④

$$\int_{-\infty}^{\infty} x_1(t)\, x_2(t)\, dt$$
$$= \int_{-\infty}^{\infty} X_1(f)\, X_2^*(f)\, df = 0.$$

(Note that $x_2(t) = x_2^*(t)$ since $x_2(t)$ is real).

Many other terms in ③ can be shown to be equal to zero in a similar way.

~~③~~ ③ is finally given by

$$y_p(t) = \frac{1}{2}\left[\int\left[h^I(\tau)\, x^I(t-\tau) - h^Q(\tau)\, x^Q(t-\tau)\right]d\tau\right] \cos 2\pi f_c t$$
$$- \sin 2\pi f_c t \left[\frac{1}{2}\int\left[h^I(\tau)\, x^Q(t-\tau) + h^Q(\tau)\, x^I(t-\tau)\right]d\tau\right] \quad — ④$$

comparing equation ④ with
$$y_p(t) = y^I(t) \cos 2\pi f_c t - y^Q(t) \sin 2\pi f_c t$$
we have ⑤
$$y^I(t) = \frac{1}{2}\int\left[h^I(\tau)\, x^I(t-\tau) - h^Q(\tau)\, x^Q(t-\tau)\right]d\tau$$
$$y^Q(t) = \frac{1}{2}\int\left[h^I(\tau)\, x^Q(t-\tau) + h^Q(\tau)\, x^I(t-\tau)\right]d\tau.$$

let $y(t) \triangleq y^I(t) + j y^Q(t)$, $h(\tau) \triangleq h^I(\tau) + j h^Q(\tau)$

and $x(t) \triangleq x^I(t) + j x^Q(t)$. ← ⑥