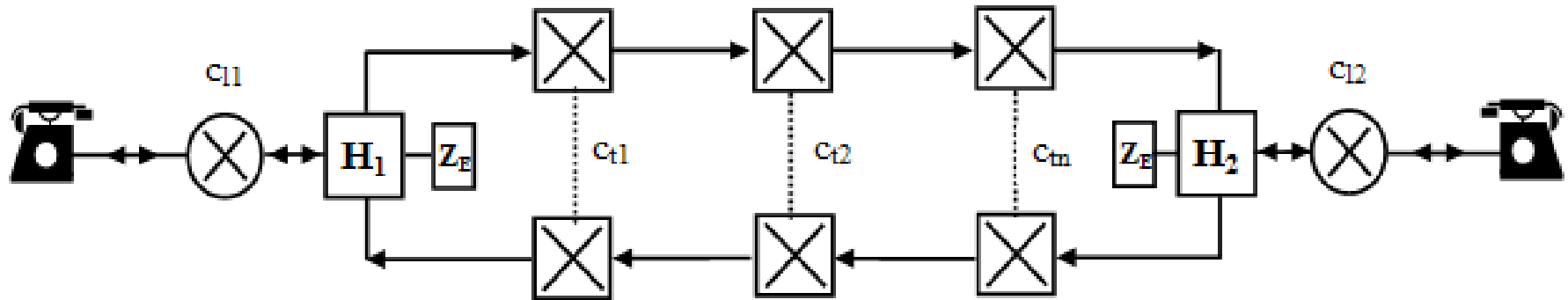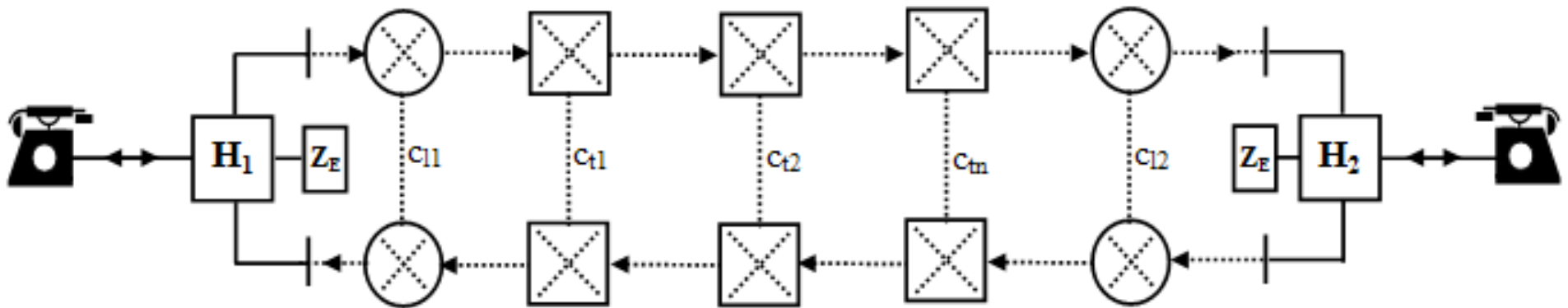# The analogue access

- The simplest access method in the telephone network;
  - it is characteristic to classical telephone networks POTS (Plain Old Telephone Service);
  - is used due to its simplicity in IDN network;

- Main characteristics of the analogue access:
  - frequency band: 300Hz – 3400Hz;
    - extended to 4kHz in digital networks;
  - two wire access and remote power supply from the exchange at -48V DC;
    - the telephone device works on four wire but the transmission to the exchange takes place on two wires;
      - the notion of four wires refers to two channels with opposite directions implemented on different physical channels (wires for example);
    - the local analogue switching takes place on two wires while the digital switching and long distance transmission (both analogue and digital) takes place on four wires.
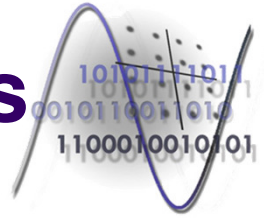
The analogue access

- Analogue switching;

