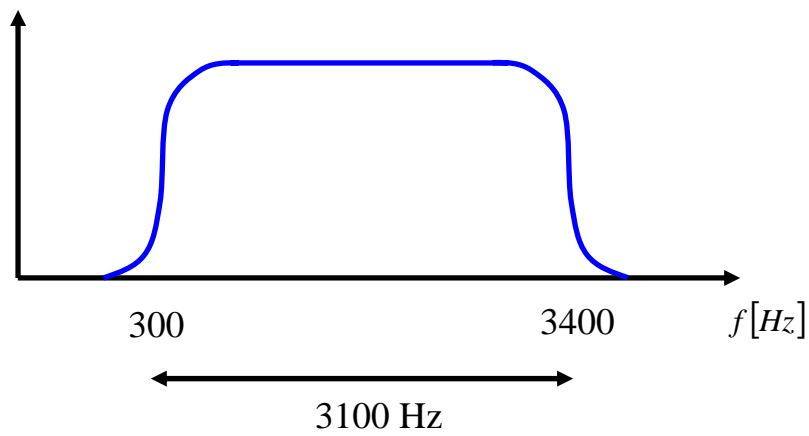




Modem

Massimiliano Pieraccini

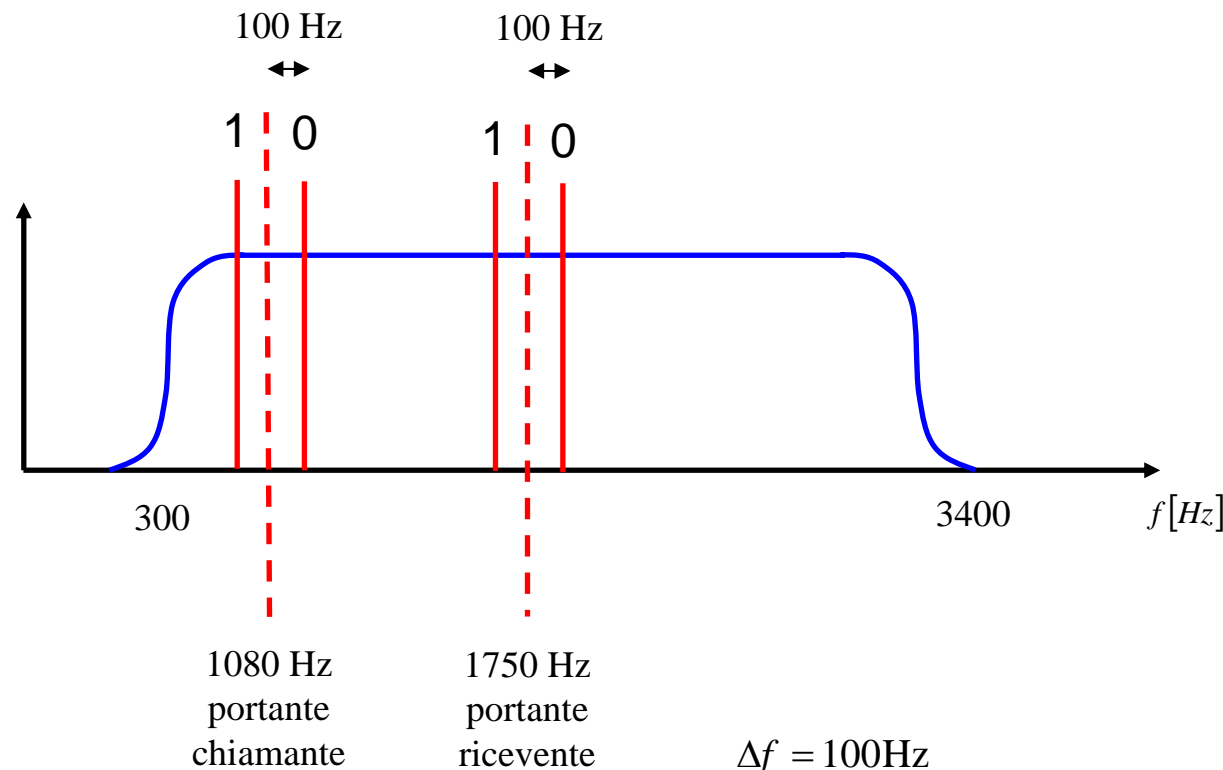
Risposta in frequenza della linea telefonica



