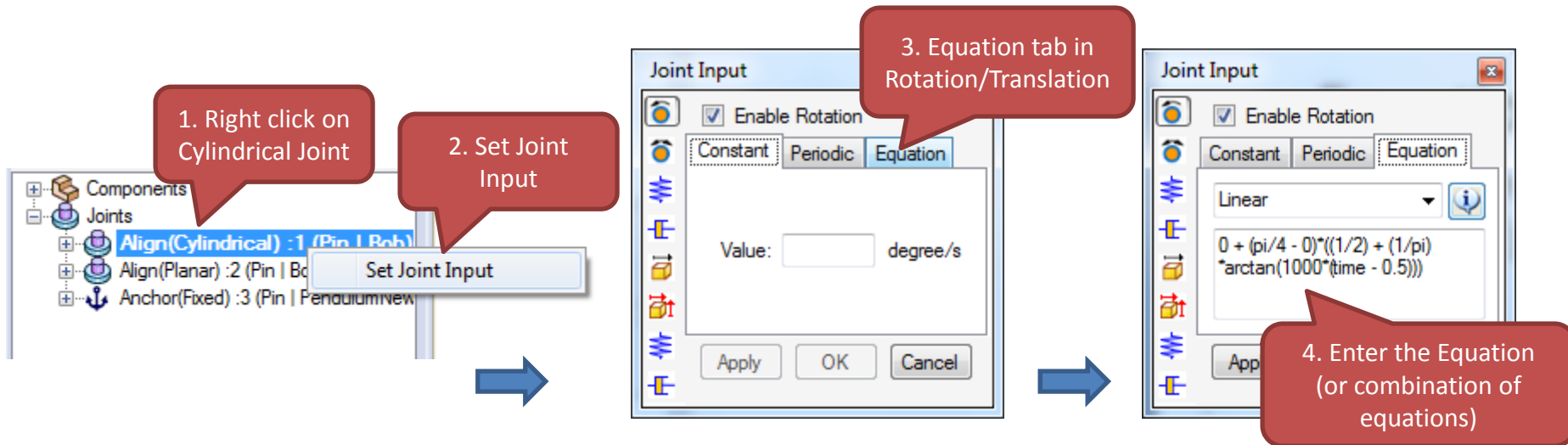


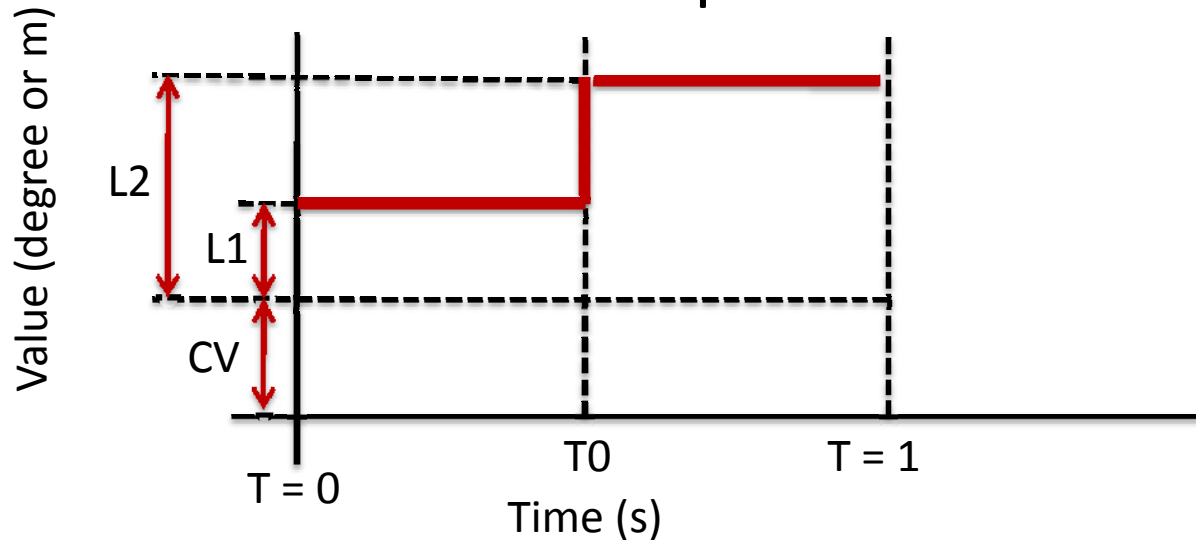
# Equations in SC-Motion 2012

- Equations can be set as input for rotation and translation of joints (cylindrical)



- All the equations are with respect to the current position (angle/translation length)
- Several equations between different time durations can be combined

# Smooth Step Function



### Equation ###

$$L1 + (L2 - L1) * ((1/2) + (1/\pi) * \arctan(\text{SLOPE} * (\text{time} - T0)))$$

CV is the current value of joint (angle or translation length). This is determined automatically.

