower Trip Pt *)

```
                    ┌───────────┐
                    │    LT     │              #08.17
                    ├───────────┤              ┌─┐
        ────────────┤EN       Q ├──────────────┤R├────────────
                    │           │              └─┘
            #07.01  │           │
          [ 49500 ]─┤I1         │
                    │           │
            #20.23  │           │
           49750 ───┤I2         │
                    │           │
                    └───────────┘
```
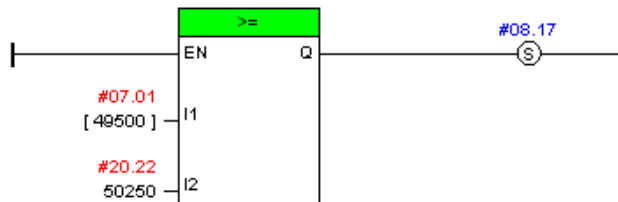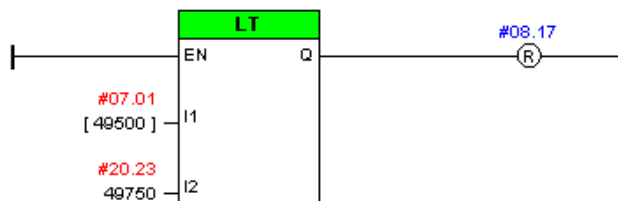
Using Aliases for Better Understanding of Program

* User Adjustable Trip Point Max Limit *)
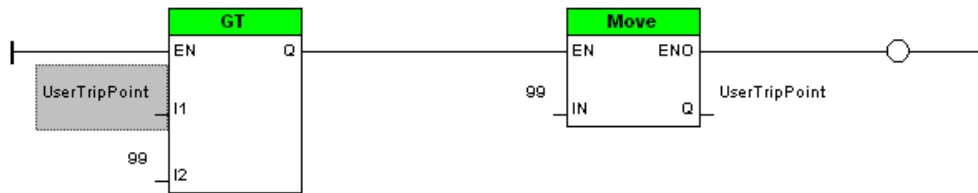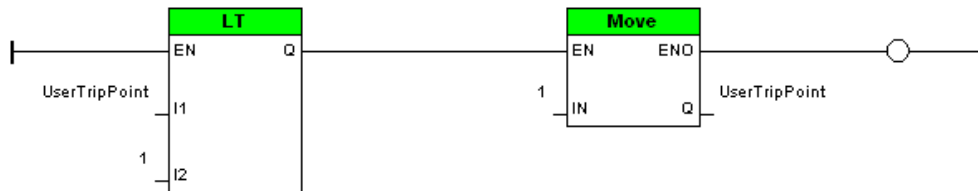
```
           ┌─────GT─────┐                  ┌────Move────┐
        ───┤EN        Q ├───             ──┤EN       ENO├────────◯───
  ┌──────┐ │            │                99│            │
  │UserTripPoint│       │              IN │          Q │  UserTripPoint
  └──────┘ │I1          │                 └────────────┘
           │            │
        99 │I2          │
           └────────────┘
```

* User Adjustable Trip Point Min Limit *)

```
           ┌─────LT─────┐                  ┌────Move────┐
        ───┤EN        Q ├───             ──┤EN       ENO├────────◯───
           │            │                 1│            │
UserTripPoint│I1        │                 IN│         Q │  UserTripPoint
           │            │                 └────────────┘
         1 │I2          │
           └────────────┘
```

* Calculate band (1%) off of the User trip point *)

```
           ┌──multiply──┐                  ┌──multiply──┐
        ───┤EN       ENO├───             ──┤EN       ENO├────────◯───
UserTripPoint│I1       Q ├─ BandAmnt  UserTripPoint│I1  Q ├─ ScaledUserTripPt
           │            │                 │            │
         5 │I2          │               1000│I2        │
           └────────────┘                  └────────────┘
```

(* Create scaled Hystersis Bands *)

```
           ┌────add─────┐                  ┌──subtract──┐
        ───┤EN       ENO├───             ──┤EN       ENO├────────◯───
ScaledUserTripPt│I1    Q ├─ScaledUpperTripPt ScaledUserTripPt│I1 Q├─ ScaledLowerTripPt
           │            │                 │            │
  BandAmnt │I2          │        BandAmnt │I2          │
           └────────────┘                  └────────────┘
```