Modem v. 21

FSK binaria full-duplex

300 bit / s



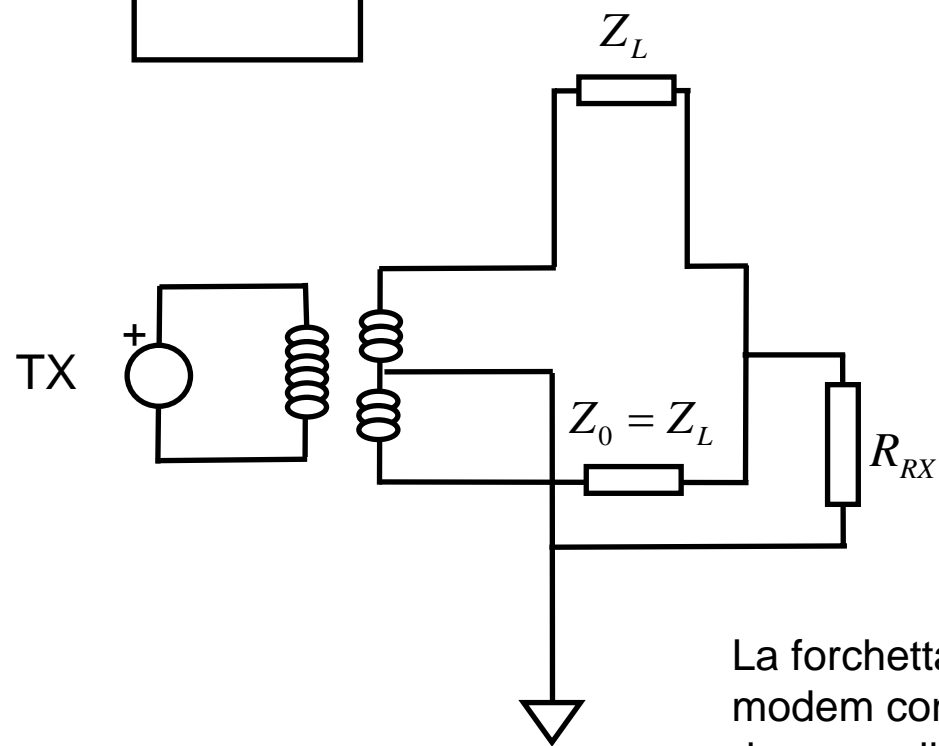
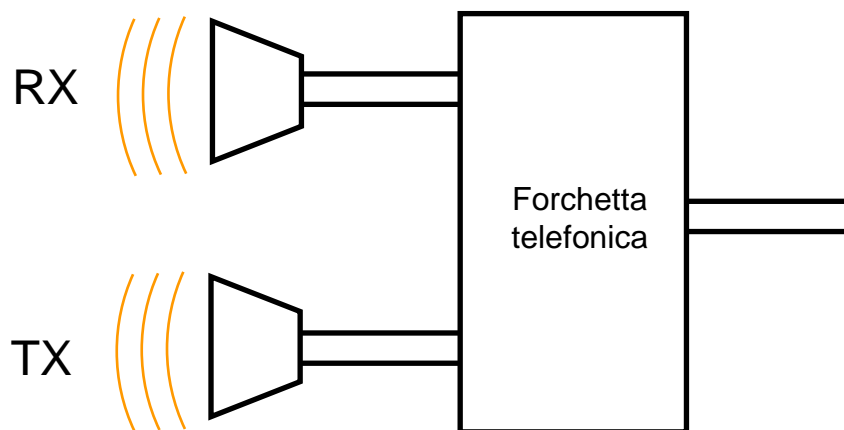
$$\Delta f = 100Hz$$

$$f_m = 300Hz$$

$$B_{upload} \approx 2(\Delta f + f_m) = 800Hz$$

$$B_{download} \approx 2(\Delta f + f_m) = 800Hz$$

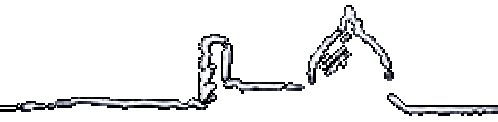
Forchetta telefonica



La forchetta telefonica applicata al modem consente di trasmettere e ricevere alla stesso tempo con la stessa banda



Poiché la banda è limitata conviene usare una codifica per cui a un simbolo corrisponde più di 1 bit (QPSK, QAM)



Fax

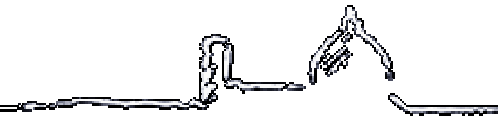
PSK a 4 fasi (Q-PSK) (2bit per simbolo)

Half Duplex (portante: 1800 Hz)

