Institute for Research in ELECTRONICS AND APPLIED PHYSICS

Communications with Mackey-Glass Electronic Circuits

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Mackey-Glass Model

- Models white blood cell production in the human body

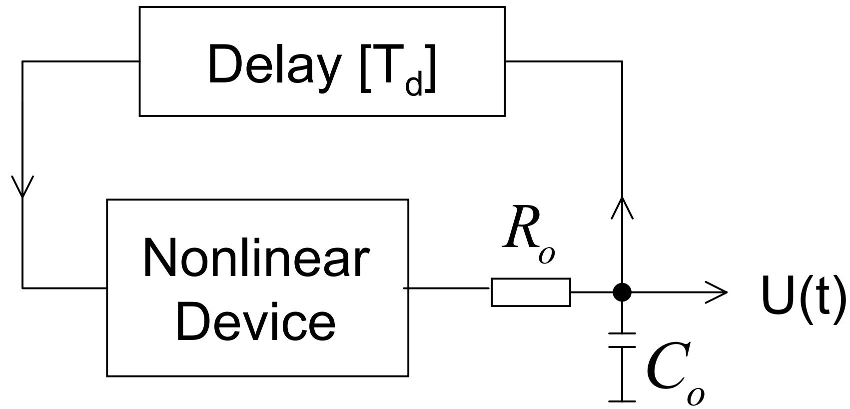
- Described by delay differential equation:

$$\dot{x} = \frac{a x_\tau}{1 + x_\tau^n} - bx$$

- Decay term is proportional to the present cell count

- Nonlinear production term is a function of past cell count

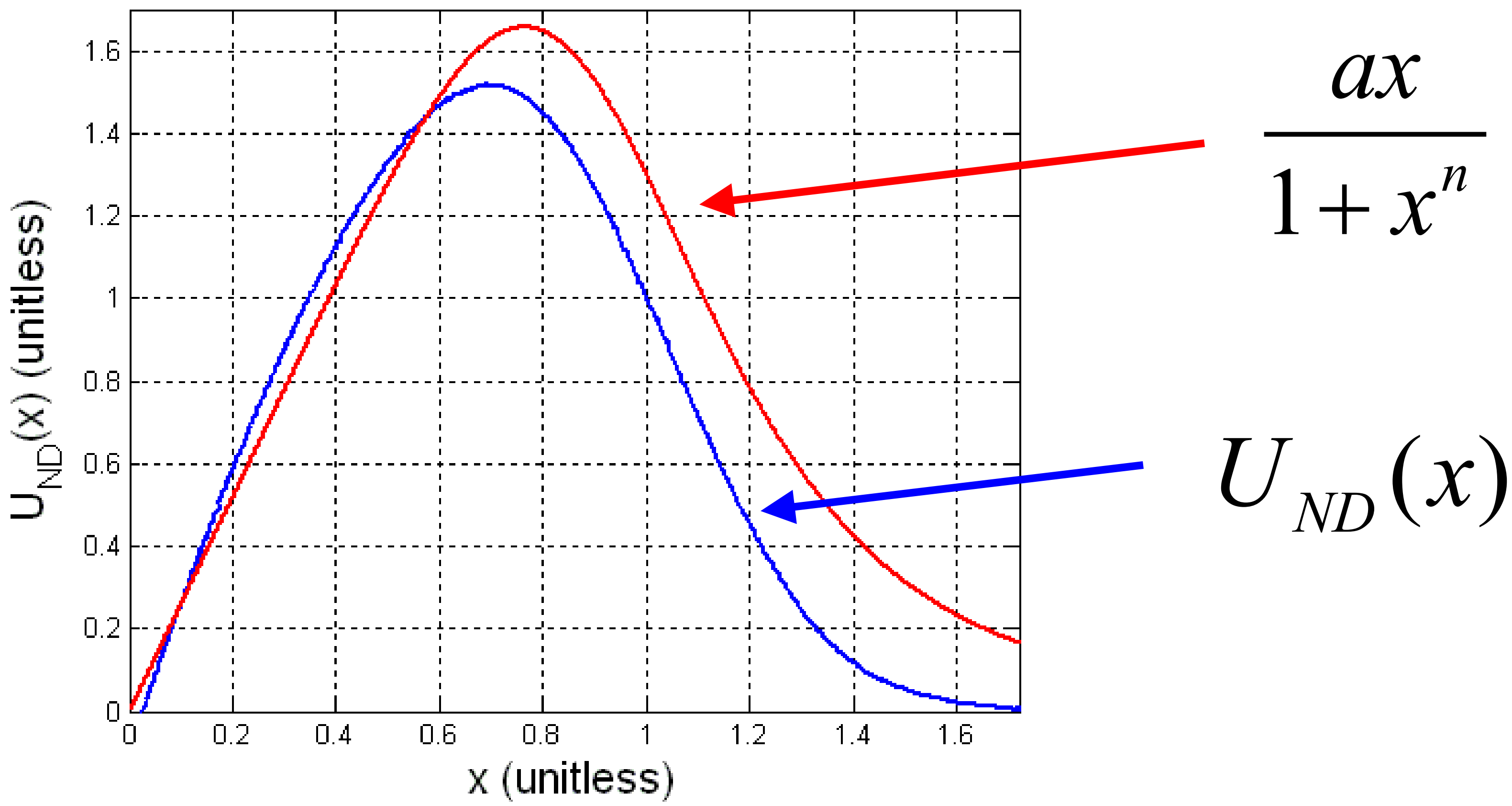
Mackey-Glass Circuit



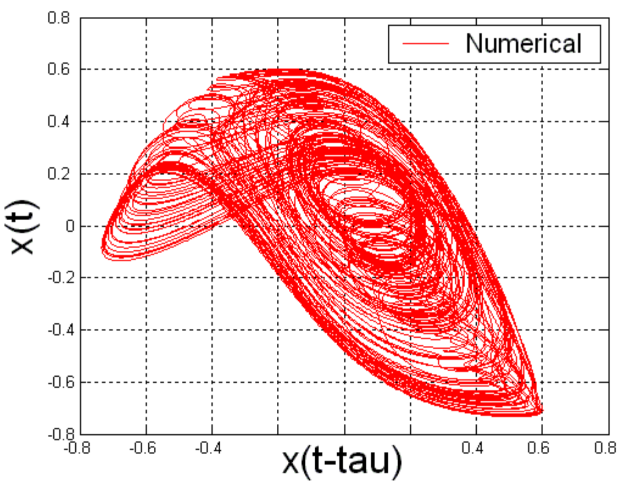
Current in circuit:

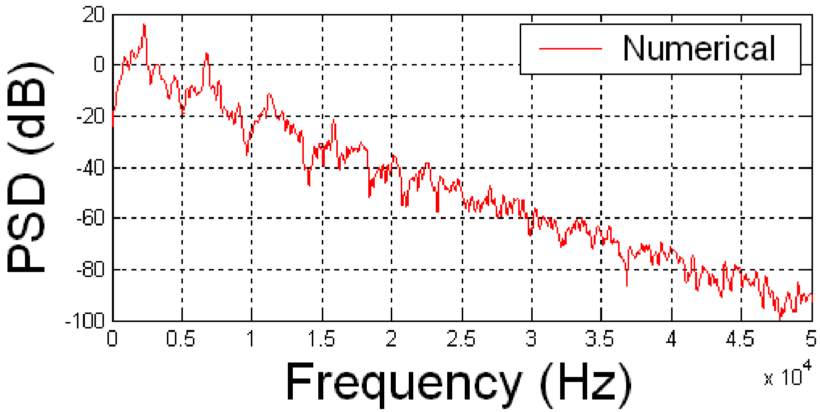
$$C_o \dot{U} = \frac{U_{ND}\left(U_{T_d}\right)}{R_o} - \frac{U}{R_o}$$

Nonlinearities:

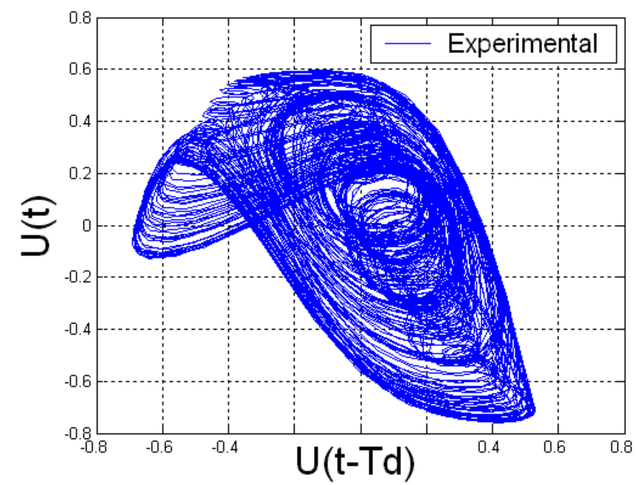


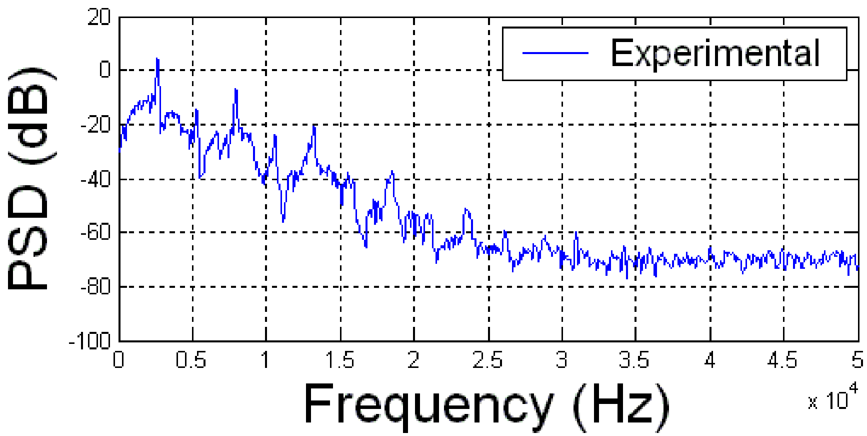
MG Model



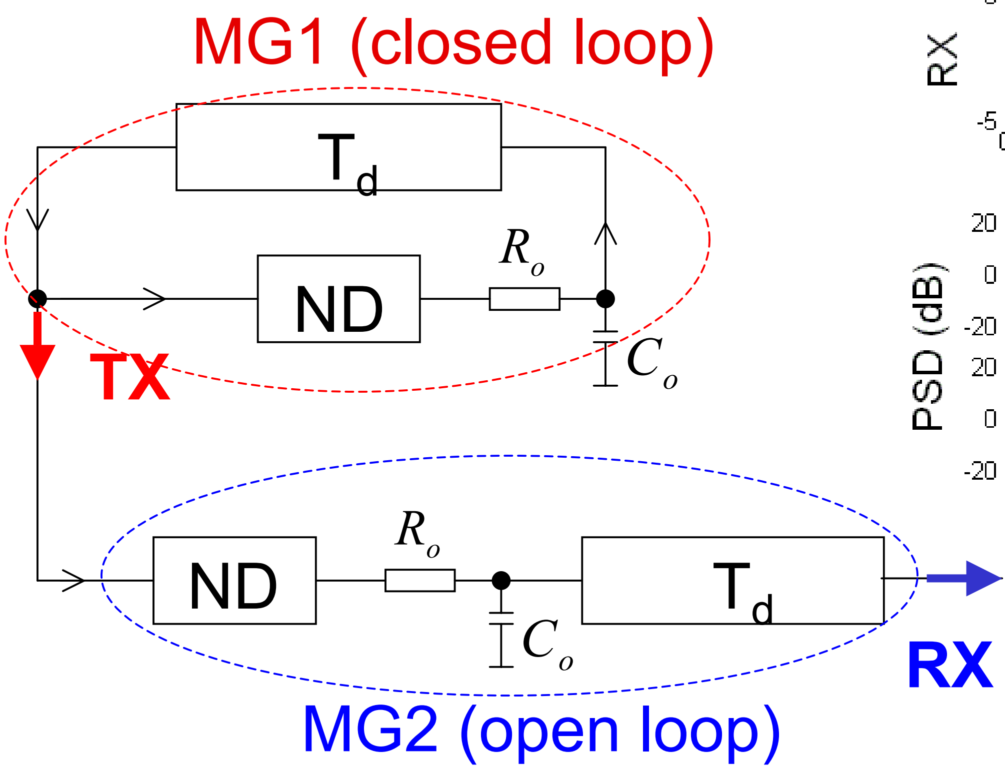


