Lab 2.

AM modulator & demodulator

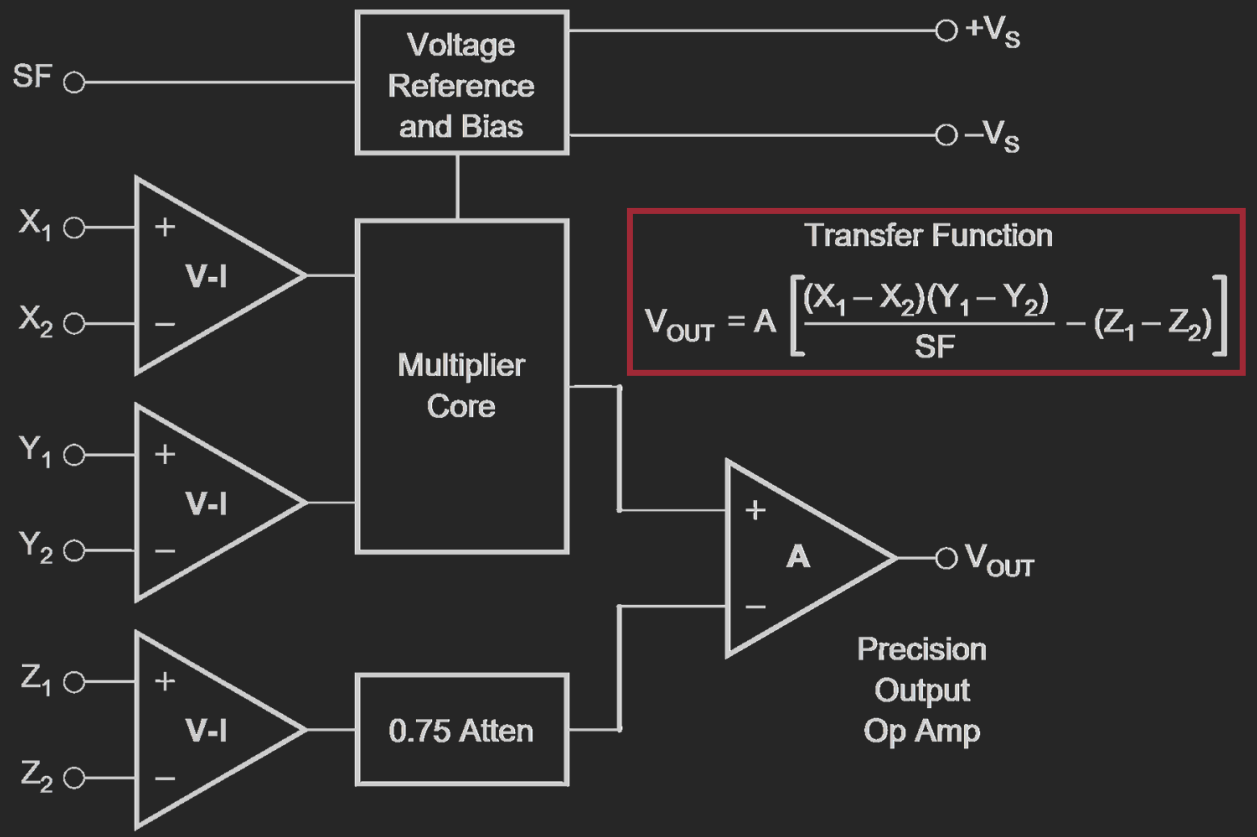
常用公式

$$\cos(a) \times \cos(b) = \frac{\cos(a-b) + \cos(a+b)}{2}$$

$$\cos(-\theta) = \cos(\theta)$$

$$\omega = 2\pi f$$

MPY634



$$V_{out} = A\left(\frac{X \times Y}{SF} - Z\right)$$

Open Loop Gain :

A = 85 dB

Scale Factor:

