Application Note CTAN #145

The Application Note is pertinent to the Unidrive Family and the Commander SE

Analog Input / Output Scaling

In general, the analog inputs and outputs on the Unidrive are automatically scaled such that a 100% input signal will produce a value in the destination register equal to it's maximum allowable value or a maximum value in a source register will produce a 10vdc output value. This is ok assuming that the maximum values of the registers are well defined or understood. In most instances, this is the case although there are some registers that require a better description of their maximum value.

Typically, analog inputs are used for speed or torque references. Outputs on the other hand are generally used for monitoring purposes.

Analog Inputs

The main speed reference inputs, by default, are parameters #1.36 and #1.37. These two registers are auto scaled such that 100% input corresponds to the maximum speed as set by parameter #1.06 and 0% input corresponds to the minimum speed as set by parameter #1.07. An exception to this is when bipolar operation is selected (# 1.10 = 1), in this case minimum speed is not available.

If the destination of the analog inputs (see menu #7) are written to other registers, such as the preset speed registers or the torque reference register, 100% input will correspond to the maximum allowable value of those registers. In the case of preset registers, the maximum allowable value is 1000 Hz in open loop operation, or 30,000 rpm in the closed loop vector and servo modes. **Care must be taken in properly setting the analog input scale factors** such that the value of the preset register ranges from 0 to maximum speed as set by the maximum speed register #1.06. The simplest of settings, 60 Hz for an open loop drive and 1800 rpm for a vector or servo, the scale factor of the analog input would be .06.

Example: scale factor = desired max value (at 100% input) ÷ register max value
= 60Hz ÷ 1000Hz = .06

When an analog input is written to parameter #4.08, torque reference, the value of this register with 100% input will be +/- Max active current limit. The active current is the torque producing current in the motor. It is simply calculated by multiplying the rated motor current (#00.46) times the motor full load power factor (#00.43). The maximum active current will be the ratio of this current with respect to the maximum current rating of the Unidrive being used (#11.32 x overload factor) x 100. The following is an example of this calculation.

Motor Data: 5 Hp , 1750rpm, 460 vac, 6.8 FLA, 0.85 pf.

Drive Type: UNI1405, 9.5 amps continuous

To scale the analog input #1 such that 0 to 10vdc equals 0 to 100% motor torque, perform the following calculations:

Rated Torque Producing Current (Active Current) = 6.8 x 0.85 = 5.78
Maximum drive current = 9.5 (#11.32) x OL factor = 9.5 x 1.5 = 14.25 (open loop)
9.5 x 1.75 = 16.6 (vector/servo)

Maximum active current (%) = (Maximum current ÷ Active current) x 100

For Open loop = (14.25 ÷ 5.78) x100 = 246%
For Vector/Servo = (16.6 ÷ 5.78) x 100 = 287%

Therefore, with an input of 10vdc, #4.08 would read 246% for open loop and 287% for Vector/Servo. If the control range (0 to 10 vdc) were to be 0 to 100% torque, the scale factor would have to be:

100% ÷ 246% = 0.406 (open loop)
or
100% ÷ 287% = 0.384 (closed loop or servo)

Note: The Commander SE analog inputs are unipolar (0 to +10vdc). An option card is available for applications requiring a bi-directional speed reference.

Analog Outputs

The analog outputs are also designed to provide a 10vdc when there source register is at its maximum value (+/- 10vdc if the source register is bipolar, Commander SE is unipolar). In most cases, this relationship is straightforward although as with the analog inputs, there are a few source registers where the maximum value is not readily apparent or needs to be calculated. In order to determine the maximum value, it is best to look up the description of the parameter either in the Advanced User Guide or the drive software (UniSoft or SESoft).

The following example shows how to scale the analog output to read 10vdc when the motor is at 100% output power.

The parameter that provides output power is #5.03. The maximum value is calculated by the following equation; (1.73 * Imax * #5.09) ÷ 1000 Kw. If the drive being used were a UNI1405, the maximum value of register #5.03 would be calculated as follows:

Imax is the maximum output current of the drive, not the continuous current rating.
#5.09 is the motor rated voltage.

(1.73 * (1.5 * 9.5amps) * 460vac) ÷ 1000 = **11.34Kw** **open loop**

(1.73 * (1.75 * 9.5amps) * 460vac) ÷ 1000 = **13.23Kw** **closed loop**

These are the Kw levels that would produce a 10vdc analog signal output if the source register of the analog output were #5.03 and the scale factor was unity. Unfortunately, this is not 100% motor power, it's the maximum output power of the drive. To get the correct scale factor we need to calculate the rated motor power.

