Principles of Communications
ECS 332

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4.4 Switching MODEM

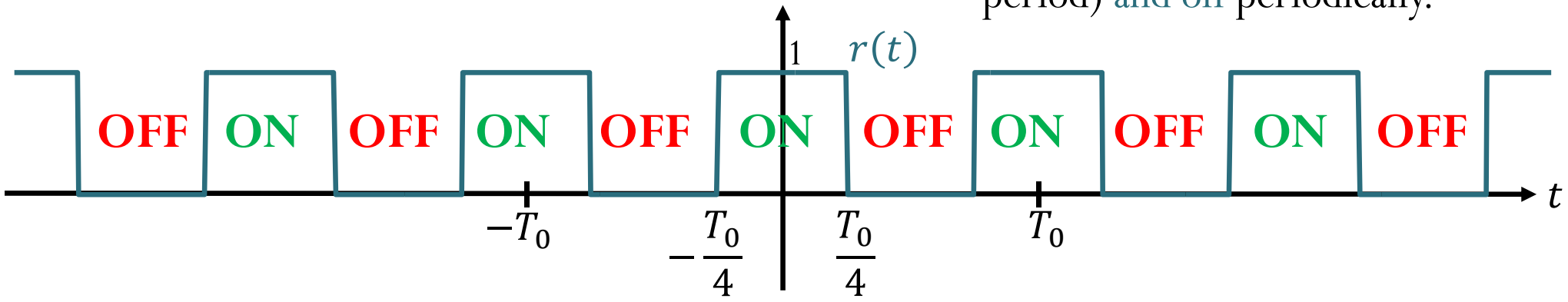
Office Hours:

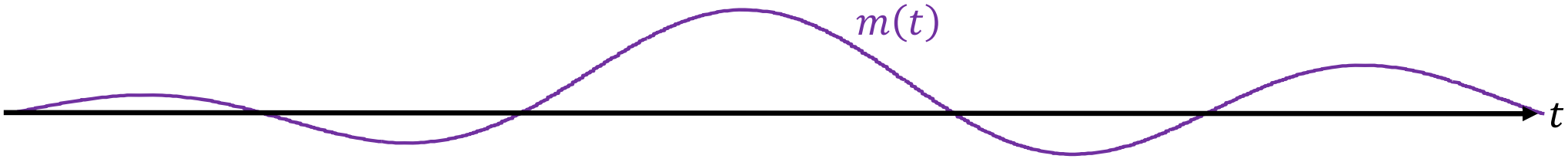
BKD, 6th floor of Sirindhralai building

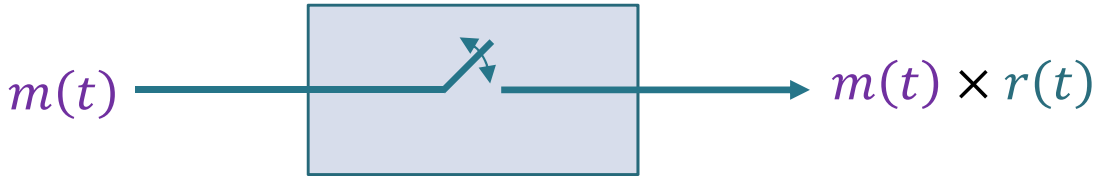
Tuesday	**9:00-10:00**
Wednesday	**14:20-15:20**
Thursday	**9:00-10:00**

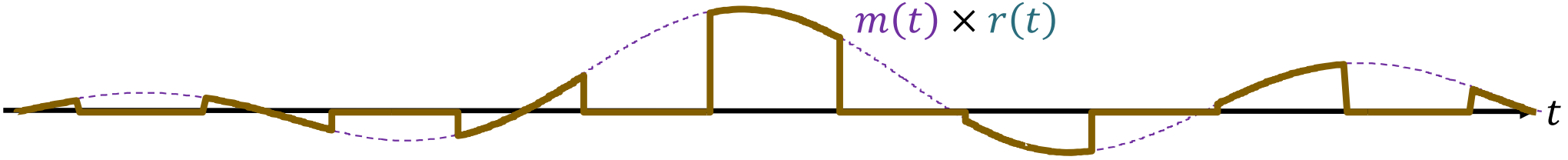
Switching Operation

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.