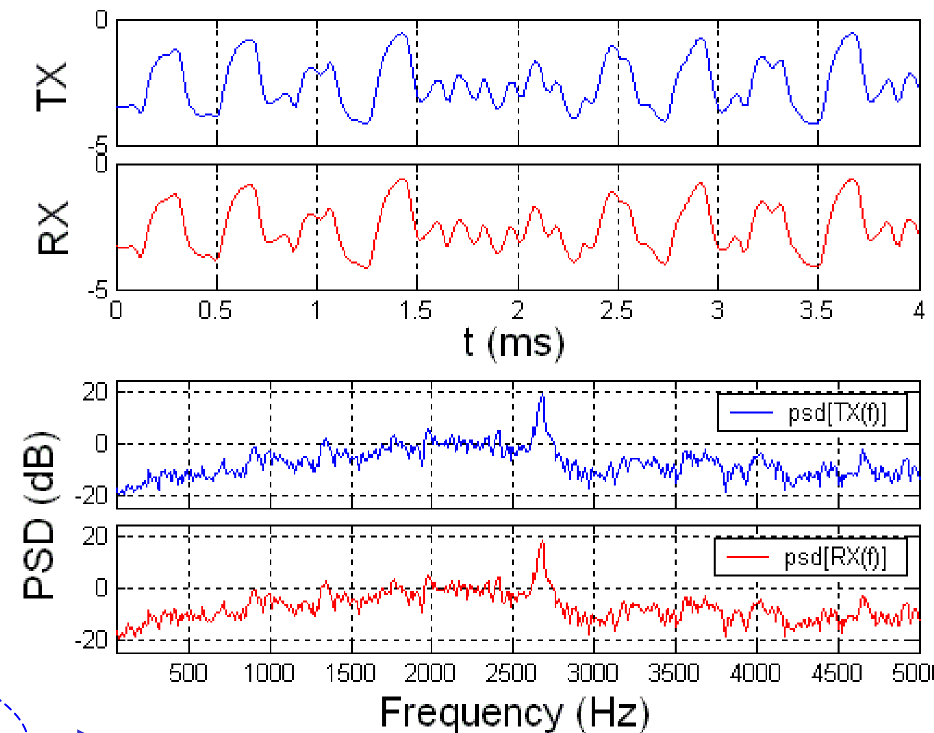
MG Circuit



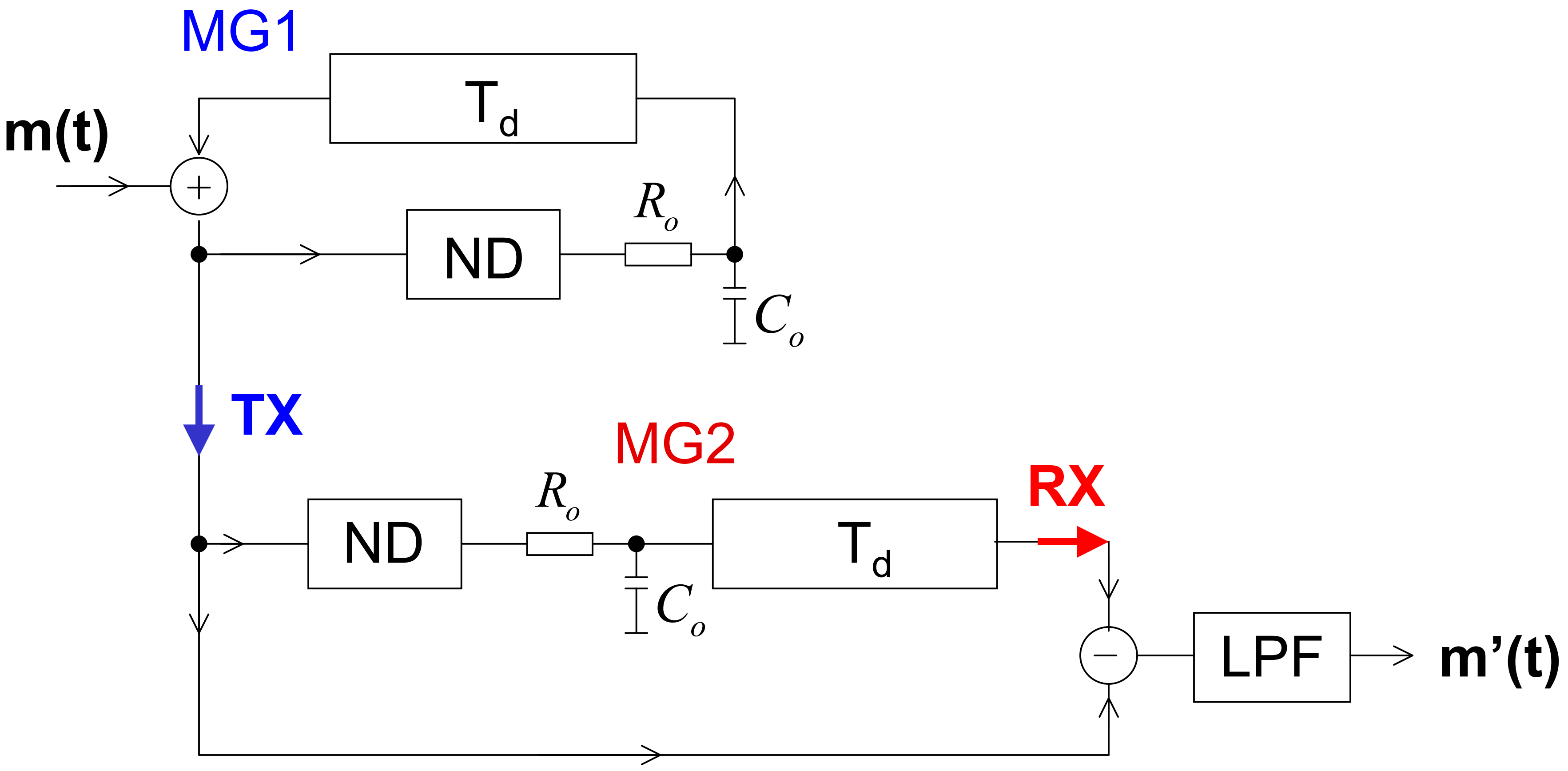


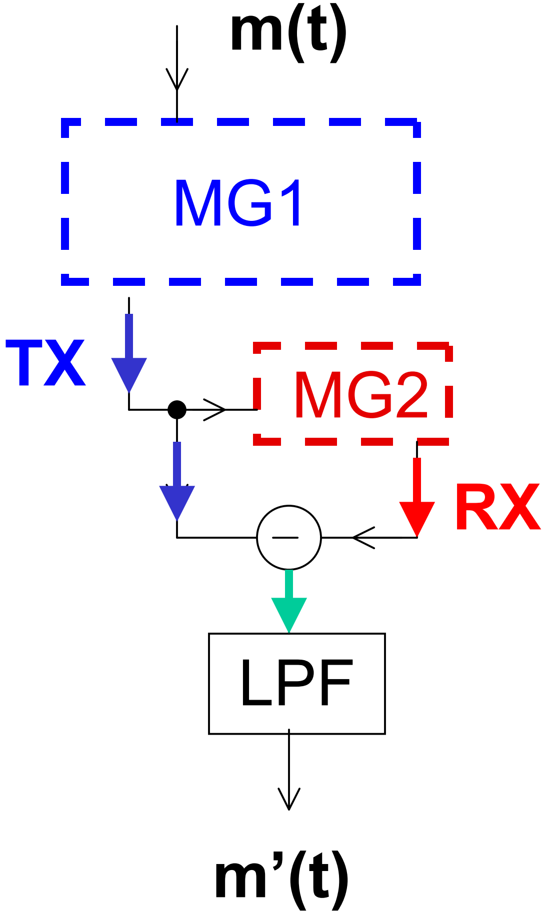
