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Six-phase line transmission – what it is, why we need it and how to protect it

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Questions

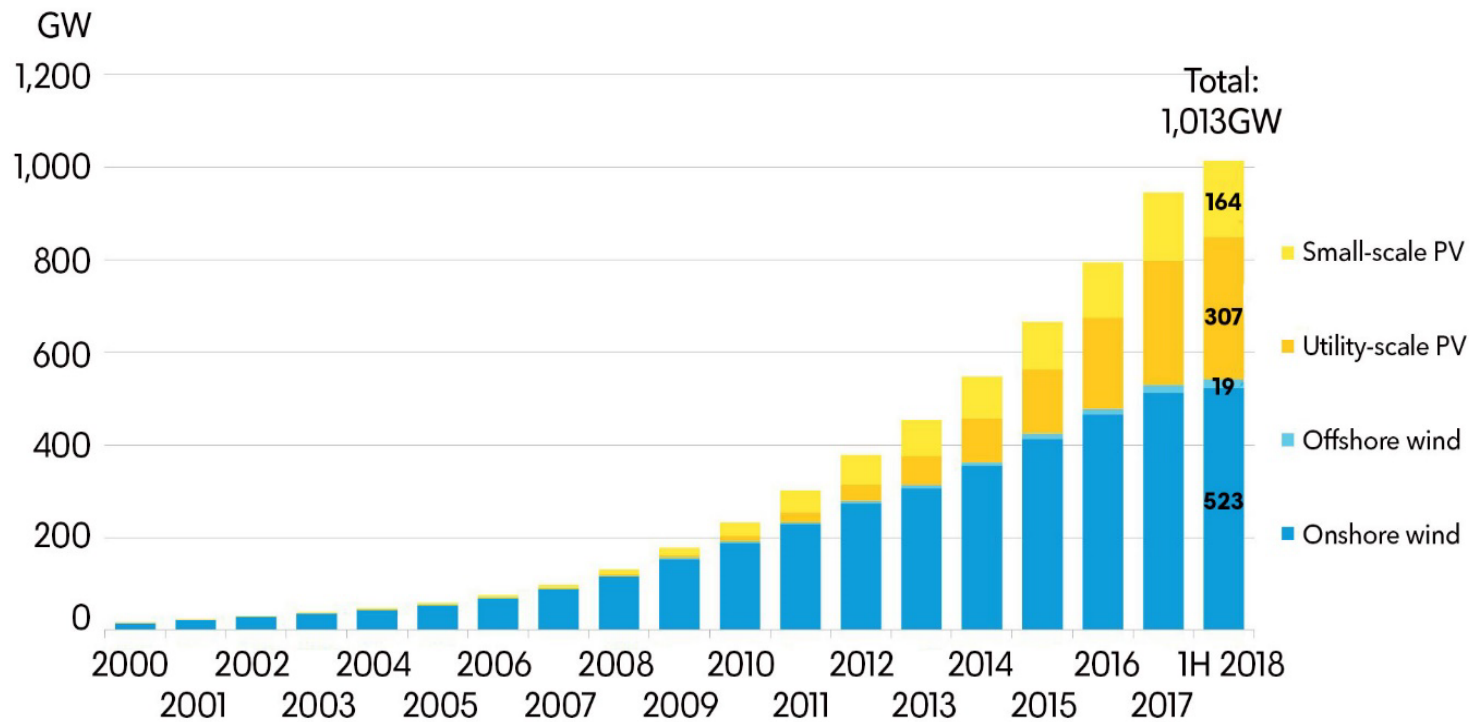
- What are we doing?
- Why are we doing it?
- How are we doing it?

What are we doing?

- Looking at six phase line transmission

Why are we doing it?

Global wind and solar installations, cumulative to June 30, 2018



Source: Bloomberg NEF. Note: 1H 2018 figures for onshore wind are based on a conservative estimate; the true figure will be higher. BNEF typically does not publish mid-year installation numbers.

How are we doing it?

- The interest in six-phase transmission was triggered by a CIGRE report on High Phase Order Power Transmission (Report presented by Study Committee No. 31 (Transmission Systems) by L. Barthold and H. Barnes, 1972.
- This resulted in it to be considered as an alternative in system planning by some utilities in the United States.
- A joint Allegheny Power System (APS)-West Virginia University (WVU) study of the feasibility of 138-kV six-phase conversion as an alternative to 230-kV three-phase double-circuit conversion was undertaken during 1976-79

Research projects

- Analysis of different possible fault combinations on the six-phase transmission line and the methods for their calculation established the foundation for an EPRI research project in 1984 on fault protection for High Phase Order transmission lines.
- A feasibility analysis of High Phase Order transmission was also conducted in the 1970s by the US Department of Energy and based on the encouraging results led to the construction of six and 12 phase test lines at an experimental site at Malta, New York State. The six-phase line was energized and tested at 80 kV.

