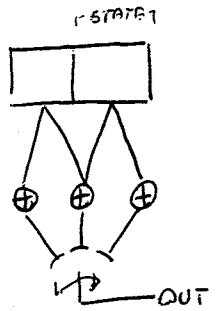
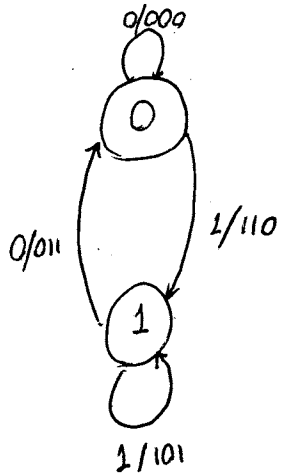
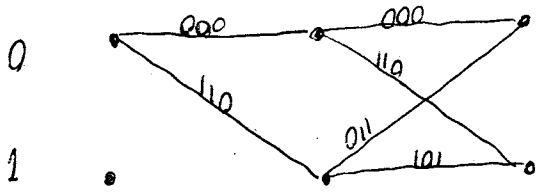
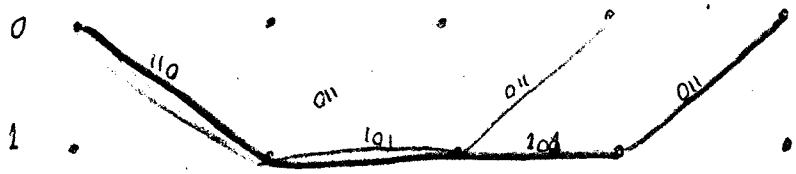
2. Convolution Codes.
   - Consider a convolutional code with $R = 1/3$, and octal generators $(2, 3, 1)$. Determine and draw the state diagram of the code.
   - Determine and draw the trellis diagram of the code.
   - Determine the bit-error probability (considering at least 3 non zero terms in the union bound), and the minimal bandwidth required in case of an information bit-rate equal to 10 Mbit/sec.




2 010
3 011
1 001




L=2 d=4 w=1
L=3 d=6 w=2
L=4 d=8 w=3

$$P_b(E) \leq \sum_d w(d)\, Q\sqrt{\frac{2E_b}{N_0} R d}$$

$$P_b(E) \leq 1\, Q\sqrt{\frac{2E_b}{N_0}\frac{1}{3}4} + 2\, Q\sqrt{\frac{2E_b}{N_0}\frac{1}{3}6^2} + 3\, Q\sqrt{\frac{2E_b}{N_0}\frac{1}{3}8}$$

$$P_b(E) \leq Q\sqrt{\frac{8}{3}\frac{E_b}{N_0}} + 2Q\sqrt{4\frac{E_b}{N_0}} + 3Q\sqrt{\frac{16}{3}\frac{E_b}{N_0}}$$

$$B_{Q_{MIN}} = \min\left\{ \frac{1}{2T_s}(1+\delta) \right\}_{T_b = T_s} = \frac{M_b}{2} = 5\,MHz$$

$$B_L = \frac{B_Q}{R} = 5 \cdot 3\,MHz = 15\,MHz$$