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# Power Division Theorem Proves Sharing Principle at a Node Disproves for Networks

**Dr. P. S. Kannan**

Professor of Electrical and Electronics Engineering Fellow of the Institution of Engineers (INDIA)
Former Dean & HOD of EEE Department, Thiagarajar College of Engineering, Madurai, Tamil Nadu, India

**Abstract:** ***Traditionally, Power System Engineers / Scientists apply Power Sharing Principle (PSP) for electrical tracing, determining the transmission cost and all other analysis needed in Deregulated Power Environment (DPE). This paper clearly demonstrates the innovated Power Division Theorem (PDT) proves the PSP applied at a Node in power system network and disproves for the network loads. It establishes a new Complex Power Sharing Principle (CPSP). However; the principle is not applicable for system network and valid for a Node only. The fundamental concept is the flow of current through a node or network creates power. The PDT is established by applying this concept along with the KCL The Complex Power Distribution Matrix (CPDM) generated by PDT at a node is the same created by CPSP, but invalid in the case of network. As an example, a node in a power system network with complex power flow at a particular operating point is considered in this paper for validation. In many IEEE research papers PSP is still now applied for the analysis in DPE. However, the innovated fundamental PDT which is the basis for PSP must be applied to perform any analysis and to solve all the problems related with the DPE. The PDT must be included in the curriculum of all the Universities as one of the Fundamental Circuit Theorem.***

**Keywords:** Deregulated Power Environment, Power Sharing principle, Power Division Theorem, complex power distribution matrix, complex power sharing, Kirchhoff's Current Law, power system network, power tracing, transmission cost

## 1. Introduction

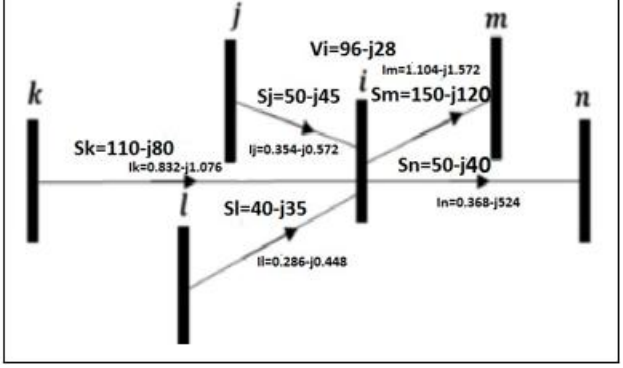
In Power Systems, proportional **Power Sharing Principle is a assumption** used in power tracing and transmission loss allocation that states incoming power flows at a bus are distributed proportionally among the outgoing lines. This means that at any point in the network, each outgoing line's power flow is a fraction of the total inflow. This principle while intuitive and widely used is a topological assumption. It is proved by the innovated fundamental concept of Power Division Theorem in this work. A tracing methodology based on PSP is proposed [5] for transmission pricing of cross-border trades in Europe. Electricity tracing problems are carried out [6] for allocating cost of transmission and loss allocation by modified methodology based on PSP. The paper [1] shows the development of equivalent circuit-based model by applying PSP to perform power and emission tracing in power grids.

The work [4] presented is to find the share in a consumer load by applying PSP. Impact of generators on the power system [3] in Deregulated Power Environment (DPE) has been considered. The work claims that the issues in the contribution of generators are solved by PSP. The real power transfer between individual generators and loads [7] has been performed by Graph Theory without load flow. The European zonal market design is explained [8] by a novel power flow tracing methodology. The work in the paper [2] is the determination allocation of transmission losses by tracing the reactive power flows. When networks are considered the PSP fails to give the correct shares on loads leaving from the network. The fundamental lapse is no power balance and the voltages at various load point are different. The PDT estimates the active and reactive power shares simultaneously. The following example clarifies.

## 2. Example for Proving/disproving PSP

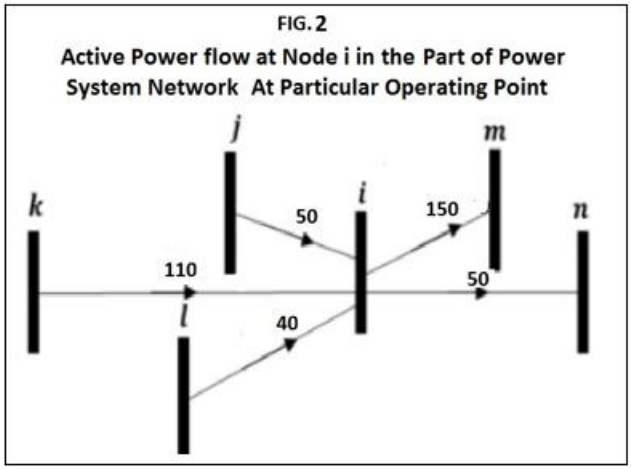
Actual complex power flow at a node **i** is shown in the **FIG.1**.The node **i** voltage Vi=96-j28 and the complex current flow in the three in feed lines {ik,il,ij) and outgoing lines (im,in) are calculated by dividing the complex powers by Vi conjugate.