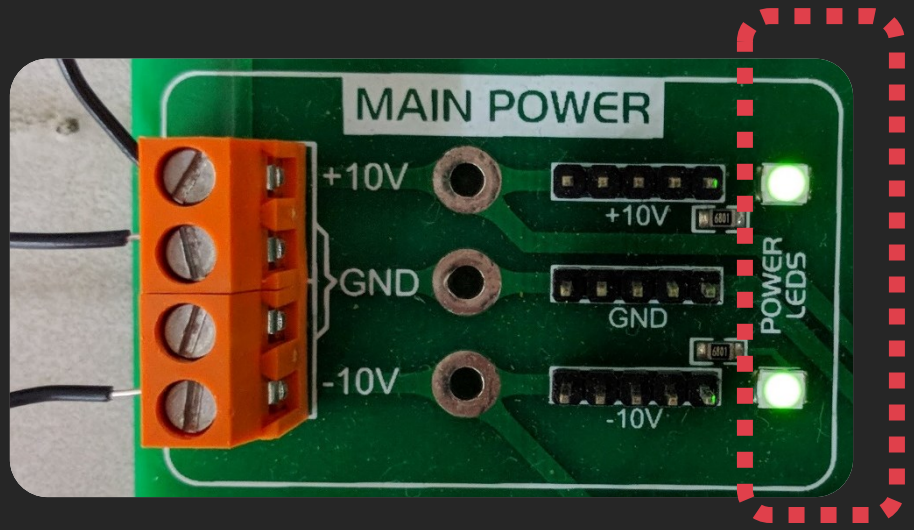
SF = 10 V (default)

使用LTspice模擬時
SF須給電壓 (建議用10V)

#REF: MPY634 datasheet, Texas Instrument. https://www.ti.com/lit/ds/symlink/mpy634.pdf

TI Module Board Power Status

Power OFF



Power ON

AM-DSB-SC

Double Sideband Suppressed Carrier Amplitude Modulation

Modulation Input

$$s_i(t) = A_i \cos(\omega_i t)$$

+

Carrier

$$s_c(t) = A_c \cos(\omega_c t)$$

→

AM-DSB-SC

$$s_{am-dsb-sc}(t) \triangleq s_i(t) \times s_c(t)$$

$$s_{am-dsb-sc}(t) = \frac{A_i A_c}{2}\left[\cos\left((\omega_C - \omega_i)t\right) + \cos\left((\omega_C + \omega_i)t\right)\right]$$

