Power Quality
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Lecture - 15
Loads which Cause Power Quality Problems

Welcome to the course on Power Quality.

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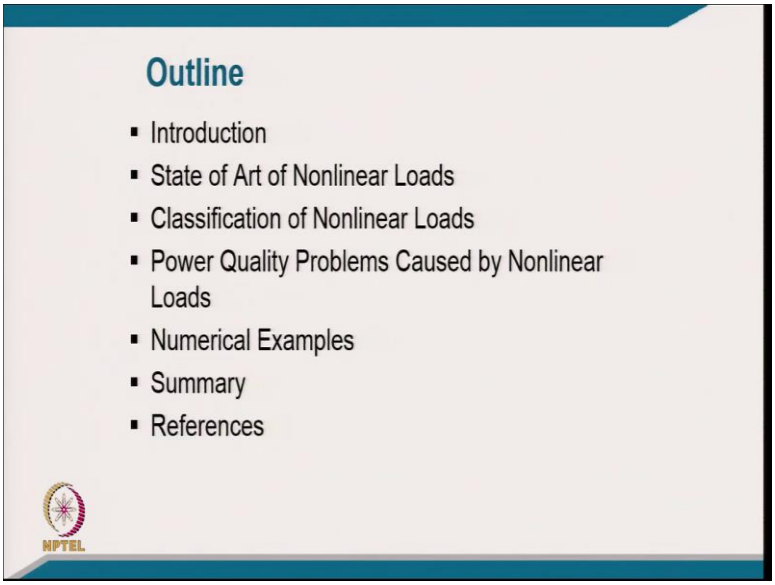

Well, we will like to start with the introduction and state of art on the non-linear load, classification of non-linear load, then power quality problems caused by non-linear loads, then followed by numerical examples, summary, and references.

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Coming to the objectives of this topic, we will talk about the non-linear load and power quality indices; then we will go to the configuration of non-linear load, analysis of non-linear load, then single phase non-linear load, three phase non-linear load, and power quality problem caused by non-linear load.

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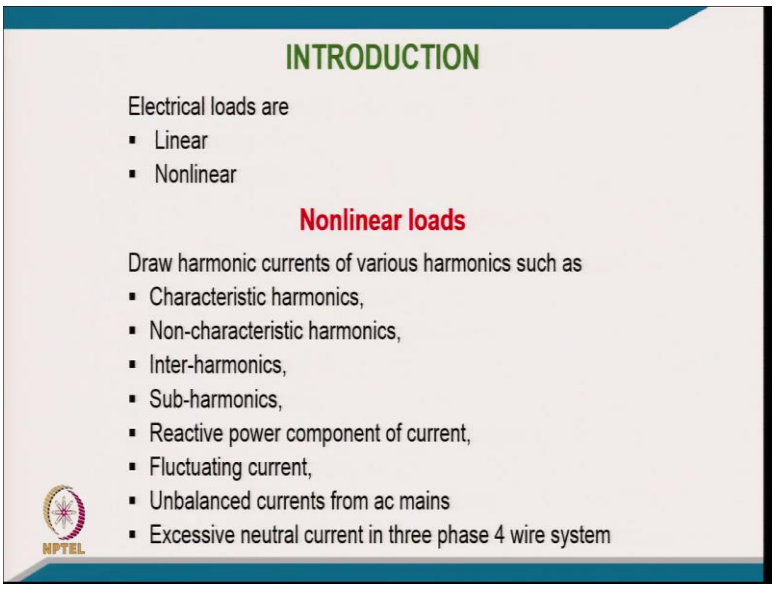

Two categories of load, linear load and non-linear load. The concept of linear electrical load where the current is proportional to the voltage, we call it linear relation.

But the non-linear load draw the harmonic currents of various multiple harmonics of the fundamental frequency of the supply voltage.

Then we also have non characteristic harmonics, inter harmonics, and sub harmonics. Then in many such non-linear load, we have a reactive power consuming loads also. The typical example may be a thyristor converter. Moreover, there are unbalanced current drawing loads. Well, in three phase four wire system there may be excessive neutral current due to unbalance and harmonics.

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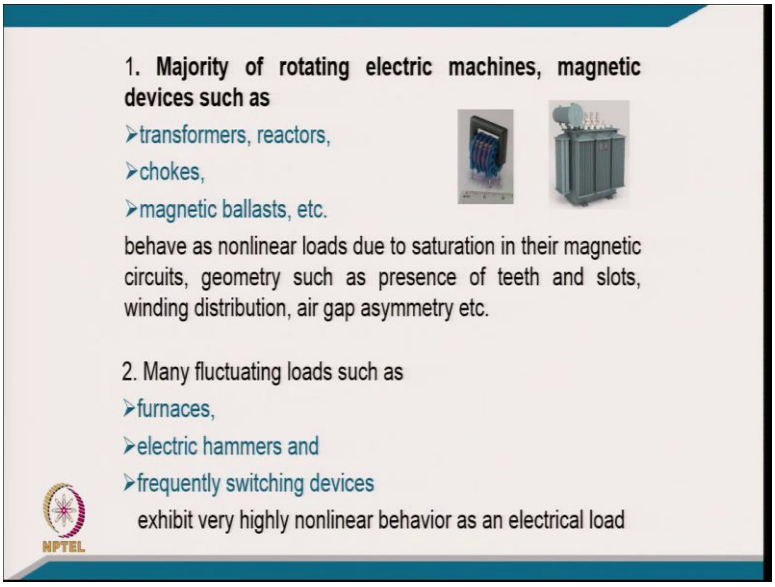

Majority of rotating electrical machine and magnetic devices, such as transformer reactors, choke and magnetic ballast behave as a non-linear load due to the saturation in their magnetic circuit.

Another category of non-linear load is the many fluctuating load, such as furnaces, electric hammers and other frequently switching devices.

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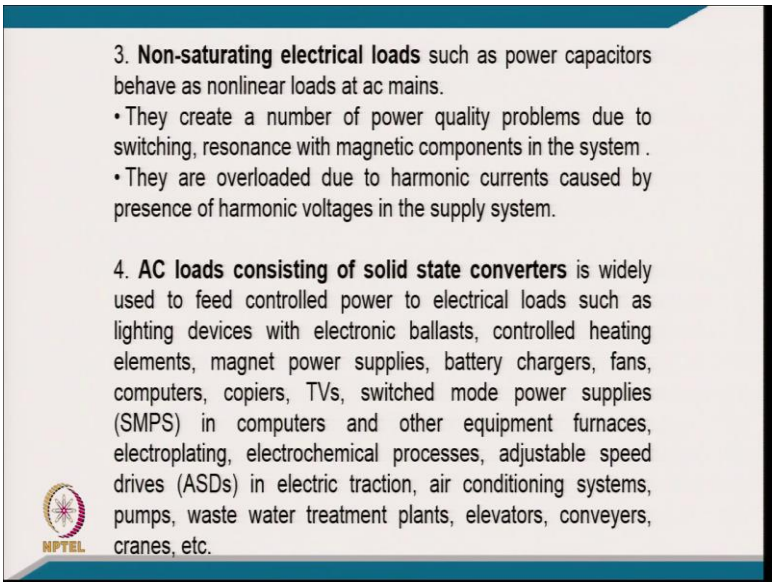

Now, coming to the third type of non-linear load is the non saturating electrical loads, such as power capacitor. In a power capacitor as the frequency increases its impedance reduces, and even a small voltage harmonics cause large current harmonics.

If some harmonics are present in the load that coincide with the resonance frequency of this source impedance and power capacitor circuit; then this can amplify that particular harmonic manifold.

Coming to the fourth category of non-linear load, the AC load consisting the solid state converter. Controlled heating elements, computers power supply, battery chargers, LEDs, air conditioning system, waste water treatment plant, elevators, conveyors, cranes etc., draw nonlinear currents. Whether it is energy efficient lighting or energy efficient fan, they behave as a non-linear load and draw the harmonics current from the supply system.