FIG. 1
Complex Power flow at Node i in a Part of Power System Network At Particular Operating Point




The**FIG2**.is considered for **Power Sharing Principle (PSP).**

**Note that only active power flows are considered.**




The calculation and the results of Sharing of active and reactive power on each outgoing lines are shown in the**Table1a.and 1b**

**Table 1a (PSP) Active Power Sharing**

| | | OUT m=150 | OUT n=50 | |
|---|---|---|---|---|
| | k=110 | Pkm=150×110/200=82.5 | Pkn=50×110/200=27.5 | 110 |
| IN | l=40 | Plm=150×40/200=30 | Pln=50×40/200=10 | 40 |
| | j=50 | Pjm=150×50/200=37.5 | Pjn=50×50/200=12.5 | 50 |
| | | 150 | 50 | |

**Table 1b (PSP) Reactive Power Sharing**

| | | OUT m=120 | OUT n=40 | |
|---|---|---|---|---|
| | k=80 | Qkm=120×80/160=60 | Qkn=40×80/160=20 | 80 |
| IN | l=35 | Qlm=120×35/160=26.25 | Qln=40×35/160=8.75 | 35 |
| | j=45 | Qjm=120×45/160=33.75 | Qjn=40×45/160=11.25 | 45 |
| | | 120 | 40 | |

The **FIG1**.is considered for **Power Division Theorem (PDT). Note that Currents through in feed lines (Source currents) are used for calculation.** The results of Sharing of Each in feed line on each outgoing line are shown in the **Table 2., is the Complex Power Distribution Matrix. The Results are the same as in Table 1a and 1b. PDT proved the PSP.**

**Table 2 (PDT) Results**

| | | OUT Sm=150-j120 | OUT Sn=50-j40 | |
|---|---|---|---|---|
| | Sk=110-j80 | Skm=Sm ik/io= 82.5-j60 | Skn=Sn ik/io=27.5-j20 | 110-j80 |
| IN | Sl=40-j35 | Slm=Sm il/io=30-j26.25 | Sln=Sn il/io=10-j8.75 | 40-j35 |
| | Sj=50-j45 | Sjm=Sm ij/io=37.5-j33.75 | Sjn=Sn ij/io=12.5-j11.25 | 50-j45 |
| | | 150-j120 | 50-j40 | |

Since the total of Complex Power inputs is equal to the total of Complex Outgoing Powers as shown in the FIG1, the complex Power Sharing Principle (CPSP) results the same Sharing as in the case of PDT (Table 2) as shown in the Table **3.**