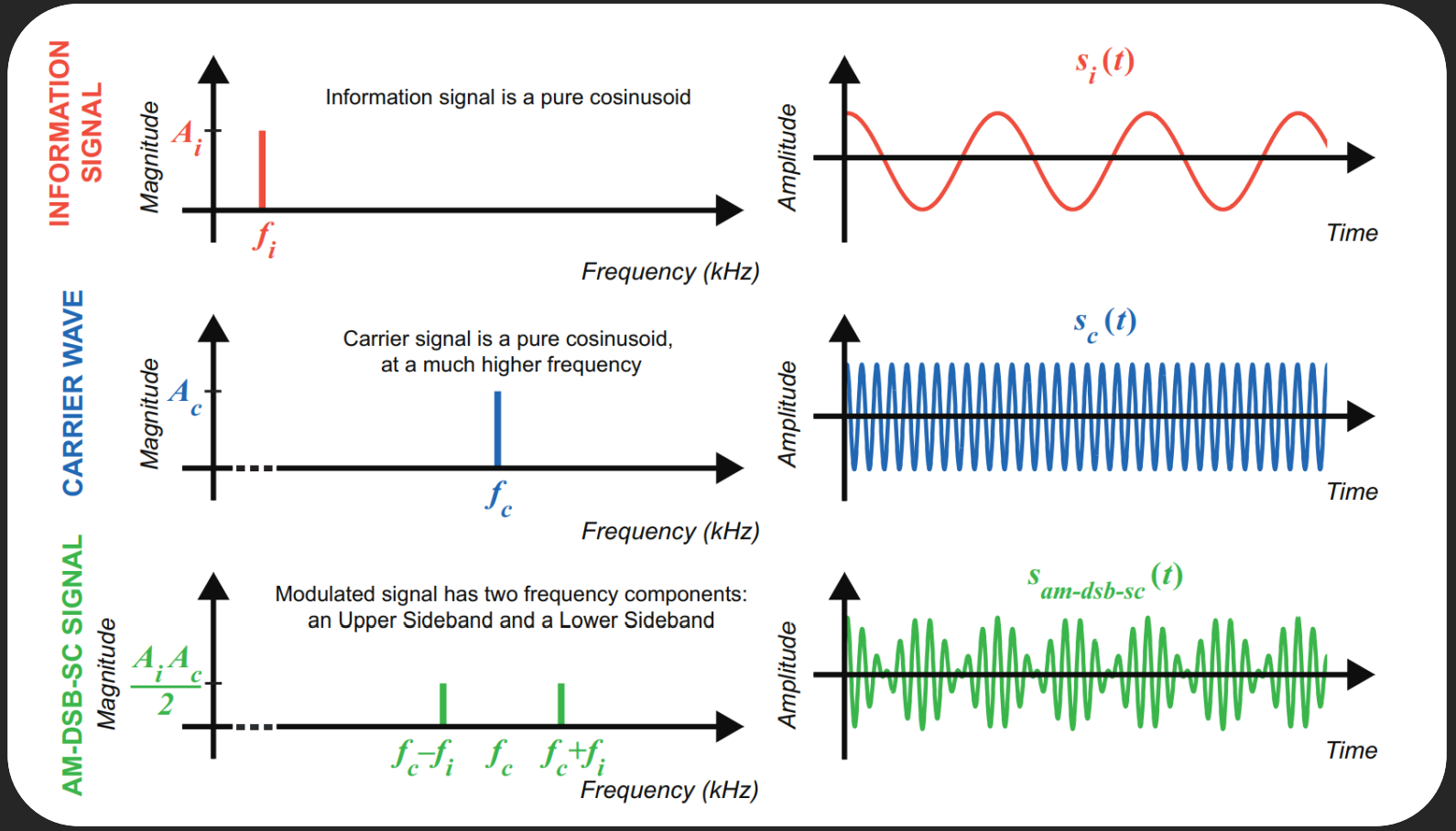
Lower Sideband

$$|\omega_C - \omega_i|$$

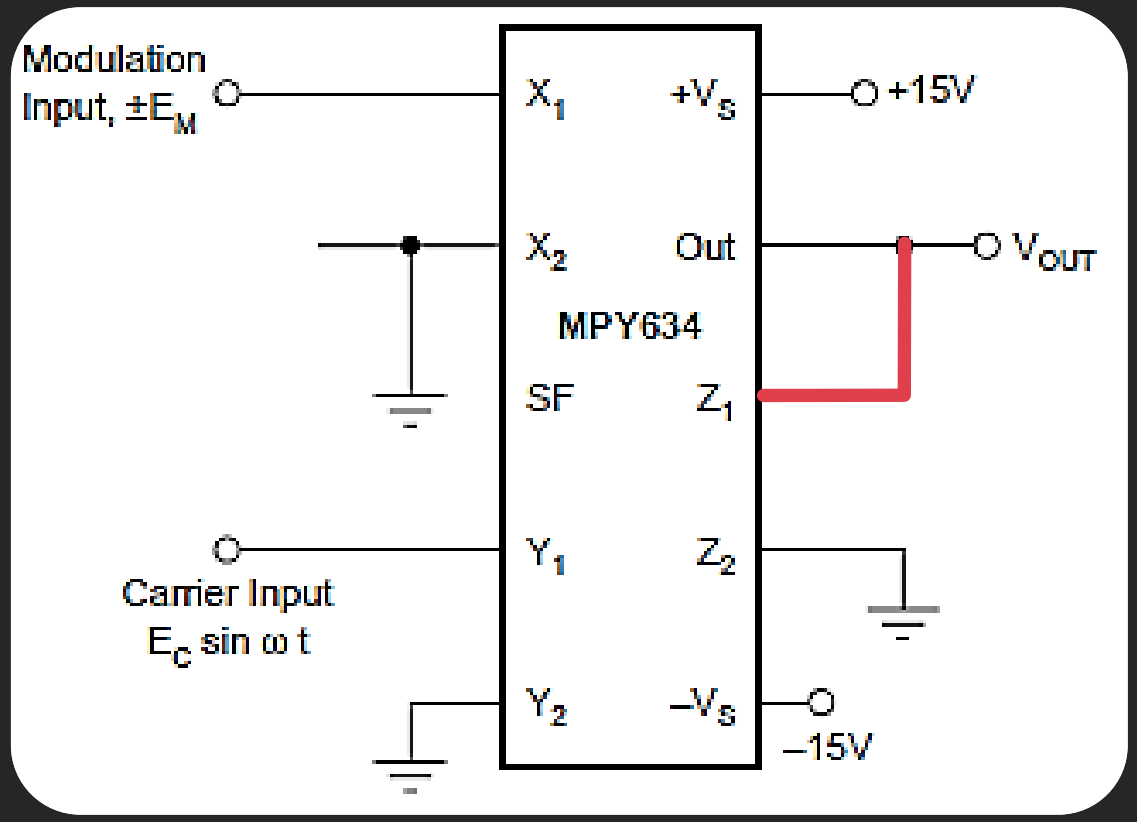
Upper Sideband

$$|\omega_C + \omega_i|$$

AM-DSB-SC


INFORMATION SIGNAL
Information signal is a pure cosinusoid
Magnitude
A_i
f_i
Frequency (kHz)
Amplitude
$s_i(t)$
Time
CARRIER WAVE
Carrier signal is a pure cosinusoid, at a much higher frequency
Magnitude
A_c
f_c
Frequency (kHz)
Amplitude
$s_c(t)$
Time
AM-DSB-SC SIGNAL
Modulated signal has two frequency components: an Upper Sideband and a Lower Sideband
Magnitude
$\frac{A_i A_c}{2}$
$f_c - f_i$
f_c
$f_c + f_i$
Frequency (kHz)
Amplitude
$s_{am\text{-}dsb\text{-}sc}(t)$
Time

