

Electrical and Instrumentation (E&I) Engineering
for Oil and Gas Facilities

THIS BOOK WAS DEVELOPED BY IDC TECHNOLOGIES

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IDC Technologies is internationally acknowledged as the premier provider of practical, technical training for engineers and technicians.

We specialize in the fields of electrical systems, industrial data communications, telecommunications, automation and control, mechanical engineering, chemical and civil engineering, and are continually adding to our portfolio of over 60 different workshops. Our instructors are highly respected in their fields of expertise and in the last ten years have trained over 200,000 engineers, scientists and technicians.

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We deliver engineering and technology training that will maximize your business goals. In today's competitive environment, you require training that will help you and your organization to achieve its goals and produce a large return on investment. With our 'training that works' objective you and your organization will:

- Get job-related skills that you need to achieve your business goals
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- Improve your troubleshooting abilities
- Sharpen your competitive edge
- Boost morale and retain valuable staff
- Save time and money

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We search the world for good quality instructors who have three outstanding attributes:

1. Expert knowledge and experience – of the course topic
2. Superb training abilities – to ensure the know-how is transferred effectively and quickly to you in a practical, hands-on way
3. Listening skills – they listen carefully to the needs of the participants and want to ensure that you benefit from the experience.

Each and every instructor is evaluated by the delegates and we assess the presentation after every class to ensure that the instructor stays on track in presenting outstanding courses.

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Technology Training that Works

Presents

Electrical and Instrumentation (E&I) Engineering for Oil and Gas Facilities

Revision 1

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Contents

1	Fundamentals of Electrical Engineering	3
2	Fundamentals of Instrumentation, Measurement and Process Control Engineering	15
3	General Instrumentation Standards in Oil and Gas	39
4	Best Practice in Process, Electrical and Instrumentation Drawings and Documentation	67
5	Process Instrumentation	89
6	Calibration, Installation and Maintenance of Instruments	101
7	Process Control Basics	119
8	Control Valves Sizing, Selection and Maintenance	151
9	Programmable Logic Controllers	169
10	SCADA Systems	177
11	Distributed Control Systems	187
12	Industrial Data Communications	195
13	Safety Instrumentation and Emergency Shutdown Systems for Oil and Gas	207
14	Wellhead and Flowline Control	225
15	Emergency Wellhead Blowout Controls	241
16	Power Generation	265

17	Cathodic Protection	275
18	Compressor Surge Control	283
19	Drilling Control Systems and Instrumentation	289
20	Subsea Instrumentation and Control Systems	297
21	Pig Launchers/Receivers	305
22	Flare Knockout Drum Control and Instrumentation	311
23	Flare Flame Front Generator and Ignition Monitoring	319
24	Electrical Drawings, Documentation and Schematics	325
25	Transformers	335
26	Troubleshooting, Maintenance and Protection of AC Electrical Motors	351
27	Power Distribution	361
28	Power System Protection and Coordination	373
29	Switchgear and Distribution Systems	403
30	Cables and Wires – Maintenance and Installation Practice	413
31	Variable Speed Drives (VSDs) for Instrumentation	435
32	Electrical Safety	445
33	Earthing/Grounding, Power System Harmonics and Power Quality	461
34	Lightning and Surge Protection	479
35	Uninterruptible Power Supplies (UPS) and Batteries	495

36	Emergency Power Supplies	503
37	Electrical Equipment in Hazardous Areas	513
38	Practical Exercises	521
39	Answers to Practical Exercises	529

1

Fundamentals of Electrical Engineering

FUNDAMENTALS OF ELECTRICAL ENGINEERING



Technology Training that works

Power system

- Power generation plants are located based on fuel availability
- Other considerations like water, pollution issues etc.
- Often they are in remote locations
- Loads are situated in population centers
- Transporting generated power to population centers for use requires a power system



Technology Training that works

Why AC?

- Almost the entire power generation and transmission is by AC (alternating current)
- AC lends itself to voltage changes easily
- Voltage can be chosen for optimum efficiency and optimum capital cost
- Thus better economy of power system operations



Technology Training that works

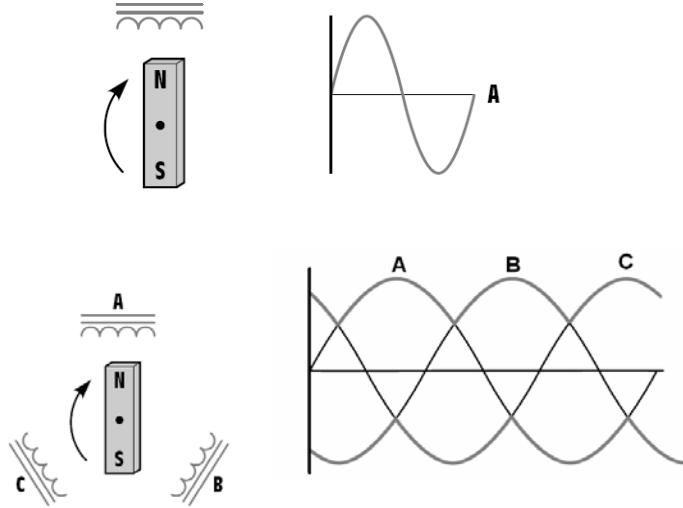
AC Waveform

- A voltage or current in AC circuits varies cyclically a number of times per second
- This number is called the frequency (F)
- The time for one cycle is thus $1/F$
- The variation follows a sine relationship and the waveform is called a sine wave
- An electrical system can be of single or 3 phase type