1200 baud \rightarrow 2400 bit/s



Non si può aumentare a piacimento il numero di bit di un singolo simbolo (ovvero il numero di simboli della costellazione), perché a i simboli diventano sempre più vicini e oltre un certo limite a causa del rumore risultano indistinguibili



Capacità del canale telefonico

$$C = B \log_2 \left(1 + \frac{S}{N} \right) \text{ bit/s}$$

Teorema di Shannon

$$B = 3400 \text{ Hz}$$

$$\frac{S}{N} = 30 \text{ dB} = 1000$$

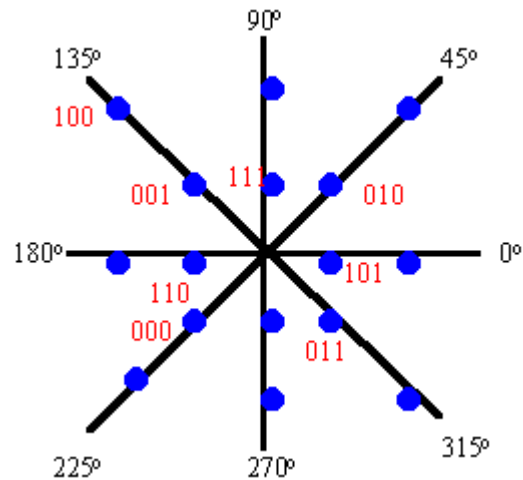


$$C = 34 \text{ kbit/s} \quad \text{Limite teorico}$$

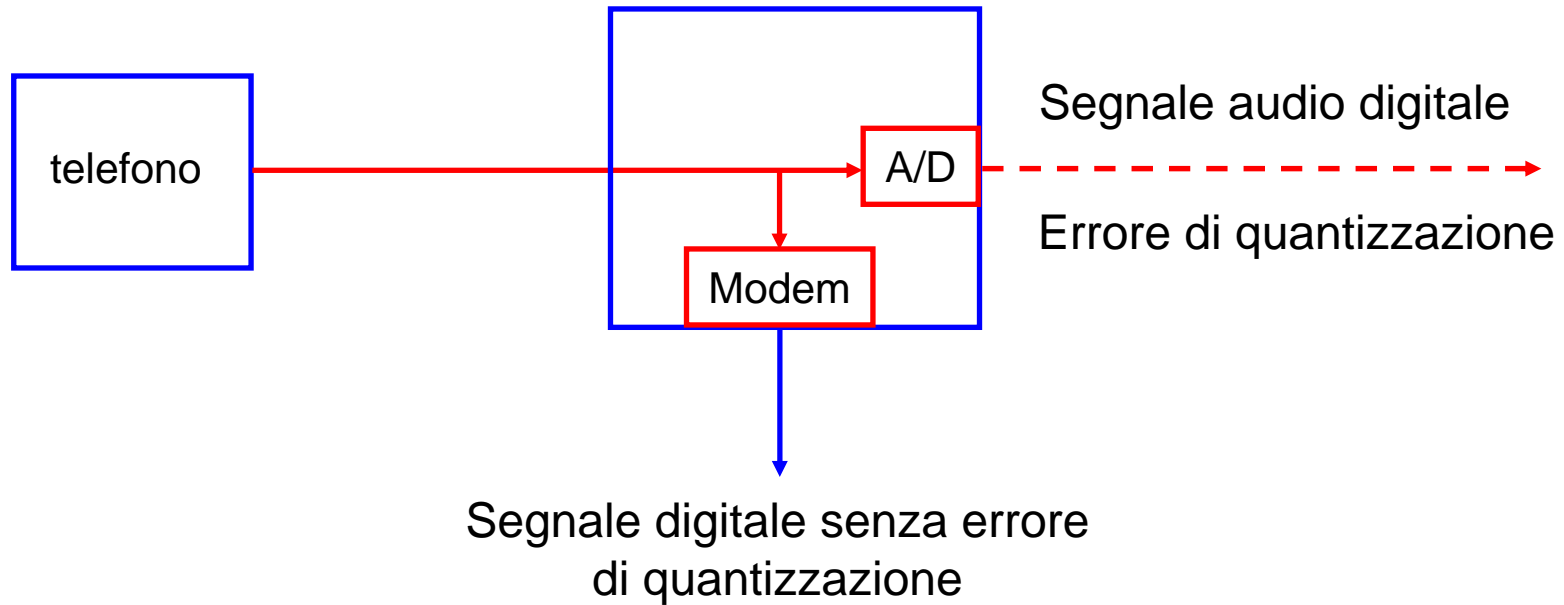
33.6 kbps

QAM a 3 bit

Full Duplex (2 portanti)