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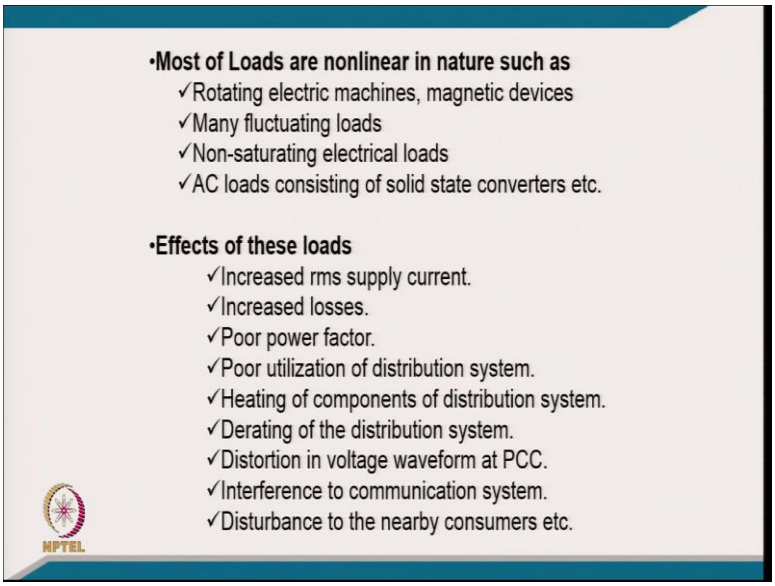

Nonlinear loads cause power quality problems such as increased RMS current supply current, increasing the losses. Moreover the utilization of the distribution system will be poor. Meanwhile, derating and losses of distribution equipments will increase. It also degrades the power factor. Moreover, it leads to interference in the communication system.

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Few typical the kinds of non-linear load are the fluorescent lamp, lighting lamp, other vapor lamp with electronic ballasts, switched mode power supply of computers, printers,

scanners, fax machines, etc., welding machines, solid state controlled ceiling fans, microwave ovens, induction heating devices, medial equipments, air conditioning system, battery chargers, electric traction, furnaces, harmonic injection by renewables, and so on.

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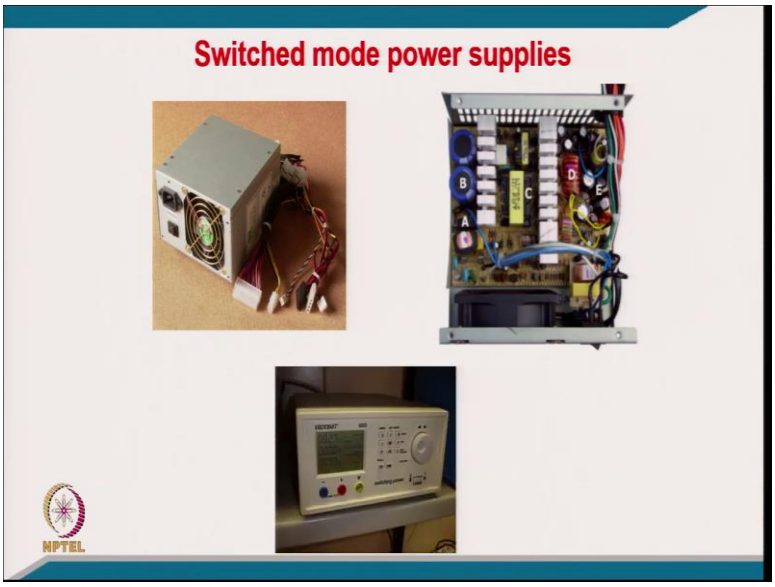

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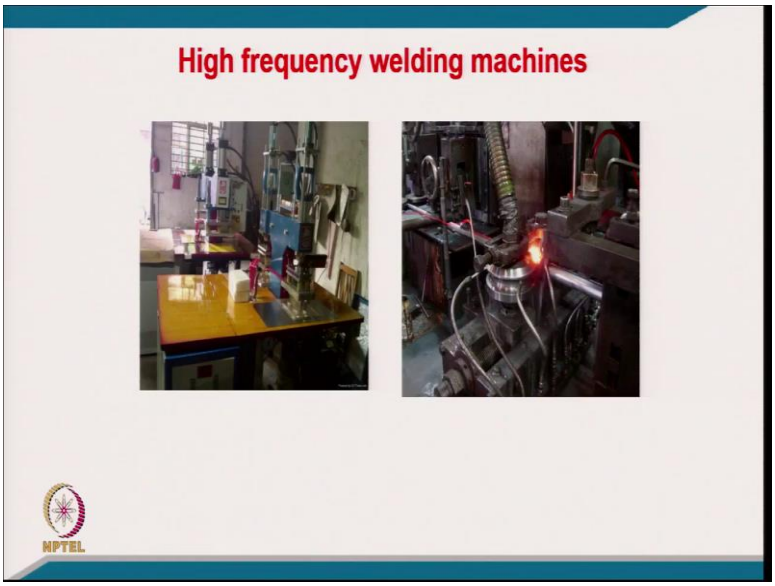

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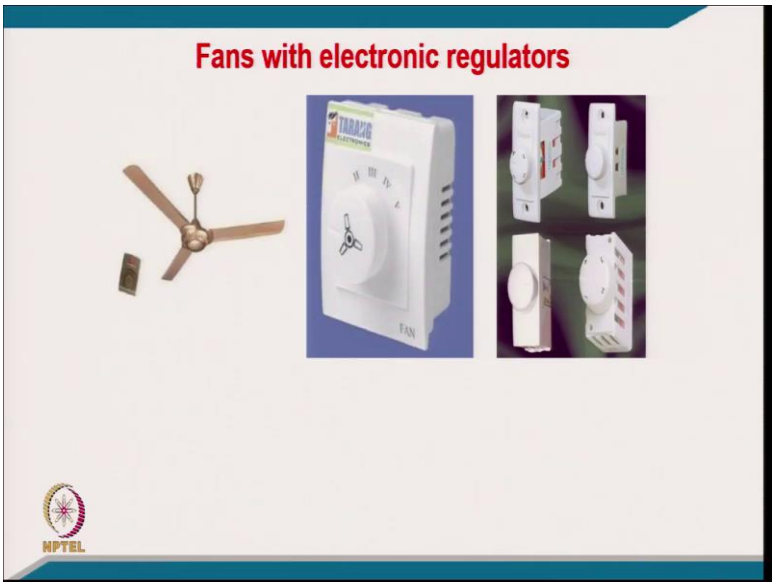

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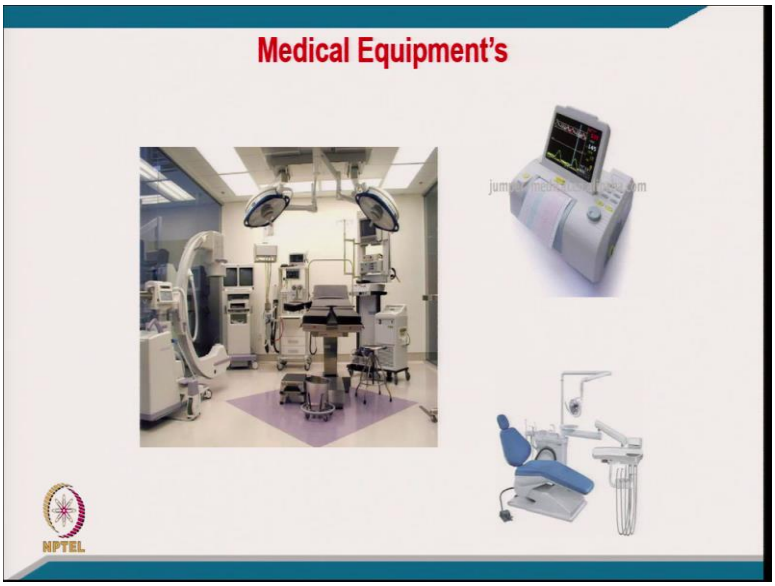

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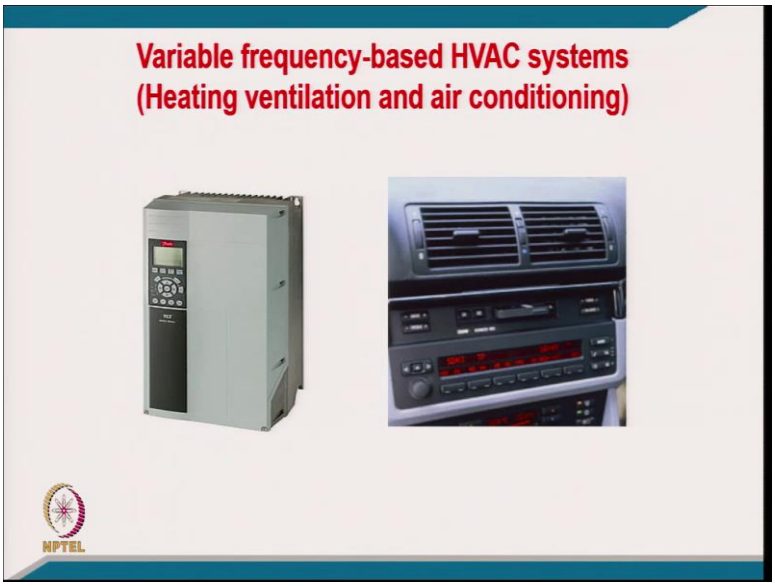