L1 is step level before time = T0, value is with respect to CV

L2 is step level after time = T0, value is with respect to CV

SLOPE defines the steepness of the transition between L1 and L2 about time = T0. Higher values gives sharper cornered steps. SLOPE = 1000 or greater are suitable.

### Example###

$$0 + (\pi/4 - 0) * ((1/2) + (1/\pi) * \arctan(1000 * (\text{time} - 0.5)))$$

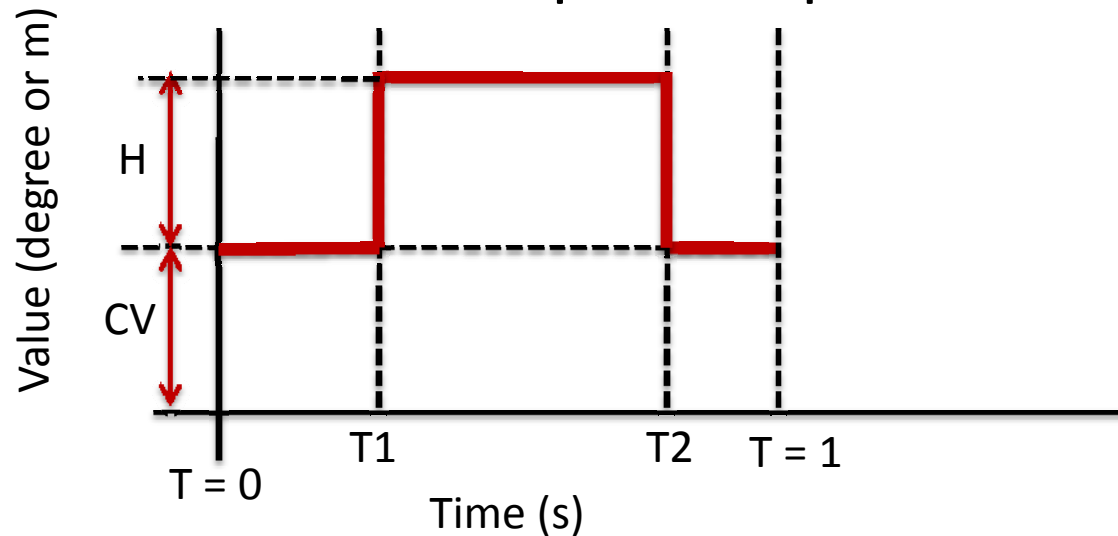
L1 is angle from the current joint angle value. In our case, let it be zero (0 radians).

T0 = 0.5 seconds.

L2 is step level after time = T0, in our case, it is pi/4 radians i.e., 45°

SLOPE = 1000

# Smooth Square Impulse



### Equation ###

$$(H/\pi) * (\arctan(\text{SLOPE} * (\text{time} - T1)) - \arctan(\text{SLOPE} * (\text{time} - T2)))$$

CV is the current value of joint (angle or translation length). This is determined automatically.

T1 is the start of the impulse.

T2 is the end of the impulse.

H is the height of the impulse, value is with respect to CV

SLOPE defines the steepness of the transition between 0 and H about time = T1 and T2. Higher values gives sharper cornered impulses. SLOPE = 1000 or greater are suitable.

