

# Principles of Communications

## ECS 332

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### 4.4 Switching MODEM



#### Office Hours:

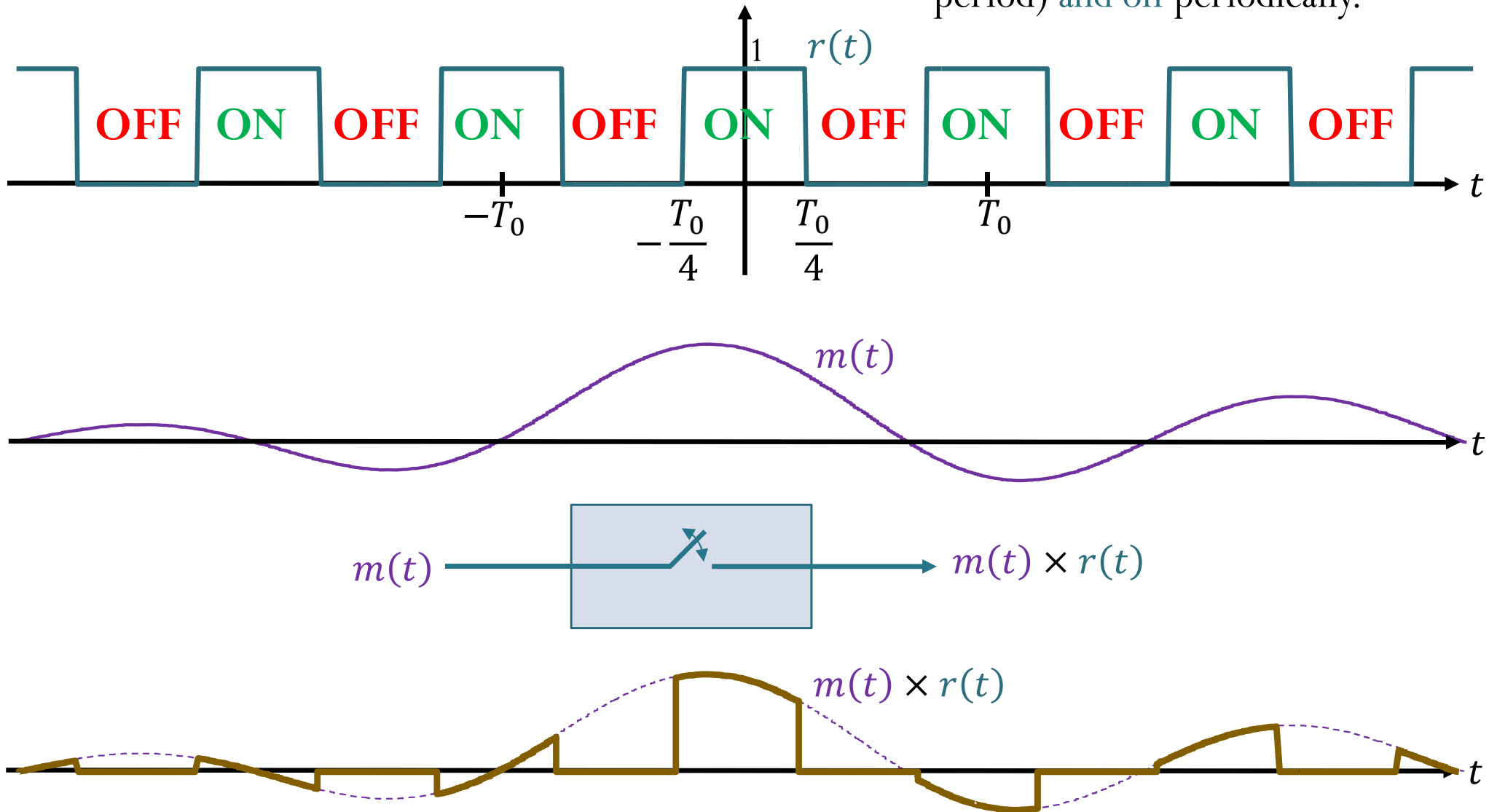
BKD, 6th floor of Sirindhralai building

Wednesday 14:00-15:30

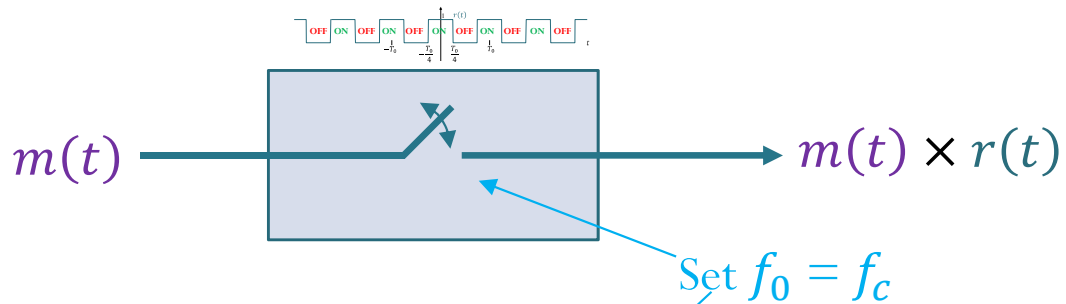
Friday 14:00-15:30

# Switching Operation

Multiplying a signal  $m(t)$  by the square-wave  $r(t)$  is equivalent to switching  $m(t)$  on (for half a period) and off periodically.

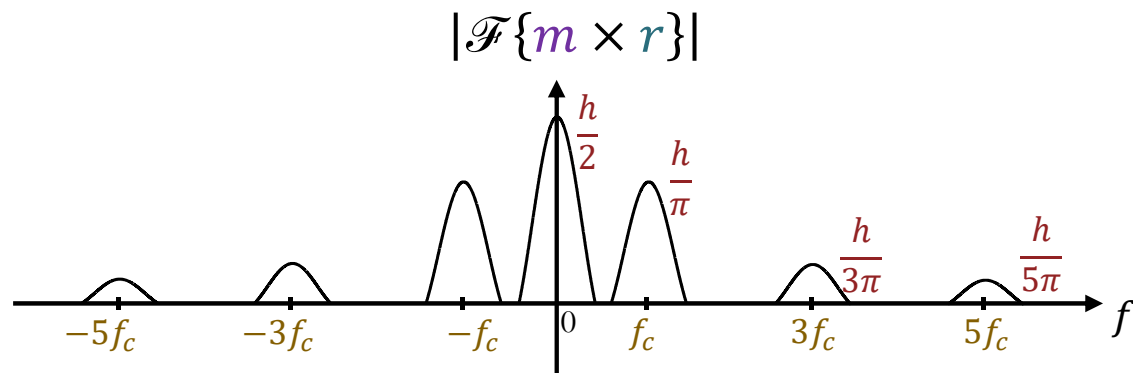
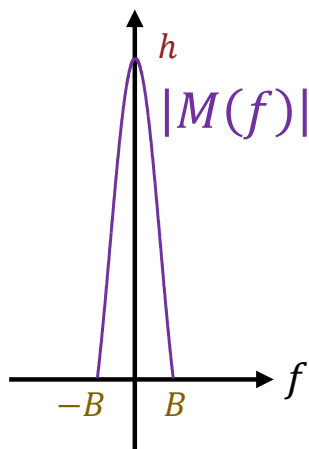


# Switching Modulator

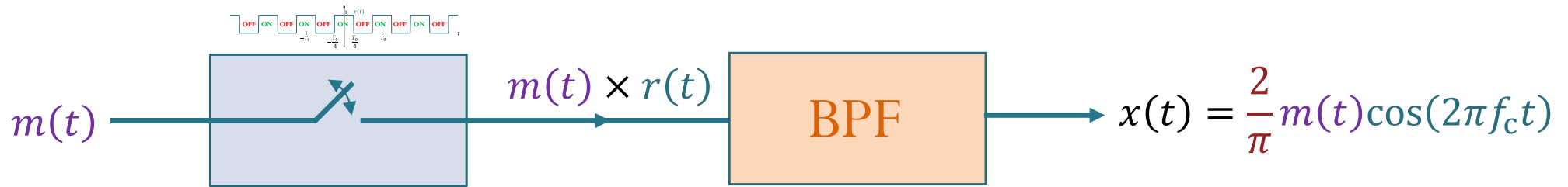


$$r(t) = \frac{1}{2} + \frac{2}{\pi} \cos(2\pi f_c t) - \frac{2}{3\pi} \cos(2\pi(3f_c)t) + \frac{2}{5\pi} \cos(2\pi(5f_c)t) + \dots$$