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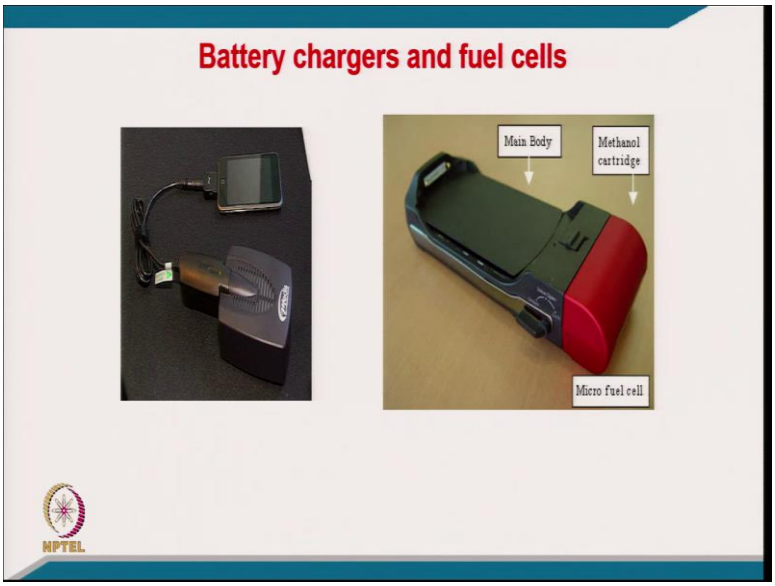

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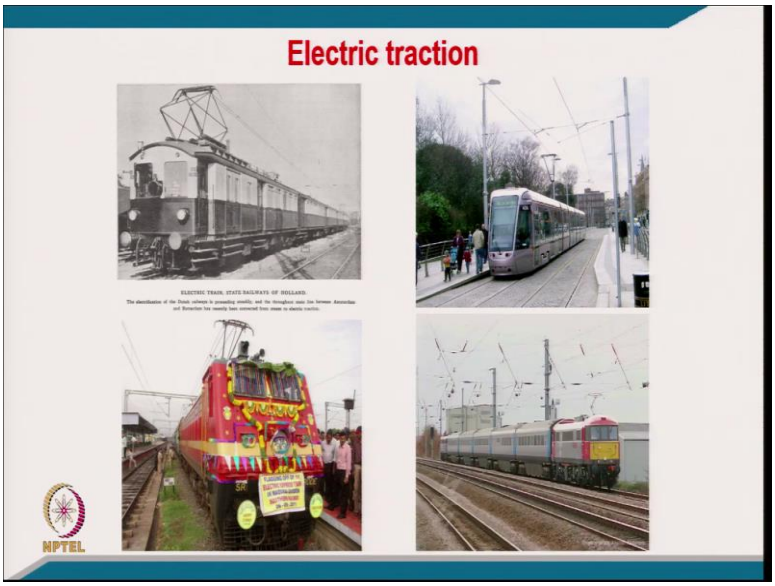

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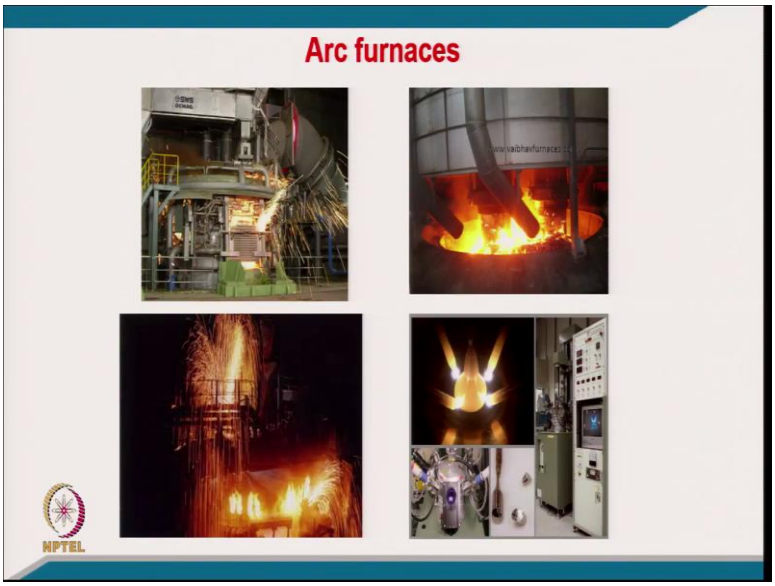

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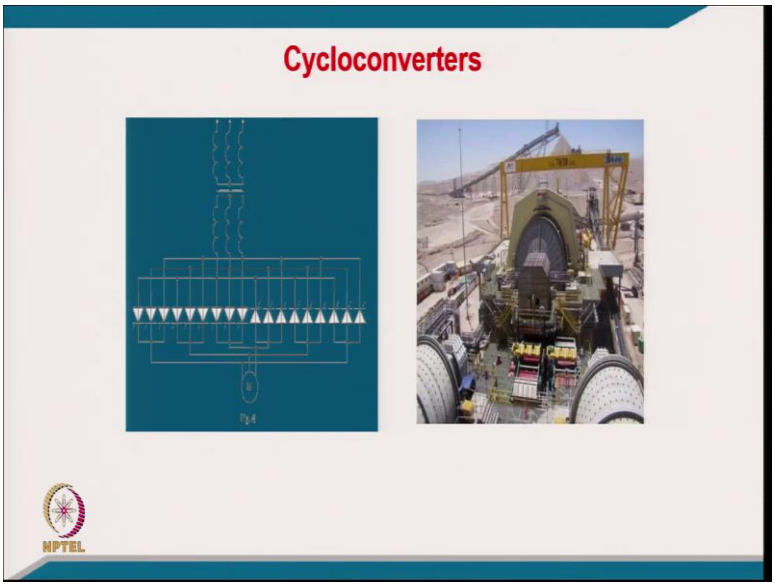

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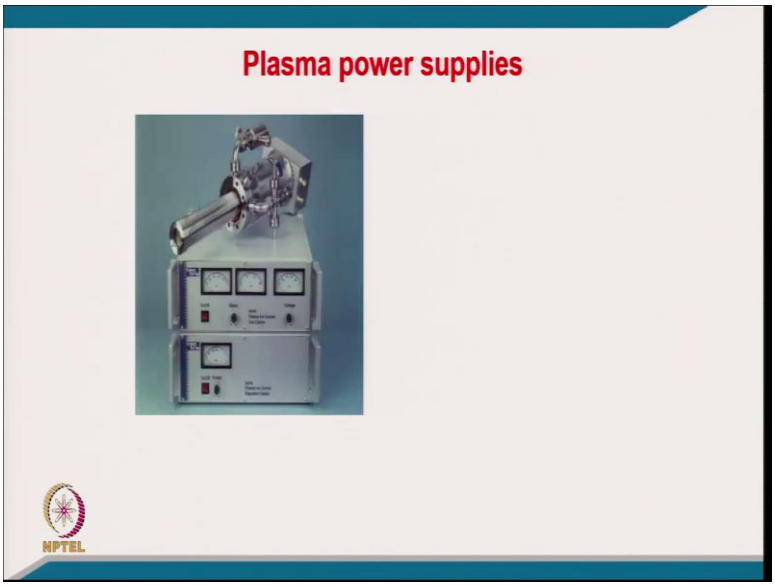

