For a narrowband channel

$$g(t) = \sum_{n=1}^{N} C_n e^{j\phi_n(t)}$$

where $\phi_n(t) = \phi_n - 2\pi c \tau_n/\lambda_c + 2\pi f_{D,n} t$

and $f_{D,n} t = f_m \cos(\theta_n) t$

we have,

$$g(t) = \underbrace{\sum_{n=1}^{N} C_n \cos\phi_n(t)}_{g_I(t)} + j \underbrace{\sum_{n=1}^{N} C_n \sin\phi_n(t)}_{g_Q(t)}$$

$$\begin{aligned}
\phi_{g_I g_I}(\tau) &= E\left[g_I(t)\, g_I(t+\tau)\right] \\
&= E\left[\sum_{n=1}^{N} C_n \cos\phi_n(t) \sum_{m=1}^{N} C_m \cos\phi_m(t+\tau)\right] \\
&= E\left[\sum_{n=1}^{N}\sum_{m=1}^{N} C_n C_m \cos\phi_n(t)\cos\phi_m(t+\tau)\right] \\
&= \sum_{n=1}^{N}\sum_{m=1}^{N} C_n C_m E\left[\cos\phi_n(t)\cos\phi_m(t+\tau)\right]
\end{aligned}$$

For $n \neq m$ in the double sum, the i.i.d. uniform random phases

$\phi_n - 2\pi c \tau_n/\lambda_c$; ϕ_n, τ_n are random

and $\phi_m - 2\pi c \tau_m/\lambda_c$

ensure that $\phi_n(t)$ and $\phi_m(t+\tau)$ are i.i.d. uniform random variables on $[-\pi, \pi)$

$$\phi_{S_I S_I}(\tau) = \sum_{n=1}^{N} C_n^2\, E\left[\cos\phi_n(t)\cos\phi_n(t+\tau)\right]$$

$E[\cos x] = 0$

$x \sim U[-\pi, \pi)$

$$+ \sum_{n}\sum_{m \neq n} E\left[\overset{0}{\cancel{\cos\phi_n(t)}}\right] E\left[\overset{0}{\cancel{\cos\phi_m(t+\tau)}}\right]$$

$$= \sum_{n=1}^{N} C_n^2\, E\Big[\tfrac{1}{2}\cos(2\pi f_{D,n}\, t)$$

$$+ \tfrac{1}{2}\cos(\underbrace{2\phi_n - 4\pi c \tau_n/\lambda_c}_{\text{uniform random variable on } [-\pi,\pi)} + 2\pi f_{D,n}(2t+\tau))\Big]$$

$$= \frac{1}{2}\sum_{n=1}^{N} C_n^2\, E\left[\cos(2\pi f_m t \cos\theta_n)\right]$$

$$+ \frac{1}{2}\sum_{n=1}^{N} C_n^2\, E\left[\overset{0}{\cancel{\cos(2\phi_n - 4\pi c\tau_n/\lambda_c + 2\pi f_{D,n}(2t+\tau))}}\right]$$

$$= \frac{\Omega_p}{2}\, E\left[\cos(2\pi f_m t \cos\theta_n)\right]$$

where $\sum_{n=1}^{N} C_n^2 = \Omega_p$