### Example ###

$$((\pi/4)/\pi) * (\arctan(1000 * (\text{time} - 0.25)) - \arctan(1000 * (\text{time} - 0.75)))$$

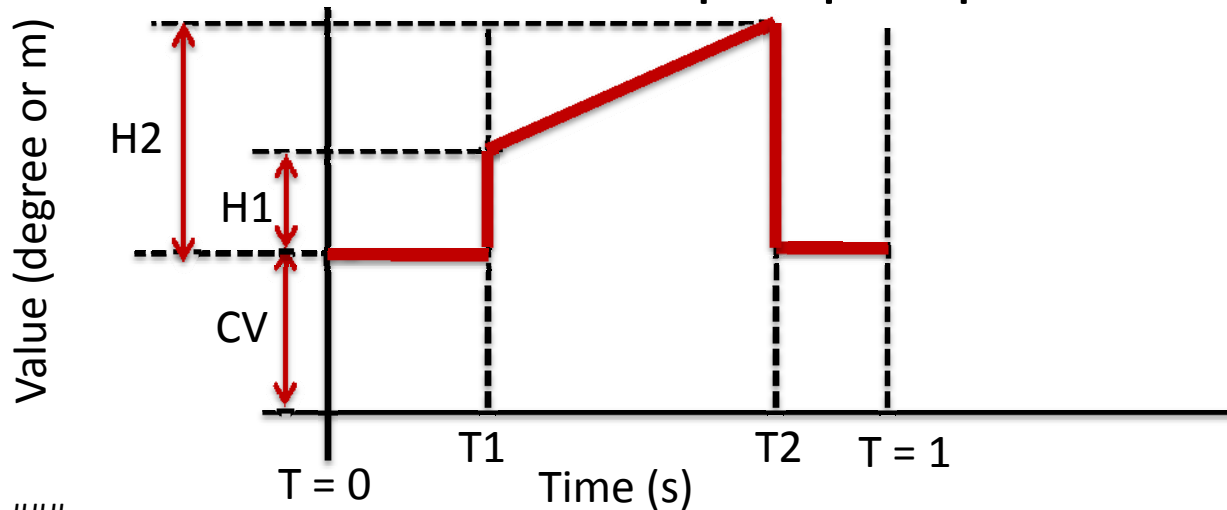
H =  $\pi/4$  (values should be in radians)

T1 is the start of the impulse = 0.25 seconds

T2 is the end of the impulse = 0.75 seconds

SLOPE = 1000

# Smooth Ramp Top Impulse



### Equation ###

$$\left(\frac{1}{\pi}\right) * \left(\arctan(\text{SLOPE} * (\text{time} - T1)) - \arctan(\text{SLOPE} * (\text{time} - T2))\right) * \left(\frac{H2 - H1}{T2 - T1}\right) * (\text{time} - T1) + H1$$

This is similar to the square impulse but the top has a sloping ramp. It is good for building a smooth piecewise linear function by adding a series of these.

CV is the current value of joint (angle or translation length). This is determined automatically.

T1 is the start of the impulse.

T2 is the end of the impulse.

H1 is the height at T1 at the beginning of the ramp, value is with respect to CV.

H2 is the height at T2 at the end of the ramp, value is with respect to CV.

SLOPE defines the steepness of the transition between 0 and H1 and H2 to 0 about time = T1 and T2 respectively. Higher values gives sharper cornered impulses. SLOPE = 1000 or greater are suitable.

### Example ###

$$\left(\frac{1}{\pi}\right) * \left(\arctan(1000 * (\text{time} - 0.25)) - \arctan(1000 * (\text{time} - 0.75))\right) * \left(\frac{(\pi/2) - (\pi/4)}{(0.75 - 0.25)}\right) * (\text{time} - 0.25) + (\pi/4)$$