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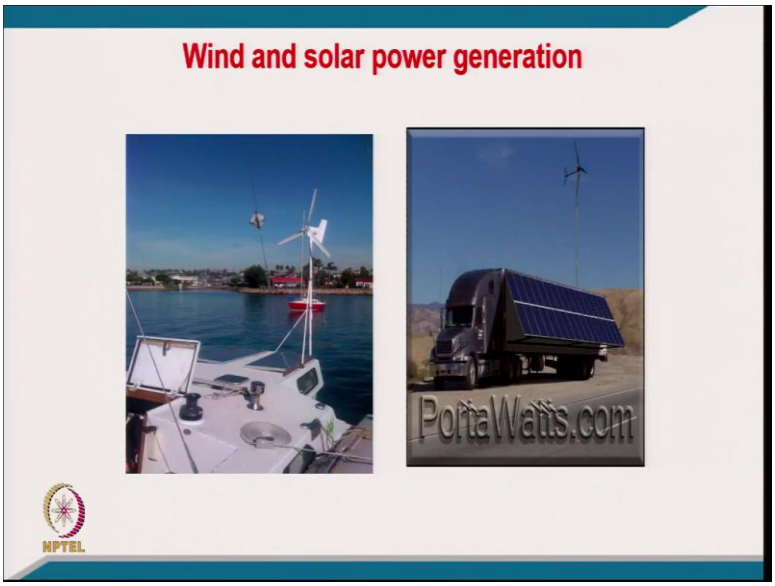

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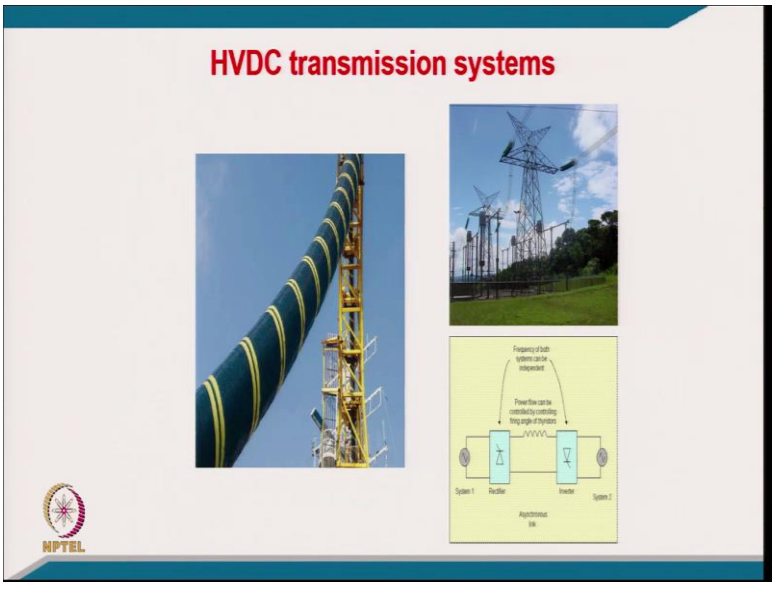

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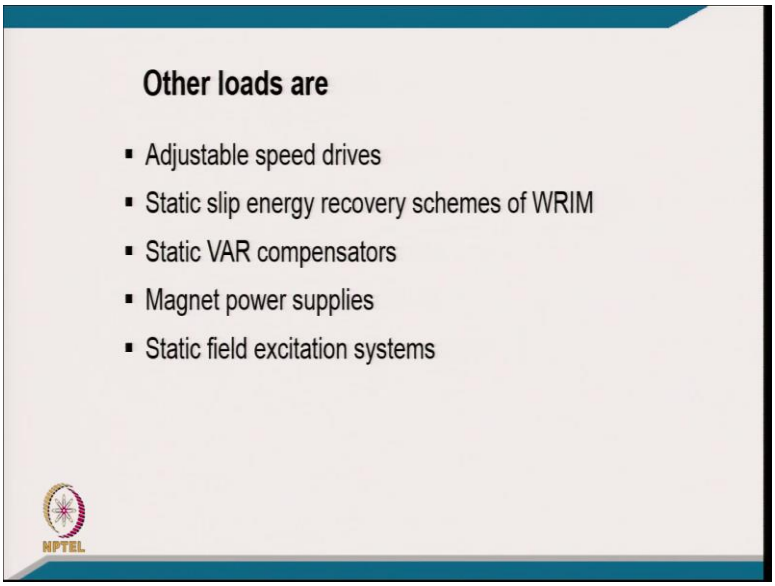

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Coming to the classification of non-linear loads, we classify them into many categories,

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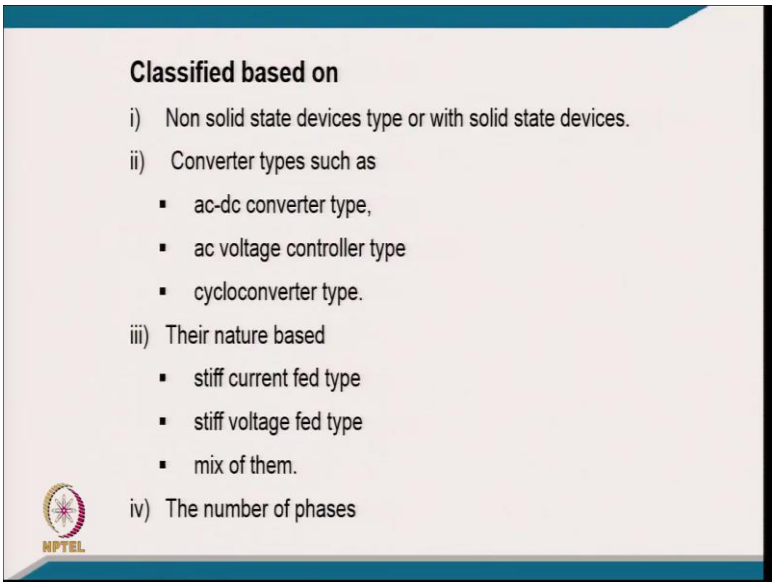

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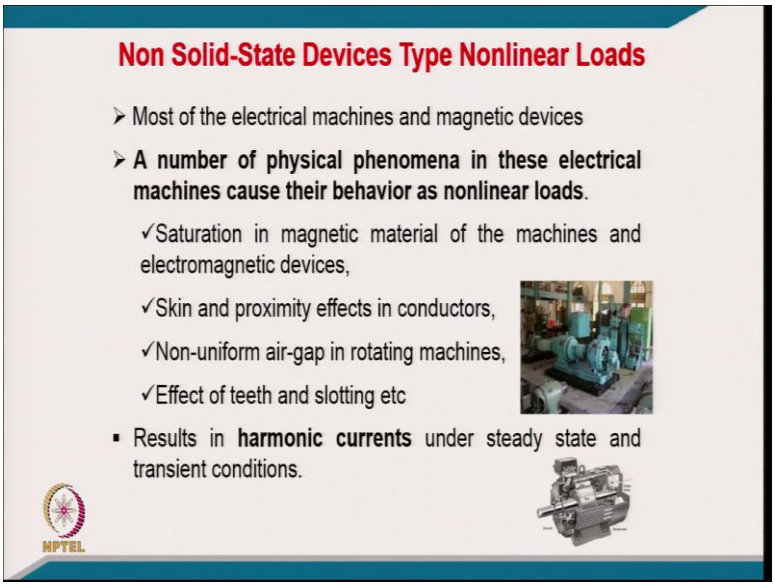

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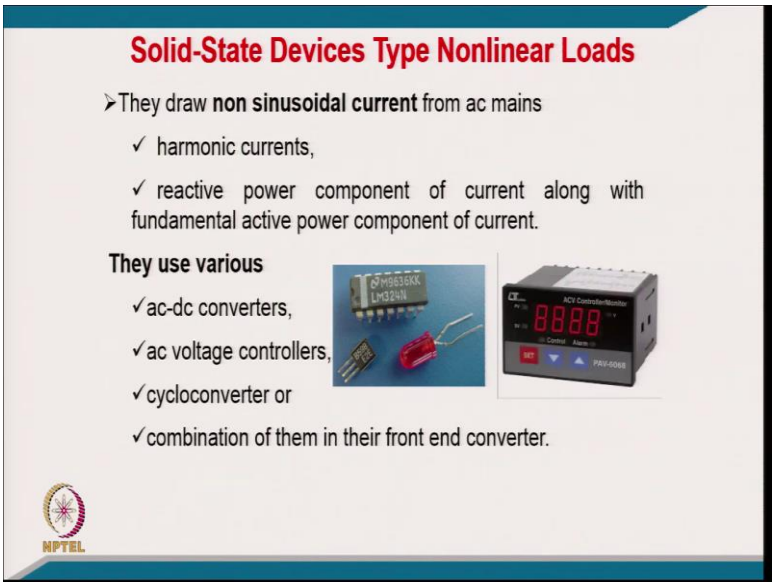

