石家莊鐵道大學
SHIJIAZHUANG TIEDAO UNIVERSITY

在线开放课程

信号的描述及其频谱分析

信号的分类与描述（二）

主讲 ： 牛江川

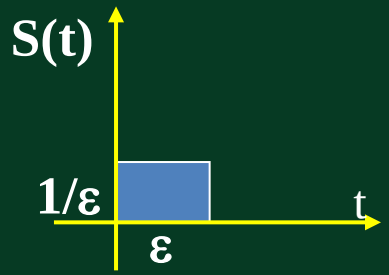
7 信号分析中常用的函数

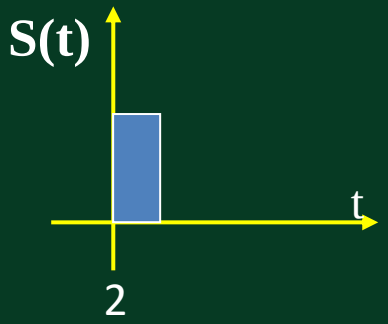
a) δ函数：是一个理想函数，是物理不可实现信号。

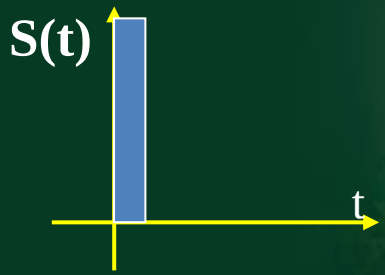
$$\delta(t)=\begin{cases}\infty, t=0\\ 0, t\neq 0\end{cases}$$

$$\int_{-\infty}^{\infty}\delta(t)dt=1$$

$$\delta(t)=\lim_{\varepsilon\to 0}S_{\varepsilon}(t)$$







特性：

1）乘积特性（抽样）

$$f(t)\delta(t) = f(0)\delta(t), f(t)\delta(t-t_0) = f(t_0)\delta(t-t_0)$$

2）积分特性（筛选）

$$\int_{-\infty}^{\infty} f(t)\delta(t) = f(0), \int_{-\infty}^{\infty} f(t)\delta(t-t_0) = f(t_0)$$

3）卷积特性

$$f(t) * \delta(t) = \int_{-\infty}^{\infty} f(\tau)\delta(t-\tau)d\tau = f(t)$$

4）拉氏变换

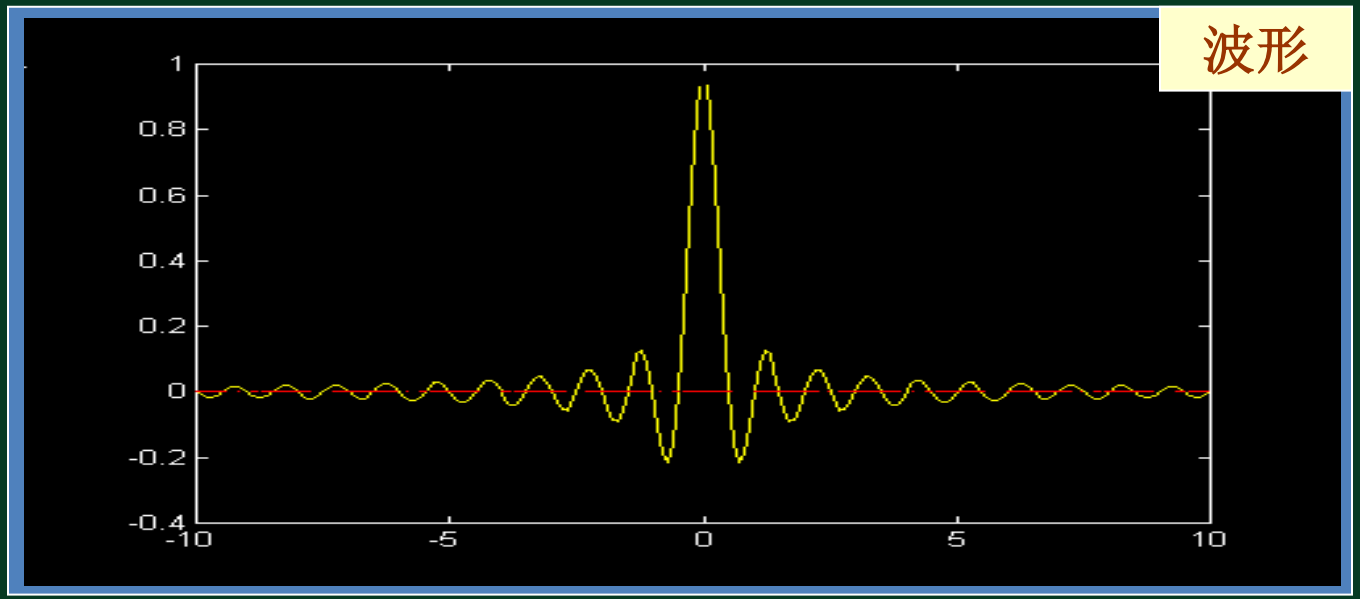
$$\Delta(s) = \int_{-\infty}^{\infty} \delta(t) e^{-st} dt = 1$$