EXP 1. Circuit 1



X : Modulation input

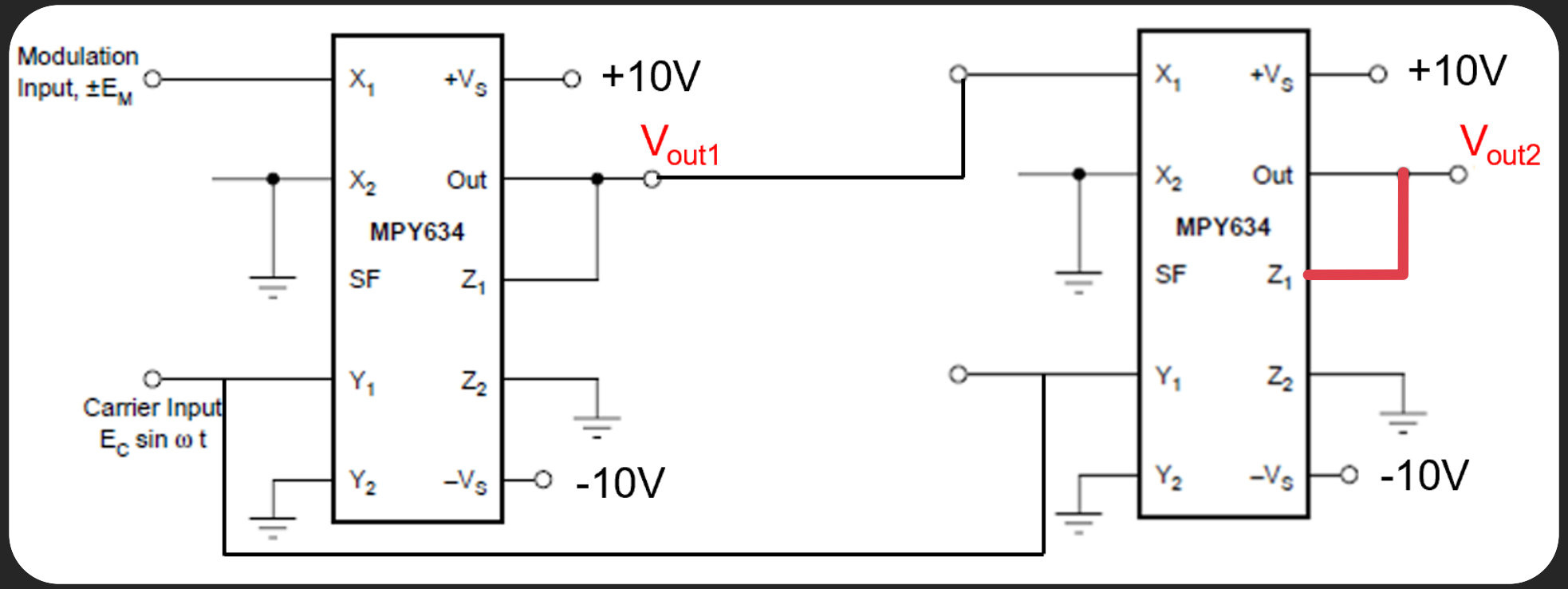
Y : Carrier input

Z : 接至 V_{out} 以控制增益

示波器 : DC Coupling

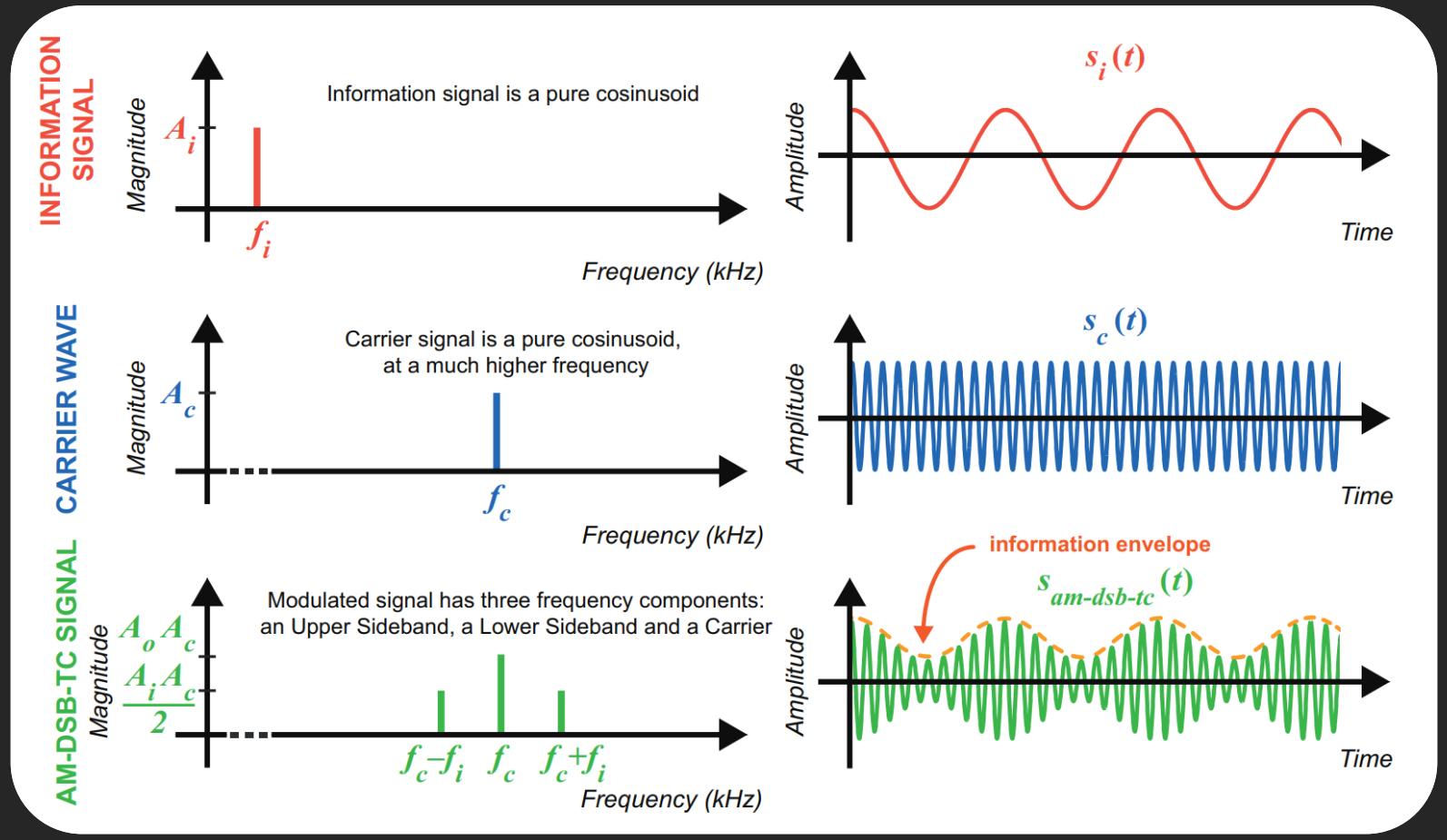
$$V_{out} = \frac{A}{A+1} \times \frac{S_{am-dsb-sc}}{SF} \approx \frac{S_{am-dsb-sc}}{SF}$$

EXP 1. Circuit 2 (Based on Circuit 1.)



$$V_{out2}(t) \approx \frac{V_{out1} \times s_c}{\mathrm{SF}} = \frac{s_i(t)}{\mathrm{SF}^2} + \frac{cos(2\pi(2f_C - f_i)t) + \cos(2\pi(2f_C + f_i)t)}{2\mathrm{SF}^2}$$

