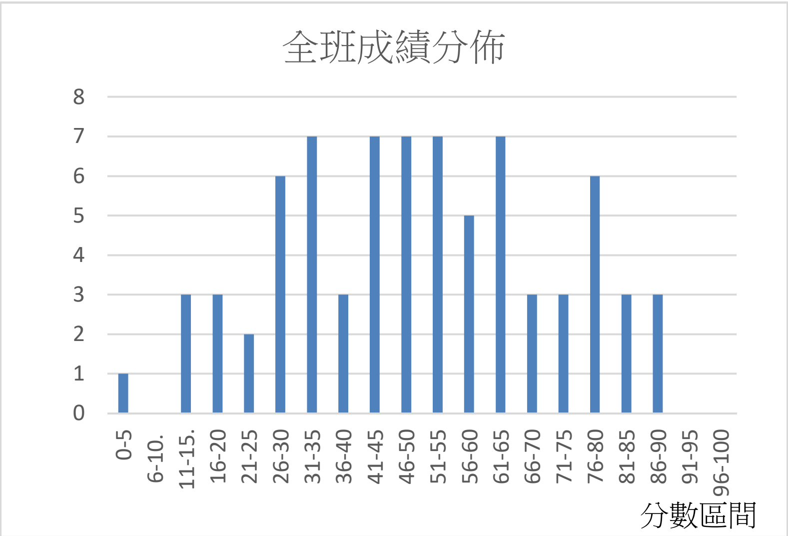
%%

成績統計：

組距	人數
0-5	1
6-10.	0
11-15.	3
16-20	3
21-25	2
26-30	6
31-35	7
36-40	3
41-45	7
46-50	7
51-55	7
56-60	5
61-65	7
66-70	3
71-75	3
76-80	6
81-85	3
86-90	3
91-95	0
96-100	0
交卷人數	76
缺考人數	10
班平均	50.18



常見錯誤：

<table>
<tr><th>題號</th><th>錯誤</th><th>正確</th></tr>
<tr><td>Q1</td><td>(n)w/2
(m)空白
(l)空白
(o) Parseval</td><td>(n)2W
(m) $\phi(t) << 1$
(l) constant instantaneous power
(o) Carson's rule</td></tr>
<tr><td>Q2</td><td colspan="2">(a)直接寫答案，沒有 cos 角度變化過程
(c)直接寫答案，沒有寫 1/2 怎麼得到的</td></tr>
<tr><td>Q3</td><td>$\mathcal{F}\{\cos(2\pi f_c t)\} = \delta(f - f_c) + \delta(f + f_c)$</td><td>$\mathcal{F}\{\cos(2\pi f_c t)\} = \frac{1}{2}[\delta(f - f_c) + \delta(f + f_c)]$</td></tr>
<tr><td rowspan="2">Q4</td><td>Index 標示有誤 fm-fc</td><td>Index 標示有誤 fc-fm</td></tr>
<tr><td colspan="2">message signal 為脈衝非三角波。
$\mathcal{F}\{\cos(2\pi f_c t)\} = \delta(f - f_c) + \delta(f + f_c)$
$\mathcal{F}\{\cos(2\pi f_c t)\} = \frac{1}{2}[\delta(f - f_c) + \delta(f + f_c)]$</td></tr>
<tr><td>Q5</td><td colspan="2">沒有寫單位 (rad)</td></tr>
<tr><td>Q6</td><td>$a = \frac{1}{5} = 0.2$
$E = \frac{a\ \langle m_n^2(t)\rangle}{1 + a\ \langle m_n^2(t)\rangle} \times 100\%$</td><td>$a = \frac{10}{25} = 0.4$
$E = \frac{a^2 \langle m_n^2(t)\rangle}{1 + a^2 \langle m_n^2(t)\rangle} \times 100\%$</td></tr>
</table>