5）傅氏变换

$$\Delta(f) = \int_{-\infty}^{\infty} \delta(t) e^{-j2\pi ft} dt = 1$$

b）sinc 函数

$$\sin c(t)=\frac{\sin t}{t},\text{或},\frac{\sin \pi t}{\pi t},(-\infty<t<\infty)$$



$$Sa(t)=\frac{\sin t}{t}$$

$$\int_{-\infty}^{\infty} Sa(t)dt=\pi$$

$$\int_{-\infty}^{0} Sa(t)dt=\int_{0}^{\infty} Sa(t)dt=\frac{\pi}{2}$$

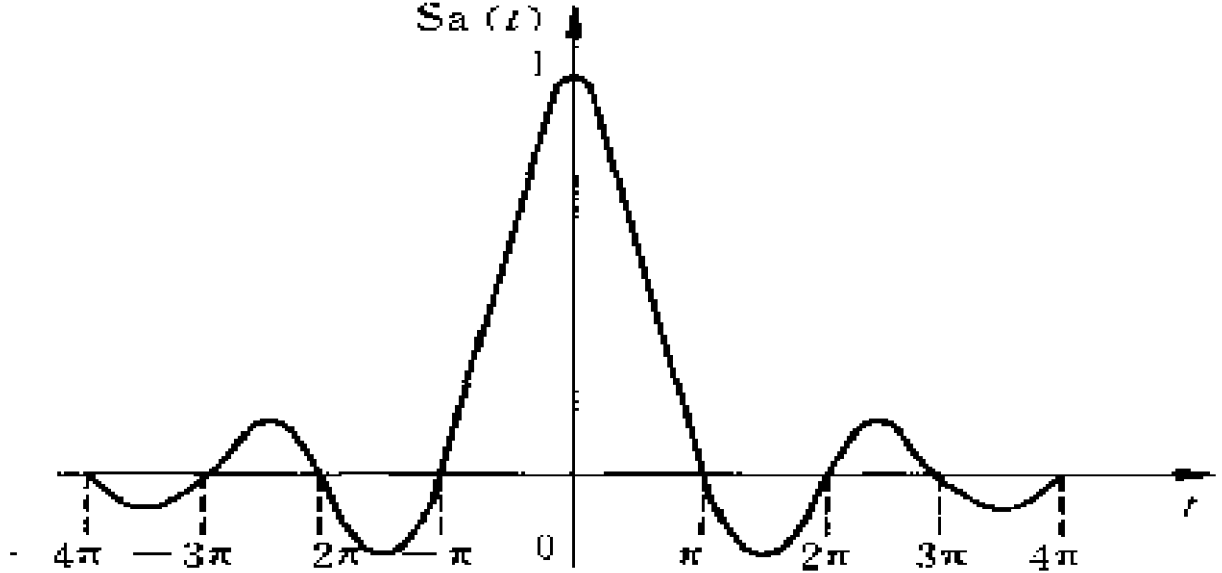


图 1-2　Sa 函数的波形

c) 符号函数sgn(t)

