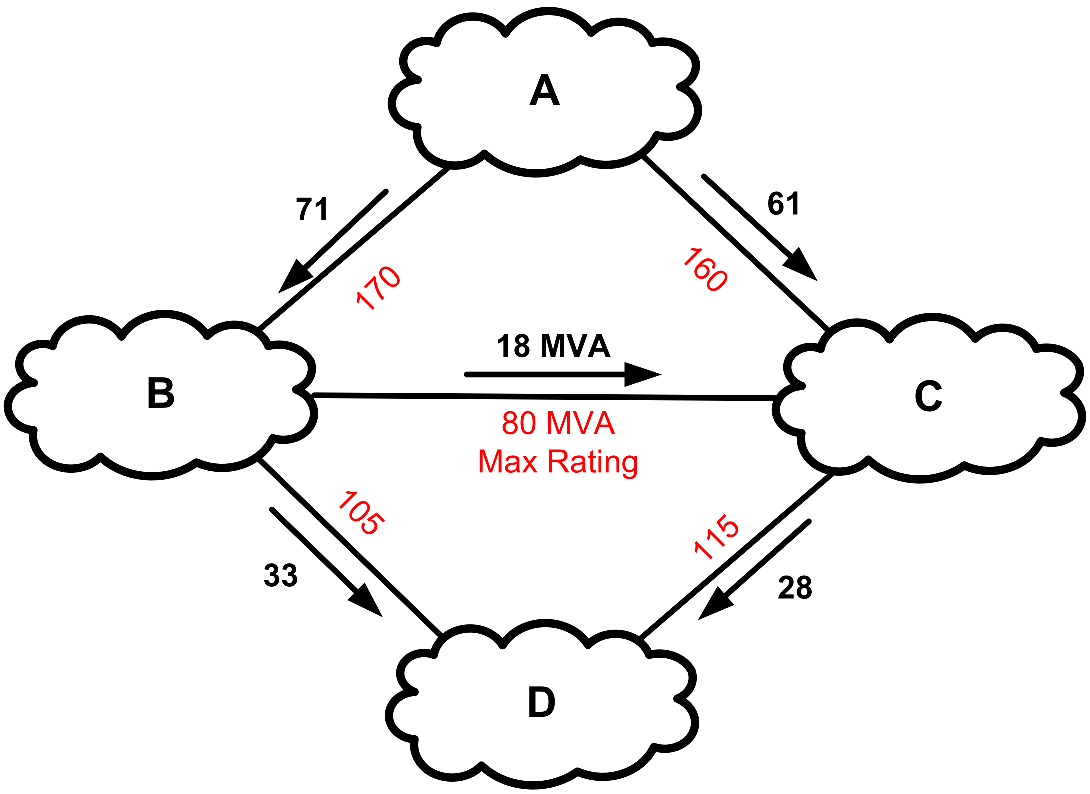
Example ATC Calculation Procedure

(Rated System Path Method)