56 Kbit/s



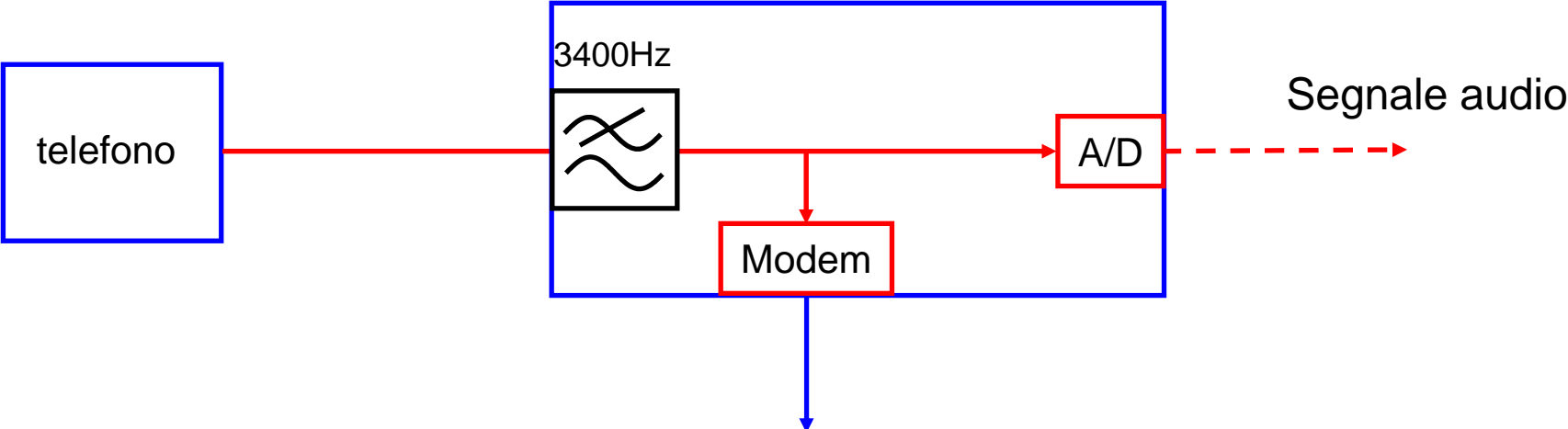
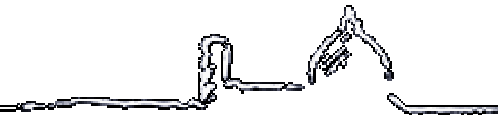
$$C = B \log_2 \left(1 + \frac{S}{N} \right) \text{ bit / s} \quad \text{Teorema di Shannon}$$

$$B = 3100 \text{ Hz}$$

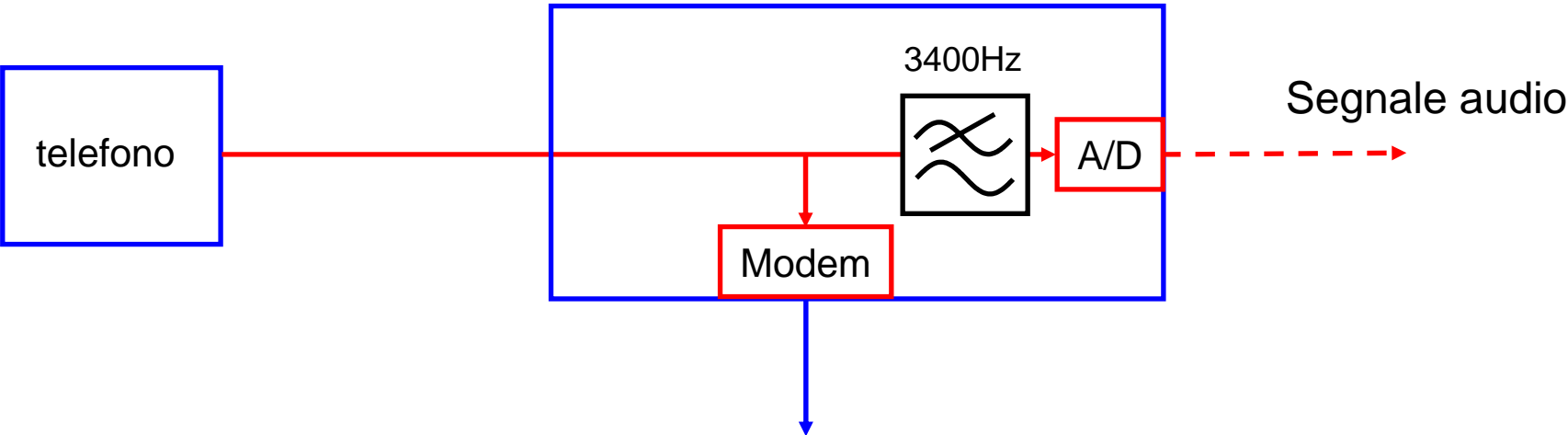
$$\frac{S}{N} = 100 \text{ dB} = 100000$$