$$\operatorname{sgn}(t)=\begin{cases}1, & t>0\\ -1, & t<0\end{cases}$$

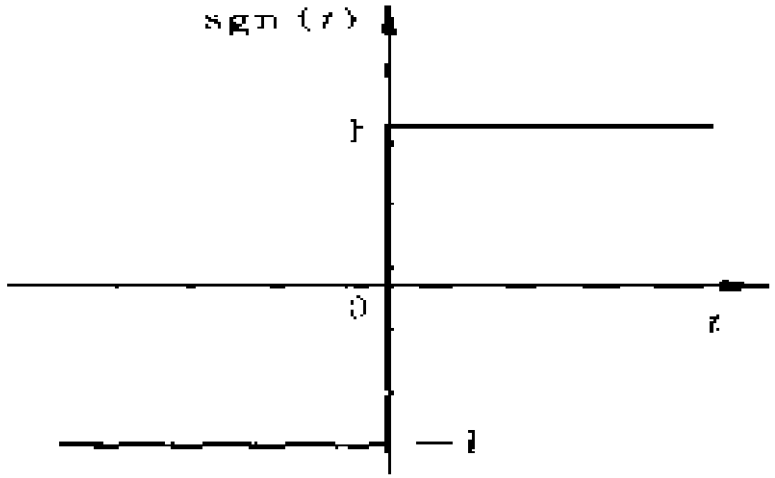
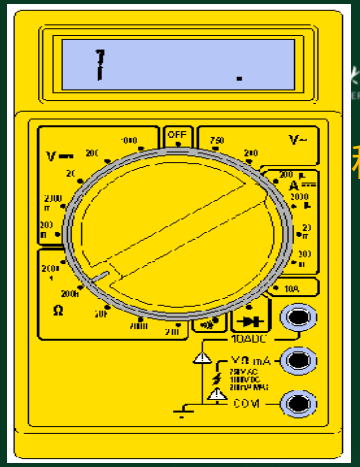
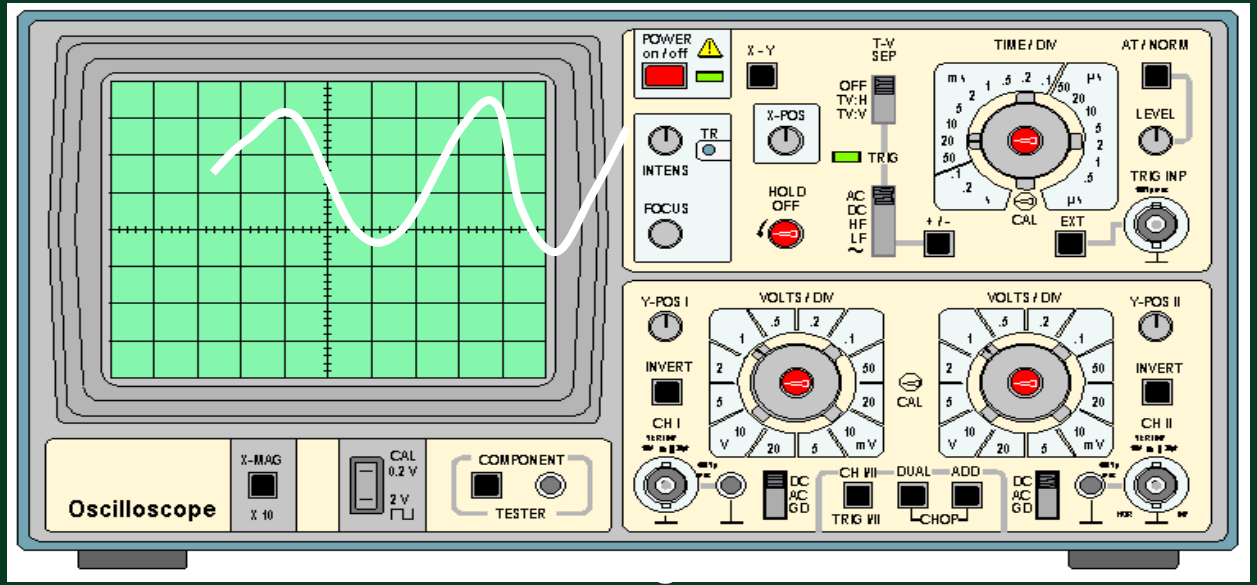