- Digital switching;
- There are necessary two 2 wire – 4 wire transition points ensured by a differential system called hybrid transformer (H);
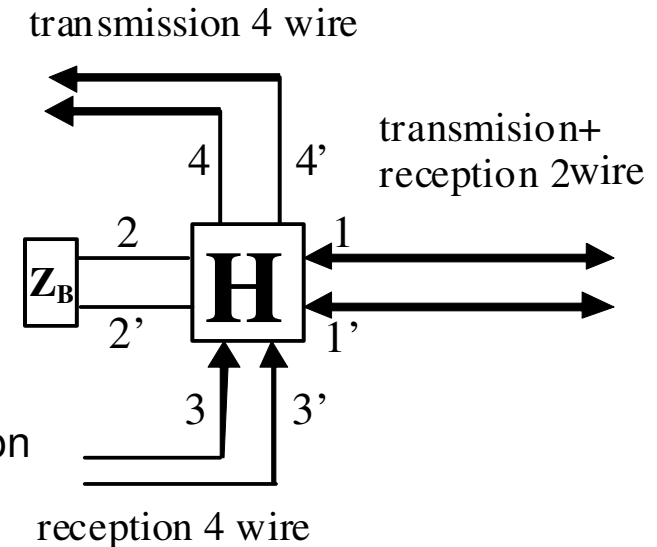
The analogue access

- The roles of the hybrid transformers:
  - transfers the signals generated by the terminal on the unidirectional transmission path of the 4 wire circuit;
  - transfers the signals from the transmission paths of the 4 wire circuit on the 2 wire subscriber loops;
  - attenuate the signals passing from the reception path on the transmission path of the 4 wire circuit;
    - the differential system (or hybrid transformer) represents a bridge whose balance is ensured by the relation: $Z_l = Z_b$ (or Z_E) (1), where Z_l is the line (subscriber loop) impedance, and Z_b (Z_E) is the balance impedance;
    - condition (1) cannot be fulfilled in the whole frequency band and for all subscriber loop lengths;
      - it is not ensured a perfect balance and impedance mismatch appears;
      - a fraction of the signal received from the reception path of the 4 wire loop is sent back on the transmission path of the 4 wire loop as an echo signal.

The analogue access

- Characteristics of the hybrid transformer;

  - It is called also differential system;

  - It is characteristic also to systems/equipments where is necessary a separation of the transmission and the reception paths:

    - for ex. a radio equipment using the same antenna for transmissions and reception requires a differential system to separate the output of the transmitter amplifier from the input of the receiver amplifier;

  - Represents a 4 port circuit having the following ports:

    - bidirectional port (1 – 1'):

      - ensures the connection of the 2 wire line;

    - balancing port (2 – 2'):

      - connects the balance impedance;

    - unidirectional reception port (3 – 3');

    - unidirectional transmission port (4 – 4')

