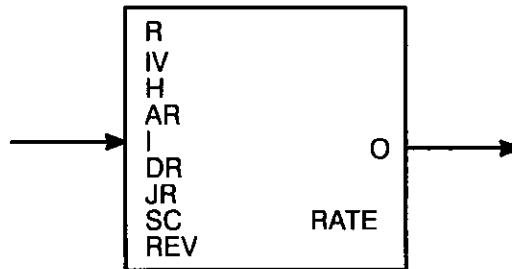


26.0 S CURVE

This function can be used in AutoMax Control Block tasks and UDC Control Block tasks



Function

The S_CURVE block performs the same basic function as the RAMP block with a jerk rate added. The jerk rate is the maximum rate of change of the rate used to ramp output to input, just as the accel and decel rates are the maximum rate of change of output to input. It is, therefore, the second derivative of the input. The primary requirement of the S_CURVE function is to ensure that the rate never changes by more than the specified jerk rate.

When a step change occurs on the input, the rate increases at the jerk rate up to the accel or decel rate. The accel or decel rate is maintained until output reaches a distance from input at which point the rate must begin decreasing. Rate will decrease by the jerk rate such that output equals input when rate is less than or equal to the jerk rate. In some cases, depending on the values of accel, decel, and jerk, the accel or decel rate may not be reached before the rate must begin decreasing by the jerk rate.

If the reverse bit = TRUE, the input accel rate will become the decel rate and the input decel rate will become the accel rate. This provides a function similar to the "motor" type RAMP block (ABS_RAMP = TRUE). With the S_CURVE block, however, this function can be dynamically controlled by the application.

Program Statement

```
CALL S_CURVE(INPUT = input%,           &
              RESET = reset@,          &
              HOLD = hold@,            &
              ACCEL_RATE = accel_rate%, &
              DECEL_RATE = decel_rate%, &
              JERK_RATE = jerk_rate%,   &
              SCALE = nnnnn,           &
              REVERSE = reverse@,       &
              INITIAL_VALUE = initial_value%, &
              OUTPUT = output%,         &
              RATE = rate%)
```

Inputs

R (RESET) =

BOOLEAN S_CURVE reset. The default for this parameter is FALSE. When TRUE, OUTPUT will be held equal to INITIAL_VALUE.

IV (INITIAL_VALUE) =

INTEGER initial value of S_CURVE. The default for this parameter is zero. When RESET = TRUE, OUTPUT will equal INITIAL_VALUE.

H (HOLD) =

BOOLEAN S_CURVE hold. The default for this parameter is FALSE. When TRUE, OUTPUT will be held at its current value. (See item 3 under "S_CURVE Internal Block Diagram.") OUTPUT will continue to move from that value until it equals INPUT when HOLD is FALSE.

AR (ACCEL_RATE) =

INTEGER acceleration rate (in units of counts per scan). The absolute value of this input is used to obtain the maximum acceleration rate from OUTPUT to INPUT. The default for this parameter is 32767.

I (INPUT) =

INTEGER signal input (initial output in equation). This parameter must be specified.

DR (DECEL_RATE) =

INTEGER deceleration rate (in units of counts per scan). The absolute value of this input is used to obtain the maximum deceleration rate from OUTPUT to INPUT. The default for this parameter is 32767.

JR (JERK_RATE) =

INTEGER jerk rate (in units of counts per scan²). The absolute value of this input is used to obtain the jerk rate. The default for this parameter is 32767. The jerk rate defines the rate of change in the rate used when ramping output to input.

SC (SCALE) =

INTEGER scale factor for ACCEL_RATE, DECEL_RATE and JERK_RATE. The default for this parameter is 1. This parameter must be entered explicitly as a numeric literal and, therefore, cannot be modified while the task is active. This parameter must be positive between 1 and 32767 inclusive.

REV (REVERSE) =

BOOLEAN S_CURVE direction. The default for this parameter is FALSE. If TRUE, the ACCEL_RATE will be used as the deceleration rate and the DECEL_RATE will be used as the acceleration rate.

Outputs

O (OUTPUT) =

INTEGER signal output (final output in equations). This parameter must be specified.

RATE (RATE) =

INTEGER. Internal change in the OUTPUT * SCALE. This parameter is optional. It is calculated from the internal 32-bit value of OUTPUT * SCALE.