图 1-7　符号函数的波形

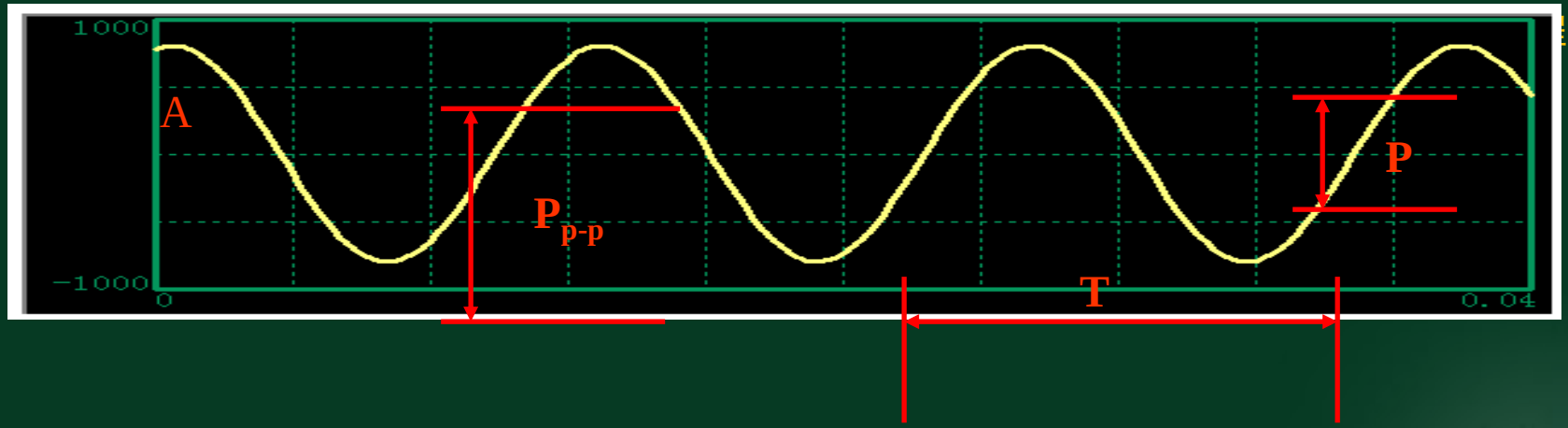
3 信号的时域波形分析

信号的时域波形分析是最常用的信号分析手段，用示波器、万用表等普通仪器直接显示信号波形，读取特征参数。





1、信号波形图



周期T，频率f=1/T

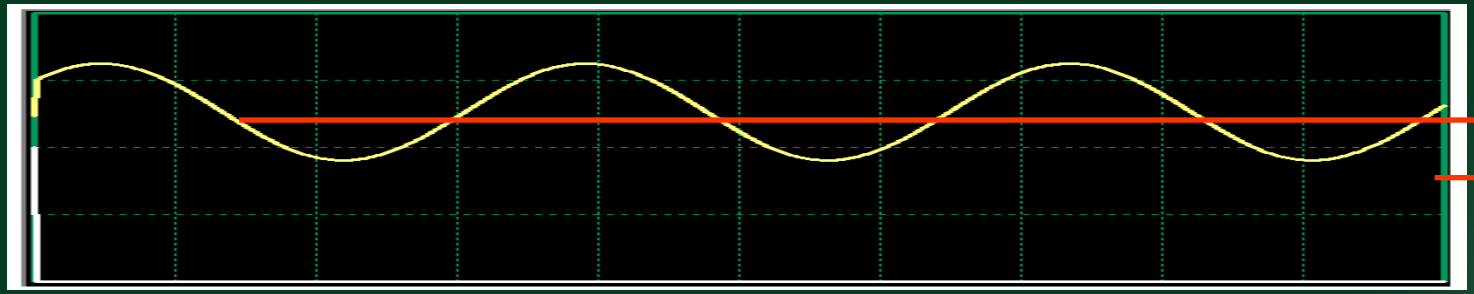
峰值P