Assume: 5Hp motor , 6.6 amps full load , .833 power factor and 0.85 efficiency

To get 5Hp at the motor shaft, the drive must provide;

6.6 amps * 460vac * .833 pf * 1.73 = **5.258 Kw to the motor**

The *scale factor* would then be; Max value ÷ Value for 10vdc output
11.34 ÷ 5.258 = 2.156 for open loop
13.23 ÷ 5.258 = 2.516 for closed loop

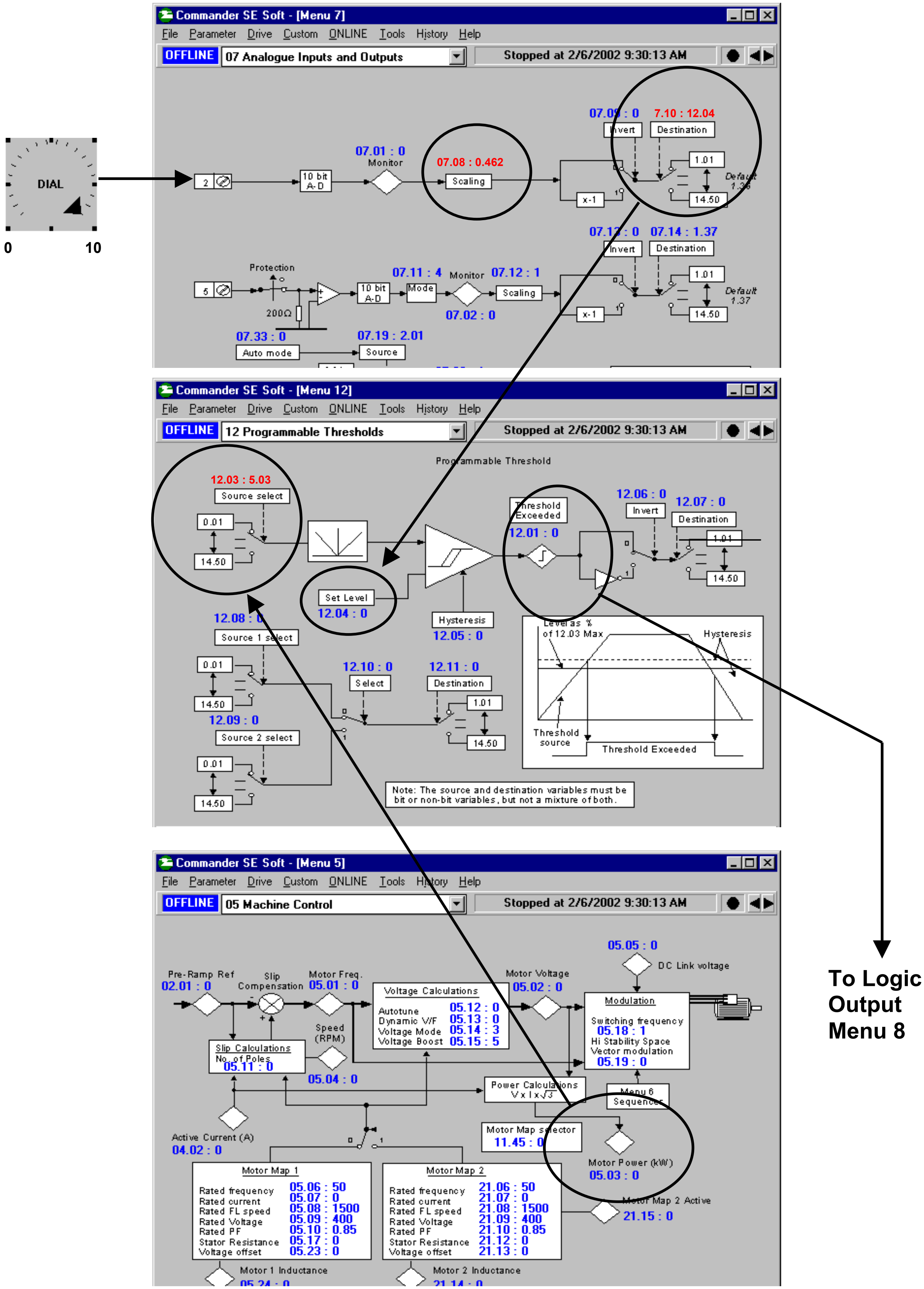
The analog output would then be scaled so that at 100% Motor rated power the output would be 10vdc.