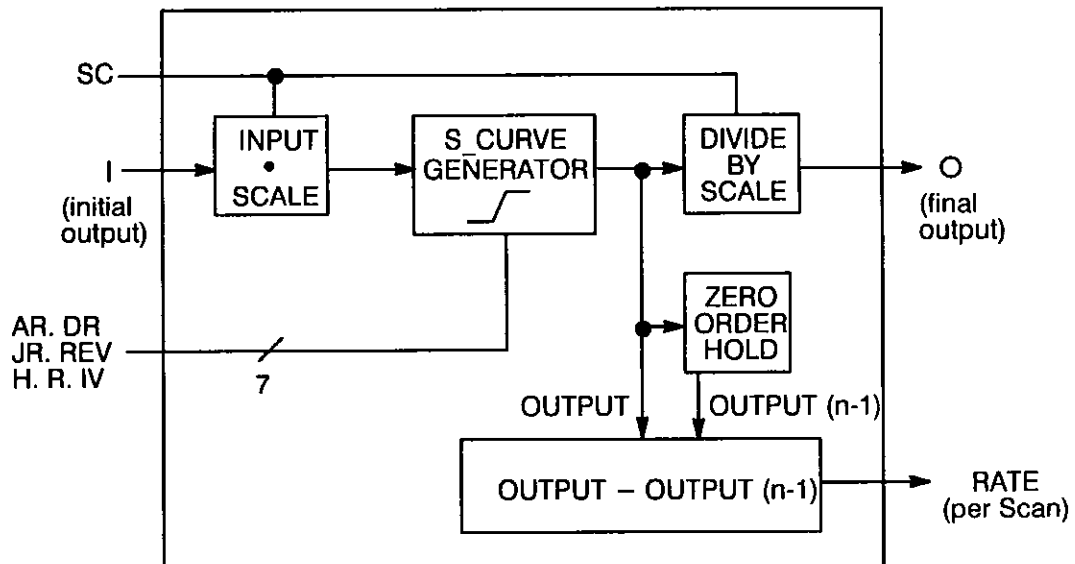
Notes

The SCALE input is optional. It is used only to change the units for the two rate inputs (ACCEL_RATE and DECEL_RATE) from per-scan to per-second units. To do this, the SCALE input is set to the number of times the block is executed in one second.

For example, if the S_CURVE block is used in a UDC task running at 20 ticks, SCALE should be set to 100. On the UDC, 1 tick=0.0005 seconds, so 20 ticks=0.01 seconds. SCALE is then $(1/0.01)=100$.

In this example, if an accel rate of 500 counts per second is desired, ACCEL_RATE would be set to 500. If the SCALE input was not used (it defaults to 1), ACCEL_RATE would have to be set to 5 to achieve the desired 500 counts per second.

S_CURVE Internal Block Diagram



1. When accel rate and/or decel rate is equal to zero (0), the block will effectively be held (not permitted to move) in that direction.
2. The actual rate of change of the output is inversely proportional to the scan time. Thus, the actual rates in counts/second can be calculated as:

$$\text{RATE} = \frac{\text{rate \%}}{\text{scale \%}} * \frac{1}{T_s}$$

where:

rate% = accel_rate% or decel_rate% (or jerk_rate% ÷ Ts)

Ts = scan period in seconds/scan

The slowest rate, therefore, is when rate% is equal to its minimum (1) and scale% is equal to its maximum value (32767). Similarly, the fastest rate is when rate% is equal to its maximum value (32767) and scale% is equal to its minimum value (1).

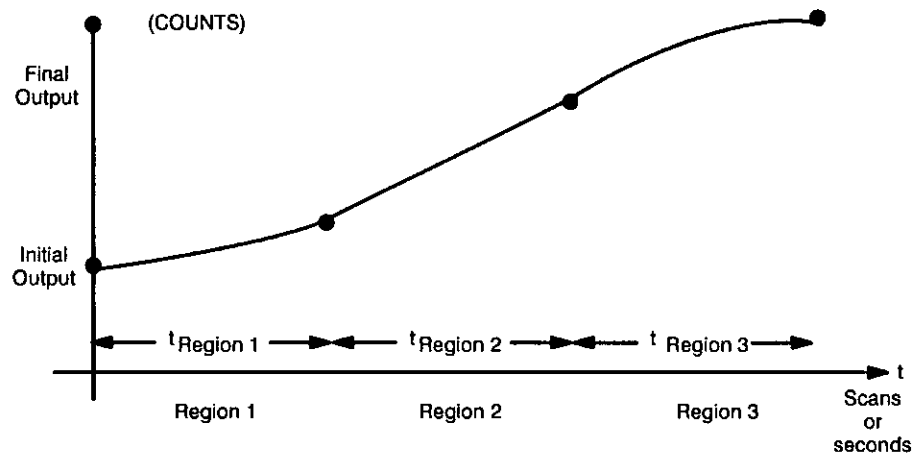
For example, when Ts = 5.5 msec:

$$\text{Min rate} = (1 \div 32767) \div .0055 = .00554882 \text{ counts/sec}$$

$$\text{Max rate} = (32767 \div 1) \div .0055 = 5957636.4 \text{ counts/sec}$$

3. When OUTPUT (final) is moving toward input and HOLD is SET = TRUE, the rate will immediately begin decreasing towards zero at the jerk rate. OUTPUT (initial) will be held at whatever value it had when the rate reached zero. This is due to the jerk rate requirement. Therefore, when OUTPUT is finally held constant, it will have a value different from its value the instant that HOLD was SET = TRUE.
4. If JERK_RATE is greater than or equal to ACCEL_RATE and DECEL_RATE, the function will be identical to that of the RAMP block.
5. Reducing the JERK_RATE during a transition may cause the following to occur: the OUTPUT may overshoot the INPUT and/or the calculated output value may exceed the limits of an integer variable (± 32767). If overshoot occurs, it is the result of enforcing the entered JERK_RATE. To enforce the JERK_RATE, if the RATE is at a value which, when the JERK_RATE is lowered, cannot be decreased to zero by the new JERK_RATE before OUTPUT = INPUT, OUTPUT must overshoot INPUT. This can be avoided by decreasing JERK_RATE in small steps while tuning or only decreasing JERK_RATE while OUTPUT = INPUT (not during a transition). If the computed output value exceeds +32767 or -32768, the OUTPUT will be clamped to +32767 or -32768, respectively, and an error will be logged. Also, the internal value for OUTPUT will be clamped to avoid internal overshoot and the RATE will be set to zero.
6. The time that is required for the output to equal a change in the input is a function of ACCEL_RATE, JERK_RATE, and the difference between INPUT and OUTPUT.

System Reaches ACCEL_RATE



$$t_{\text{Total}} = \frac{\text{FINAL OUTPUT} - \text{INITIAL OUTPUT}}{\text{ACCEL}} + \frac{\text{ACCEL}}{\text{JERK}}$$

Region 1 Equations

$$t_1 = \frac{\text{ACCEL}}{\text{JERK}}$$

$$y(t) = \text{INITIAL OUTPUT} + \frac{1}{2} (\text{JERK}) t^2$$

Region 2 Equations

$$t_2 = \frac{\text{JERK} \left(\frac{\text{FINAL OUTPUT} - \text{INITIAL OUTPUT}}{\text{ACCEL}} \right) - \text{ACCEL}^2}{\text{JERK} * \text{ACCEL}}$$

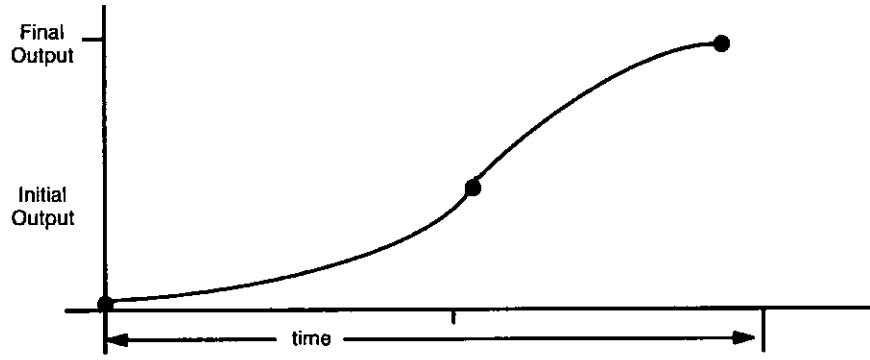
$$y(t) = \text{INITIAL OUTPUT} + (\text{ACCEL}) t - \left(\frac{\text{ACCEL}^2}{2 * \text{JERK}} \right)$$

Region 3 Equations

$$t_3 = \frac{\text{ACCEL}}{\text{JERK}}$$

$$y(t) = \text{FINAL OUTPUT} - \frac{1}{2} (\text{JERK}) * \left[t - \frac{\text{FINAL OUTPUT} - \text{INITIAL OUTPUT}}{\text{ACCEL}} - \frac{\text{ACCEL}}{\text{JERK}} \right]^2$$

System Does Not Reach ACCEL_RATE



When $\text{INITIAL OUTPUT} - \text{FINAL OUTPUT} < (\text{ACCEL_RATE}^2 / \text{JERK_RATE})$

$$\text{time} = 2 \sqrt{\frac{\text{INITIAL OUTPUT} - \text{FINAL OUTPUT}}{\text{JERK_RATE}}}$$