$$\longrightarrow C = 64 \text{ kbit / s} \quad \text{Limite teorico}$$

ADSL



Asymmetric Digital Subscriber Line (ADSL)

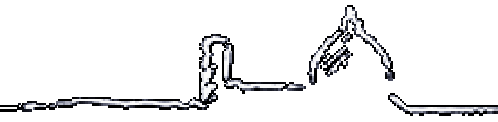




1) Attenuazione del doppino



Maggiore potenza, tuttavia la potenza non può essere aumentata indefinitamente, perché aumentano i disturbi radiati sulle altre linee



2) Dispersione del doppino



Divisione del segnale in molti canali a banda stretta

$$v(f)$$

$$\delta t = \frac{L}{v_2} - \frac{L}{v_1} = \frac{L(v_1 - v_2)}{v_1 v_2} \approx -\frac{L \Delta v}{v^2}$$

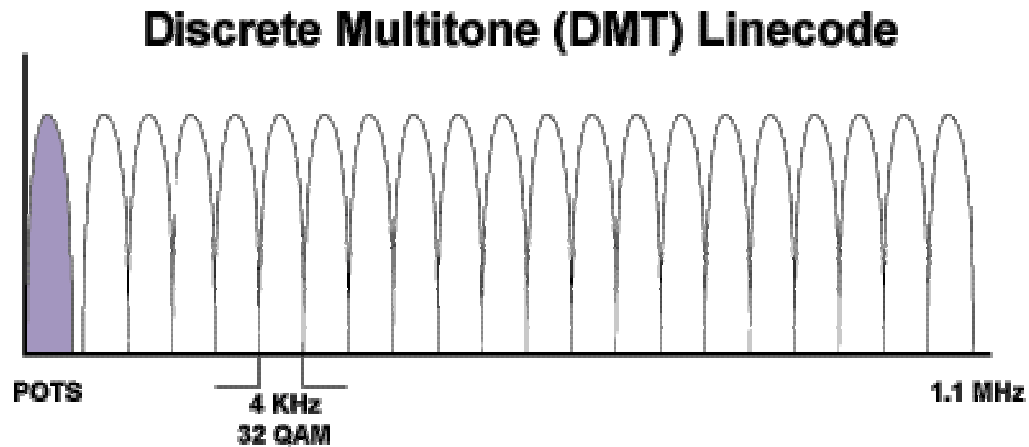
$$\delta t = \frac{L}{v^2} \frac{\partial v}{\partial f} B$$

$$\text{rate [baud]} = \frac{\beta v^2}{LB}$$

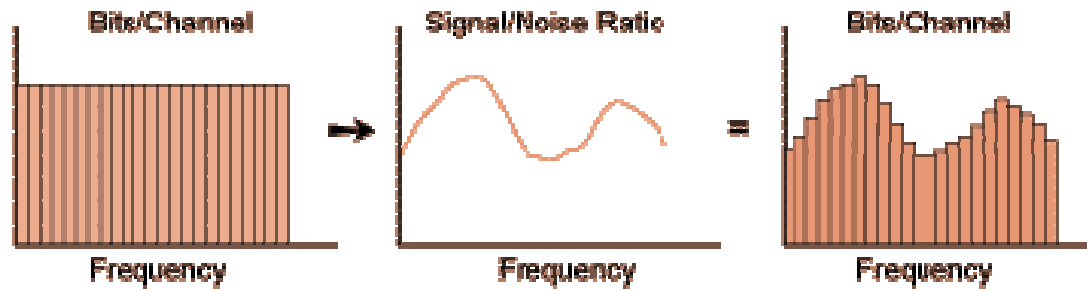
$$\beta = \frac{1}{\left(\frac{\partial v}{\partial f} \right)}$$

$$B < \frac{\beta v^2}{LB}$$

$$B < v \sqrt{\frac{\beta}{L}}$$



I canali sono indipendenti, ciascuno con un diverso S/N



Il modem monitora continuamente ogni singolo canale e modifica il bit-rate in maniera adattiva

Limite: circa 6Mbit/s