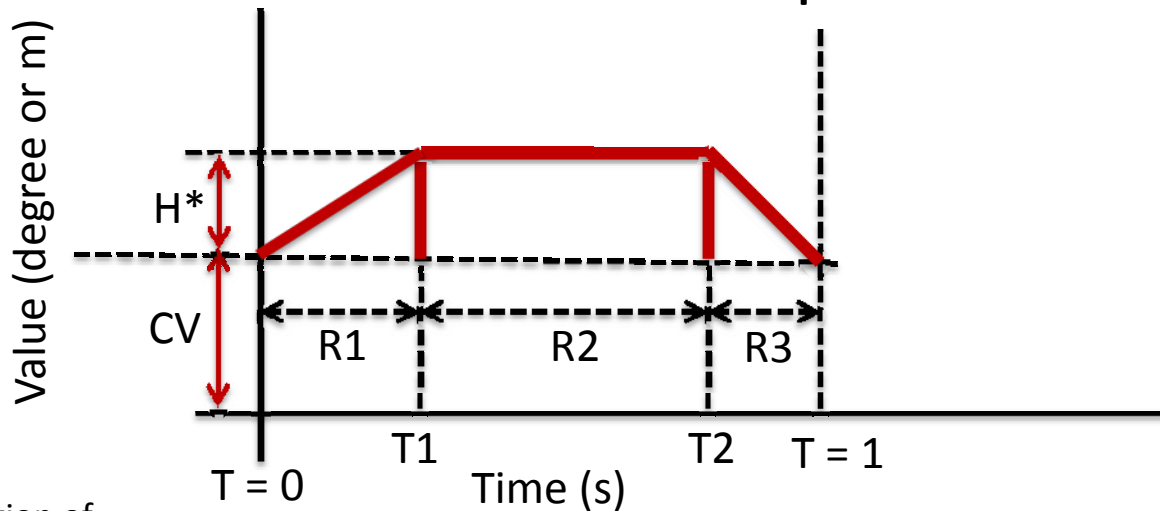
H1 =  $\pi/4$  (values should be in radians) ; H2 =  $\pi/2$  (values should be in radians)

T1 is the start of the impulse = 0.25 seconds

T2 is the end of the impulse = 0.75 seconds

SLOPE = 1000

# Combination of Equations



This is a combination of

R1 = Region 1: Smooth Ramp Top Impulse with  $H_1 = 0$ ;  $H_2 = H^*$ ; Duration between  $T=0$  and  $T_1$

R2 = Region 2: Smooth Square Impulse with  $H = H^*$ ; Duration between  $T_1$  and  $T_2$

R3 = Region 3: Smooth Ramp Top Impulse with  $H_1 = H^*$ ;  $H_2 = 0$ ; Duration between  $T_2$  and  $T=1$

## ### Example Equation###

$$\left(\frac{1}{\pi}\right) \cdot \left(\arctan(1000 \cdot (\text{time} - 0)) - \arctan(1000 \cdot (\text{time} - 0.25))\right) \cdot \left(\frac{(\pi/4) - 0}{(0.25 - 0)} \cdot (\text{time} - 0) + 0\right)$$

+

$$\left(\frac{\pi/4}{\pi}\right) \cdot \left(\arctan(1000 \cdot (\text{time} - 0.25)) - \arctan(1000 \cdot (\text{time} - 0.75))\right)$$

+

$$\left(\frac{1}{\pi}\right) \cdot \left(\arctan(1000 \cdot (\text{time} - 0.75)) - \arctan(1000 \cdot (\text{time} - 1))\right) \cdot \left(\frac{0 - (\pi/4)}{(1 - 0.75)} \cdot (\text{time} - 0.75) + (\pi/4)\right)$$

$H^* = \pi/4$  (values should be in radians) ;

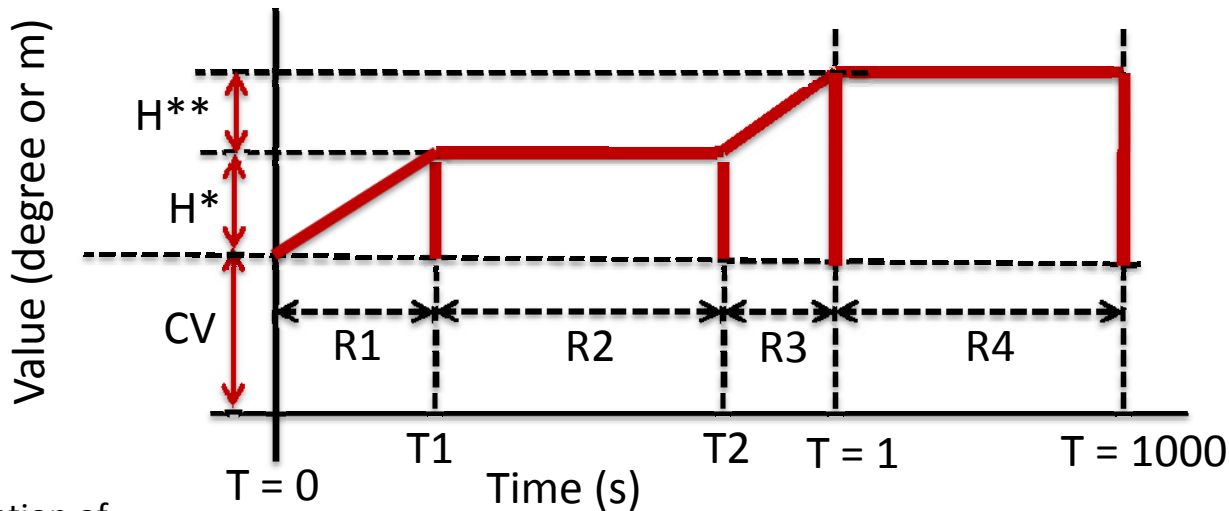
$T_1$  is the start of the impulse = 0.25 seconds