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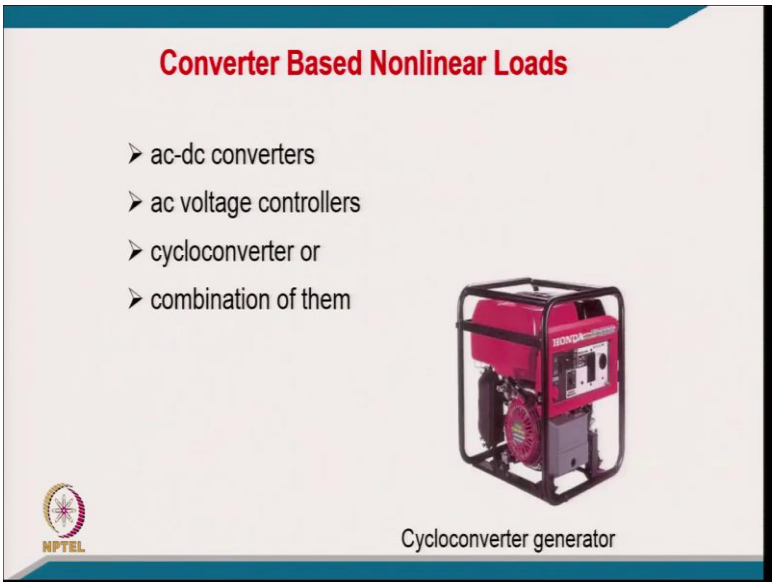

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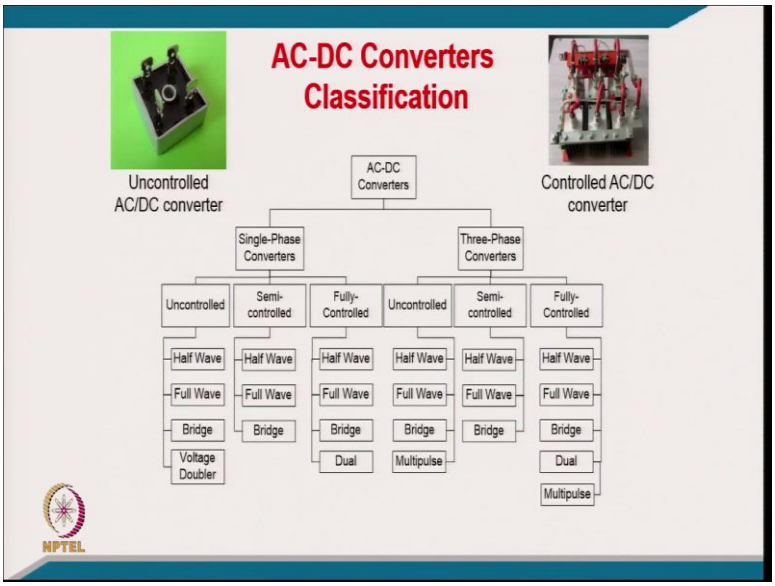

Many non-linear load consist of your AC DC converter. Large number of loads use ac dc converter as front end converter from few watts to mega Watt rating.

Here we have a classification of the AC DC converter like uncontrolled and controlled pulse converter.

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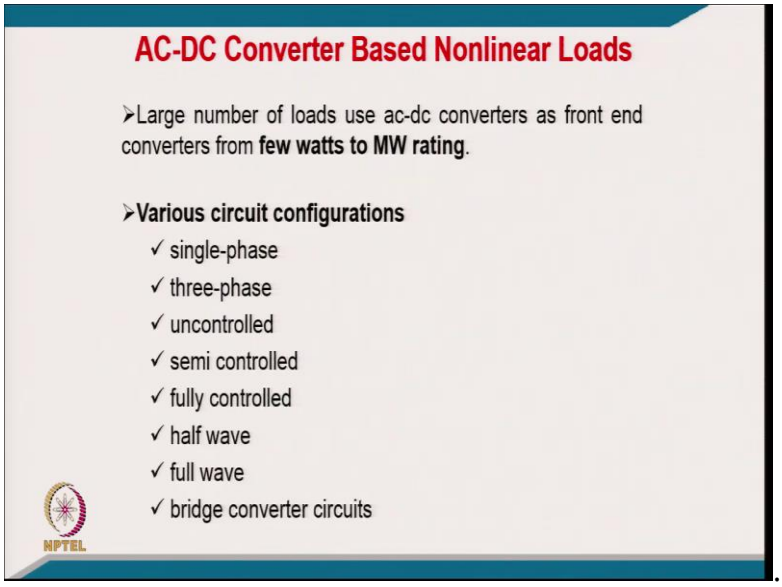

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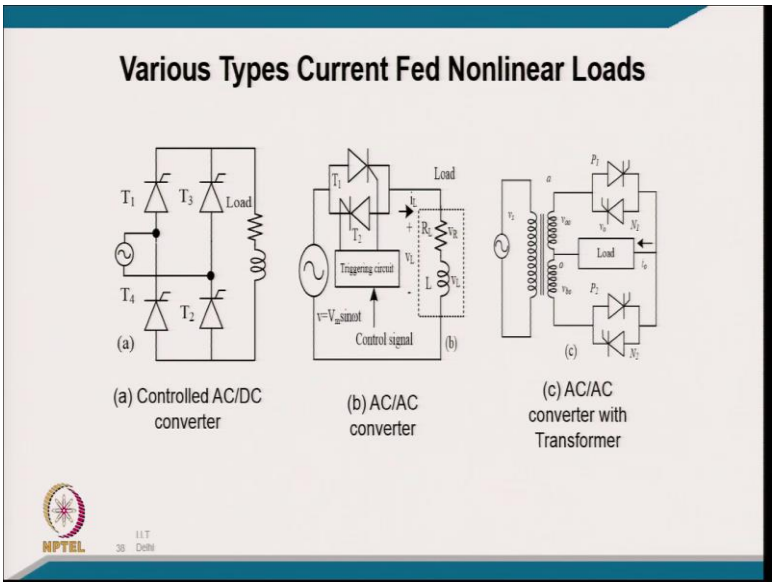

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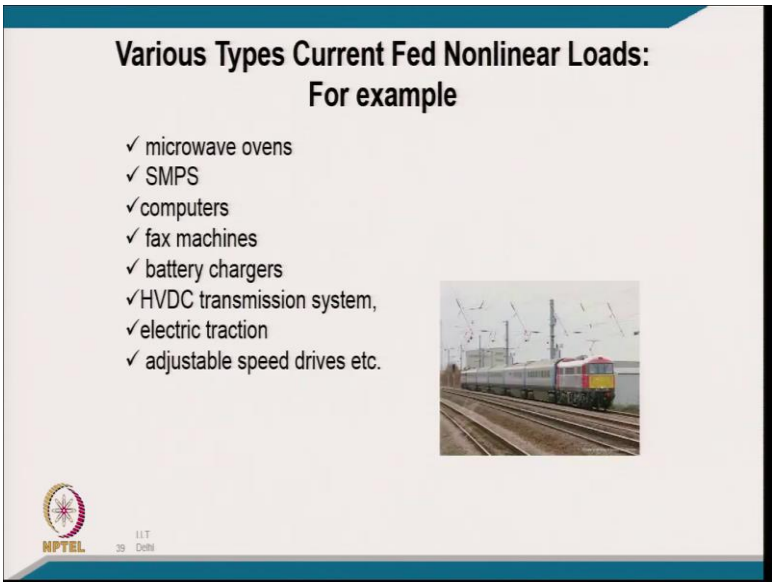

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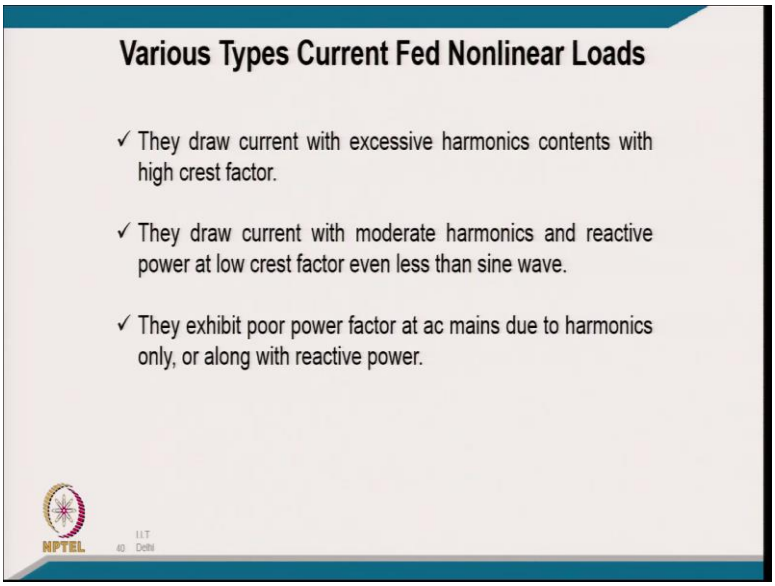

The loads that draw excessive harmonics content with the high crest factor; are voltage fed non-linear load. The current fed nonlinear loads draw the current with moderate harmonics and reactive power at low crest factor.