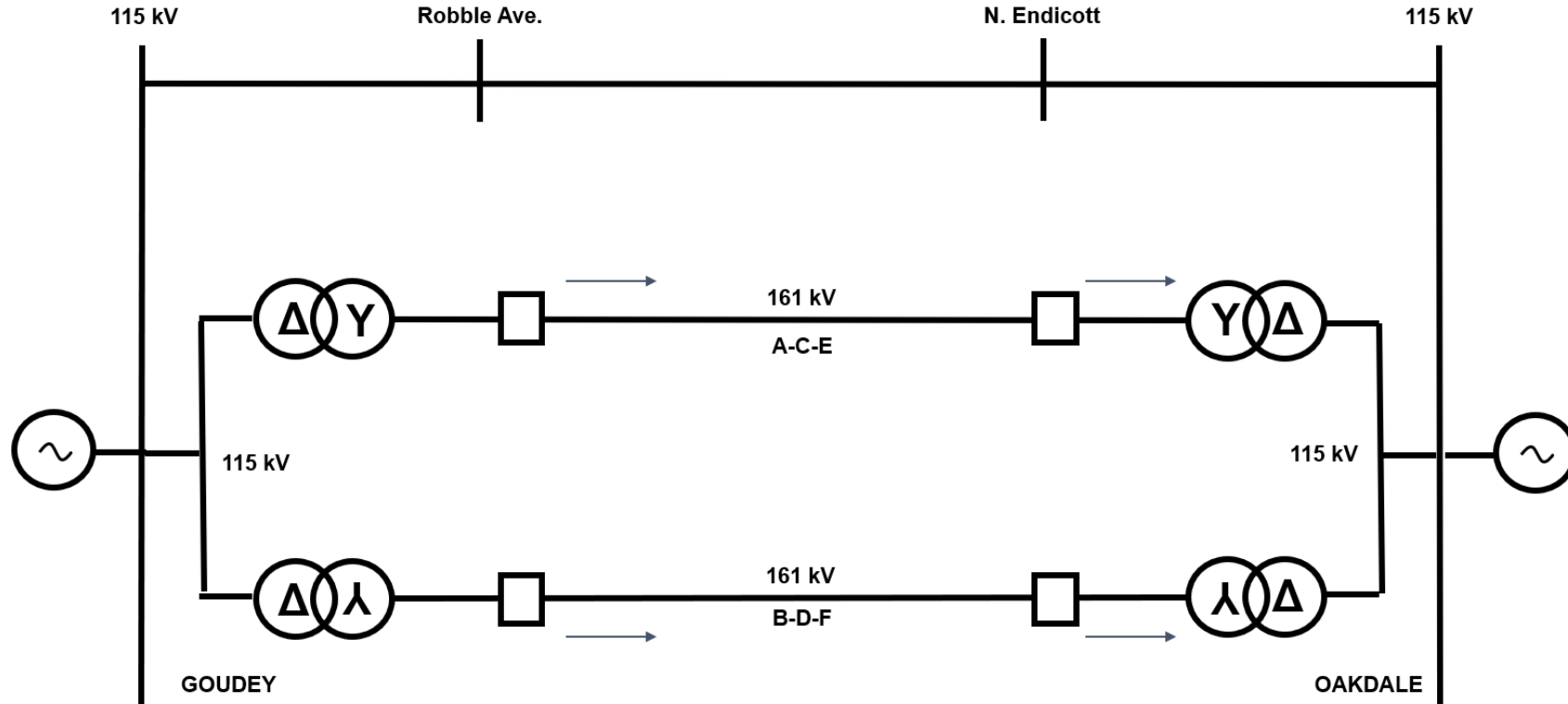
NYSEG Demonstration project

- Two decades of research led to a decision to try the concept of six-phase transmission in real life conditions. A High Phase Order Transmission Demonstration Project sponsored by the Electric Power Research Institute (EPRI), the Department of Energy (DOE), Empire State Electric Energy Research Corporation (ESEERCO), New York State Energy Office (SEO), New York State Energy Research and Development Authority (NYSERDA) and New York State Electric & Gas Corp. (NYSEG) was initiated to convert an existing 115 kV double circuit line to a six-phase line to demonstrate the commercial viability of the concept.