AM-DSB-TC


INFORMATION SIGNAL
Magnitude
A_i
f_i
Frequency (kHz)
Information signal is a pure cosinusoid
$s_i(t)$
Amplitude
Time
CARRIER WAVE
Magnitude
A_c
f_c
Frequency (kHz)
Carrier signal is a pure cosinusoid, at a much higher frequency
$s_c(t)$
Amplitude
Time
AM-DSB-TC SIGNAL
Magnitude
$A_o A_c$
$\frac{A_i A_c}{2}$
$f_c - f_i$
f_c
$f_c + f_i$
Frequency (kHz)
Modulated signal has three frequency components: an Upper Sideband, a Lower Sideband and a Carrier
information envelope
$s_{am\text{-}dsb\text{-}tc}(t)$
Amplitude
Time

AM-DSB-TC

Double Sideband Transmitted Carrier Amplitude Modulation

$$s_{am-dsb-tc}(t) \triangleq [A_o + s_i(t)] \times s_c(t) = [A_o + A_i \cos(\omega_i t)] A_c \cos(\omega_c t)$$

$$s_{am-dsb-tc}(t) = A_o s_c(t) + \frac{A_i A_c}{2}\left[\cos\left((\omega_C - \omega_i)t\right) + \cos\left((\omega_C + \omega_i)t\right)\right]$$

Carrier

Lower Sideband

$|\omega_C - \omega_i|$

Upper Sideband

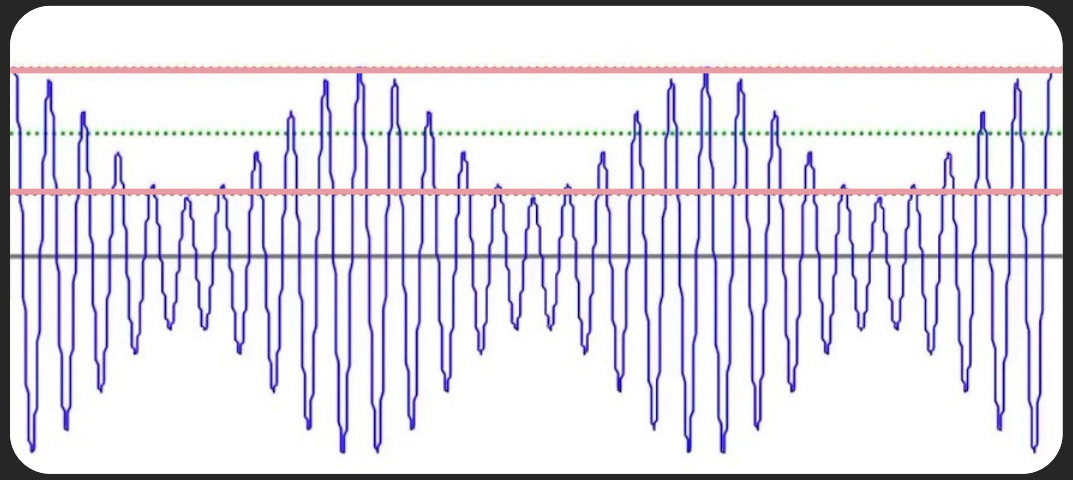
$|\omega_C - \omega_i|$

AM Depth (AM Modulation index)

AM-DSB-TC 的另一種定義型式

$$s_{am-dsb-tc}(t) \triangleq A_o[1 + ms_i(t)] \times s_c(t) \qquad \Rightarrow m = \frac{A_i}{A_o}$$