Application example:

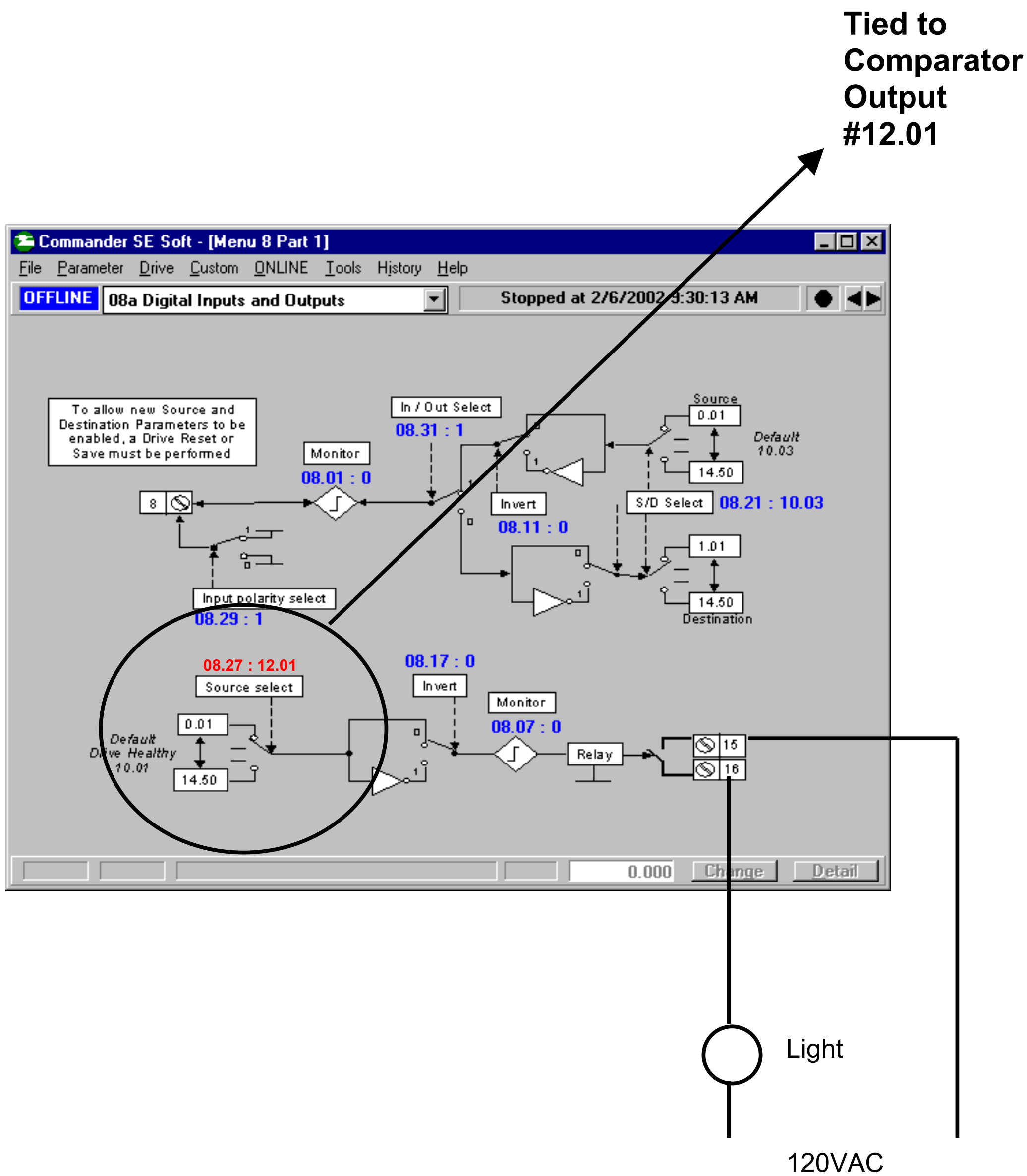
A machine manufacturer uses a Commander SE to run the spindle motor on a lathe. It's a basic unit, non-automatic where the operator starts stops and sets the spindle speed with the keypad on the drive. A hand crank moves the tool into the material and sets the force of the tool into the material. The amount of material cut is a function of the force of the tool into the material. In general, the cutting tools are "constant power" devices, which basically means that most tools can do a "heavier" cut at low speeds and lighter cuts at high speeds. Some customers have complained that with the hand crank, they can't tell when they are over working a particular tool and sometimes damage it. They ask, is there some option that can give us an indication that we are exceeding the limit of a particular tool. It would be nice if you could "tell " the drive what tool you are using and the drive could indicate if the tool was being overworked.

Solution: We could feed the drive a 0 to 10vdc signal from a potentiometer having a 0 to 10 dial indicator. This could represent zero to rated power of the drive. Each tool could be marked with a rating from zero to ten based on its "constant power" rating. If power rating of the tool is exceeded, we could turn off (or on) a light. This is easy with a Commander SE (and a Unidrive).