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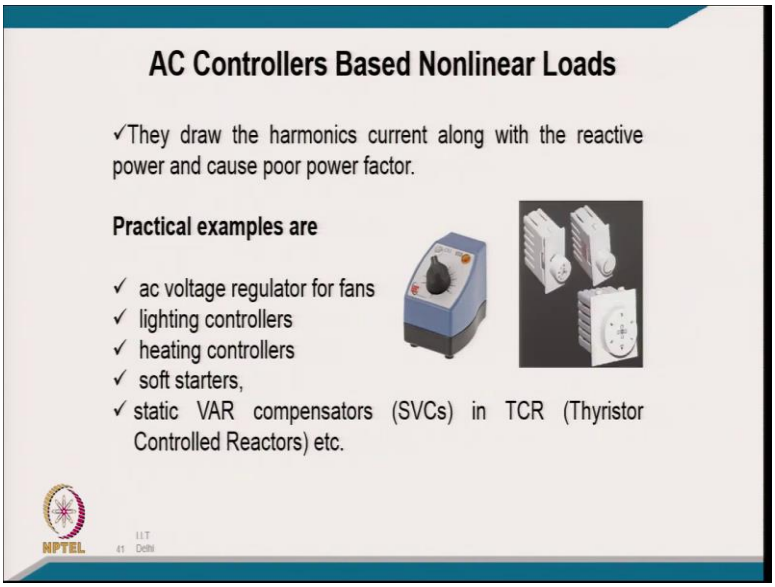

AC voltage controller based non-linear load, draw the harmonics current along with the reactive power and cause the poor power factor. And practical examples are ac voltage regulator for fans, lighting controller, heating controllers, and static VAR compensator in thyristor controlled reactor.

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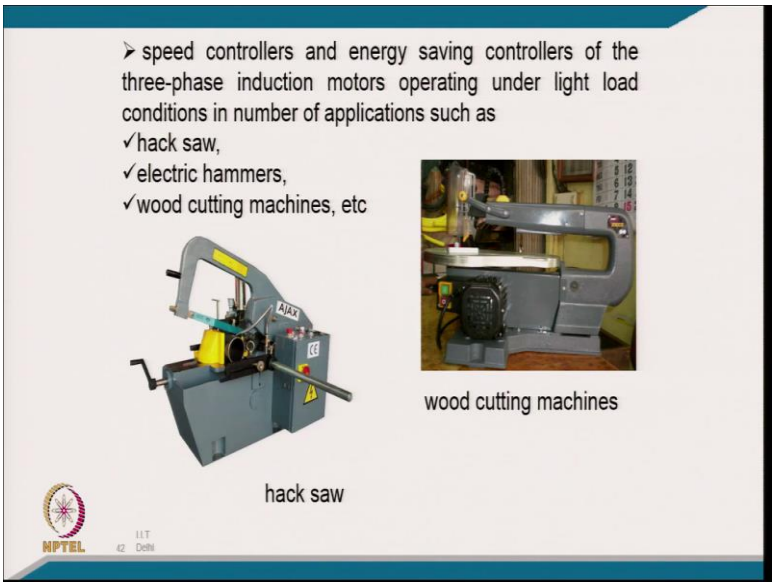

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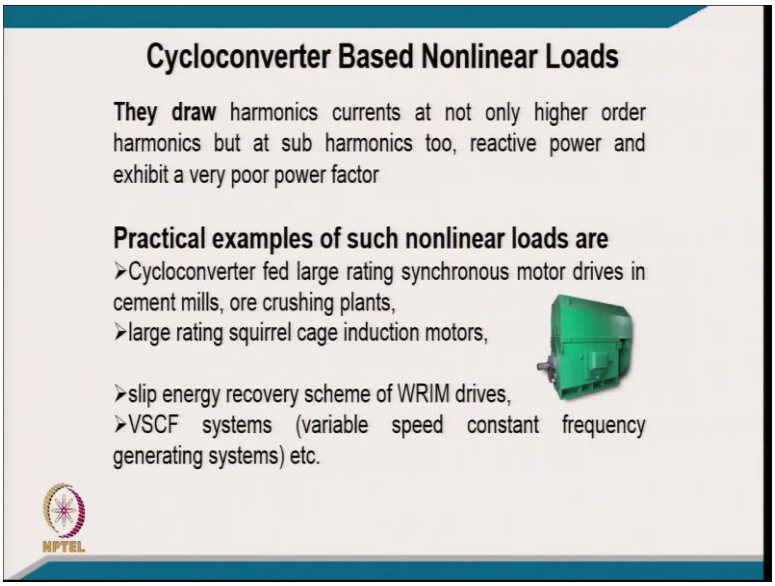

Another is the cycloconverter based non-linear load; they draw the harmonics current at not only higher order, but at the sub harmonics too and exhibit a very poor factor. Practical examples of such non-linear load are cycloconverter fed large rating synchronous motor drive in cement mill, ore crushing plant; large rating squirrel cage induction motor; slip recovery scheme of wound rotor induction motor drive; variable speed constant frequency generation system.

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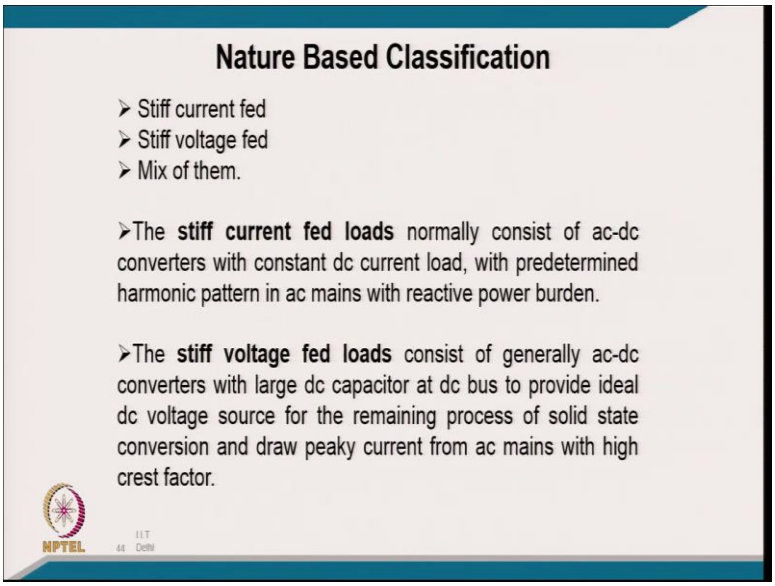

Now, stiff current fed, which is like a thyristor converter with the highly inductive load; I mean they behave like as a current fed, in the sense dc side current is constant. Stiff voltage source is diode rectifier with the capacitive filter on dc side.