$$m(t) \times r(t) = \frac{1}{2} m(t) + \frac{2}{\pi} m(t) \cos(2\pi f_c t) - \frac{2}{3\pi} m(t) \cos(2\pi(3f_c)t) + \frac{2}{5\pi} m(t) \cos(2\pi(5f_c)t) + \dots$$

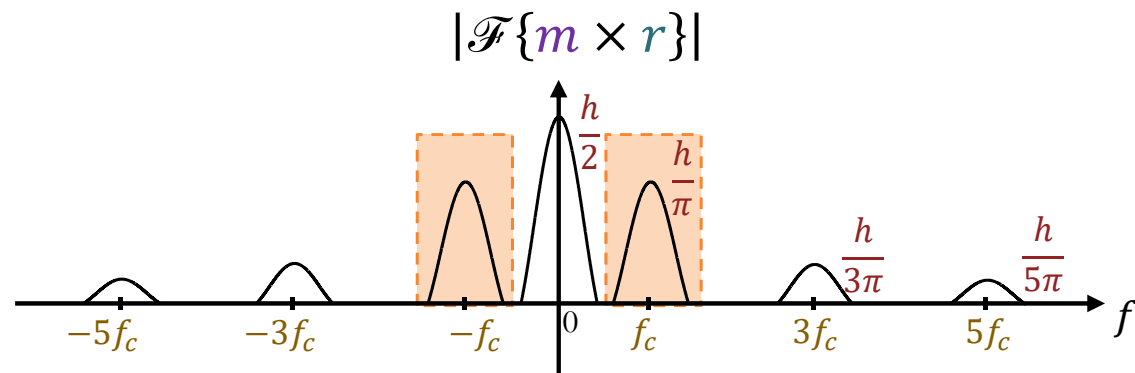
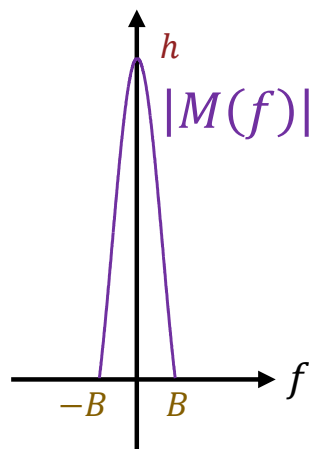


# Switching Modulator

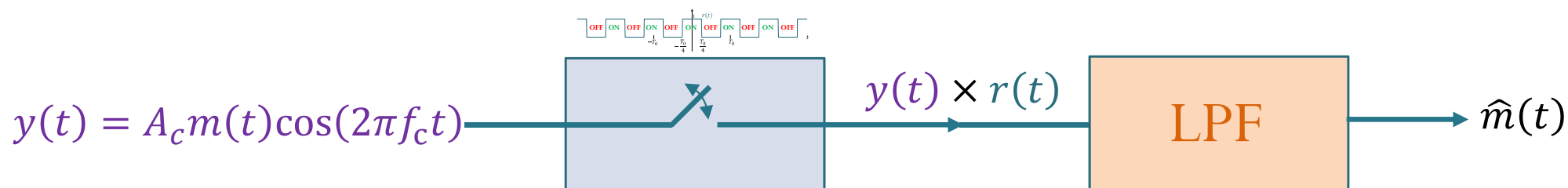


$$r(t) = \frac{1}{2} + \frac{2}{\pi} \cos(2\pi f_c t) - \frac{2}{3\pi} \cos(2\pi(3f_c)t) + \frac{2}{5\pi} \cos(2\pi(5f_c)t) + \dots$$

$$m(t) \times r(t) = \frac{1}{2} m(t) + \frac{2}{\pi} m(t) \cos(2\pi f_c t) - \frac{2}{3\pi} m(t) \cos(2\pi(3f_c)t) + \frac{2}{5\pi} m(t) \cos(2\pi(5f_c)t) + \dots$$