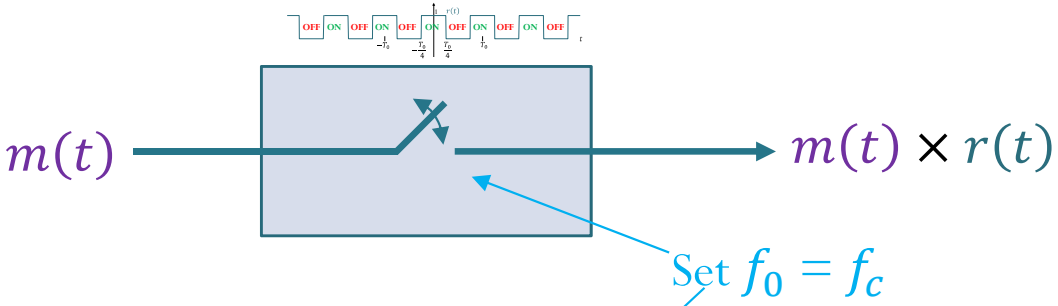






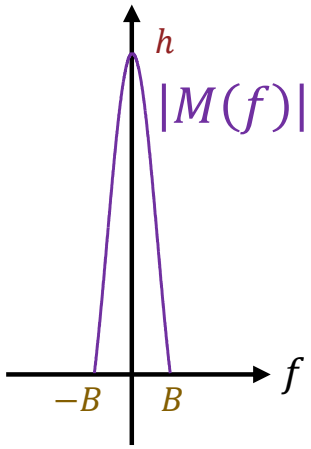


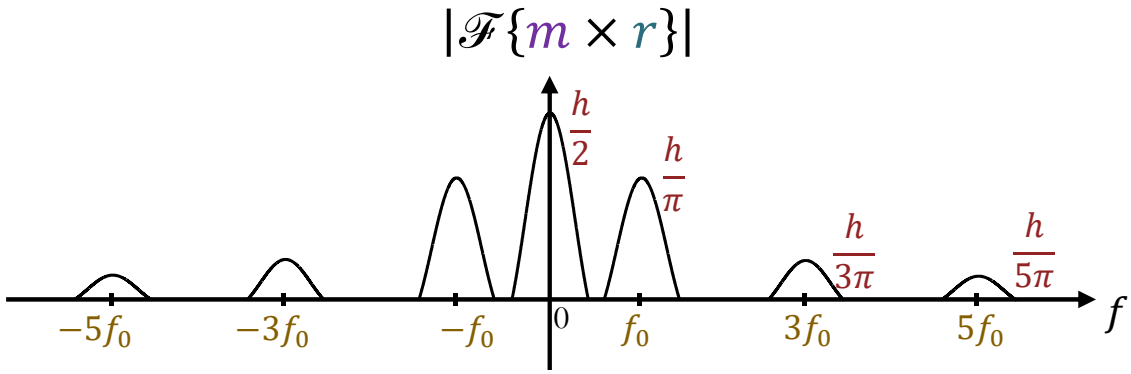
Switching Modulator



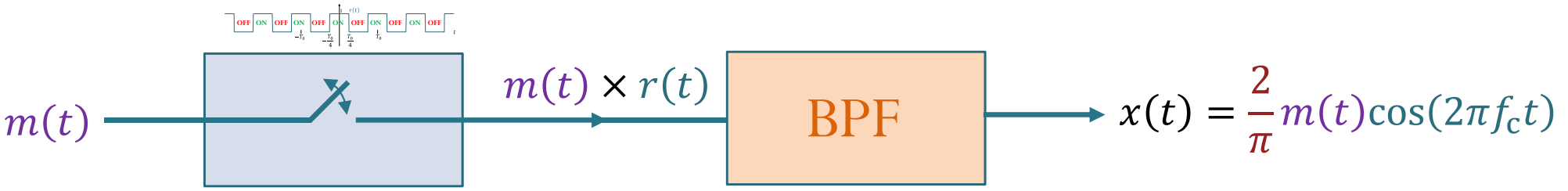
$$r(t) = \frac{1}{2} + \frac{2}{\pi}\cos(2\pi f_c t) - \frac{2}{3\pi}\cos(2\pi(3f_c)t) + \frac{2}{5\pi}\cos(2\pi(5f_c)t) + \cdots$$