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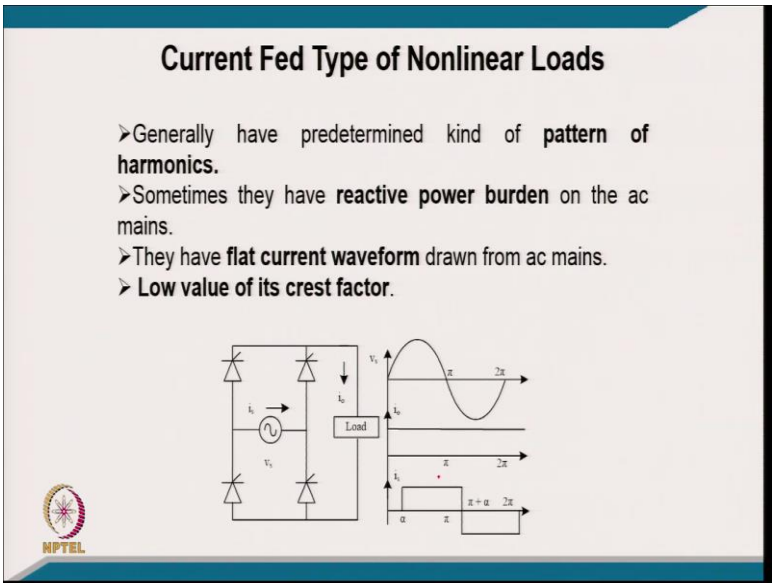

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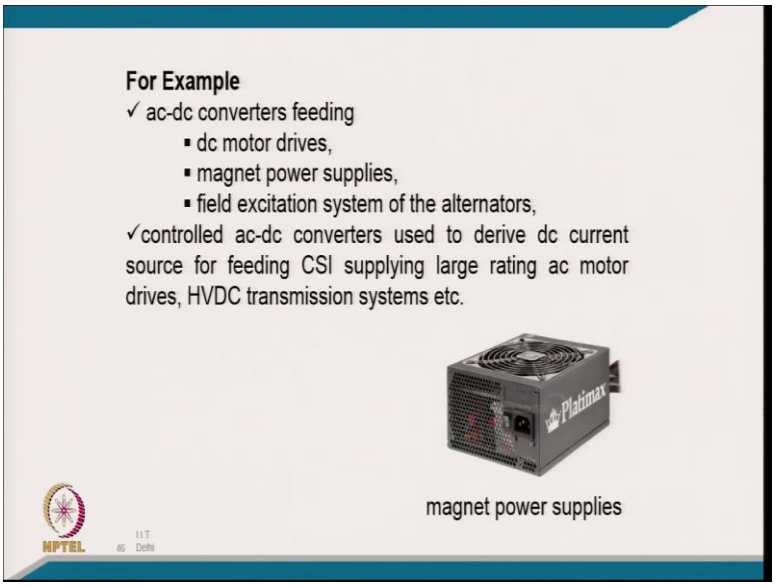

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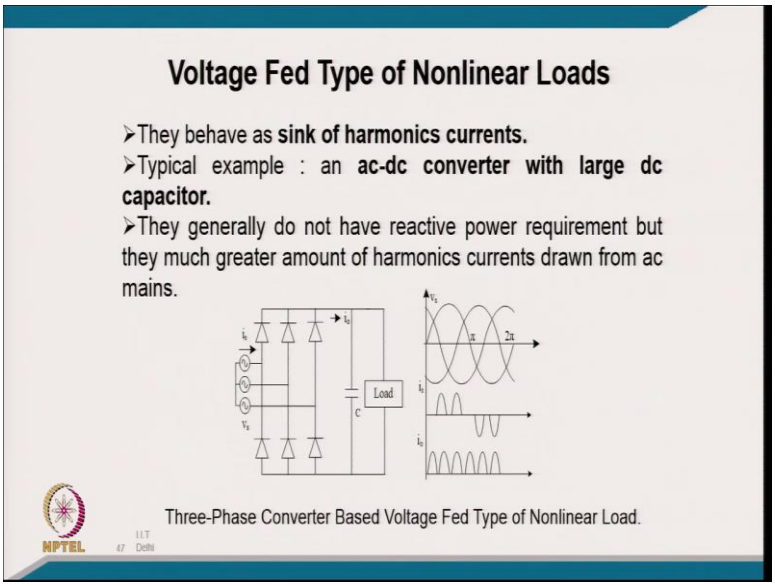

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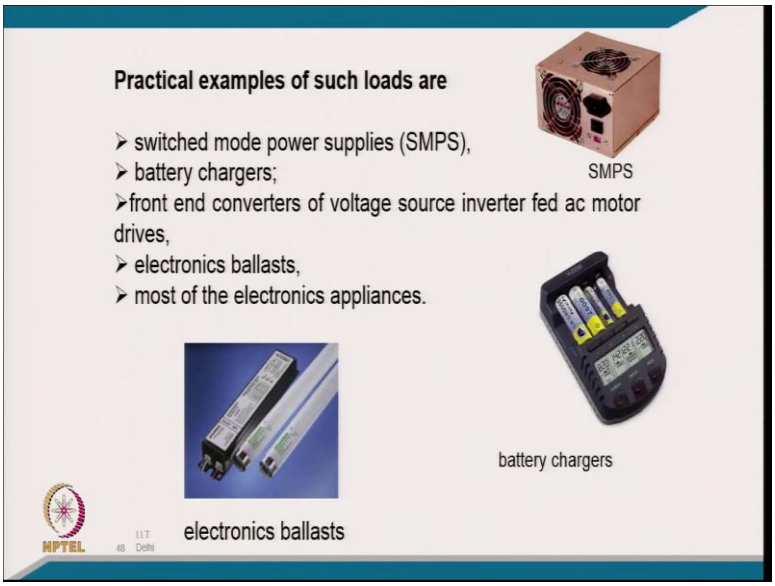

The practical example of such loads are switched mode power supply, battery charger, front end converter for voltage source inverter fed ac motor, electronic ballast, most of electronics appliances; like electronic ballast or typically your switched mode power supply comes under the category of battery charger or so with this like.

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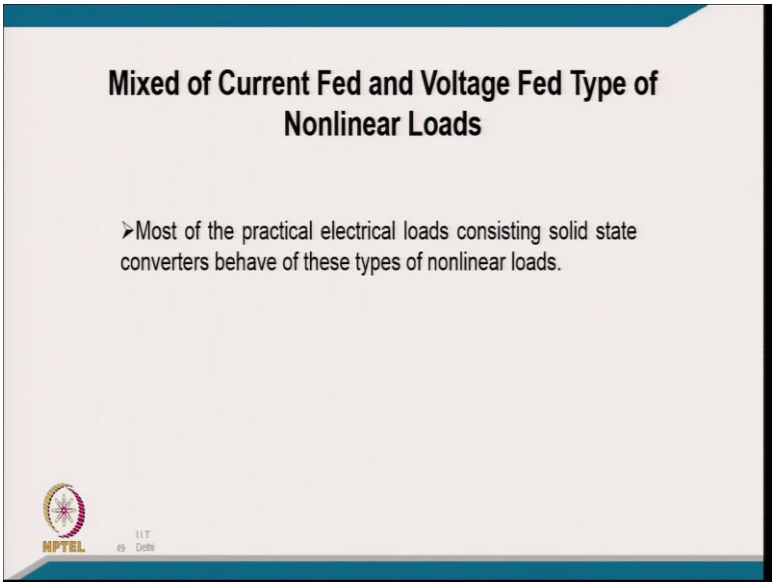

And mixed kind of current fed and voltage fed load mostly practical electrical load consisting solid state converter behave of these kind of non-linear load.

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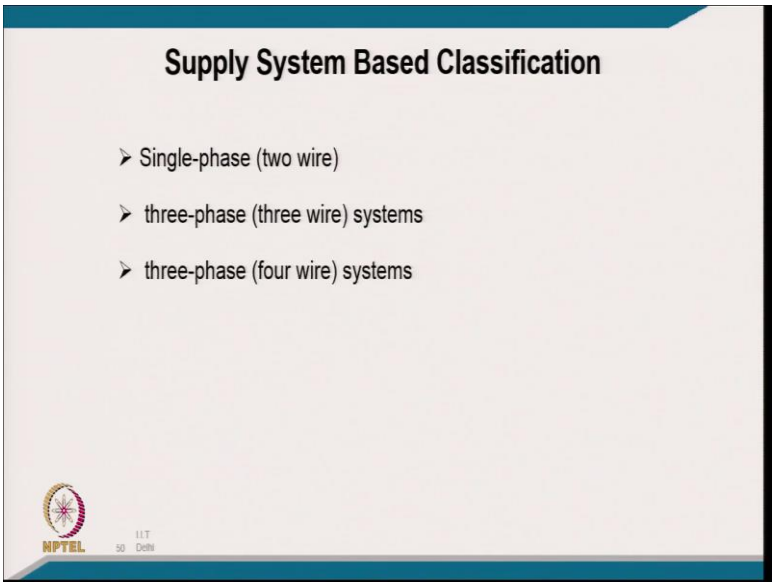

And supplies system based classification we already talk about like a single phase two wire, three phase three wire, three phase four wire.