双峰值P_{p-p}

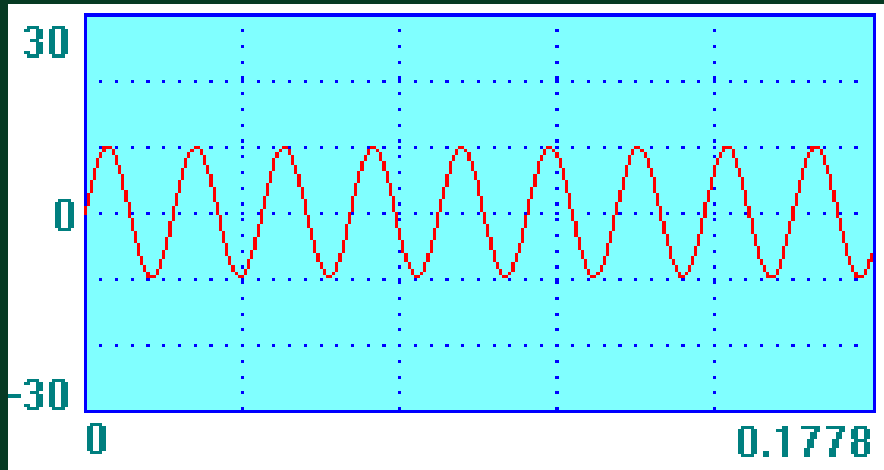
2、均值

均值E[x(t)]表示集合平均值或数学期望值。

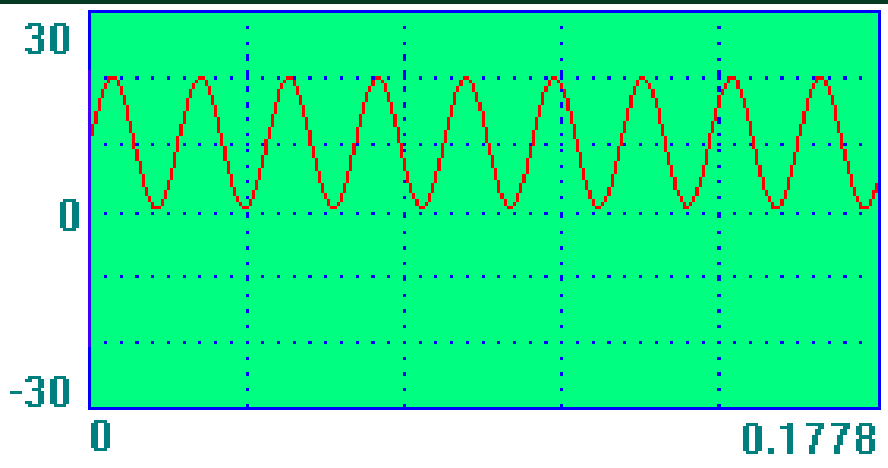
$$\mu_x = E[x(t)] = \lim_{T \to \infty} \frac{1}{T} \int_0^T x(t)dt$$