$T_2$  is the end of the impulse = 0.75 seconds

Total duration is between 0 and 1 seconds

SLOPE = 1000

# Set Different Joint Value at end of Simulation Time



This is a combination of

R1 = Region 1: Smooth Ramp Top Impulse with  $H_1 = 0$ ;  $H_2 = H^*$ ; Duration between  $T=0$  and  $T_1$

R2 = Region 2: Smooth Square Impulse with  $H = H^*$ ; Duration between  $T_1$  and  $T_2$

R3 = Region 3: Smooth Ramp Top Impulse with  $H_1 = H^*$ ;  $H_2 = H^{**}$ ; Duration between  $T_2$  and  $T=1$

R4 = Region 4: Smooth Square Impulse with  $H = H^{**}$ ; Duration between  $T=1$  and  $T=1000$  (high value, instead of infinity)

## ### Example Equation###

$$\left(\frac{1}{\pi} \cdot (\arctan(1000 \cdot (\text{time} - 0)) - \arctan(1000 \cdot (\text{time} - 0.25)))\right) \cdot \left(\frac{(\pi/4) - 0}{(0.25 - 0)} \cdot (\text{time} - 0) + 0\right)$$

+

$$\left(\frac{(\pi/4)}{\pi}\right) \cdot (\arctan(1000 \cdot (\text{time} - 0.25)) - \arctan(1000 \cdot (\text{time} - 0.75)))$$

+

$$\left(\frac{1}{\pi} \cdot (\arctan(1000 \cdot (\text{time} - 0.75)) - \arctan(1000 \cdot (\text{time} - 1)))\right) \cdot \left(\frac{(\pi/2) - (\pi/4)}{(1 - 0.75)} \cdot (\text{time} - 0.75) + (\pi/4)\right)$$

+

$$\left(\frac{(\pi/2)}{\pi}\right) \cdot (\arctan(1000 \cdot (\text{time} - 1)) - \arctan(1000 \cdot (\text{time} - 1000)))$$

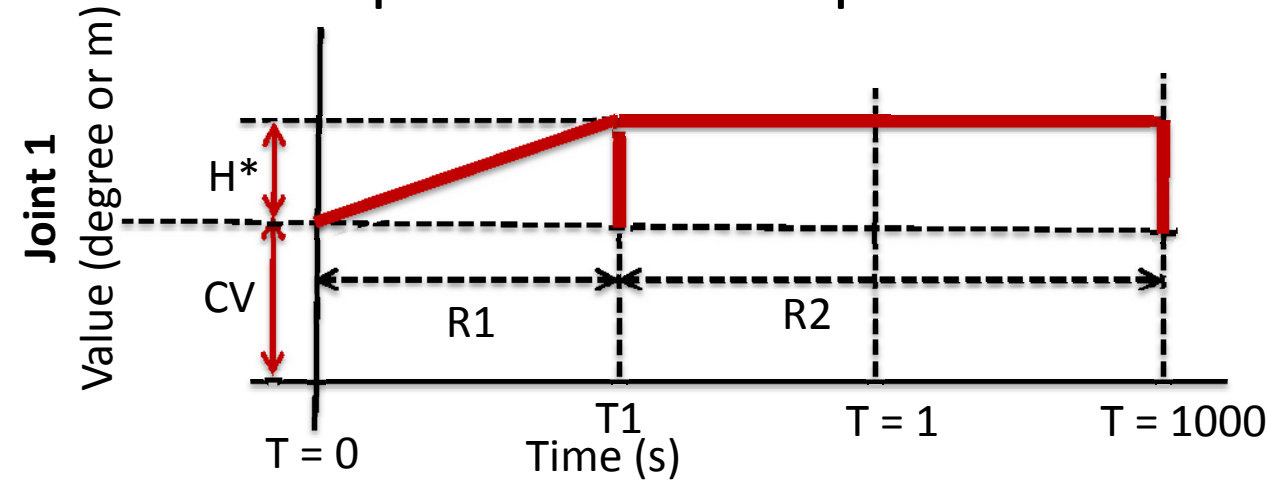
$H^* = \pi/4$  (values should be in radians);  $H^{**} = \pi/2$  (values should be in radians)