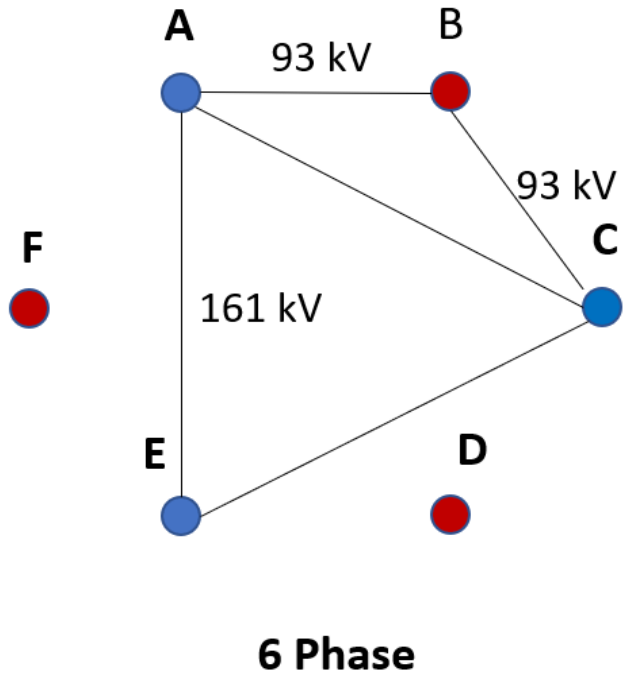
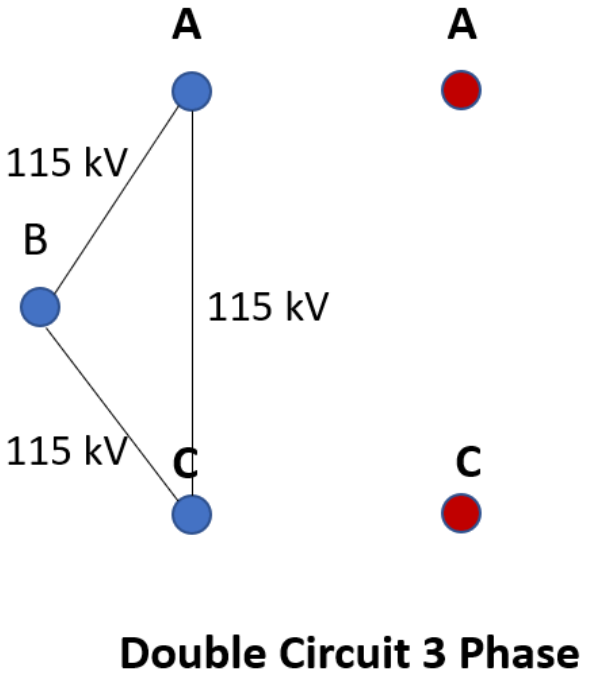
Project objectives

- To prove that it is possible to operate a six-phase transmission line integrated into an existing three phase network
- To design and implement the interface of the six-phase line to the three-phase system in the most efficient way
- To design and identify all potential issues with the protection and control of the six-phase transmission line
- To confirm the expected environmental benefits of transforming a double circuit three phase line into a six-phase single circuit
- To demonstrate that the existing double circuit three phase towers can be used for the six-phase transmission