均值：反映了信号变化的中心趋势，也称之为直流分量。



零均值信号

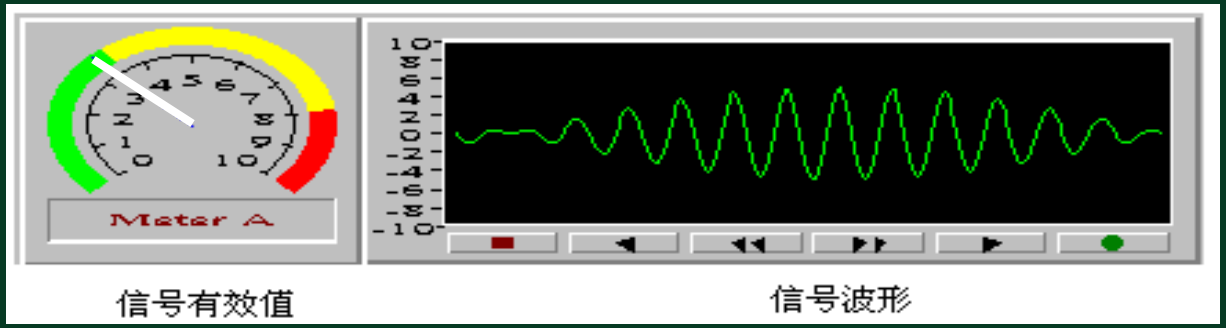


非零均值信号

3、均方值

信号的均方值E[x²(t)]，表达了信号的强度；其正平方根值，又称为有效值(RMS)，也是信号平均能量的一种表达。

$$\psi^2_x = E[x^2(t)] = \lim_{T\to\infty}\frac{1}{T}\int_0^T x^2(t)dt$$

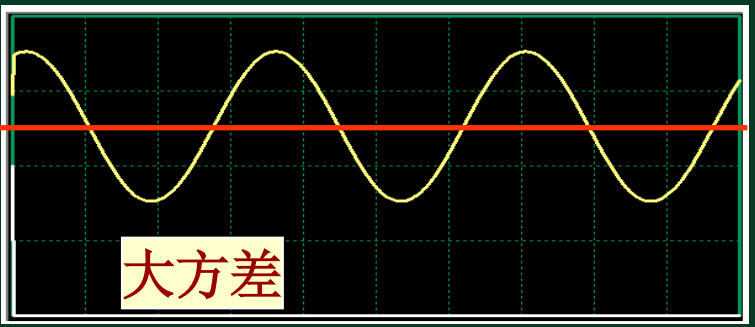


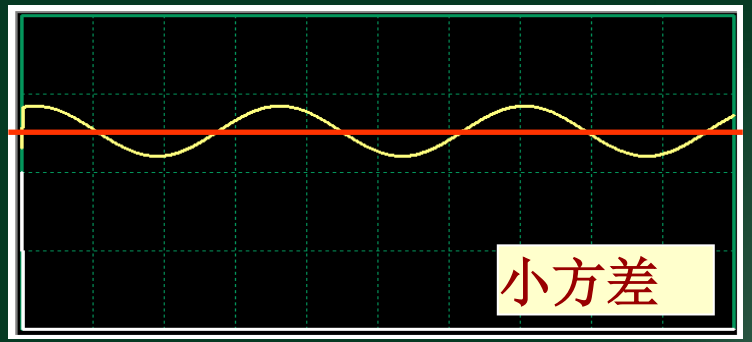
信号有效值　　信号波形

4、方差

信号x(t)的方差定义为：

$$\sigma^2_x = E[(x(t)-E[x(t)])^2] = \lim_{T\to\infty}\frac{1}{T}\int_0^T (x(t)-\mu_x)^2 dt$$