# Switching Demodulator

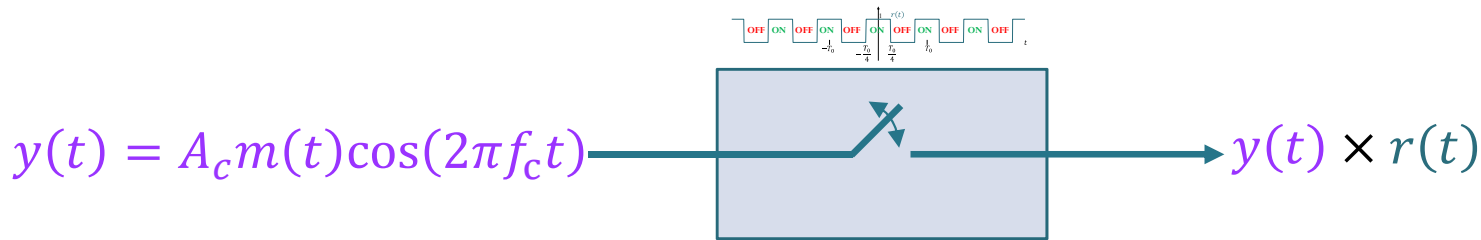


$$r(t) = \frac{1}{2} + \frac{2}{\pi} \cos(2\pi f_c t) - \frac{2}{3\pi} \cos(2\pi(3f_c)t) + \frac{2}{5\pi} \cos(2\pi(5f_c)t) + \dots$$

$$y(t) \times r(t) = \frac{1}{2} y(t) + \frac{2}{\pi} y(t) \cos(2\pi f_c t) - \frac{2}{3\pi} y(t) \cos(2\pi(3f_c)t) + \frac{2}{5\pi} y(t) \cos(2\pi(5f_c)t) + \dots$$



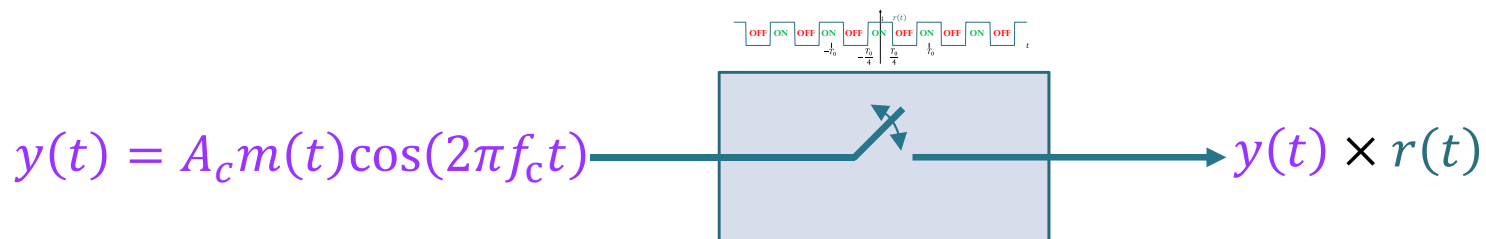
# Switching Demodulator



$$\begin{aligned}
 y(t)r(t) &= \frac{1}{2} y(t) + \frac{2}{\pi} y(t) \cos(2\pi f_c t) - \frac{2}{3\pi} y(t) \cos(2\pi(3f_c)t) + \frac{2}{5\pi} y(t) \cos(2\pi(5f_c)t) + \dots \\
 &= \frac{1}{2} A_c m(t) \cos(2\pi f_c t) \\
 &\quad + \frac{2}{\pi} A_c m(t) \cos(2\pi f_c t) \cos(2\pi f_c t) \\
 &\quad - \frac{2}{3\pi} A_c m(t) \cos(2\pi f_c t) \cos(2\pi(3f_c)t) \\
 &\quad + \frac{2}{5\pi} A_c m(t) \cos(2\pi f_c t) \cos(2\pi(5f_c)t) + \dots
 \end{aligned}$$