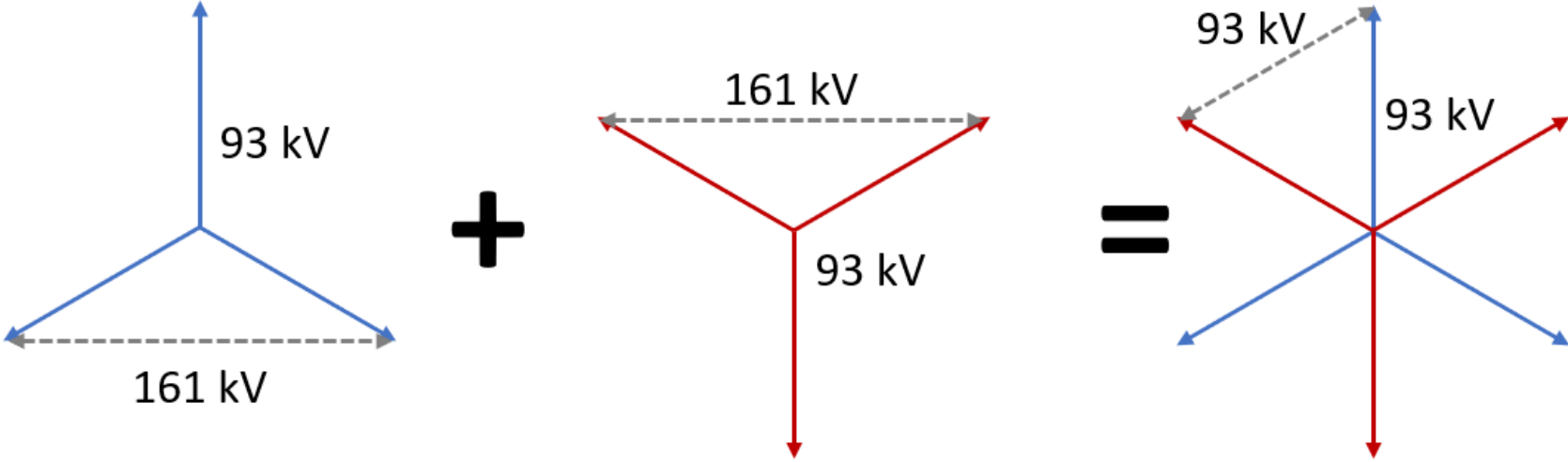
NYSEG's six-phase line