Synchronization



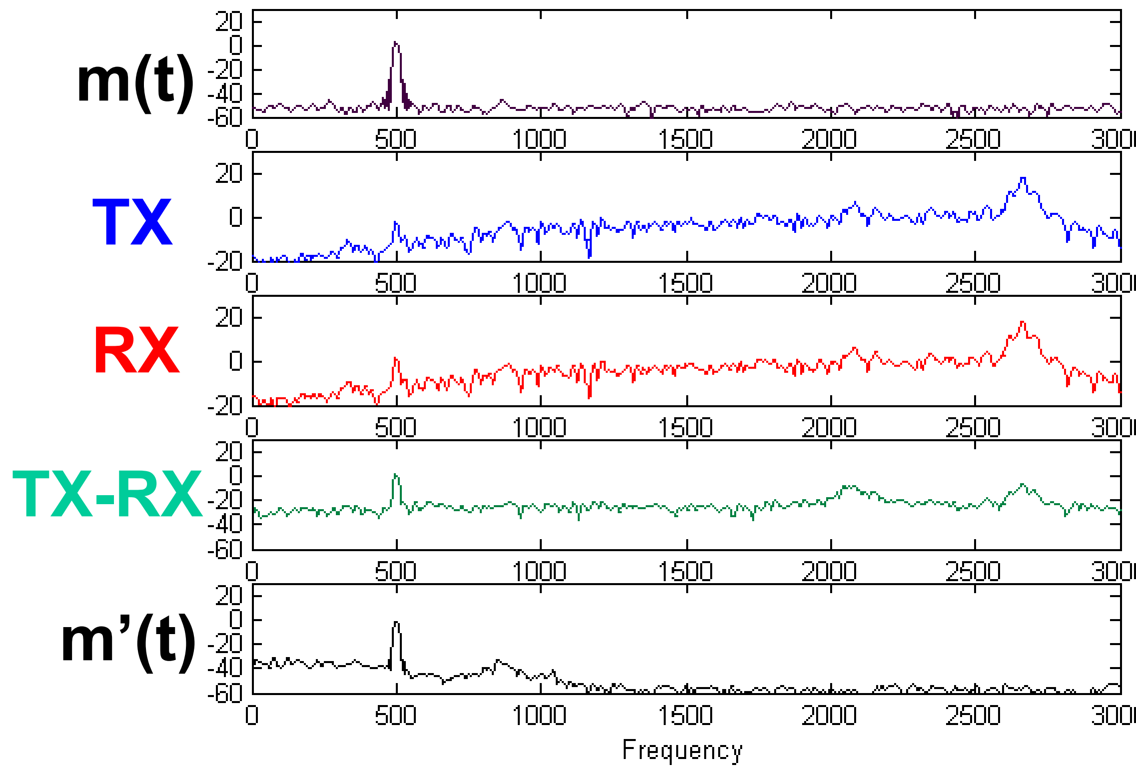


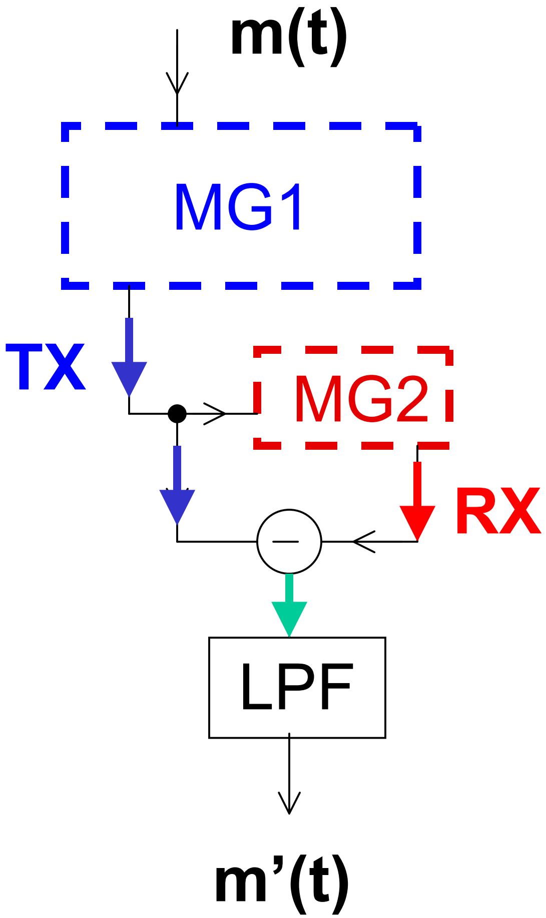
Encoded Communication