Technology Training that works

Single and three phase generators



Technology Training that works

Three phase AC

- Universally adopted because of lower equipment cost per unit power handled
- Helpful while interconnecting several generating sources (the sources tend remain in phase or stay synchronised)
- Three phase AC motors (which account for most of the energy used) have a simple design and are self starting



Technology Training that works

Electrical Power and Energy

- In DC circuits
 - Power=Voltage x Current (Watts)
 - Energy= Power x Time (Watt Hours)
- In AC circuits instantaneous voltage and current keep changing as they follow a sine curve
 - Power is computed using Root Mean Square (RMS) voltage and RMS current



Technology Training that works

AC Power

- Fundamental Definition of Power:

$$p(t) = v(t) \cdot i(t)$$

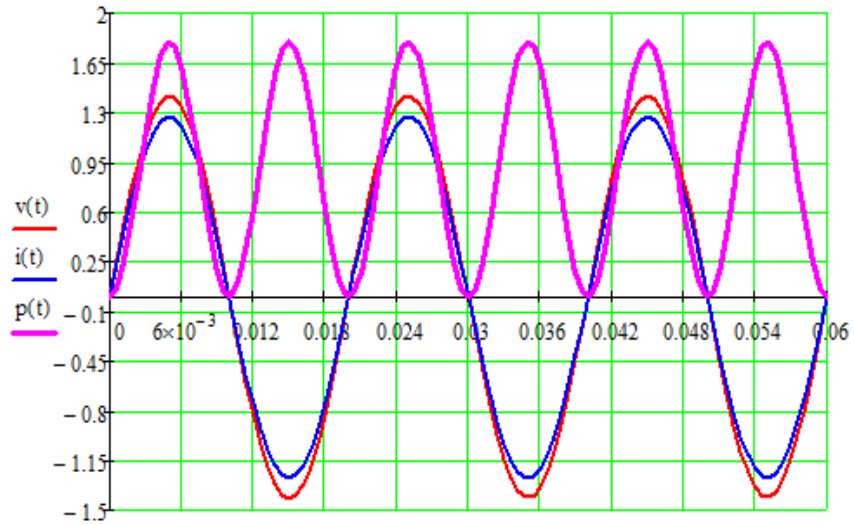
- In an AC circuit both are sinusoidal against time
- Sinusoidal Voltage and Current are defined in RMS magnitudes where:

$$V_{rms} = \frac{V_{peak}}{\sqrt{2}} \qquad I_{rms} = \frac{I_{peak}}{\sqrt{2}}$$



Technology Training that works

Single Phase AC Power



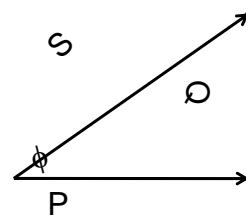
The Power Triangle

$$S = \sqrt{P^2 + Q^2}$$

$$\text{power factor} = \cos \phi = \frac{P}{S}$$

$$\phi = \arccos(\text{power factor})$$

$$P = S \cdot \cos \phi \quad Q = S \cdot \sin \phi$$



Formulae for Power

- Apparent power $S = V \cdot I$
- Active Power $P = V \cdot I \cdot \cos \phi$
- Reactive Power $Q = V \cdot I \cdot \sin \phi$
- $\cos \phi$ is known as the Power Factor and ϕ is the power factor angle
- The angle depends on the ratio of the resistance to the reactance in a circuit



Power Generation

- *Explained in detail in subsequent chapter.*



Typical Transmission Substation & transmission lines



Technology Training that works

Power distribution

- Distribution is done at lower voltage levels
- Distances are much shorter than transmission
- Voltage levels are typically 33 kV and less
- Bulk of the consumers draw power at lower voltages
- This requires distribution at two different levels
- Distribution substations convert power from transmission to distribution voltages
- We will discuss the equipment used for T&D in the next webcast



Technology Training that works

Three phase power network

- All AC generation, Transmission and Distribution is through 3 phase systems
 - Exception: Single phase/SWER distribution systems
- Utilisation can be 3 phase (motors and rectifiers for drives, furnaces) or single phase (commercial and lighting)
- Ability to transmit larger amount of power for a given voltage/conductor volume
- Availability of rugged 3 phase cage motors with self starting capability



Technology Training that works

Distribution equipment

- Switching and isolation equipment
 - Circuit breakers
 - Disconnectors
 - Control gear
- Conductors for carrying power
 - Overhead bare
 - Overhead insulated
 - UG cables



Technology Training that works

Substations

- A facility incorporating
 - Transformers
 - Switching/isolation equipment
 - Control/protection/measuring
 - Auxiliary power equipment
- Indoor or Outdoor type
- Air-insulated or gas-insulated
- Different configurations



Technology Training that works



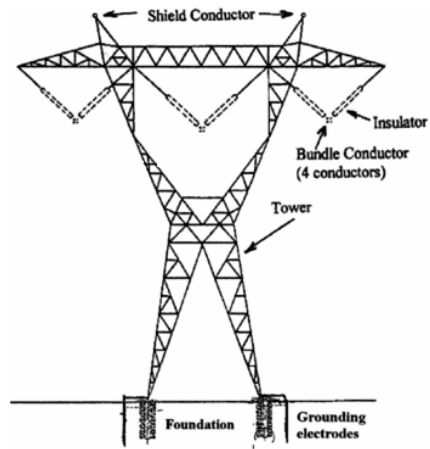
**Outdoor 330 kV switchyard
(Transmission)**

**Typical indoor
distribution substation**



Technology Training that works

A 400 kV Transmission line and Structure



Technology Training that works