系所	學號	姓名	HW#2
電機系 4B	402415078	沈上荏	O
電機系 4A	405220003	林柏漢	V
電機系 4A	405220012	吳定濬	V
電機系 4A	405415007	陳億賢	X
電機系 4B	405415010	劉鎮宇	X
電機系 4A	405415029	呂羿葦	V
電機系 4B	405415048	鍾文宏	V
電機系 4B	405415052	李曜任	V
電機系 4A	405415075	林詩婷	V
電機系 4B	405415076	李承侑	V
電機系 4A	405430008	蔡秉欣	V
電機系 3A	406415001	張言睿	V
電機系 3A	406415005	賴欣儀	V
電機系 3B	406415010	陳信宏	V
電機系 3A	406415011	張峻祥	V
電機系 3A	406415013	連奕丞	X
電機系 3B	406415014	許博惟	V
電機系 3B	406415018	蔡培鑑	V
電機系 3B	406415020	楊博禕	V
電機系 3A	406415025	劉彥廷	X
電機系 3A	406415027	鄭筠賡	V
電機系 3B	406415028	黃柏瑜	V
電機系 3B	406415030	陳昱凱	V
電機系 3B	406415032	姚松伯	V
電機系 3A	406415033	詹佰晉	V
電機系 3A	406415035	陳彥邦	V
電機系 3B	406415036	吳祝樟	V
電機系 3B	406415038	黃柏軒	X
電機系 3A	406415049	郭　恕	O
電機系 3A	406415055	朱冠誌	V
電機系 3B	406415058	黃彥勛	V
電機系 3A	406415061	楊詠舜	V
電機系 3B	406415064	莊博傑	V
電機系 3A	406415071	詹育平	V
電機系 3B	406415082	陳妍臻	V

電機系 3B	406420062	黃議賢	X
電機系 3A	406530020	洪澤廷	V
N/A	408415901	張國璇 (GUOXUAN ZHANG)	V
N/A	408415904	孫道源 (DAOYUAN SUN)	V
N/A	408420904	吳俊宏 (JUNHONG WU)	V
N/A	408420906	王崧年 (SONGNIAN WANG)	V
N/A	408420908	江育聰 (YUCONG JIANG)	V

系所	學號	姓名	HW#2
通訊系 3A	404430045	王振宇	X
通訊系 4A	405430007	林郁鈞	X
通訊系 4A	405430013	黃信豪	V
通訊系 4A	405430032	區雅婷	O
通訊系 4A	405430039	林佑宸	V
通訊系 3A	406430001	陳有朋	V
通訊系 3A	406430002	鄭佳宣	V
通訊系 3A	406430003	丁凱文	V
通訊系 3A	406430004	姜昱丞	V
通訊系 3A	406430006	李柏豫	V
通訊系 3A	406430007	王繼賢	V
通訊系 3A	406430009	曾國珩	V
通訊系 3A	406430010	鄭宇倫	V
通訊系 3A	406430011	邱靖博	V
通訊系 3A	406430012	李逸帆	V
通訊系 3A	406430013	陳美瑜	O
通訊系 3A	406430014	王信荃	V
通訊系 3A	406430015	簡敬倫	V
通訊系 3A	406430016	陳姿妤	V
通訊系 3A	406430017	鍾念慈	V
通訊系 3A	406430018	詹哲嘉	V
通訊系 3A	406430019	黃宇傑	X
通訊系 3A	406430020	陳昱瑋	V
通訊系 3A	406430022	徐子翔	V
通訊系 3A	406430023	林宥均	V

通訊系 3A	406430024	曹智捷	V
通訊系 3A	406430026	楊鎧安	V
通訊系 3A	406430028	李翊嘉	X
通訊系 3A	406430029	廖辰偉	V
通訊系 3A	406430030	廖岳軒	V
通訊系 3A	406430033	李孟寰	V
通訊系 3A	406430034	鄭又華	V
通訊系 3A	406430035	陳御任	V
通訊系 3A	406430036	陳奕禹	X
通訊系 3A	406430037	郭慶安	X
通訊系 3A	406430038	林顥庭	V
通訊系 3A	406430039	江昱瑩	V
通訊系 3A	406430040	翁浩昀	V
通訊系 3A	406430041	鄭博駿	V
通訊系 3A	406430042	陳彥邑	V
通訊系 3A	406430043	楊士緯	V
通訊系 3A	406430044	郭信俞	V
通訊系 3A	406430045	廖章甫	X
通訊系 4A	405430034	徐國越	V

108 學年度第一學期「通訊原理」Ans#2

Date:12/18/2019

1. 每題 2 分，共 30 分

(a) $A_c m(t)\cos(2\pi f_c t)$

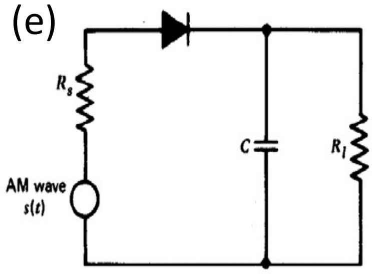
(b) $\frac{A_c}{2}\left[M(f-f_c)+M(f+f_c)\right]$