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



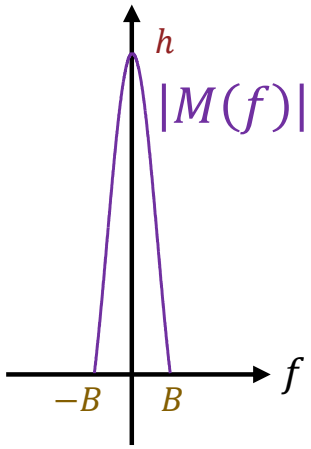


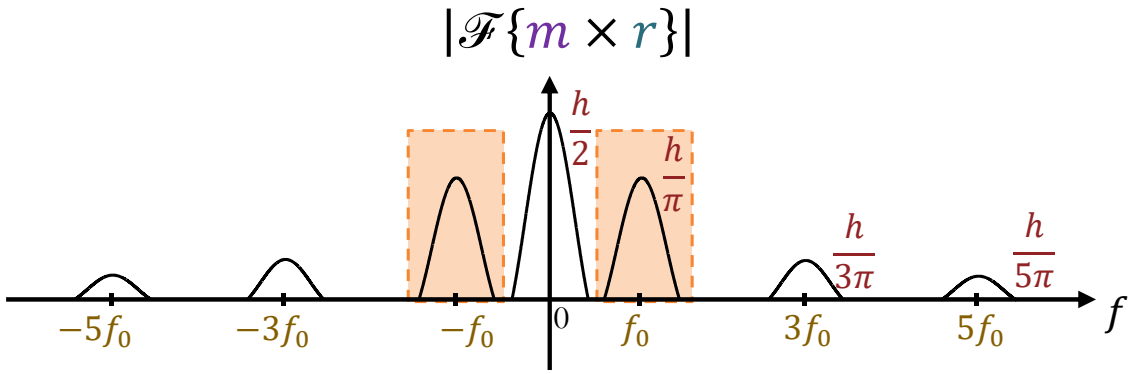
Switching Modulator



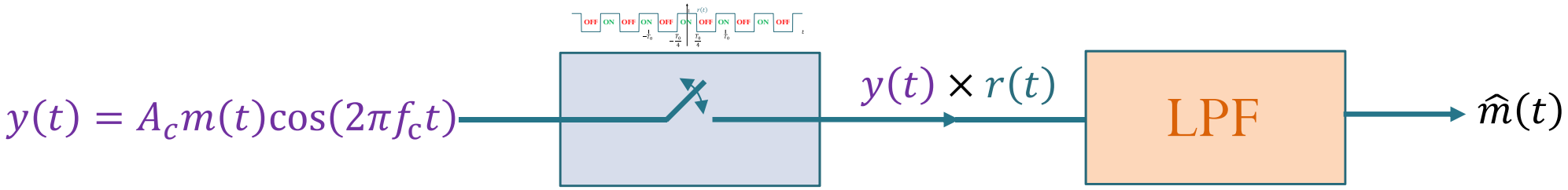
$$r(t) = \frac{1}{2} + \frac{2}{\pi}\cos(2\pi f_c t) - \frac{2}{3\pi}\cos(2\pi(3f_c)t) + \frac{2}{5\pi}\cos(2\pi(5f_c)t) + \cdots$$

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





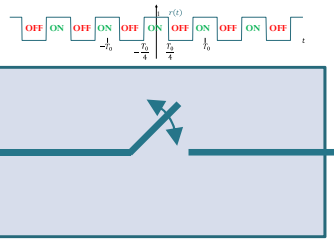
Switching Demodulator



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

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

Switching Demodulator



$y(t) = A_c m(t)\cos(2\pi f_c t)$ → $y(t) \times r(t)$

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

$$= \frac{1}{2}A_c m(t)\cos(2\pi f_c t)$$

$$+ \frac{2}{\pi}A_c m(t)\cos(2\pi f_c t)\cos(2\pi f_c t)$$

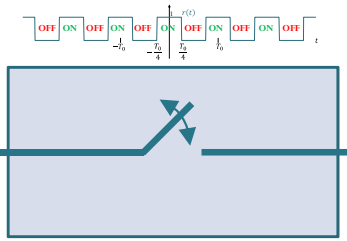
$$- \frac{2}{3\pi}A_c m(t)\cos(2\pi f_c t)\cos(2\pi(3f_c)t)$$