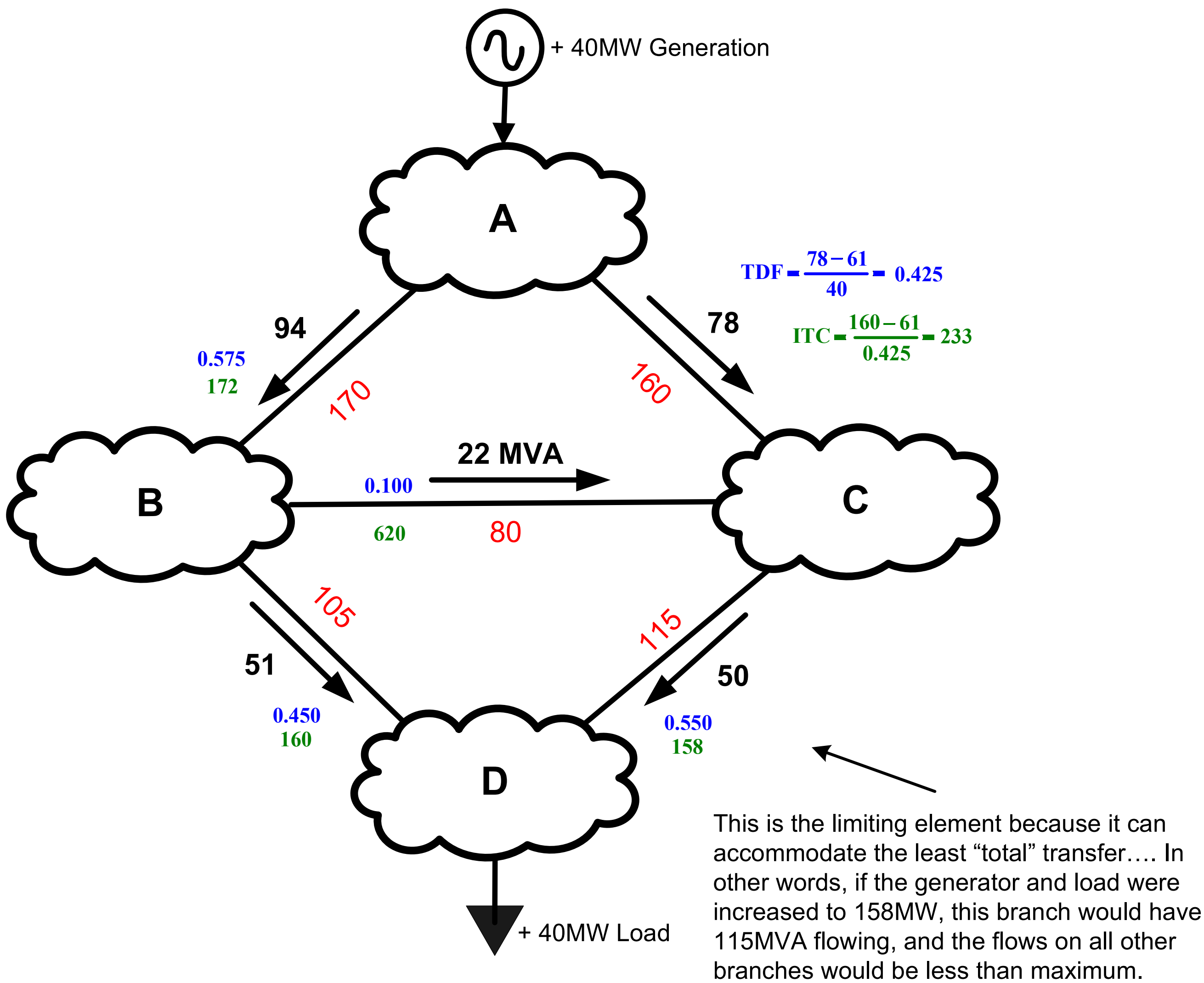
Seasonal Base Case



A power transfer from A to D has been proposed and this example will attempt to demonstrate how the maximum possible "reliable" transfer is determined.
This illustration displays flows that would be obtained from a seasonal base case power flow model, and represent the branches of the "Identified" A-D Path.
Red quantities are maximum allowable flows based on most limiting equipment.
A,B,C & D represent areas or points in the system that contain generation and/or distributed load.

Note for this example:
Total Transfer Capability (TTC) for each segment is considered equal to the maximum flow rating.
Existing Transmission Commitments (ETC) for each segment is equal to the flow shown here resulting from the base case power flow simulation.

Power Transfer from A to D Simulated during Normal System Conditions



This figure illustrates how branch flows in the transfer path would change for an "arbitrary" but realistic interchange of 40MW.

The flows shown here are during N-0 or normal system conditions with all elements in service.

A linear analysis is then used to calculate the maximum possible transfer:

1. **Calculate the Transfer Distribution Factor (TDF) for each branch. TDF represents what fraction of the total transfer appears on a given segment.**
2. **Calculate the Incremental Transfer Capability (ITC) for each branch. ITC represents the maximum "total" transfer each branch could accommodate over and above base flows.**
3. **The branch with the lowest ITC will be the limiting element for this transfer.**
4. **Calculate the ATC for that limiting element: ATC = TTC – ETC****
5. **The ATC of this limiting element is considered the ATC for this A-D path during normal system conditions.**

Segment C-D is the limiting element in transfer path A-D with an ITC = 158MVA, therefore the ATC for path A-D is TTC – ETC for this element.