(c) $A_c\left[1+am_n(t)\right]\cos(2\pi f_c t)$

(d) $A_c\left[1+am_n(t)\right]$ or $1+am_n(t)$

(e)

(e)



(f) $x_{SSB}(t)=\frac{1}{2}A_c m(t)\cos(2\pi f_c t)\mp\frac{1}{2}A_c\hat{m}(t)\sin(2\pi f_c t).$

(g) $\left[H(f-f_c)+H(f+f_c)\right]=\text{constant},\ |f|\le W$

(h) $\cos(2\pi\left(f_1\pm f_2\right)t)$

(i) $A_c\cos(2\pi f_c t+k_p m(t))$

(j) $A_c\cos(2\pi f_c t+\int_{-\infty}^{t}2\pi f_d m(\alpha)d\alpha)$

(k) $J_n(\beta)\triangleq\frac{1}{2\pi}\int_{-\pi}^{\pi}e^{-\left[jnx-\beta\sin(x)\right]}dx$

(l) Constant instantaneous power or robust to additive noise

(m) $\phi(t)$ is small or $\phi(t)<<1$

(n) $2W$

(o) Carson's rule

2. 每題 5 分，共 15 分

a) Assume that a DSB signal $x_c(t) = A_c m(t)\cos(2\pi f_c t + \phi_0)$ is demodulated using the demodulation carrier $2\cos[2\pi f_c t + \theta(t)]$.

Determine, in general, the demodulated output $y_D(t)$.

Sol:

The demodulated output, in general, is

$$y_D(t) = \mathrm{Lp}\left\{x_c(t) 2\cos\left[\omega_c t + \theta(t)\right]\right\}$$

where Lp {•} denotes the lowpass portion of the argument. With

$$x_c(t) = A_c m(t)\cos\left[\omega_c t + \phi_0\right]$$

the demodulated output becomes

$$y_D(t) = \mathrm{Lp}\left\{2A_c m(t)\cos\left[\omega_c t + \phi_0\right]\cos\left[\omega_c t + \theta(t)\right]\right\}$$

$$= \mathrm{Lp}\left\{2A_c m(t)\frac{1}{2}\left(\cos\left[2\omega_c t + \theta(t) + \phi_0\right] + \cos\left[\theta(t) - \phi_0\right]\right)\right\}$$

Performing the indicated multiplication and taking the lowpass portion yields

$$y_D(t) = A_c m(t)\cos\left[\theta(t) - \phi_0\right]$$

b) Let $A_c = 1$ and $\theta(t) = \theta_0$, where θ_0 is a constant, and determine the mean-square error between $m(t)$ and the demodulated output as a function of ϕ_0 and θ_0.

Sol:

If $\theta(t) = \theta_0$ (a constant), the demodulated output becomes

$$y_D(t) = A_c m(t)\cos(\theta_0 - \phi_0)$$

Letting $A_c = 1$ gives the error

$$\varepsilon(t) \triangleq m(t) - y_D(t) = m(t)\left[1 - \cos(\theta_0 - \phi_0)\right]$$

The mean-square error is

$$\left\langle \varepsilon^2(t) \right\rangle = \left\langle m^2(t)\left[1 - \cos(\theta_0 - \phi_0)\right]^2 \right\rangle$$

where $\langle \bullet \rangle$ denotes the time-average value. Since the term $[1 - \cos(\theta_0 - \phi_0)]$ is a constant, we have $\left\langle \varepsilon^2(t) \right\rangle = \left\langle m^2(t) \right\rangle \left[1 - \cos(\theta_0 - \phi_0)\right]^2$.