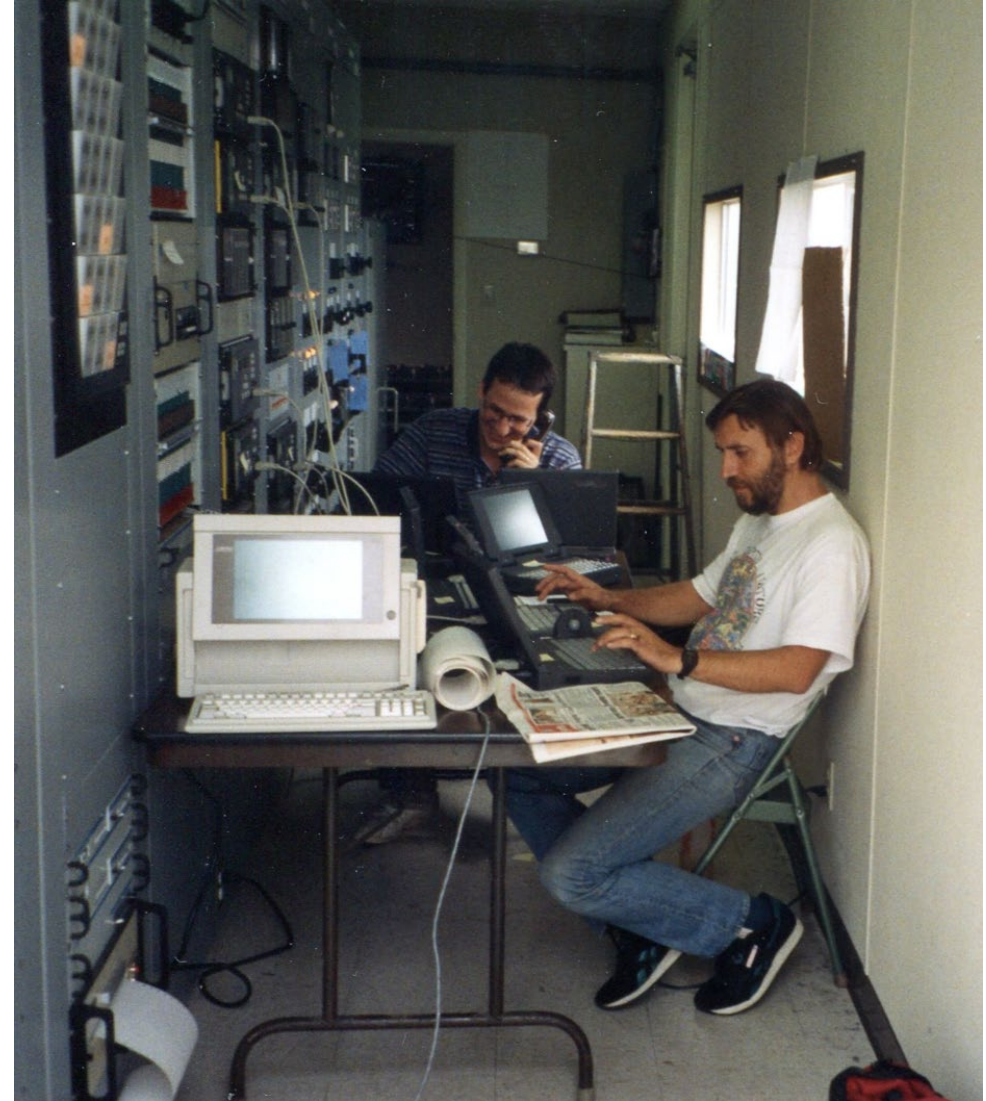
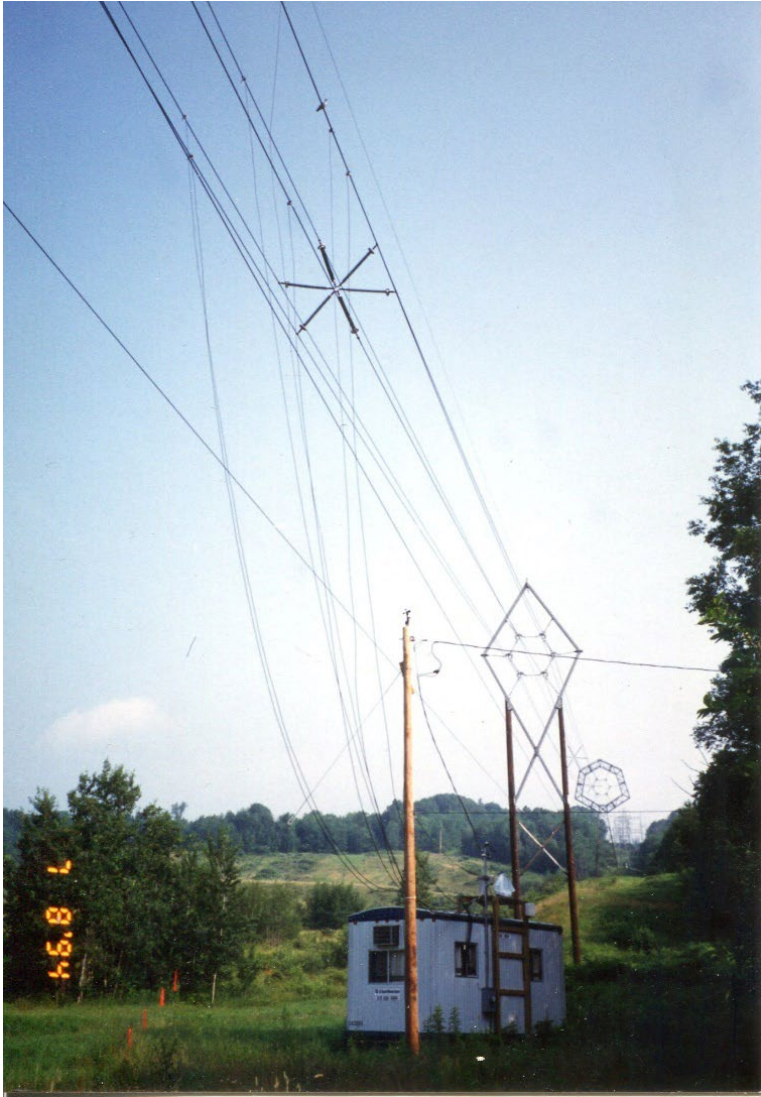
Line reconfiguration