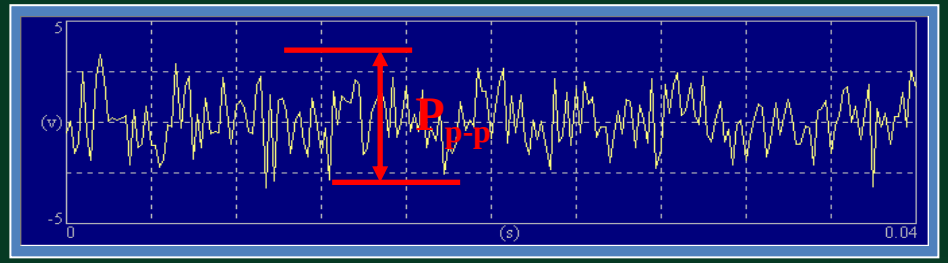


方差：反映了信号绕均值的波动程度。

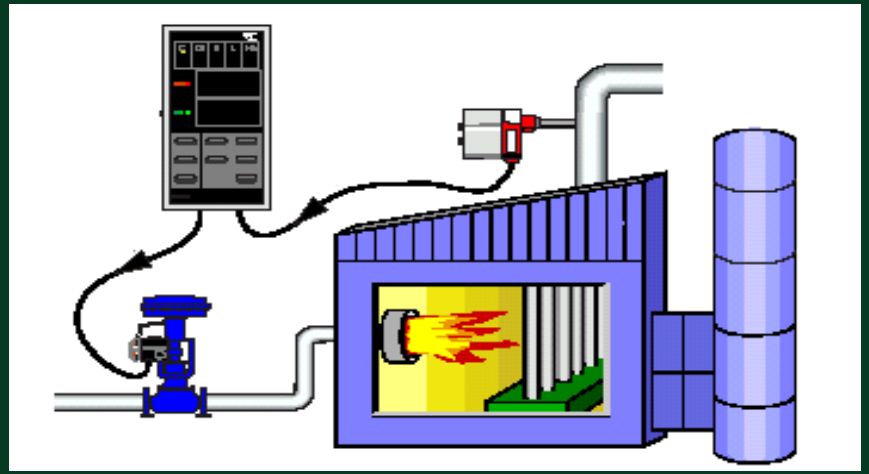
5、波形分析的应用

信号类型识别

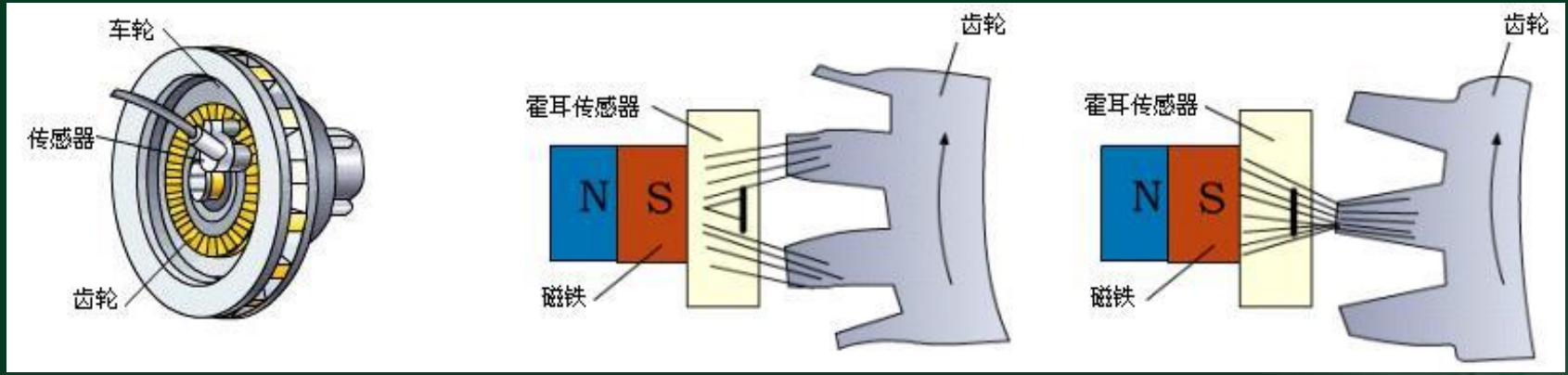
基本参数识别