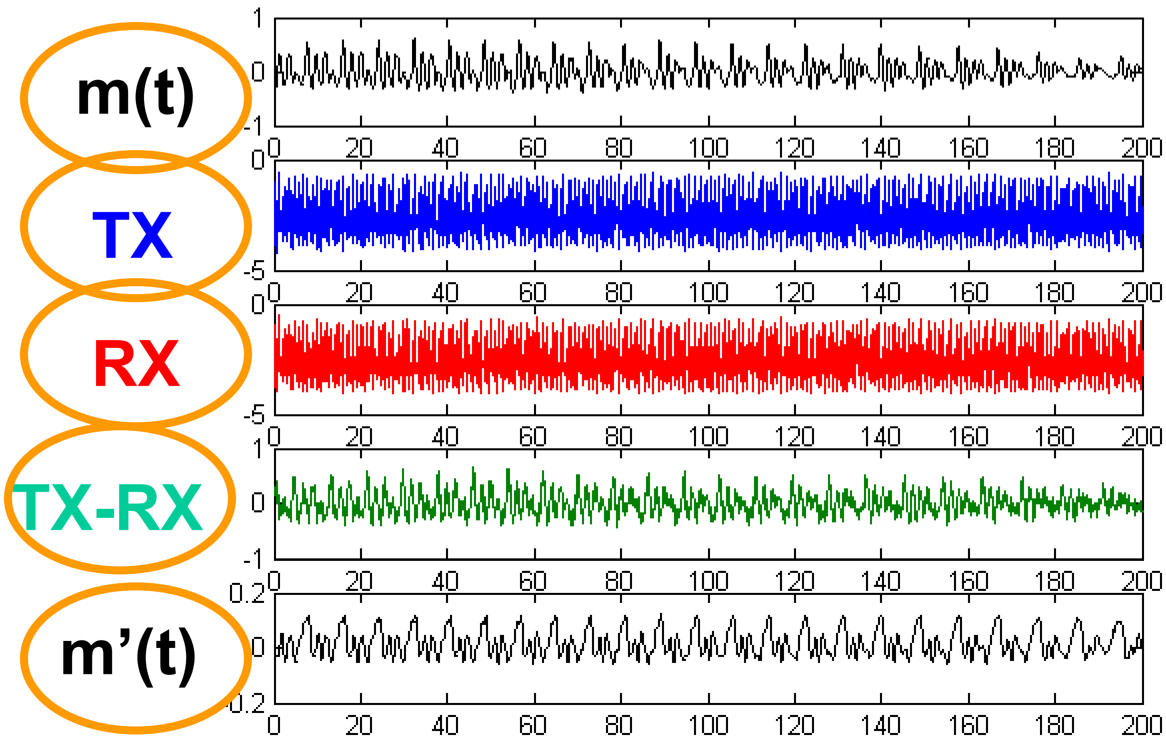


Power Spectra:

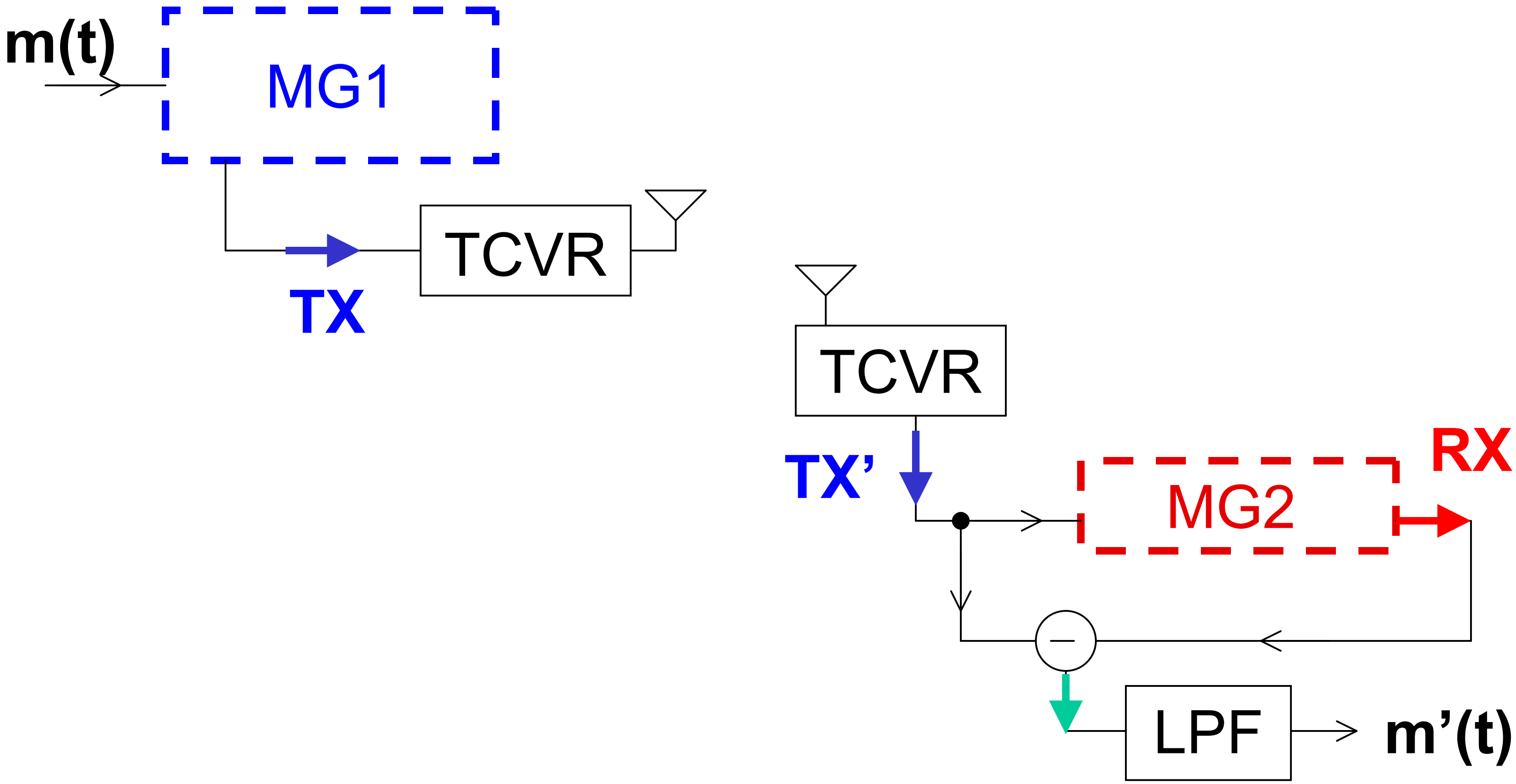



m(t)
MG1
TX
MG2
RX
LPF
m’(t)