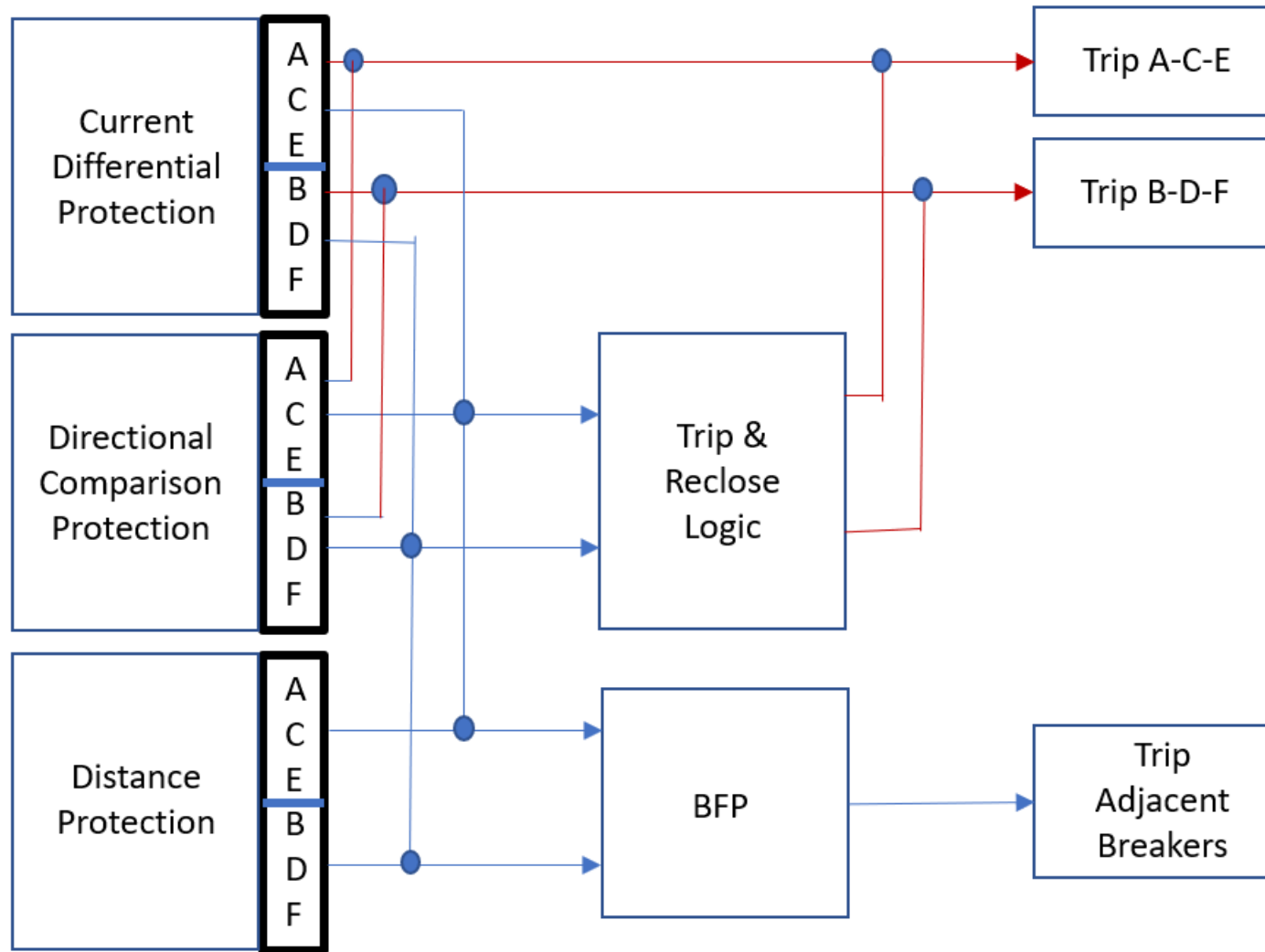
Line reconfiguration



NYSEG's six-phase line

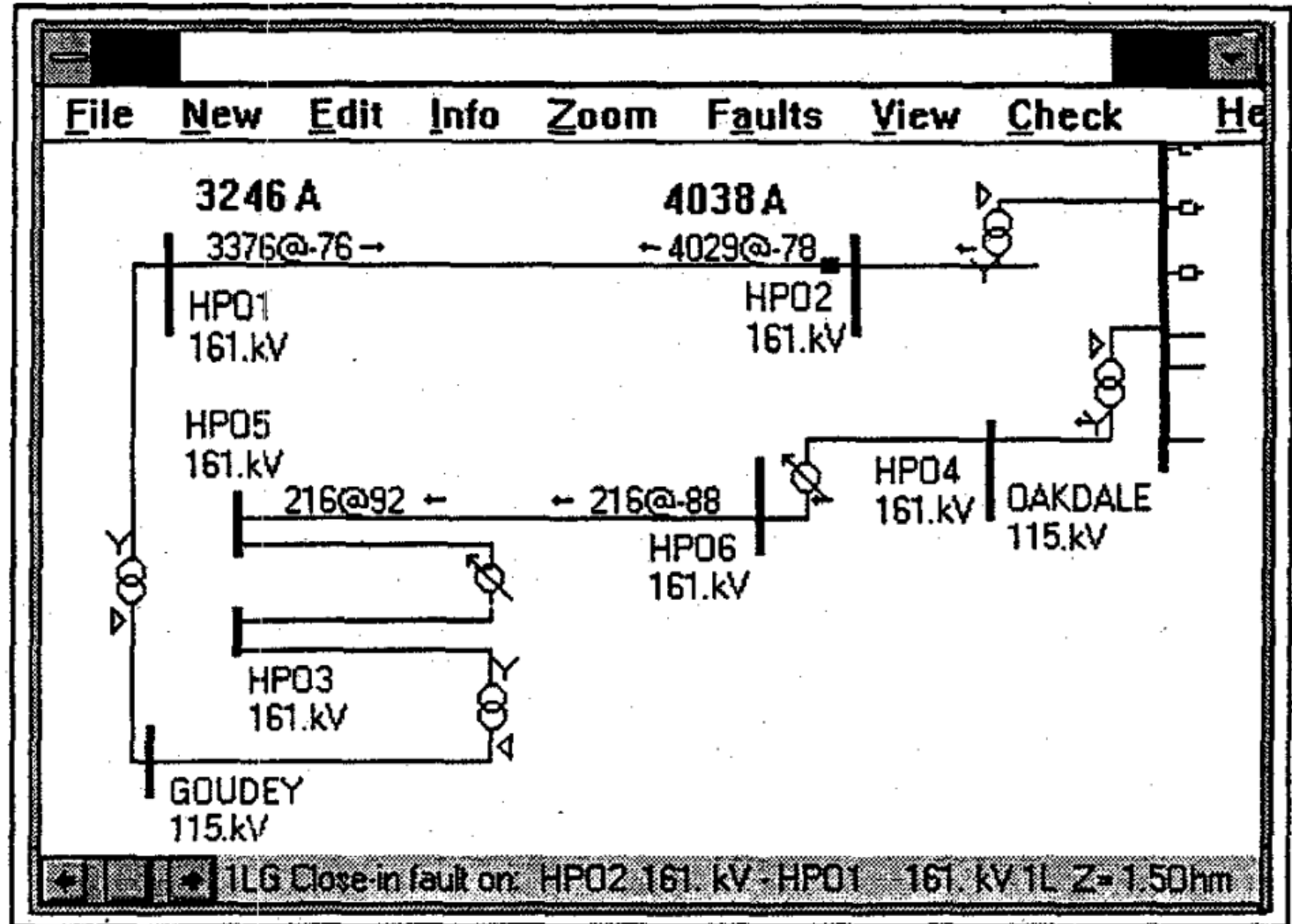


Protection

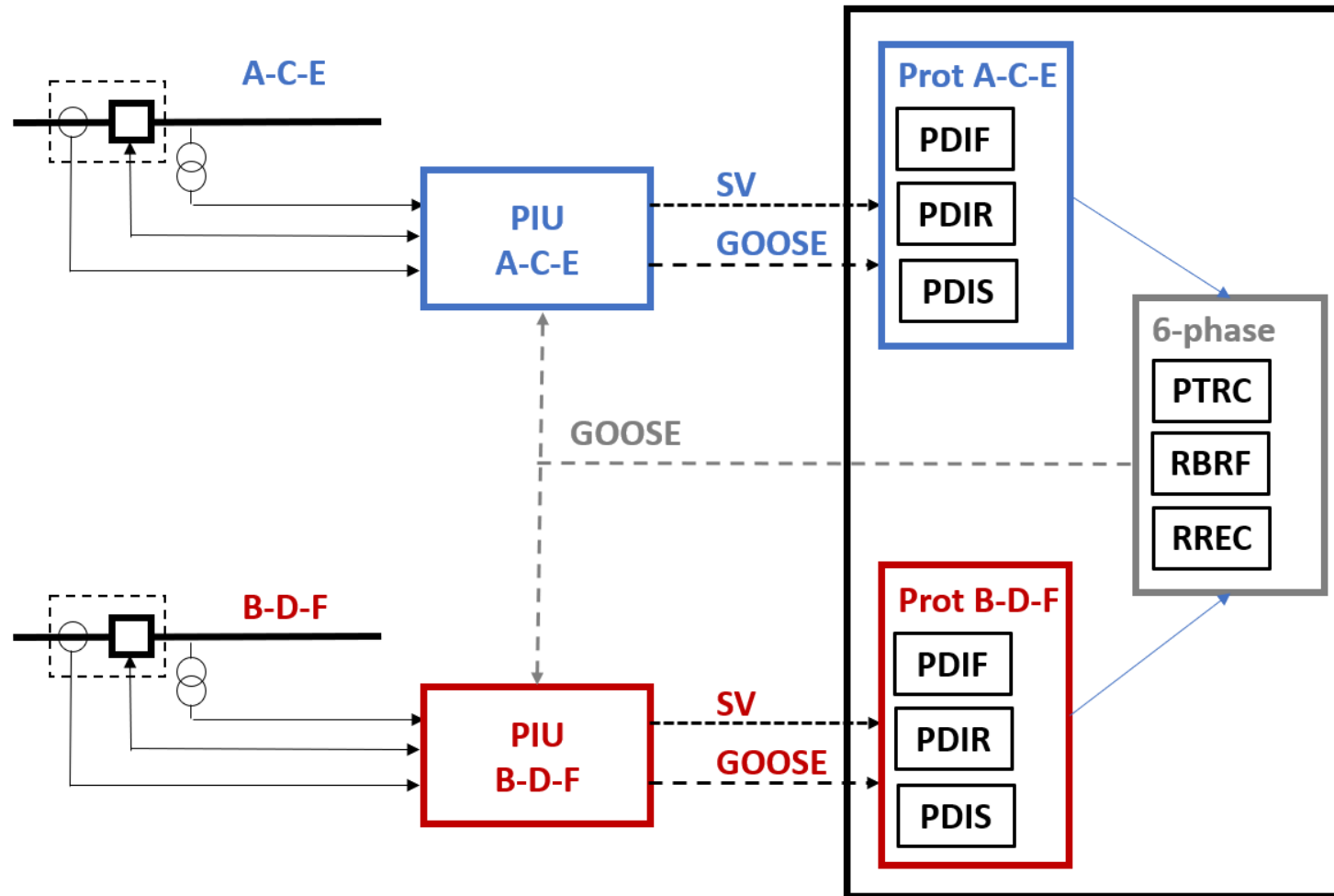


Faults on the line

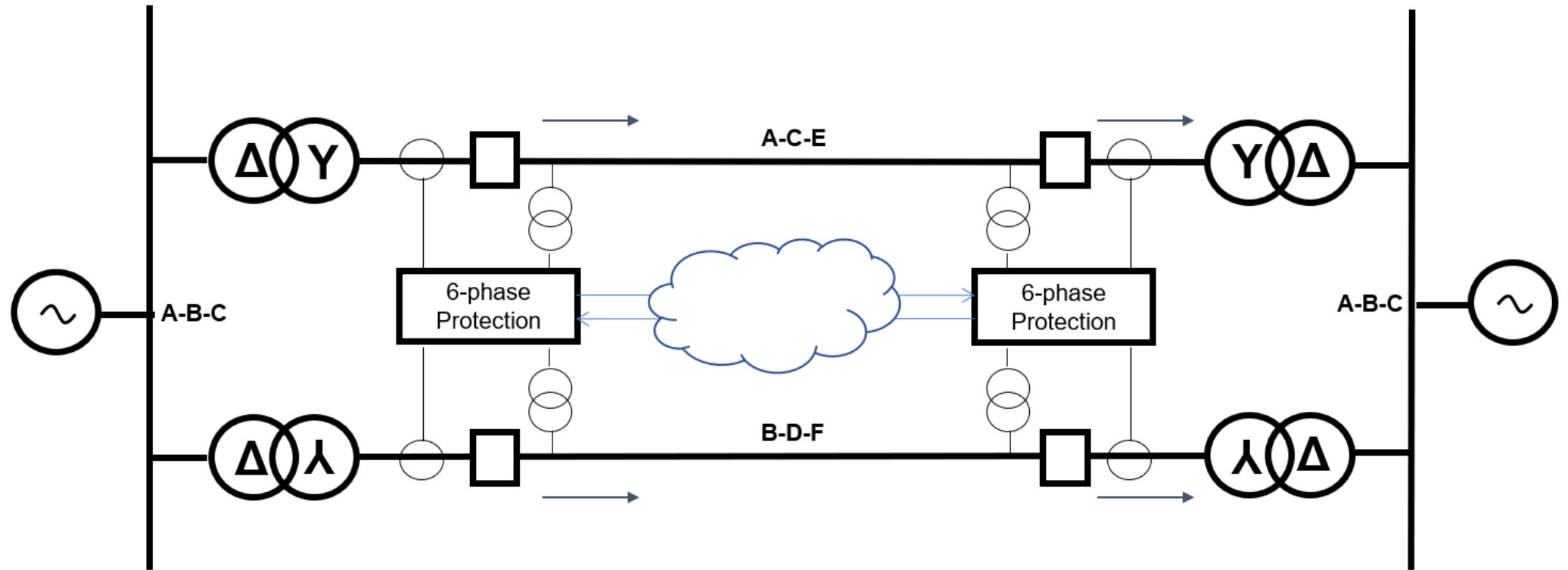
- Two faults
- January 3, 1993
- February 19, 1993



Future six-phase line protection



Future six-phase line protection



Conclusions

- We need power transfer capabilities to support the renewable energy resources
- There are many double circuits transmission lines available in the power grid
- Converting them to six phase really increases their power transfer capabilities by up to 73%
- Protection and control based on IEC 61850 technology is a trivial solution
- Let's do it!