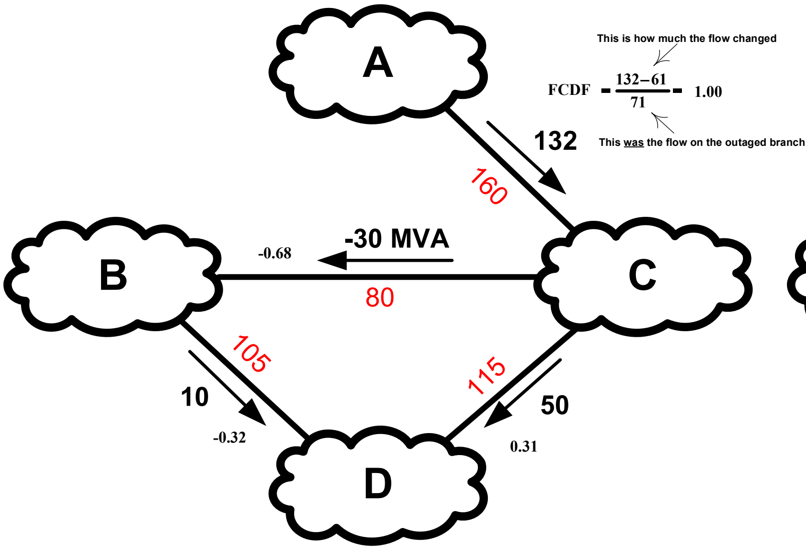
<u>ATC = 115 – 28 = 87MVA during N-0 Conditions</u>.

Notice that simply calculating TTC- ETC for each branch and using the minimum would not yield the same results.

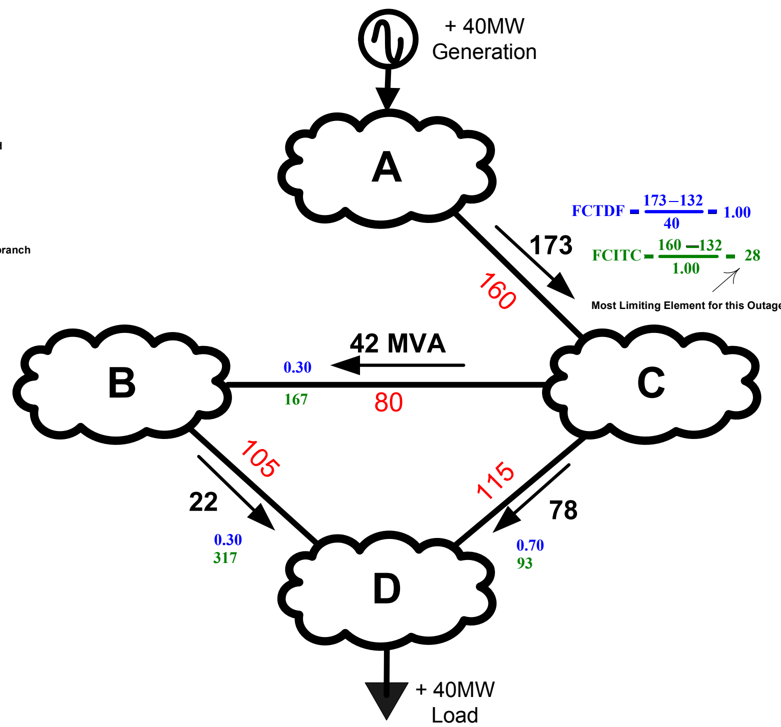
****(TRM and CBM neglected and considered zero in this example)**

Power Transfer from A to D Simulated during N-1 Conditions
(Loss of a Single Transmission Element)

Standards state that ATC values shall be valid during normal system conditions (N-0) and single contingency conditions (N-1). Therefore, all significant outages within the system must be considered, and the previous analysis effectively repeated to determine the limiting path element during outage conditions.
The following figures will attempt to demonstrate this analysis process.
Although only the five branch segments in this example are opened and the power transfer analyzed, the real power system must consider many more outages greatly exceeding those in the transfer path.