$T_1$  is the start of the impulse = 0.25 seconds;  $T_2$  is the end of the impulse = 0.75 seconds

Total duration is between 0 and 1 seconds; SLOPE = 1000

We use a very high value of  $T=1000$  for a time that should not be reached

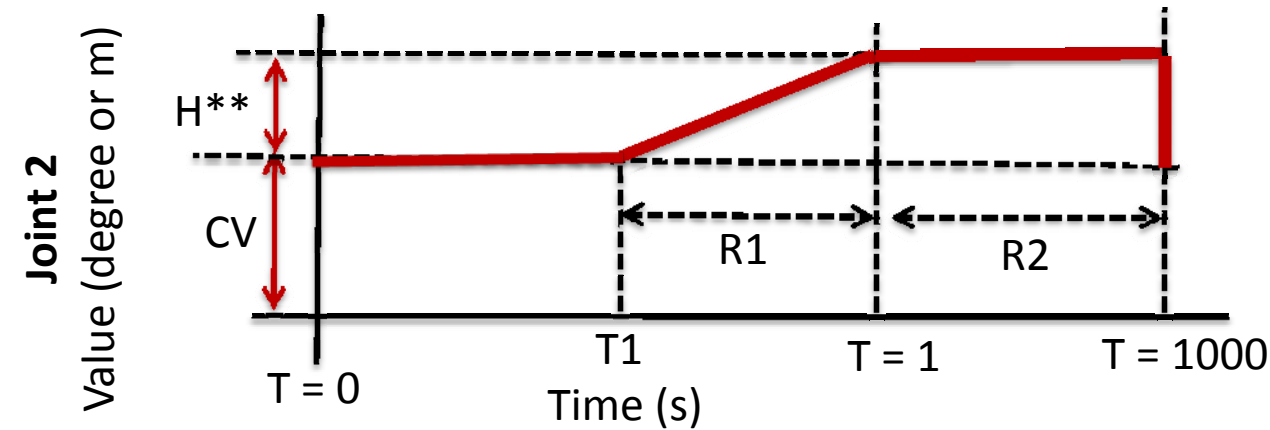
# Sequential Joint Inputs: Joint 1 and Joint 2



Joint 1 moves between time duration of  $T=0$  seconds and  $T=T1$ .

R1 = Smooth Ramp Top Impulse; Between  $T=0$  and  $T1$ ; R2 = Smooth Square Impulse; Between  $T1$  and  $T = 1000$  (we want the value to be  $H^*$  (with respect to  $CV$ ) at  $T=1$ )

$$((1/\pi) * (\arctan(1000 * (\text{time} - 0)) - \arctan(1000 * (\text{time} - 0.5)))) * (((\pi/2) - 0) / (0.5 - 0)) * (\text{time} - 0) + 0) \\ + \\ ((\pi/2) / \pi) * (\arctan(1000 * (\text{time} - 0.5)) - \arctan(1000 * (\text{time} - 1000)))$$



Joint 2 moves between time duration  $T=T1$  and  $T=1$  seconds.

R1 = Smooth Ramp Top Impulse; Between  $T1$  and  $T = 1$  ; R2 = Smooth Square Impulse; Between  $T=1$  and  $T = 1000$  ; (we want the value to be  $H^{**}$  (with respect to  $CV$ ) at  $T=1$ )

$$((1/\pi) * (\arctan(1000 * (\text{time} - 0.5)) - \arctan(1000 * (\text{time} - 1)))) * (((\pi/2) - 0) / (1 - 0.5)) * (\text{time} - 0.5) + 0) \\ + \\ ((\pi/2) / \pi) * (\arctan(1000 * (\text{time} - 1)) - \arctan(1000 * (\text{time} - 1000)))$$