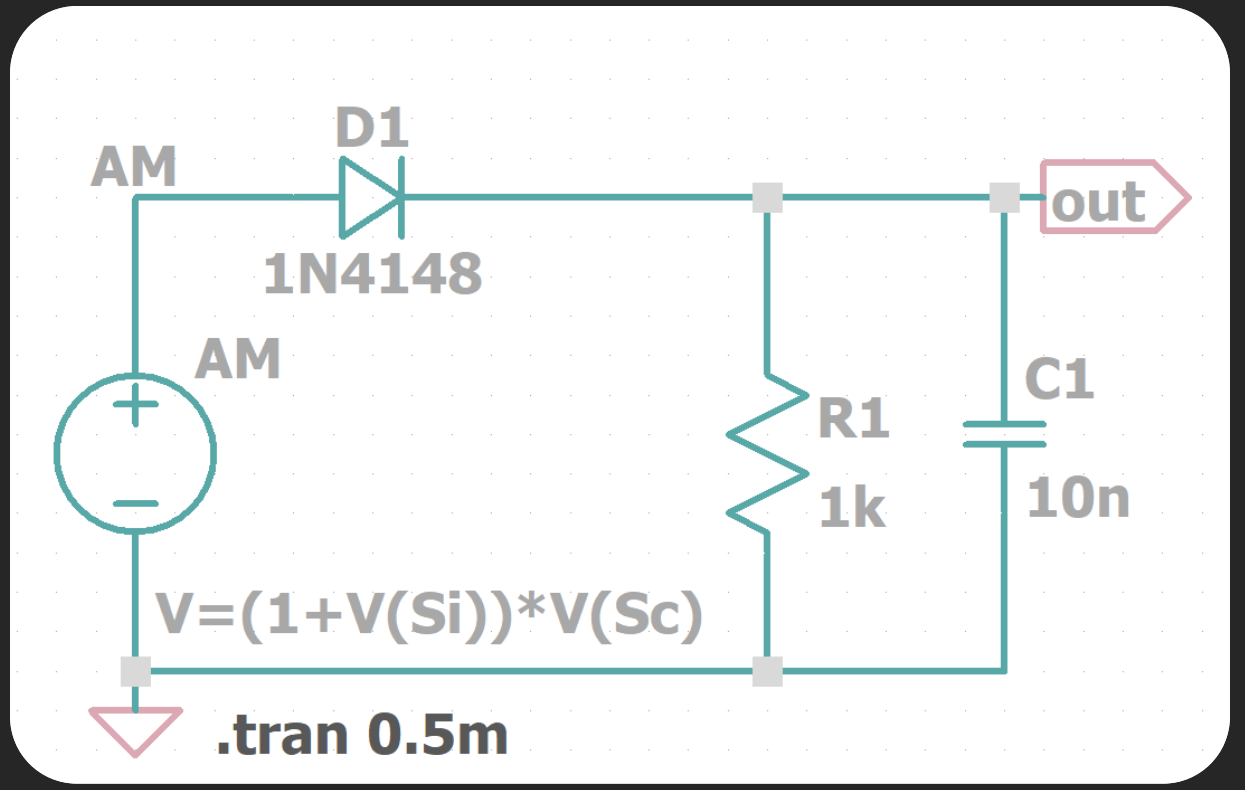
如何測量調變深度? (EXP 2.)



$$m = \frac{V_{max} - V_{min}}{V_{max} + V_{min}} \text{ , since}$$

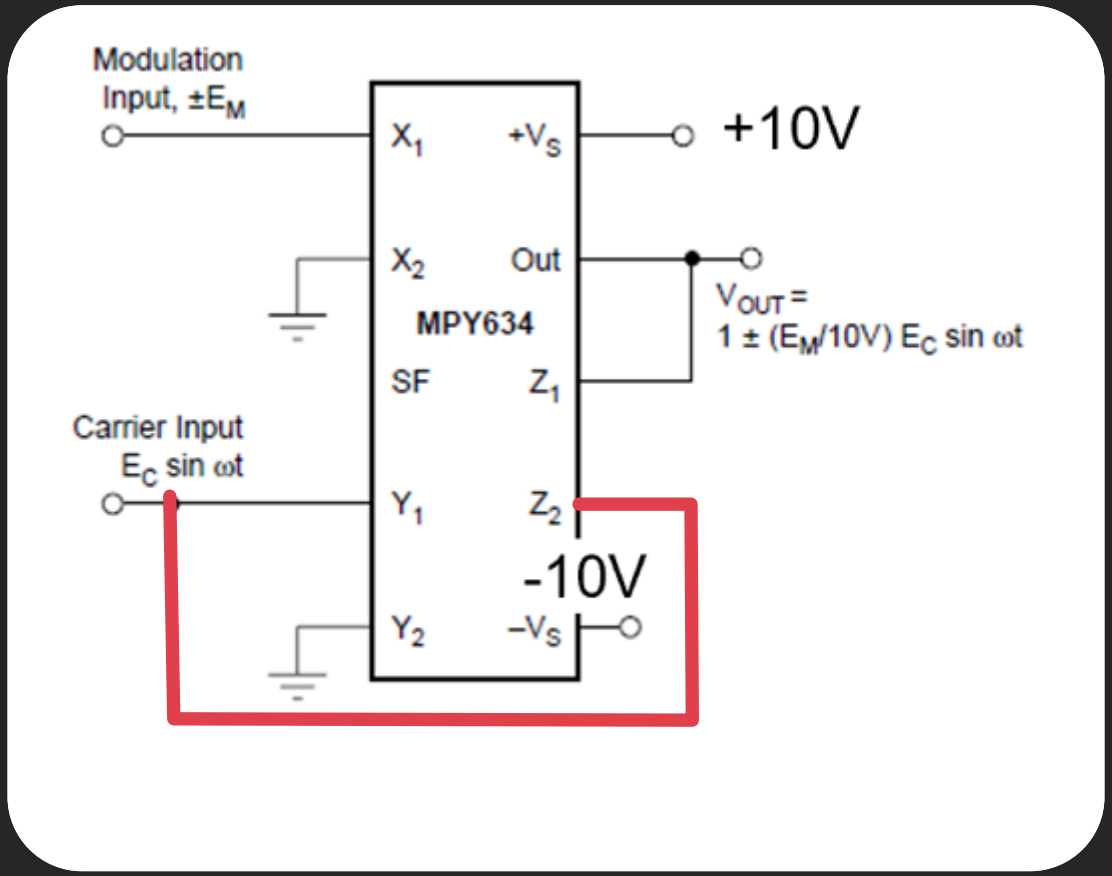
$$V_{max} = A_c(A_o + A_i) \text{ ,}$$
$$V_{min} = A_c(A_o - A_i) \text{ .}$$

