**ANALYSIS OF MULTI-SOURCE CIRCUITS**

Tellegen’s Theorem: conductance multi-port with one output.

For all branches

***vT. j’ = v’ T. j =*** 0.

Splitting port branches and internal branches, and assuming only resistors and transconductances in the multi-port circuit **N**, Tellegen’s theorem gives

**[*vT. j’*]**port + **[*vT. G’.v’*]**int = **[*v’T. j***]port + **[*v’T. G.v*]**int

If **N’** is the adjoint of **N,** then **G’ = GT**. Since **[*v’T. G.v*]**int is a scalar, it is equal to its transpose, and hence

**[*v’T. G.v*]**int = **[*v’T. G.v*]**int**T = [*vT. G’.v’*]**int .

Therefore, also

**[*vT. j’*]**port = **[*v’T.j*** ]port

To analyze the multi-source circuit **N**, in **N’** choose the source at the output port as 1 A (if we want an output voltage *vo* ) or -1 V (for *io*), and all sources equal to zero.



Then *vo* = ***V.Iv’*** + ***J.Vj’***, where ***V*** and ***J*** are the sources in **N,** and ***Iv’*** and ***Vj’*** are in the same branches of **N’.** This also gives all gains from the sources to the output.

In addition, the output impedance of the physical network for ***V*** = **0**and ***J*** = **0**is given by

*Z = -vo*/*io* =  *-vo*’/*io*’ = *vo*’.

Thus, the complete Thevenin equivalent of the physical circuit **N** can be found from a single analysis of **N’**.