Note that for $\theta_0 = \phi_0$, the demodulation carrier is phase coherent with the original modulation carrier, and the mean-squared error $\langle \varepsilon^2(t) \rangle$ is zero.

c) For $\theta(t) = \omega_0 t$, $A_c = 1$, we have the demodulated output for convenience

$$y_D(t) = m(t)\cos(\omega_0 t - \phi_0),$$

give the error

$$\varepsilon(t) = m(t)\left[1 - \cos(\omega_0 t - \phi_0)\right],$$

giving the mean-square error

$$\left\langle \varepsilon^2(t) \right\rangle = \left\langle m^2(t)[1 - \cos(\omega_0 t - \phi_0)]^2 \right\rangle$$

The MSE

$$\left\langle \varepsilon^2(t) \right\rangle = \left\langle m^2(t)[1 - \cos(\omega_0 t - \phi_0)]^2 \right\rangle$$

$$= \left\langle m^2(t) \cdot \left[1 - 2\cos(\omega_0 t - \phi_0) + \frac{1}{2}(1 + \cos(2\omega_0 t - 2\phi_0))\right] \right\rangle$$

$$= \frac{3}{2}\left\langle m^2(t) \right\rangle + \left\langle m^2(t) \cdot \left[-2\cos(\omega_0 t - \phi_0) + \frac{1}{2}\cos(2\omega_0 t - 2\phi_0)\right] \right\rangle$$

$$\approx \frac{3}{2}\left\langle m^2(t) \right\rangle + \left\langle m^2(t) \right\rangle \left\langle \left[-2\cos(\omega_0 t - \phi_0) + \frac{1}{2}\cos(2\omega_0 t - 2\phi_0)\right] \right\rangle,$$

f_0 far larger than W

$$= \frac{3}{2}\left\langle m^2(t) \right\rangle$$

3. 每題 2/2/3/3 分，共 10 分

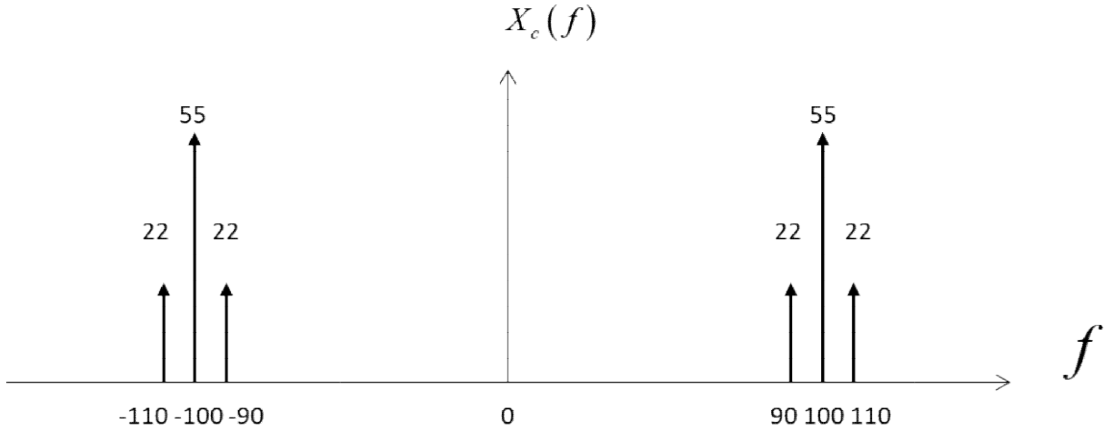
(a) $m_n(t) \triangleq \dfrac{m(t)}{\max|m(t)|} = \dfrac{9\cos(20\pi t)}{9} = \cos(20\pi t)$

(b) $\left\langle m_n^2(t) \right\rangle = \left\langle \cos^2(20\pi t) \right\rangle = \left\langle \dfrac{1}{2}\left\langle 1 + \cos(40\pi t) \right\rangle \right\rangle = \dfrac{1}{2} = 0.5$

(c) $E = \dfrac{a^2 \left\langle m_n^2(t) \right\rangle}{1 + a^2 \left\langle m_n^2(t) \right\rangle} = \dfrac{\left[(0.8)^2 \bullet 0.5\right]}{\left[1 + (0.8)^2 \bullet 0.5\right]} = 0.2424 = 24.24\%$

(d) $x_c(t) = 110\left[1 + 0.8\cos(20\pi t)\right]\cos(200\pi t)$

$$= 110\cos(200\pi t) + 44\cos(180\pi t) + 44\cos(220\pi t)$$



4. 每題 10 分，共 10 分

$$x_c(t)=\frac{1}{2}A_c m(t)\cos(2\pi f_c t)\pm\frac{1}{2}A_c\hat{m}(t)\sin(2\pi f_c t)$$
$$m(t)=4\cos(2\pi f_m t)+\cos(4\pi f_m t)$$
Hilbert Transform : $\hat{m}(t)=4\sin(2\pi f_m t)+\sin(4\pi f_m t)$