EXP 2. Circuit



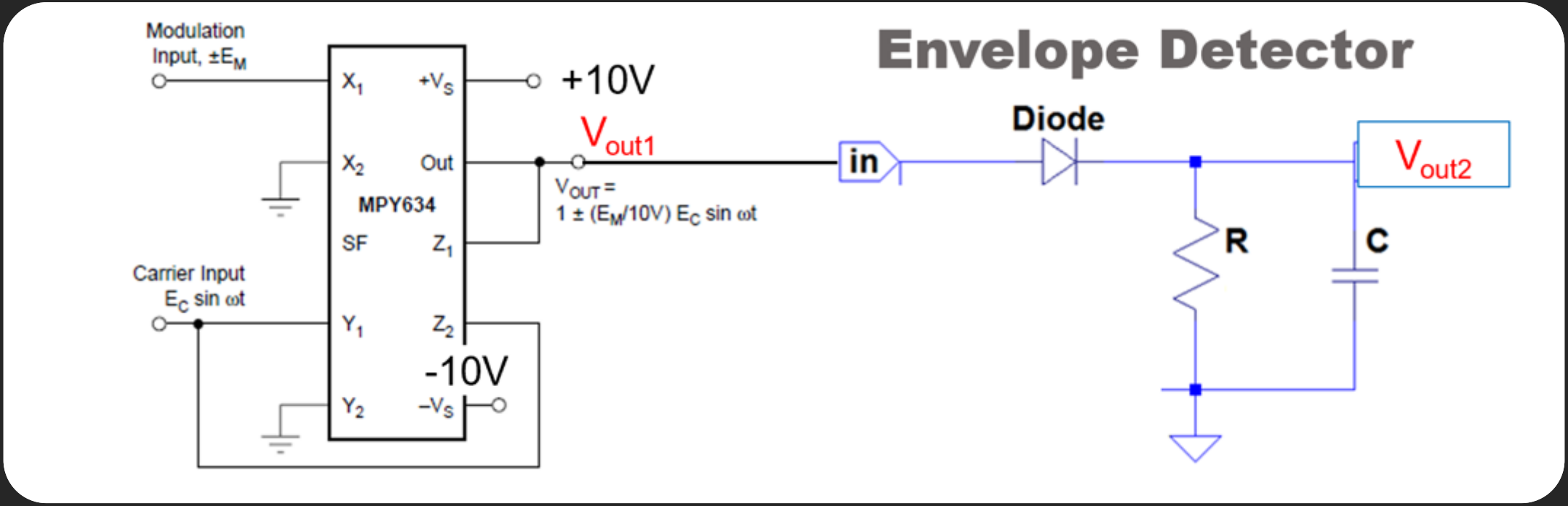
使用函數產生器(FG)產生調變訊號。

EXP 3. Circuit 1



$$\Rightarrow V_{out} \approx (1 + \frac{1}{SF} \times s_i)s_c$$

EXP 3. Circuit 2 (Based on Circuit 1.)



用 Envelope detector 包絡出原始訊號