A simple approach would be to use the comparator (menu 12) to compare the input 0 to 10vdc to the motor output power parameter and then use the comparator output to toggle the output relay to control a light. The screen shots below show the basic signal flow:



Commander SE Soft - [Menu 7]
File Parameter Drive Custom ONLINE Tools History Help
OFFLINE
07 Analogue Inputs and Outputs
Stopped at 2/6/2002 9:30:13 AM
DIAL
0
10
07.01 : 0
Monitor
07.08 : 0.462
Scaling
10 bit A-D
07.09 : 0
7.10 : 12.04
Invert
Destination
1.01
14.50
Default 1.36
x-1
07.13 : 0
07.14 : 1.37
Protection
200Ω
07.11 : 4
Mode
Monitor
07.12 : 1
07.02 : 0
Default 1.37
07.33 : 0
Auto mode
07.19 : 2.01
Source
Commander SE Soft - [Menu 12]
12 Programmable Thresholds
Programmable Threshold
12.03 : 5.03
Source select
0.01
Set Level
12.04 : 0
Hysteresis
12.05 : 0
Threshold Exceeded
12.01 : 0
12.06 : 0
Invert
12.07 : 0
Destination
12.08 : 0
Source 1 select
12.09 : 0
Source 2 select
12.10 : 0
Select
12.11 : 0
Level as % of 12.03 Max
Threshold source
Threshold Exceeded
Note: The source and destination variables must be bit or non-bit variables, but not a mixture of both.
Commander SE Soft - [Menu 5]
05 Machine Control
05.05 : 0
DC Link voltage
Pre-Ramp Ref
02.01 : 0
Slip Compensation
Motor Freq.
05.01 : 0
Voltage Calculations
Autotune 05.12 : 0
Dynamic V/F 05.13 : 0
Voltage Mode 05.14 : 3
Voltage Boost 05.15 : 5
Motor Voltage
05.02 : 0
Modulation
Switching frequency
05.18 : 1
Hi Stability Space Vector modulation
05.19 : 0
Speed (RPM)
05.04 : 0
Slip Calculations
No. of Poles
05.11 : 0
Power Calculations
V x I x √3
Menu 6 Sequencer
Active Current (A)
04.02 : 0
Motor Map selector
11.45 : 0
Motor Power (kW)
05.03 : 0
Motor Map 2 Active
21.15 : 0
Motor Map 1
Rated frequency 05.06 : 50
Rated current 05.07 : 0
Rated FL speed 05.08 : 1500
Rated Voltage 05.09 : 400
Rated PF 05.10 : 0.85
Stator Resistance 05.17 : 0
Voltage offset 05.23 : 0
Motor Map 2
Rated frequency 21.06 : 50
Rated current 21.07 : 0
Rated FL speed 21.08 : 1500
Rated Voltage 21.09 : 400
Rated PF 21.10 : 0.85
Stator Resistance 21.12 : 0
Voltage offset 21.13 : 0
Motor 1 Inductance
Motor 2 Inductance
To Logic Output Menu 8



The system works as follows:

1. The “speed pot” with dial is connected to the drive as a standard speed pot would be connected. The destination of this signal will not be the standard speed reference register #1.36, it will be directed to the comparator circuit Set (or threshold) Level instead by setting parameter # 7.10 to 12.04. With the default scaling gain of 1.0 (#7.08), 0 to 10 on the dial corresponds to 0 to 100% in register #12.04.
2. The source of the comparator will be set to Motor Power, parameter #5.03.
3. The output of the comparator , parameter #12.01 will then be used to control the relay output by setting parameter #8.27 (the relay source select parameter) to 12.01. Now, any time the output of the comparator toggles to a “1” (Motor power exceeds set level) the relay will close and turn on the warning light.

The whole scenario sounds good until you read the description of parameter 12.04, Set Level. "This is the user defined threshold level entered as a percentage of the source maximum" The source maximum, which in this case for parameter #5.03, is the motor power register. An example of calculating the maximum of this register has been done for a 5Hp application on page 2. For open loop, the max was 11.34 Kw. For a 5Hp motor, 100% power is only 5.258 Kw (see top of page 3). This means that the range of the "reference pot" would be from 0 Kw to 11.34Kw, over double the 5 Hp rating. It would be nice to have the pot range only to 5 Hp at full scale. This can be done by setting the scale factor of the analog input to the ratio of desired 100% level to maximum. In this case;

$$5.258\text{Kw} \div 11.34\text{Kw max} = .462$$

If parameter #7.08 is set to 0.46, 0 to 10 on the dial will correspond to 0 to 5 Hp. Now if the operator has a tool marked "5" and sets the dial to "5", the light will light if the operator applies too much pressure on the tool and the motor power exceeds 2.5 Hp.

If you have any questions, ask the author:

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