Prior to Transfer



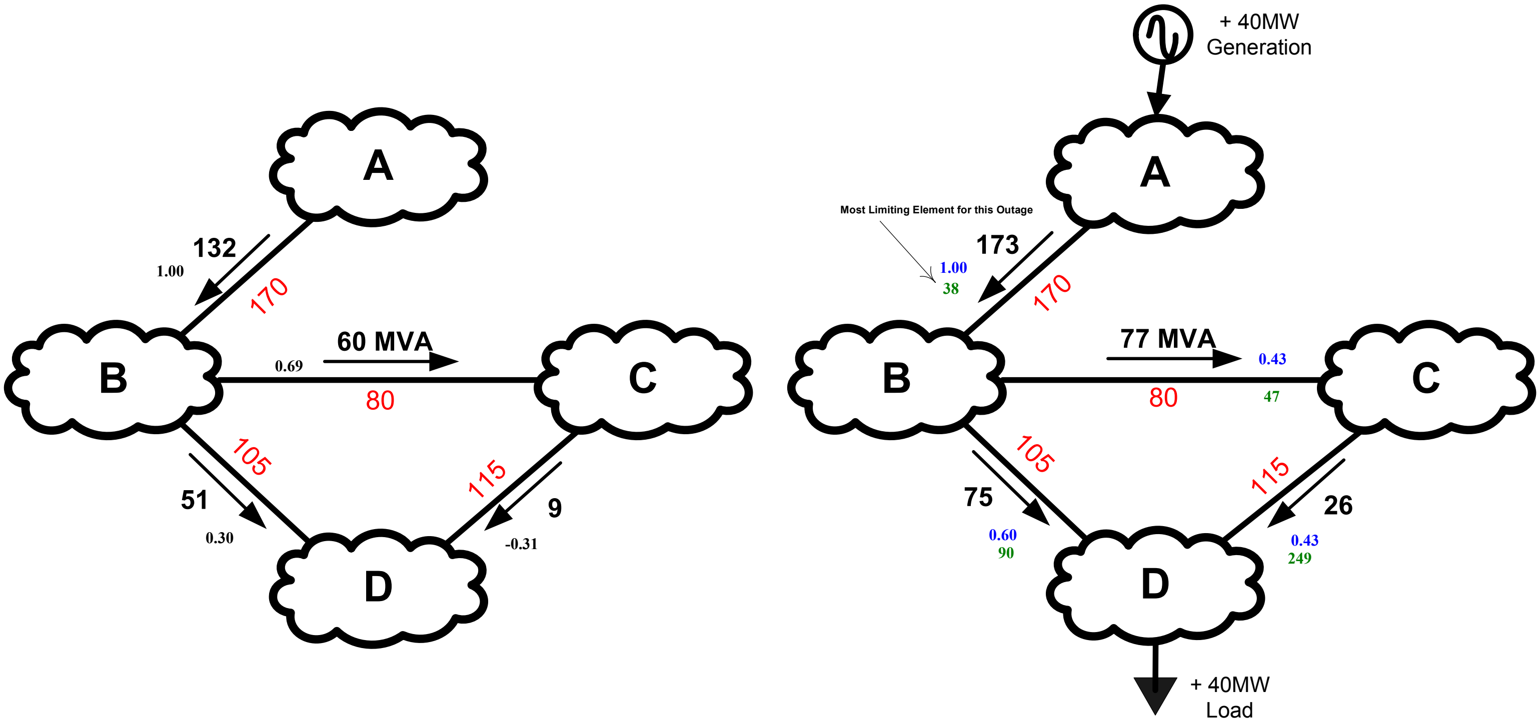
With Transfer

Line Segment A – B Out of Service

The flows shown here are during N-1 or single outage conditions.
The same linear analysis is performed to calculate the maximum possible transfer for <u>this</u> outage:

1. **Introduce and calculate yet another quantity called First Contingency Distribution Factor (FCDF) for each branch. FCDF represents what fraction of the flow that was on the outaged branch shifts and flows on the given branch. This value will be particularly useful when calculating ATCs for slightly varying system conditions.**
2. **Calculate the First Contingency Transfer Distribution Factor (FCTDF) for each branch. FCTDF represents what fraction of the <u>total</u> transfer appears on a given segment.**
3. **Calculate the First Contingency Incremental Transfer Capability (FCITC) for each branch. FCITC represents the maximum <u>total</u> transfer each branch could accommodate, over and above base flows.**
4. **The branch with the lowest FCITC will be the limiting element for this transfer and this outage.**