      - two unidirectional ports ensuring the connection of the 4 wire line (loop).
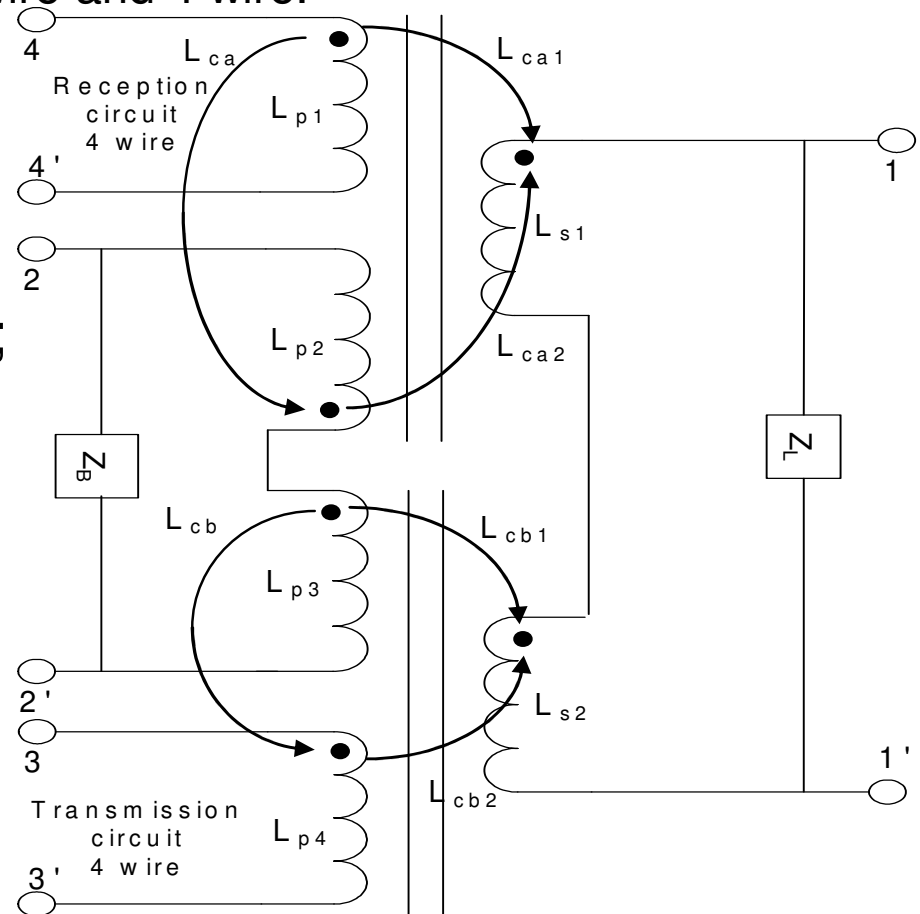
The analogue access
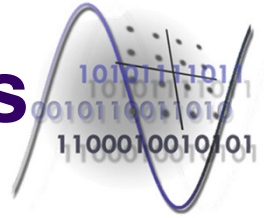
- Parameters of the hybrid transformer:
  - Attenuation between ports (3 – 3') - (4 – 4'):
    - attenuation between the reception and transmission path of the 4 wire circuit;
      - this attenuation has to be as large as possible;
      - ideally it is an infinite attenuation and in real circuits has a value of 15 - 20dB – it is about the return loss of the hybrid transformer;
      - by reciprocity the same attenuation has to be ensured between ports (1 – 1') - (2 – 2'), but this attenuation is not very important.
  - Attenuation between ports (1 – 1') - (4 – 4') and (3 – 3') - (1 – 1'):
    - attenuation between the reception path of the 4 wire circuit and the 2 wire circuit and the attenuation between the 2 wire circuit and the transmission path of the 4 wire circuit;
      - these attenuations have to be as small as possible;
      - usually they are 3dB in the case of transformers with symmetrical structure, due to equal splitting of received/transmitted power by a port to the adjacent ports;
      - by reciprocity the attenuation between ports (2 – 2') - (4 – 4') is equal with attenuation between ports (1 – 1') - (4 – 4') and the attenuation between ports (3 – 3') - (2 – 2') is equal with attenuation between ports (3 – 3') - (1 – 1').
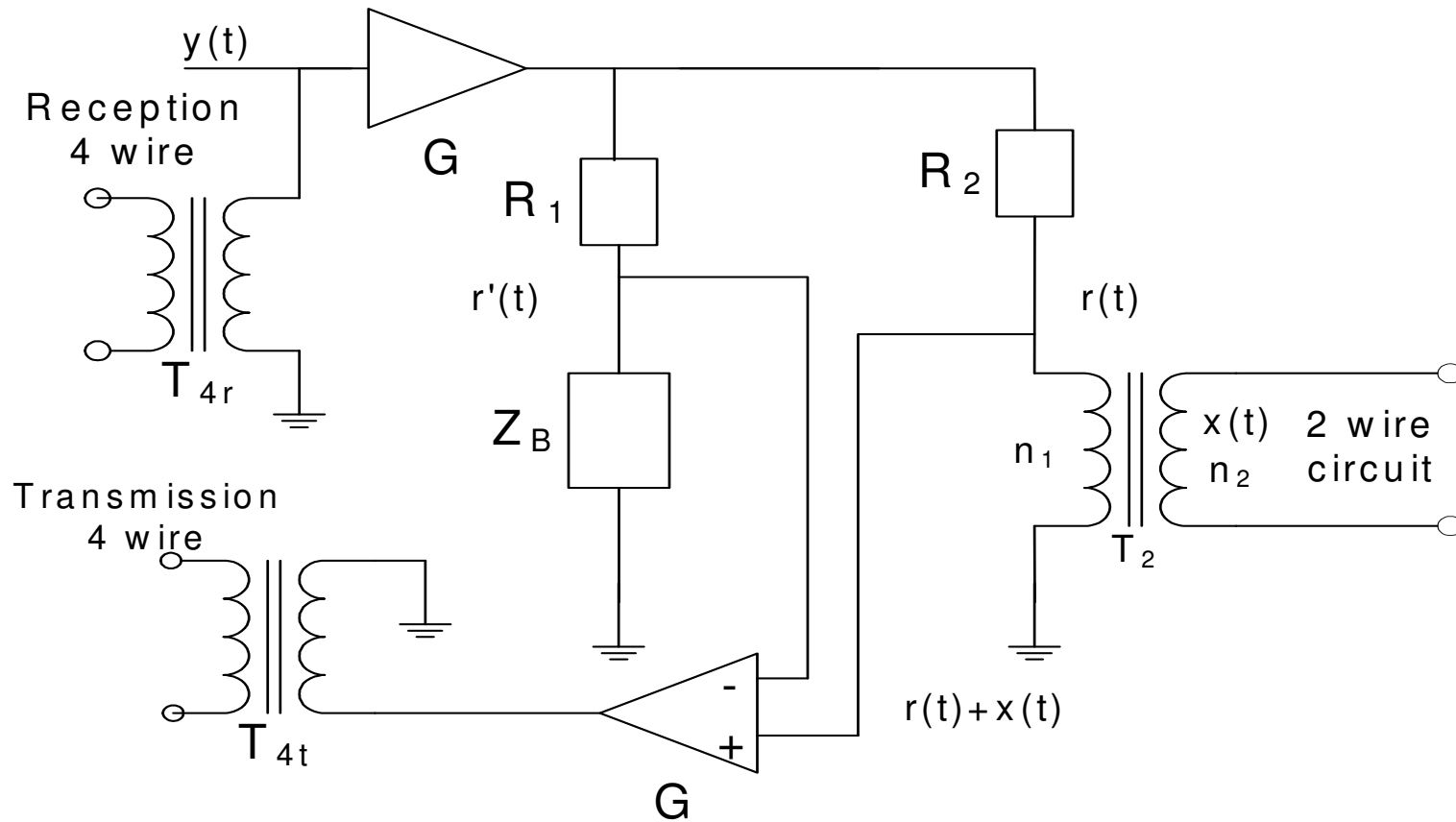
The analogue access
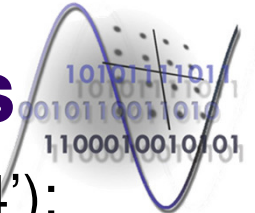
- Input / output impedances at ports (1 - 1'), (3 – 3'), (4 – 4'):
  - important from the point of view the impedance matching between the hybrid transformer and the circuits on 2 wire and 4 wire.

