Frequency modulation with modulation depth m_{FM} [Hz] at a frequency f [Hz] has the form

$$y(t) = \exp\{i\omega t\} \exp\left\{ i \int_0^t 2\pi \ m_{\mathrm{FM}} \ \Re\left\{ e^{i2\pi f t'} \right\} \ dt' \right\}$$

where ω [radians/second] is the carrier frequency. We can simply do the integral and get:

$$y(t) = \exp\{i\omega t\} \exp\left\{ i \ \frac{1}{f} \ m_{\mathrm{FM}} \ \Re\left\{ i e^{i2\pi f t} \right\} \right\}$$

which is just phase modulation at frequency f [Hz] with modulation depth $m_{\mathrm{PM}} = \left(\frac{i}{f}\right) m_{\mathrm{FM}}$ [radians]:

$$\frac{d}{dt}\left(\frac{1}{f} m_{\mathrm{FM}} \sin 2\pi f t \right) = 2\pi \ m_{FM} \cos 2\pi f t$$

The i signifies a phase shift of 90 degrees in the modulation (turning cos to sin).