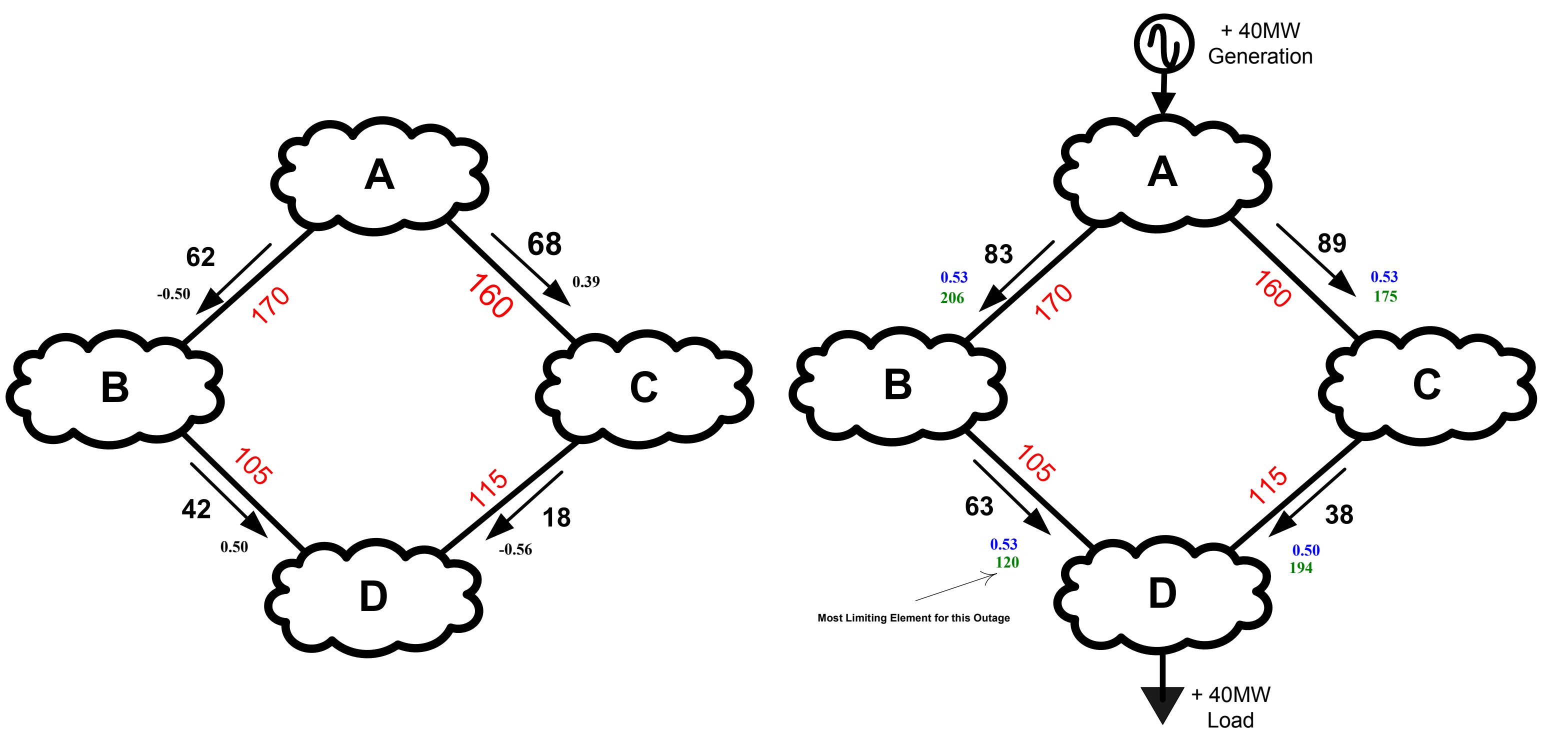
Branch A-C is the limiting element for this outage with an ITC of 28MW. This means that during this outage, with these system conditions, only 28MW of total transfer would be possible. (neglecting TRM and CBM)