- Hybrid transformers from the subscriber interfaces:
  - Passive transformer with galvanic separation of circuits;
  - It is composed of two transformer with center taps.
  - It is symmetrical:
    - the symmetry depends on the symmetry of the component transformers.
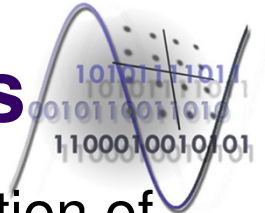
4
L_{ca} L_{ca1}
Reception circuit 4 wire L_{p1}
4'
1
L_{s1}
2
L_{p2} L_{ca2}
Z_B
Z_L
L_{cb} L_{cb1}
L_{p3}
2'
L_{s2}
3
1'
Transmission circuit 4 wire L_{p4} L_{cb2}
3'

The analogue access

- The electronic hybrid transformer;
  - The schematic of the electronic hybrid:

The analogue access

- Transformers T_{4r}, T_{4t} and T_2 ensure the galvanic separation of the hybrid from the 4 wire and 2 wire circuits;
  - ensure a symmetrical/differential character relatively to the connected circuits;

- The effective balancing bridge is composed of resistances R_1, R_2, impedance Z_b and impedance Z_{r-l};
  - Z_{r-l} is the impedance of the subscriber loop reflected in the primary winding of the transformer T_2, and is given by:

  $$Z_{r-l} = \left(\frac{n_1}{n_2}\right)^2 \cdot Z_l$$

    - Z_l is the impedance of the 2 wire subscriber loop;

  - balance condition of the bridge:
  $$\frac{R_1}{R_1 + Z_b} = \frac{R_2}{R_2 + Z_{r-l}}$$