(* Comparator with Hysteresis - Upper Trip Pt *)

```
           ┌─────>=─────┐          #08.17
        ───┤EN        Q ├───────────(S)───
SimulatedSpeedSignal│I1 │
           │            │
ScaledUpperTripPt│I2    │
           └────────────┘
```
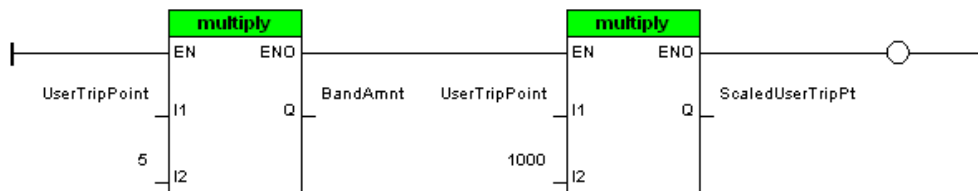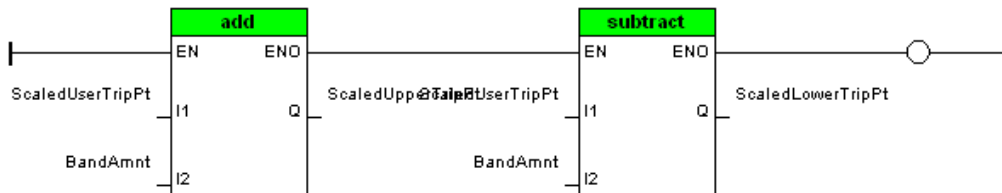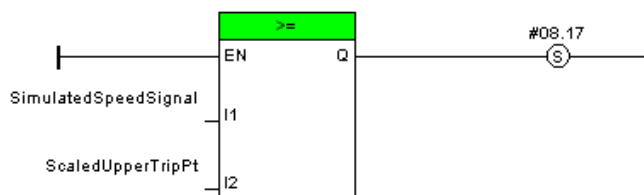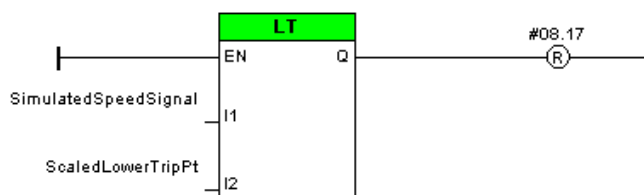
Existing Aliases:	
Alias	Parameter
UserTripPoint	#18.11
SimulatedSpeedSig...	#07.01
BandAmnt	#18.03
ScaledUserTripPt	#20.21
ScaledUpperTripPt	#20.22
ScaledLowerTripPt	#20.23

(* Comparator with Hysteresis - Lower Trip Pt *)

```
           ┌─────LT─────┐          #08.17
        ───┤EN        Q ├───────────(R)───
SimulatedSpeedSignal│I1 │
           │            │
ScaledLowerTripPt│I2    │
           └────────────┘
```

To facilitate testing the User Setpoint I also included the following rung so that Pr 61 is setup to allow one to adjust the User Trip Point conveniently.

(* Set up Pr61 to be the User Adjustable Trip Point *)
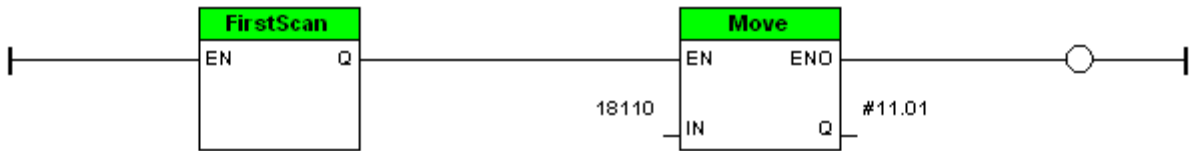
To obtain this code fragment example click -->   CTSL012.dpl

Note: This example was compiled for Commander SK drive. You could use this on our other drives by selecting the appropriate target and recompiling.

The Commander SK will need the Logic Stick to execute SyPT Lite programs.

Summary

Dealing with analog signals is always a bit more challenging.   Numerical Comparators are extremely useful but can result in erratic results if one does not account for their varying nature.

As it turns out all of our current drives contain 2 numeric comparators with hysteresis in Menu 12 which are free for such use. If those were already in use, then you could create your own using SyPT Lite.

Threshold detector 1
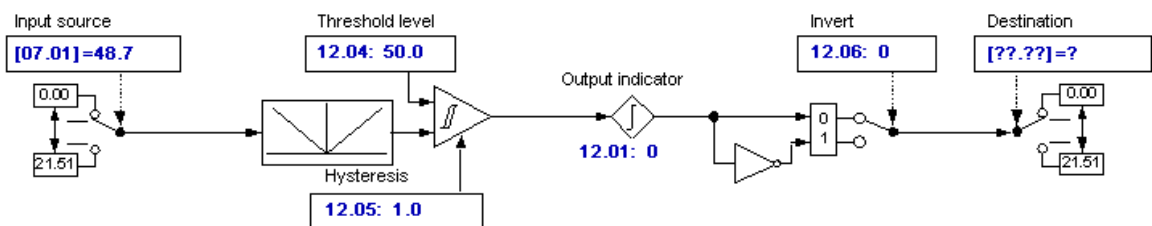
Questions ??   Ask the Author:

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