Prior to Transfer

With Transfer

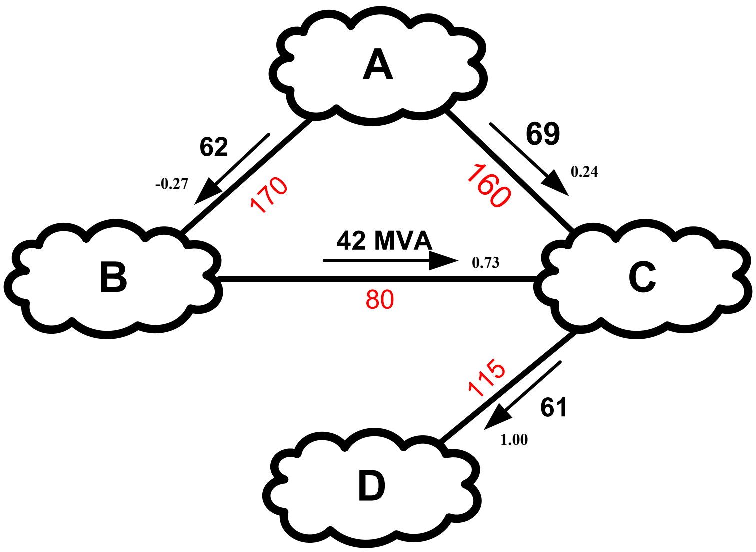
Line Segment A – C Out of Service



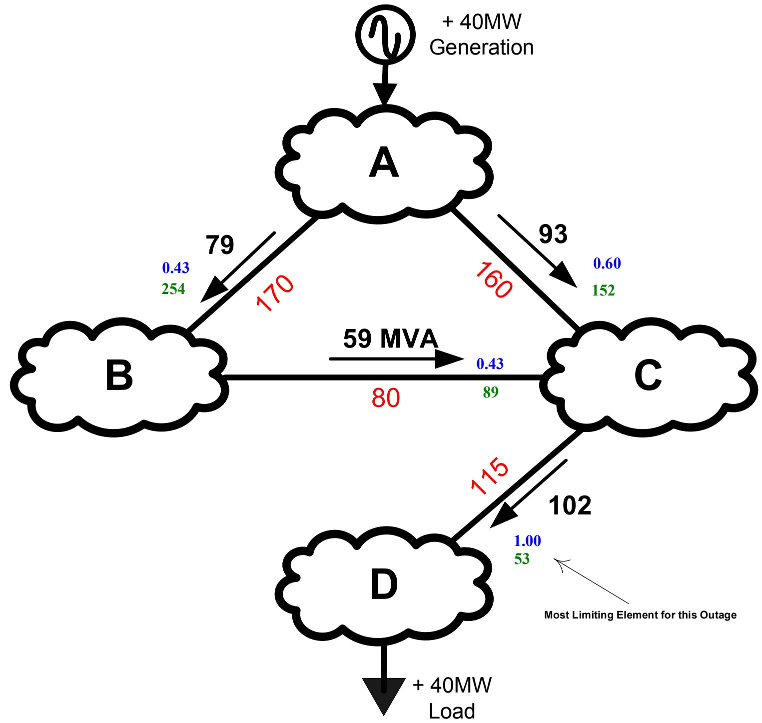
Prior to Transfer

With Transfer

Line Segment B – C Out of Service

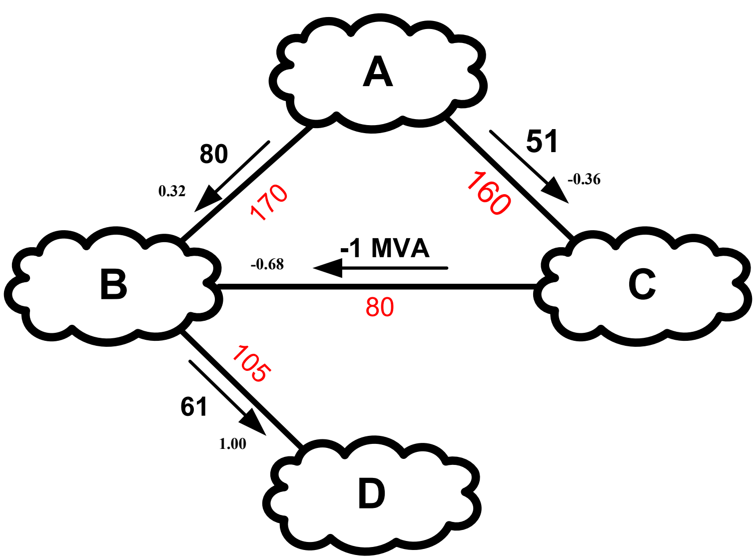


Prior to Transfer

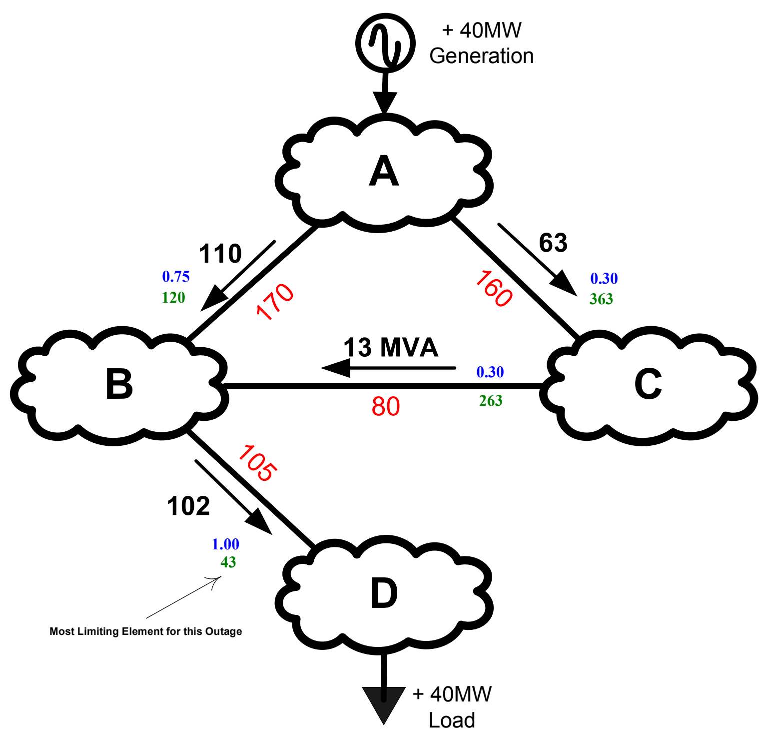


With Transfer

Line Segment B - D Out of Service



Prior to Transfer



With Transfer

Line Segment C - D Out of Service

Interpreting the Results

N-0 ANALYSIS

Segment C-D was the limiting branch in the Transfer Path because the Incremental Transfer Capability was the smallest at ITC=158.
Therefore, the ATC for this A-D path during normal system conditions is:

> **ATC for Path = TTC for this branch - ETC for this branch (pre-transfer)**
> **ATC = 115 – 28 = 87MVA**

N-1 ANALYSIS

Looking at the results of all outages, indicates that branch A-C is the limiting element for an outage of A-B. A-C had the smallest ITC of 28, meaning that only 28MVA of <u>total</u> transfer is possible if branch A-B is out of service.
Therefore, the ATC for this A-D path during single outage conditions is:

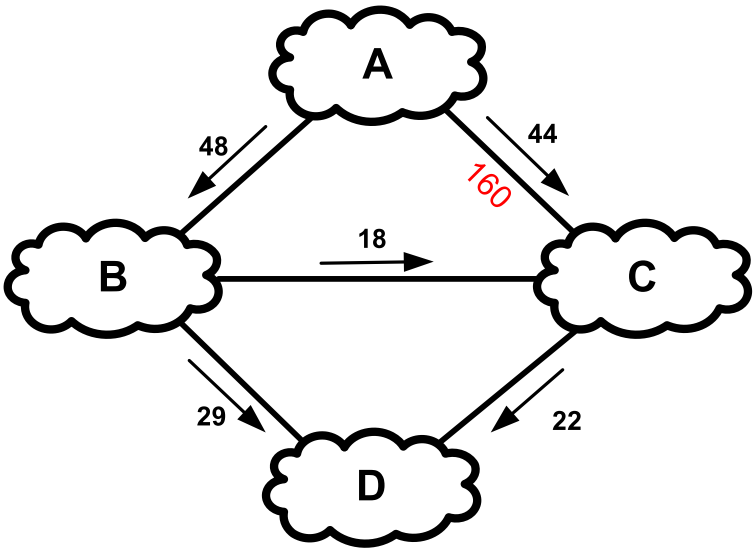
> **ATC for Path = TTC for this branch - ETC for this branch (pre-transfer, post-outage)**
> **ATC = 160 – 132 = 28MVA**

The minimum of N-0, N-1 ATC determines the "Overall" ATC rating for this A-D path for these modeled system conditions.