$$x_c(t)=\frac{1}{2}A_c m(t)\cos(2\pi f_c t)\pm\frac{1}{2}A_c\hat{m}(t)\sin(2\pi f_c t)$$
$$=\frac{1}{2}A_c(4\cos(2\pi f_m t)+\cos(4\pi f_m t))\cos(2\pi f_c t)\pm\frac{1}{2}A_c(4\sin(2\pi f_m t)+\sin(4\pi f_m t))\sin(2\pi f_c t)$$
$$=A_c\cos[2\pi(f_c+f_m)t]+A_c\cos[2\pi(f_c-f_m)t]+\frac{1}{4}A_c\cos[2\pi(f_c+2f_m)t]+\frac{1}{4}A_c\cos[2\pi(f_c-2f_m)t]$$
$$\pm\{-A_c\cos[2\pi(f+f_m)t]+A_c\cos[2\pi(f_c-f_m)t]\}+\{-\frac{1}{4}A_c\cos[2\pi(f_c+2f_m)t]+\frac{1}{4}A_c\cos[2\pi(f_c-2f_m)t]\}$$

Lower –sideband:

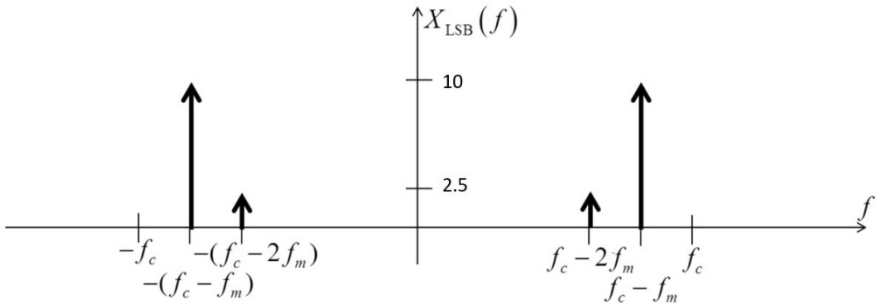
$$x_{LSB}(t) = \frac{1}{2}A_c m(t)\cos(2\pi f_c t) - \frac{1}{2}A_c \hat{m}(t)\sin(2\pi f_c t)$$

$$= 2A_c \cos[2\pi(f_c - f_m)t] + \frac{1}{2}A_c \cos[2\pi(f_c - 2f_m)t],$$

$$X_{LSB}(f) = A_c\delta[f - (f_c - f_m)] + A_c\delta[f + (f_c - f_m)]$$

$$+\frac{1}{4}A_c\delta[f - (f_c - 2f_m)] + \frac{1}{4}A_c\delta[f + (f_c - 2f_m)],$$

Assume $A_c = 10$.



Upper –sideband:

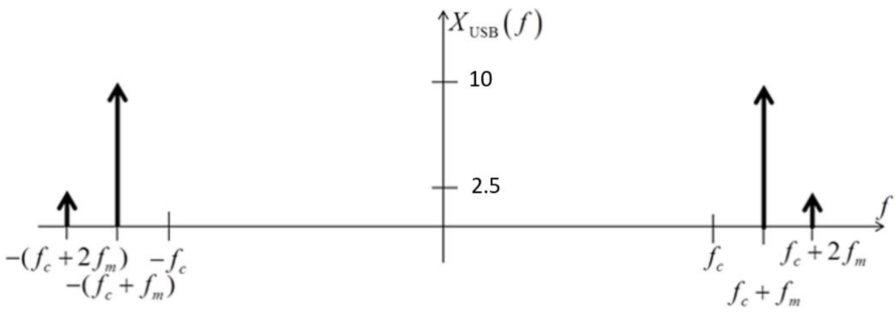
$$x_{USB}(t) = \frac{1}{2}A_c m(t)\cos(2\pi f_c t) + \frac{1}{2}A_c \hat{m}(t)\sin(2\pi f_c t)$$

$$= 2A_c \cos[2\pi(f_c + f_m)t] + \frac{1}{2}A_c \cos[2\pi(f_c + 2f_m)t],$$

$$X_{LSB}(f) = A_c\delta[f - (f_c + f_m)] + A_c\delta[f + (f_c + f_m)]$$

$$+\frac{1}{4}A_c\delta[f - (f_c + 2f_m)] + \frac{1}{4}A_c\delta[f + (f_c + 2f_m)],$$

Assume $A_c = 10$.



