Lección 4. Sistemas de control dinámico

18 de febrero de 2015

1   Transformada de Laplace (TL)

Sea $x(t)$ tal que $|x(t)| < Me^{mt}$, $M > 0$ y $m > 0$, entonces

$$X(s) = \mathscr{L}\left\{x(t)\right\} = \int_{-\infty}^{\infty} x(t)e^{-st}dt; \text{ ecuación de análisis} \tag{1}$$

y

$$x(t) = \mathscr{L}^{-1}\left\{X(s)\right\} = \frac{1}{2\pi j}\int_{\sigma-j\infty}^{\sigma+j\infty} X(s)e^{st}ds; \text{ ecuación de síntesis} \tag{2}$$

Las propiedades siguientes de la TL se emplean en el presente capítulo:

1. Linealidad
$$\mathscr{L}\left\{\alpha x_1(t) + \beta x_2(t)\right\} = \alpha X_1(s) + \beta X_2(s) \tag{3}$$

2. Desplazamiento temporal
$$\mathscr{L}\left\{x(t - t_0)\right\} = e^{-st_0}X(s) \tag{4}$$

3. Convolución[1]
$$\mathscr{L}\left\{x_1(t) * x_2(t)\right\} = X_1(s)X_2(s) \tag{5}$$

4. Diferenciación en el dominio del tiempo
$$\mathscr{L}\left\{\frac{dx(t)}{dt}\right\} = sX(s) \tag{6}$$

5. Integración en el dominio del tiempo
$$\mathscr{L}\left\{\int_{-\infty}^{t} x(\tau)d\tau\right\} = \frac{1}{s}X(s) \tag{7}$$

6. Teorema del valor final
$$\lim_{t\to\infty} x(t) = \lim_{s\to 0} sX(s) \tag{8}$$

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[1] $x_1(t) * x_2(t) = \int_{-\infty}^{\infty} x_1(\tau)x_2(t - \tau)d\tau$

2 Paquete `Ada.Calendar`

```ada
package Ada.Calendar is
   type Time is private;
   subtype Year_Number is Integer range 1901 .. 2099;
   subtype Month_Number is Integer range 1 .. 12;
   subtype Day_Number is Integer range 1 .. 31;
   subtype Day_Duration is Duration range 0.0 .. 86_400.0;
   function Clock return Time;
   function Year (Date : Time) return Year_Number;
   function Month (Date : Time) return Month_Number;
   function Day (Date : Time) return Day_Number;
   function Seconds(Date : Time) return Day_Duration;

   procedure Split (Date : in Time;
                    Year : out Year_Number;
                    Month : out Month_Number;
                    Day : out Day_Number;
                    Seconds : out Day_Duration);
   function Time_Of(Year : Year_Number;
                    Month : Month_Number;
                    Day : Day_Number;
                    Seconds : Day_Duration := 0.0)
    return Time;

   function "+" (Left : Time; Right : Duration) return Time;
   function "+" (Left : Duration; Right : Time) return Time;
   function "-" (Left : Time; Right : Duration) return Time;
   function "-" (Left : Time; Right : Time) return Duration;
   function "<" (Left, Right : Time) return Boolean;
   function "<="(Left, Right : Time) return Boolean;
   function ">" (Left, Right : Time) return Boolean;
   function ">="(Left, Right : Time) return Boolean;

   Time_Error : exception;
   private
   ... -- not specified by the language
end Ada.Calendar;
```

3   Paquete `Ada.Real_Time`

```ada
package Ada.Real_Time is
   type Time is private;
   Time_First : constant Time;
   Time_Last : constant Time;
   Time_Unit : constant := implementation-defined-real-number;

   type Time_Span is private;
   Time_Span_First : constant Time_Span;
   Time_Span_Last : constant Time_Span;
   Time_Span_Zero : constant Time_Span;
   Time_Span_Unit : constant Time_Span;

   Tick : constant Time_Span;
   function Clock return Time;
   function "+" (Left : Time; Right : Time_Span) return Time;
   function "+" (Left : Time_Span; Right : Time) return Time;
   function "-" (Left : Time; Right : Time_Span) return Time;
   function "-" (Left : Time; Right : Time) return Time_Span;
   function "<" (Left, Right : Time) return Boolean;
   function "<="(Left, Right : Time) return Boolean;
   function ">" (Left, Right : Time) return Boolean;
   function ">="(Left, Right : Time) return Boolean;

   function "+" (Left, Right : Time_Span) return Time_Span;
   function "-" (Left, Right : Time_Span) return Time_Span;
   function "-" (Right : Time_Span) return Time_Span;
   function "*" (Left : Time_Span; Right : Integer) return Time_Span;
   function "*" (Left : Integer; Right : Time_Span) return Time_Span;
   function "/" (Left, Right : Time_Span) return Integer;
   function "/" (Left : Time_Span; Right : Integer) return Time_Span;

   function "abs"(Right : Time_Span) return Time_Span;
   function "<" (Left, Right : Time_Span) return Boolean;
   function "<="(Left, Right : Time_Span) return Boolean;
   function ">" (Left, Right : Time_Span) return Boolean;
   function ">="(Left, Right : Time_Span) return Boolean;
   function To_Duration (TS : Time_Span) return Duration;
   function To_Time_Span (D : Duration) return Time_Span;

   function Nanoseconds (NS : Integer) return Time_Span;
   function Microseconds (US : Integer) return Time_Span;
   function Milliseconds (MS : Integer) return Time_Span;
   type Seconds_Count is range implementation-defined;
   procedure Split(T : in Time; SC : out Seconds_Count; TS : out Time_Span);
   function Time_Of(SC : Seconds_Count; TS : Time_Span) return Time;

private
   ... -- not specified by the language
end Ada.Real_Time;
```

4 Diagrama de componentes de la aplicación de control de un horno