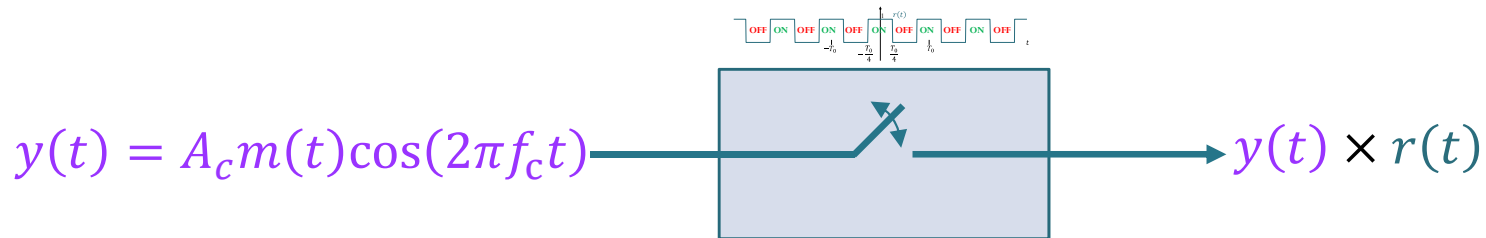
# Switching Demodulator



$$\begin{aligned}
 y(t)r(t) &= \frac{1}{2} A_c m(t) \cos(2\pi f_c t) \\
 &+ \frac{1}{\pi} A_c m(t) (1 + \cos(2\pi (2f_c)t)) \\
 &- \frac{1}{3\pi} A_c m(t) (\cos(2\pi (f_c)t) + \cos(2\pi (5f_c)t)) \\
 &+ \frac{1}{5\pi} A_c m(t) (\cos(2\pi (3f_c)t) + \cos(2\pi (7f_c)t)) + \dots
 \end{aligned}$$



# Switching Demodulator

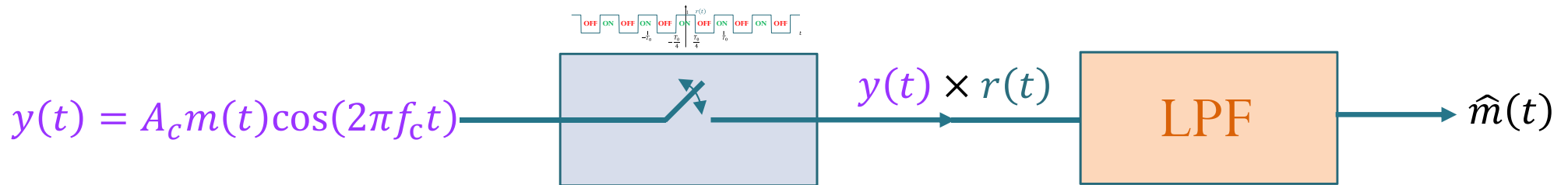


$$\begin{aligned}
 y(t)r(t) &= \frac{1}{2} A_c m(t) \cos(2\pi f_c t) \\
 &+ \frac{1}{\pi} A_c m(t) + \frac{1}{\pi} A_c m(t) \cos(2\pi(2f_c)t) \\
 &- \frac{1}{3\pi} A_c m(t) \cos(2\pi(2f_c)t) - \frac{1}{3\pi} A_c m(t) \cos(2\pi(4f_c)t) \\
 &+ \frac{1}{5\pi} A_c m(t) \cos(2\pi(4f_c)t) + \frac{1}{5\pi} A_c m(t) \cos(2\pi(6f_c)t) + \dots
 \end{aligned}$$





# Switching Demodulator



$$\begin{aligned}
 y(t)r(t) &= \frac{1}{2} A_c m(t) \cos(2\pi f_c t) \\
 &+ \frac{1}{\pi} A_c m(t) + \frac{1}{\pi} A_c m(t) \cos(2\pi(2f_c)t) \\
 &- \frac{1}{3\pi} A_c m(t) \cos(2\pi(2f_c)t) - \frac{1}{3\pi} A_c m(t) \cos(2\pi(4f_c)t) \\
 &+ \frac{1}{5\pi} A_c m(t) \cos(2\pi(4f_c)t) + \frac{1}{5\pi} A_c m(t) \cos(2\pi(6f_c)t) + \dots
 \end{aligned}$$

$$\hat{m}(t) = \frac{A_c}{\pi} m(t)$$