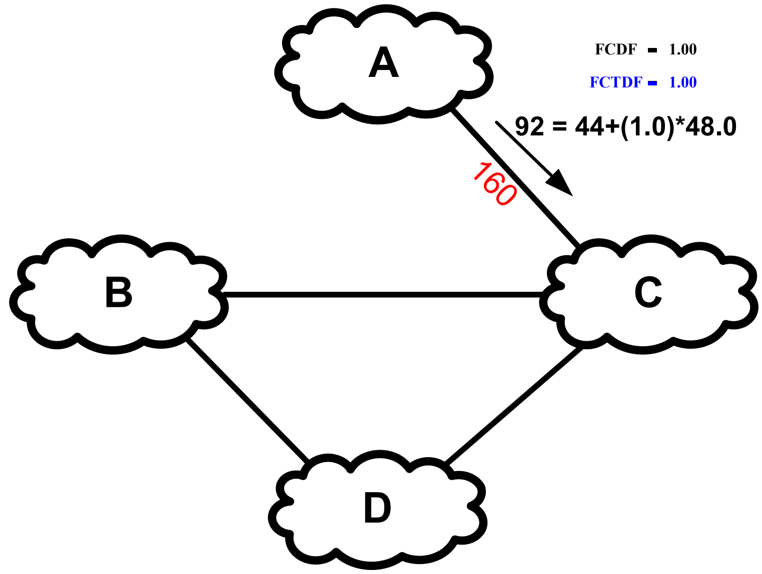
FINAL RESULT ………….. Path A-D ATC = 28MVA

Calculating ATC for Varying System Conditions

After the ATC analysis and Distribution Factors are calculated, the ATC for this path can be determined for “moderately” varying system conditions.
Using N-0 flows (possibly real time or historical SCADA) on the worst outage element (A-B) and limiting element (A-C), a new ATC can be determined.
Consider the known or predicted flows shown in the different “normal” system conditions figure below. What would be the resulting ATC for this A-D path?

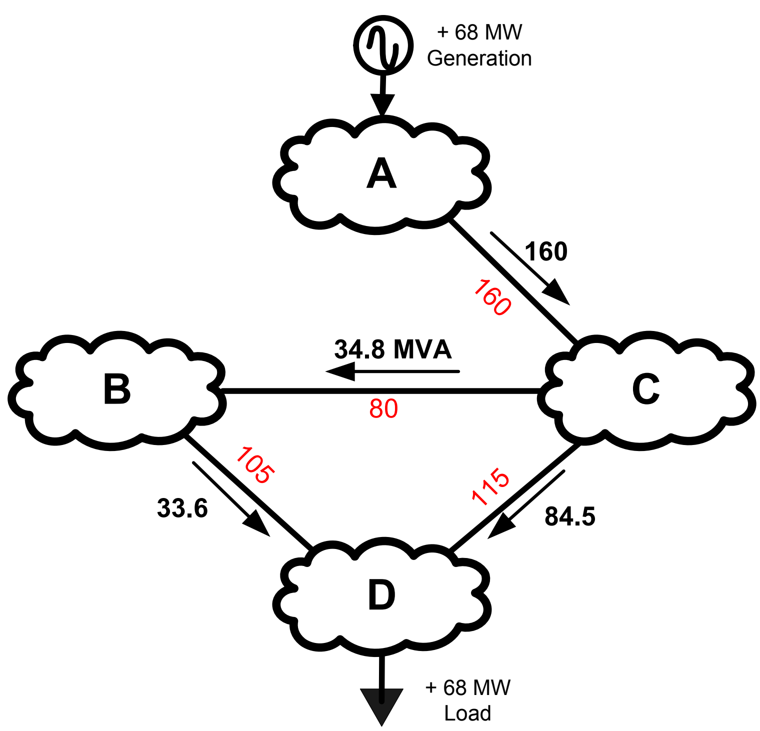


“Forecasted” Normal Conditions



Worst Outage Conditions
New Flow = Old Flow + FCDF*(pre-outage element flow)

Using the Worst Outage results shows that A-C would have 92 MVA of flow for worst outage conditions. With Total Transfer Capacity of 160, these determine ATC = 160 – 92 = 68 MVA. There is 68MVA of “Capacity” left on this line for further commercial activity.
Since the FCTDF of this line is 1.00, means that 68/1.0 = 68MW of total transfer would be possible. If 68MW of total transfer is occurring, branch A-B would be loaded to 160MVA while all other branches are less than maximum loaded.
Other branch loadings could also be predicted using the Distribution Factors calculated in the detailed ATC analysis.
Below are the results which agree well with power flow model.



Maximum Transfer During Worst Outage
“Predicted” Conditions

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