$$+ \frac{2}{5\pi}A_c m(t)\cos(2\pi f_c t)\cos(2\pi(5f_c)t) + \cdots$$

Now, recall that $\cos(A)\cos(B) = \frac{1}{2}\cos(A+B) + \frac{1}{2}\cos(A-B)$

Switching Demodulator

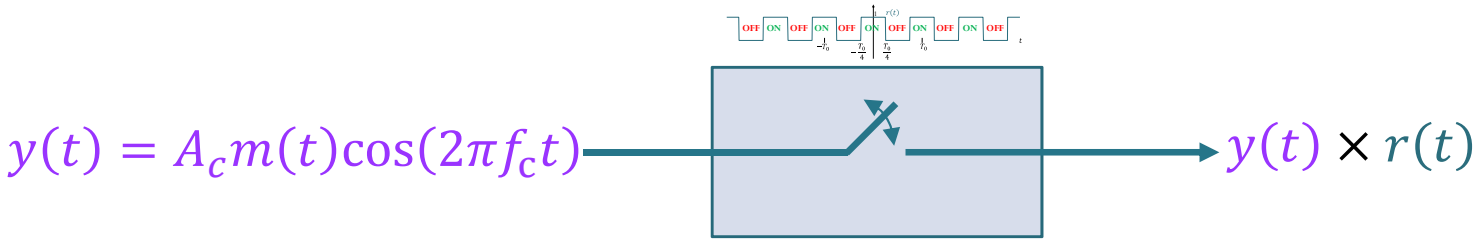
$y(t) = A_c m(t)\cos(2\pi f_c t)$



$y(t) \times r(t)$

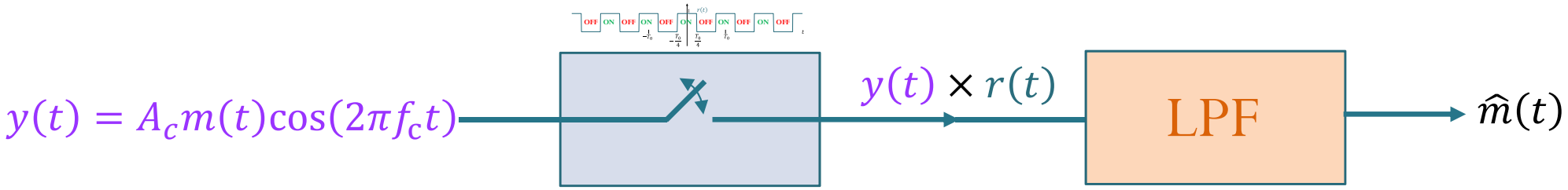
$$y(t)r(t) = \frac{1}{2}A_c m(t)\cos(2\pi f_c t)$$
$$+\frac{1}{\pi}A_c m(t)\left(1+\cos\left(2\pi(2f_c)t\right)\right)$$
$$-\frac{1}{3\pi}A_c m(t)\left(\cos\left(2\pi(f_c)t\right)+\cos\left(2\pi(5f_c)t\right)\right)$$
$$+\frac{1}{5\pi}A_c m(t)\left(\cos\left(2\pi(3f_c)t\right)+\cos\left(2\pi(7f_c)t\right)\right)+\cdots$$

Switching Demodulator



$$y(t)r(t) = \frac{1}{2}A_c m(t)\cos(2\pi f_c t)$$
$$+\frac{1}{\pi}A_c m(t) + \frac{1}{\pi}A_c m(t)\cos\left(2\pi(2f_c)t\right)$$
$$-\frac{1}{3\pi}A_c m(t)\cos\left(2\pi(2f_c)t\right) - \frac{1}{3\pi}A_c m(t)\cos\left(2\pi(4f_c)t\right)$$
$$+\frac{1}{5\pi}A_c m(t)\cos\left(2\pi(4f_c)t\right) + \frac{1}{5\pi}A_c m(t)\cos\left(2\pi(6f_c)t\right) + \cdots$$

Switching Demodulator



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

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