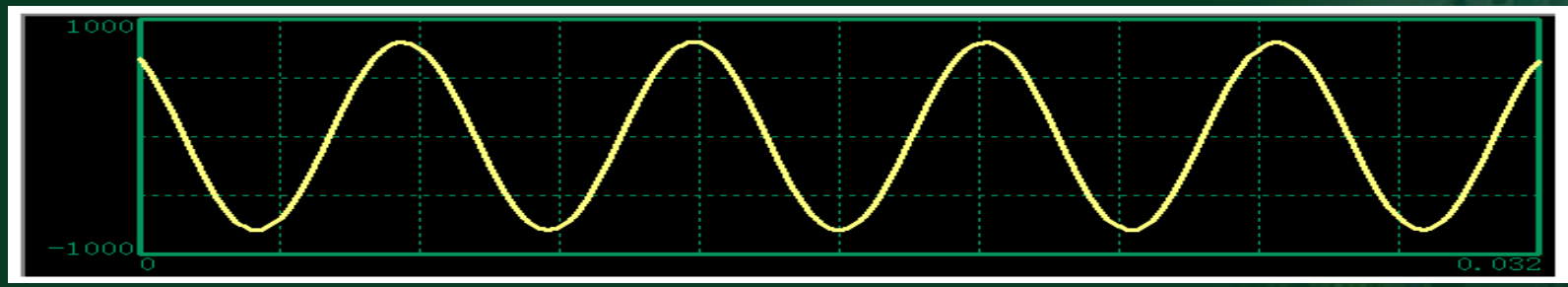


超门限报警

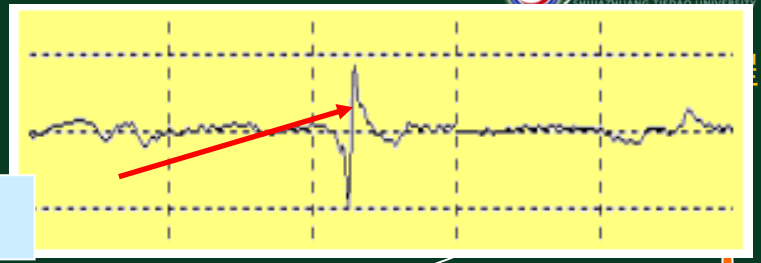


案例：汽车速度测量:

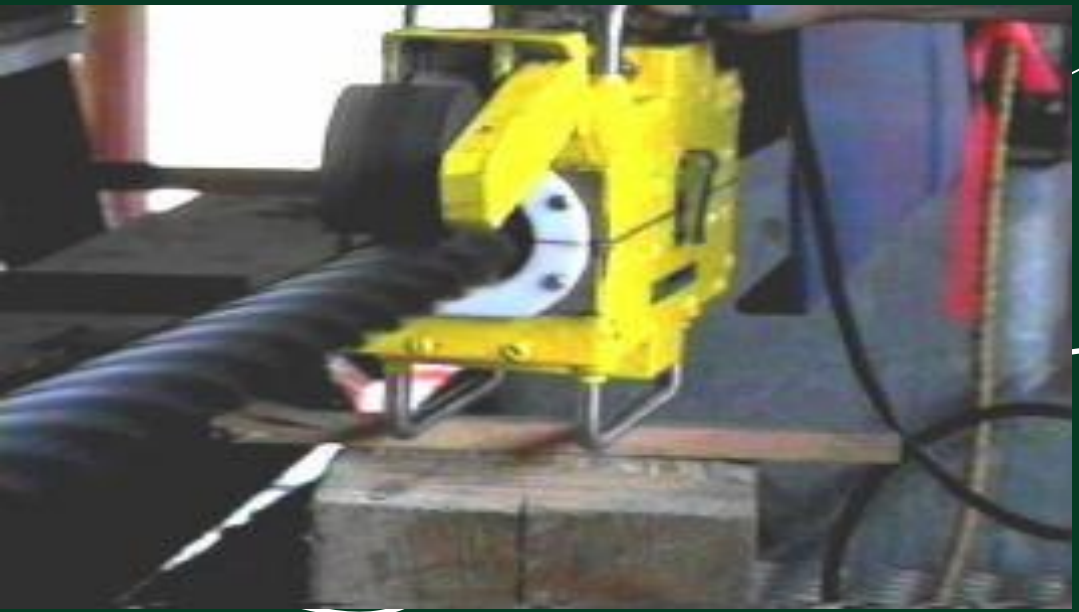




案例：旅游索道钢缆检测



超门限报警



小结

- **信号分析中常用的函数**