**Table 3 (CPSP) Results**
**S=Sk+Sl+Sj=Sm+Sn=200-j160**

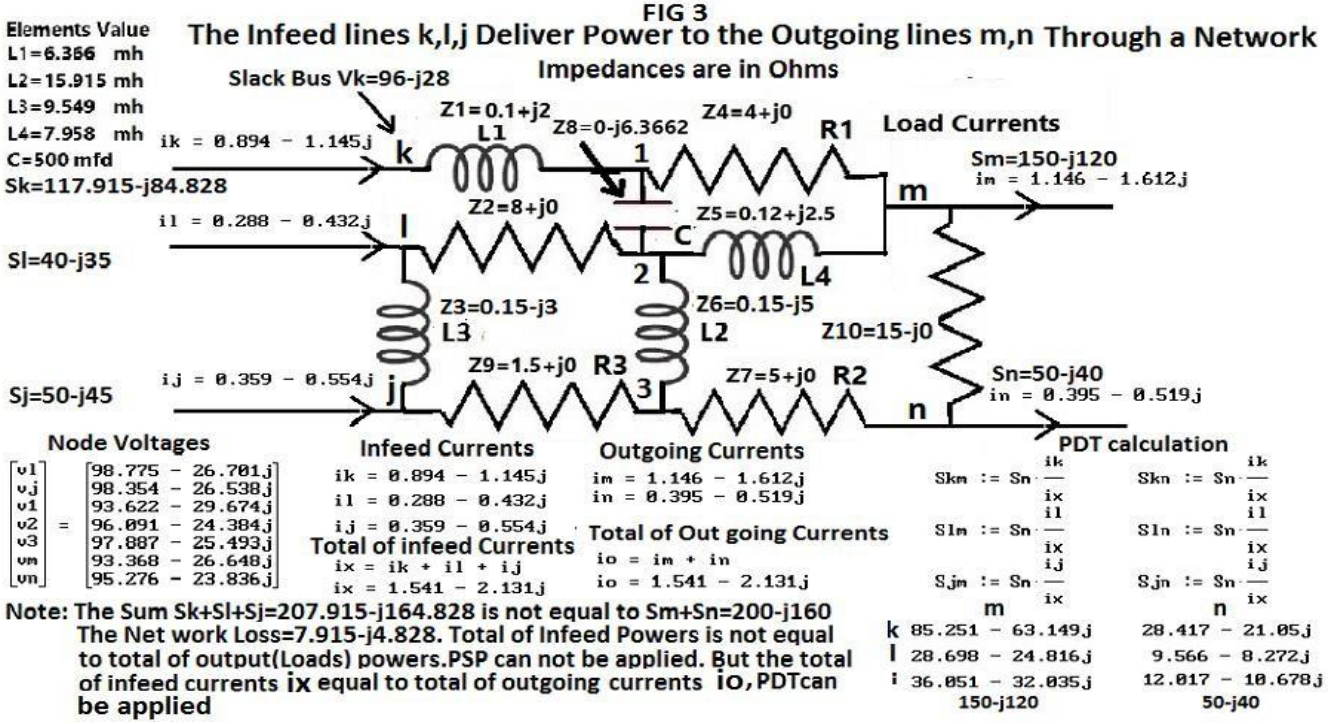
| | | OUT Sm=150-j120 | OUT Sn=50-j40 | |
|---|---|---|---|---|
| | Sk=110-j80 | Skm=Sm Sk/S= 82.5-j60 | Skn=Sn Sk/S =27.5-j20 | 110-j80 |
| IN | Sl=40-j35 | Slm=Sm Sl/S =30-j26.25 | Sln=Sn Sl/S=10-j8.75 | 40-j35 |
| | Sj=50-j45 | Sjm=Sm Sj/S=37.5-j33.75 | Sjn=Sn Sj/S=12.5-j11.25 | 50-j45 |
| | | 150-j120 | 50-j40 | |

FIG 3 shows the delivering of power by three in feed lines at the nodes k,l,j to the outgoing lines from m,n through a network. The in feed powers of the lines at l and j are the same as in FIG1. **(40-j35, 50-j45)**.The node k is considered as slack bus. The slack bus voltage is 96-j28 as in FIG.1. After finding the solution the slack bus current ik and power Sk are calculated. The slack bus power **Sk=117.915- j84.828**. **The network loss = 7.915-j4.828**. The value of in feed line currents **ik=0.894-j1.145, il=0.288-j432, ij=0.359-j554**.The load currents **im=1.146-j1.612, in=0.395-j0.519**. All are shown in the **FIG3** and it is self explanatory. Since total of in feed Power **(207.915-j164.828)** is not equal to total of outgoing power **(200-j160),** PSP will not give correct results. But the total of input currents **(1.541-j2.131)** in to the network is equal to the total of outgoing currents; PDT establishes correct sharing and **disproved the PSP**. It indicates that the source currents scheduling is the correct approach instead of Powers scheduling in Power Systems.

## 3. Conclusion

Power Division Theorem (PDT) is a fundamental circuit theorem proves the existing Power Sharing Principle (PSP). The theorem is established based on KCL, exhibits many significant concepts of Back Power Flow (BPF), finding direct expression for Kirchmayer's Hypothetical Load point Voltage (HLPV) and the independent sharing of loads from the network. It proves the PSP for a node and disproves for networks. The PDT expression is simple, powerful and common for a node, network and part of a network. It is shown in this work finding active power and Reactive power sharing calculated separately by PSP are the same as the results obtained by PDT. The Complex Power Sharing Principle (CPSP) also demonstrated and validated by PDT. The PSP and (CPSP) are applicable for a Node only. So far there is no strict prove for PSP. Now, it is proved by PDT. The power balance is the base for (PSP). PDT disproved the PSP for networks by considering a network of having 8 nodes with three in feed lines and two out going lines as an example. The existing circuit theorems are having restriction in application to networks.PDT is not having any restriction and brought out many new concepts. The Theorem is a most fundamental theorem must be included by all the Universities in the topic of circuit theory like maximum power transfer theorem. This is a very important responsibility/duty of universities to promote the innovated fundamental theorem for reorganization.

FIG 3

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