5. 每題 5 分，共 15 分

(a) Since the carrier frequency is 1000 Hertz, the general form of $x_c(t)$ is

$$x_c(t) = A_c \cos[2\pi(1000)t + 40\sin(5t^2)] = A_c \cos[2\pi(1000)t + \phi(t)]$$

The phase deviation, $\phi(t) = 40\sin(5t^2)$ rad

The frequency deviation is

$$\frac{d\phi(t)}{dt} = 400t\cos(5t^2) \text{ rad/sec}$$

or $\frac{1}{2\pi}\frac{d\phi(t)}{dt} = \frac{200}{\pi} t\cos(5t^2)$ Hz

(b) Since the carrier frequency is 1000 Hertz, the general form of $x_c(t)$ is

$$x_c(t) = A_c \cos[2\pi(1000)t - 2\pi(400)t] = A_c \cos[2\pi(1000)t + \phi(t)]$$

The phase deviation is $\phi(t) = -2\pi(400)t$ rad

(Note that we substracted the phase of the unmodulated carrier from the instantaneous carrier.) The frequency deviation is

$$\frac{d\phi}{dt} = -2\pi(400) \quad \text{rad/sec}$$

or $\frac{1}{2\pi}\frac{d\phi}{dt} = -400$ Hz

(c) Since the carrier frequency is 1000 Hertz, the general form of $x_c(t)$ is

$$x_c(t) = A_c\cos[2\pi(1000)t - 2\pi(100)t + 10\sqrt{t}] = A_c\cos[2\pi(1000)t + \phi(t)]$$

The phase deviation is

$$\phi(t) = -2\pi(100)t + 10\sqrt{t} \quad \text{rad}$$

And the frequency deviation is

$$\frac{d\phi}{dt} = -2\pi(100) + \frac{1}{2}(10)t^{-\frac{1}{2}} = -2\pi(100) + \frac{5}{\sqrt{t}} \quad \text{rad/sec}$$

or $\dfrac{1}{2\pi}\dfrac{d\phi}{dt} = -100 + \dfrac{5}{2\pi\sqrt{t}}$ Hz

6. 每題 10 分，共 10 分

$$\begin{aligned} x_c(t) &= 25\cos[2\pi(150)t] + 5\cos[2\pi(150+10)t] + 5\cos[2\pi(150-10)t] \\ &= 25\cos[2\pi(150)t] + 10\cos[2\pi(10)t]\cos[2\pi(150)t] \\ &= 25\left\{1 + \frac{10}{25}\cos[(2\pi(10)t]\right\}\cos[2\pi(150)t] \end{aligned}$$

$$a = \frac{10}{25} = 0.4$$

$$m_n(t) = \cos(2\pi \cdot 10t)$$

$$\begin{aligned} \therefore \quad E &= \frac{a^2\langle m_n^2(t)\rangle}{1 + a^2\langle m_n^2(t)\rangle} \times 100\% \\ &= \frac{0.4^2\langle \cos^2(2\pi \cdot 10t)\rangle}{1 + 0.4^2\langle \cos^2(2\pi \cdot 10t)\rangle} \times 100\% \\ &= \frac{0.4^2 \bullet 0.5}{1 + 0.4^2 \bullet 0.5} \times 100\% \\ &= 0.0741 \end{aligned}$$

7. 每題 5 分，共 10 分

(a) $\phi_1(t) = \cos[2\pi f_c t + 10K_p \cos(5\pi t)]$

(b) $\phi_2(t) = \cos\left(2\pi f_c t + K_p[10\cos(5\pi t) + 2\sin(7\pi t)]\right)$

$$\sin(\alpha)\sin(\beta) = \frac{1}{2}\left[\cos(\alpha-\beta) - \cos(\alpha+\beta)\right]$$
$$\cos(\alpha)\cos(\beta) = \frac{1}{2}\left[\cos(\alpha-\beta) + \cos(\alpha+\beta)\right]$$
$$\sin(\alpha)\cos(\beta) = \frac{1}{2}\left[\sin(\alpha-\beta) + \sin(\alpha+\beta)\right]$$
$$\sin(\alpha\pm\beta) = \sin(\alpha)\cos(\beta) \pm \cos(\alpha)\sin(\beta)$$
$$\cos(\alpha\pm\beta) = \cos(\alpha)\cos(\beta) \mp \sin(\alpha)\sin(\beta)$$