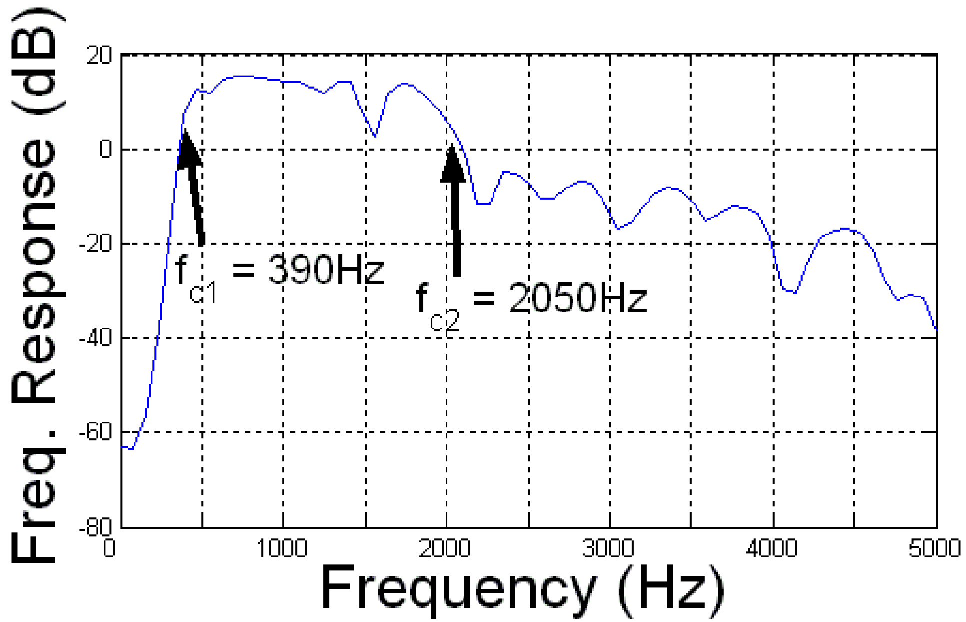
Time Series:

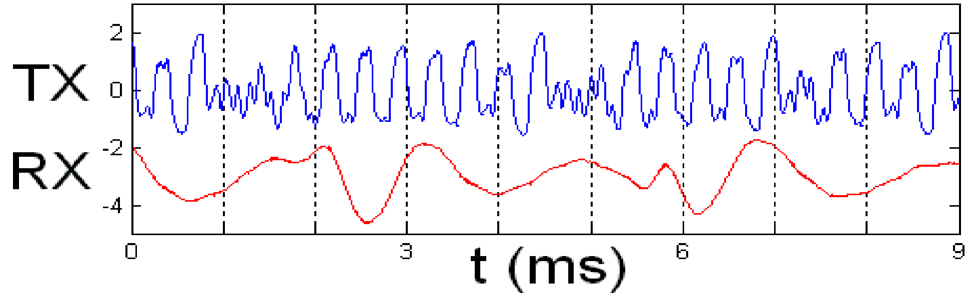

m(t)
TX
RX
TX-RX
m’(t)
1
0
-1
-5
0.2
-0.2
0 20 40 60 80 100 120 140 160 180 200

Radio Communication

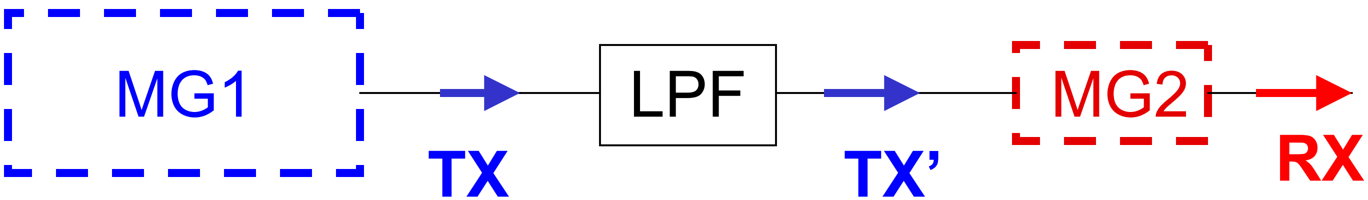


Radio Communication



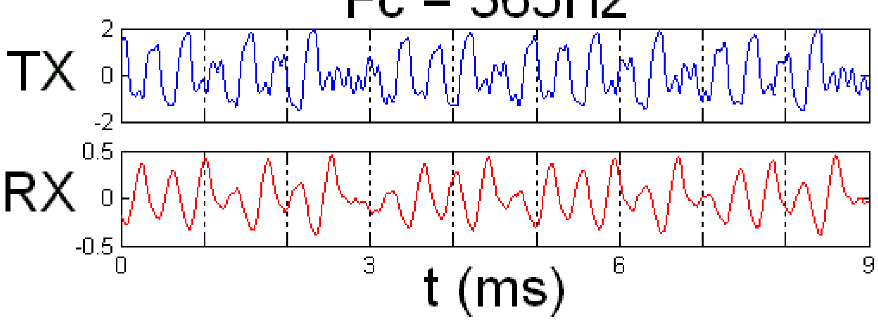


Band-limited Coupling



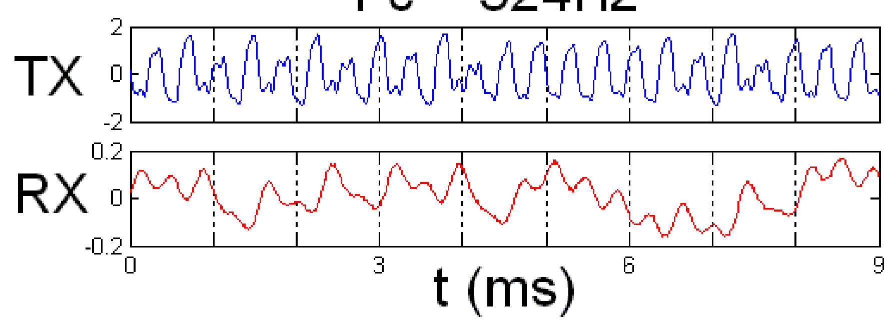
RC Network

Fc = 365Hz

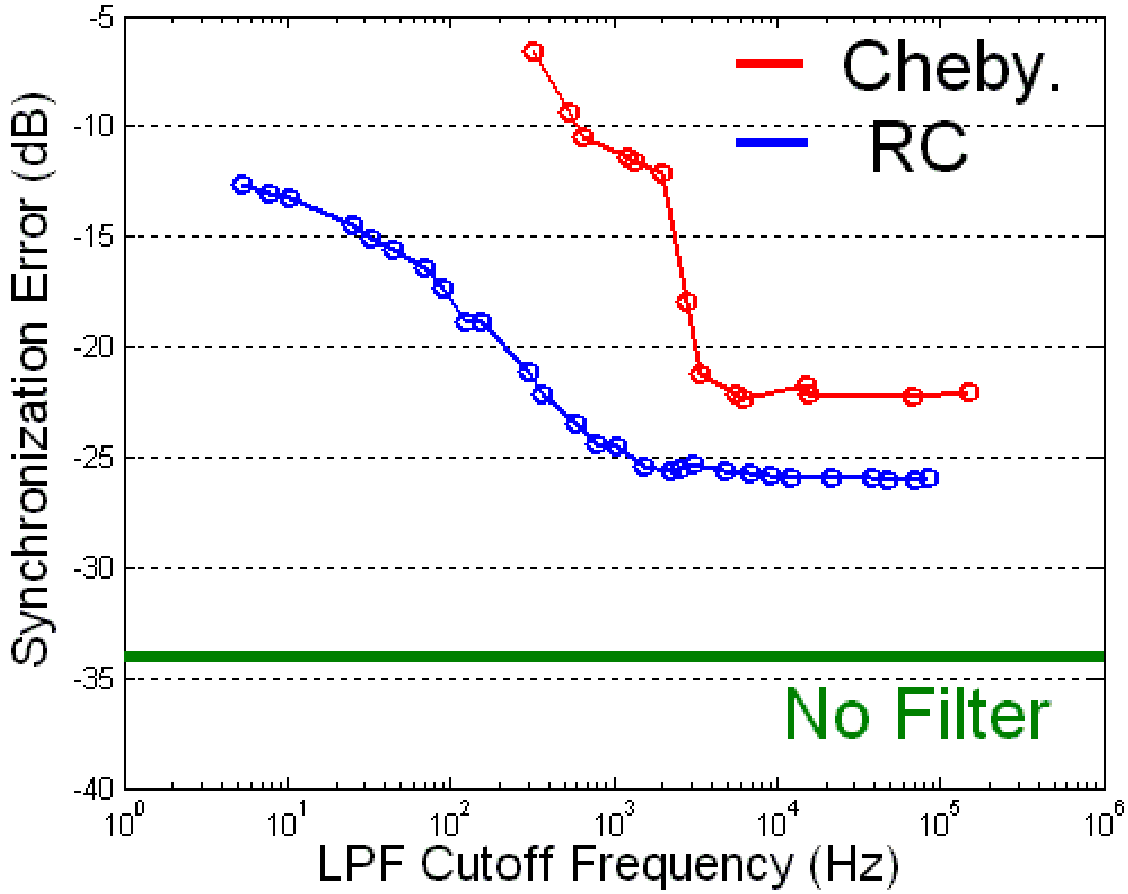


Cheby.

Fc = 324Hz



Band-limited Coupling



Conclusions

- Feedback circuits with time delay can generate chaos
- Precise synchronization of two such circuits can occur
- We can use chaotic waveforms to transmit and receive information
- Synchronization requires adequate coupling signal bandwidth
- High frequency, low power oscillations play a crucial role in synchronization