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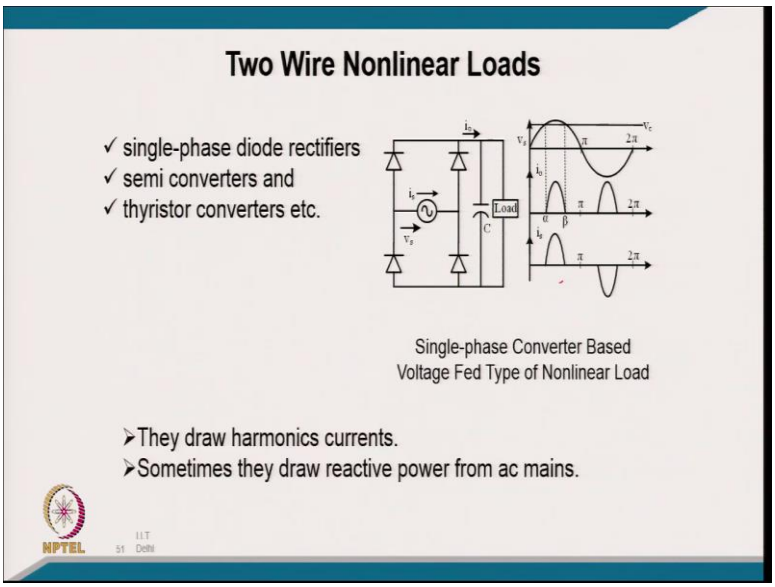

And coming to like a single phase, typically two wire non-linear load is like single phase diode rectifier, semi converter, thyristor converter. Peaky current and with crest factor quite high is drawn from ac mains.

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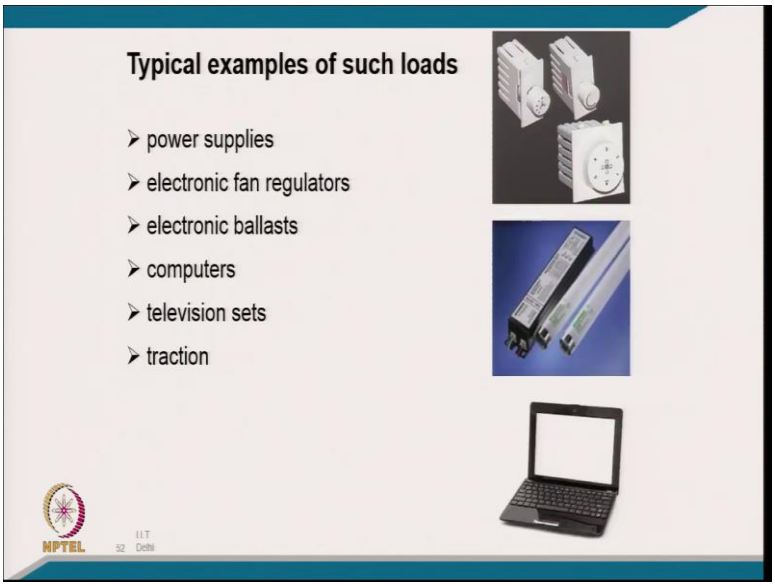

The type of examples such load are power supply, electronics fan regulator for BLDC, then electronic ballast, computers, television, traction of this kind of load, like I mean laptop or other.

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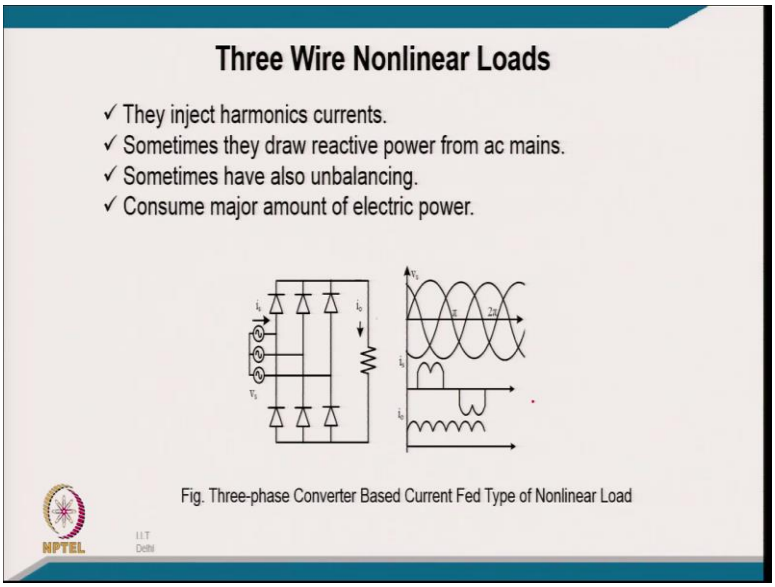

They inject the harmonics current, sometime they draw reactive power from ac mains, sometime they have also unbalanced current or unbalancing current.

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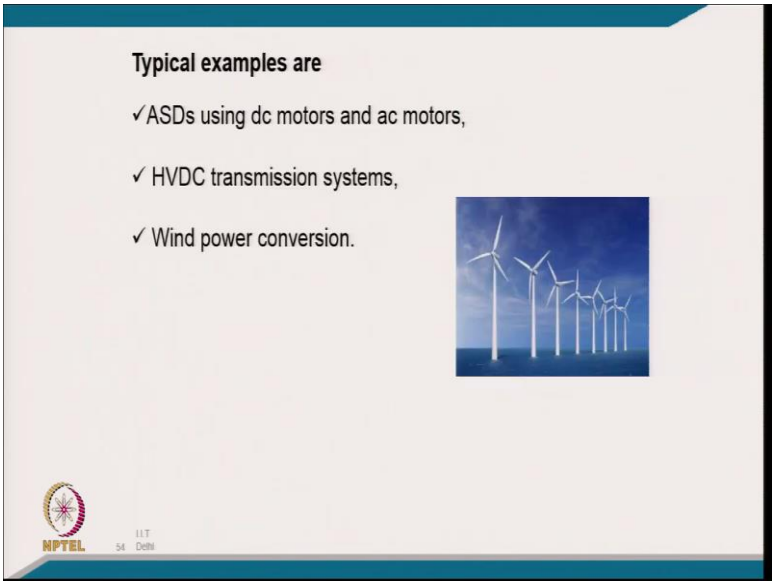

Typical examples are adjustable speed drive using dc motors and ac motor, HVDC system, wind power conversion system.

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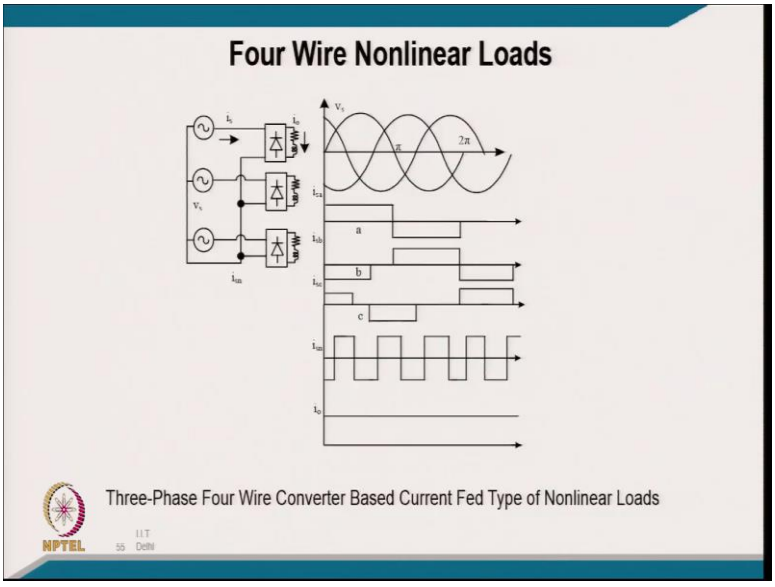

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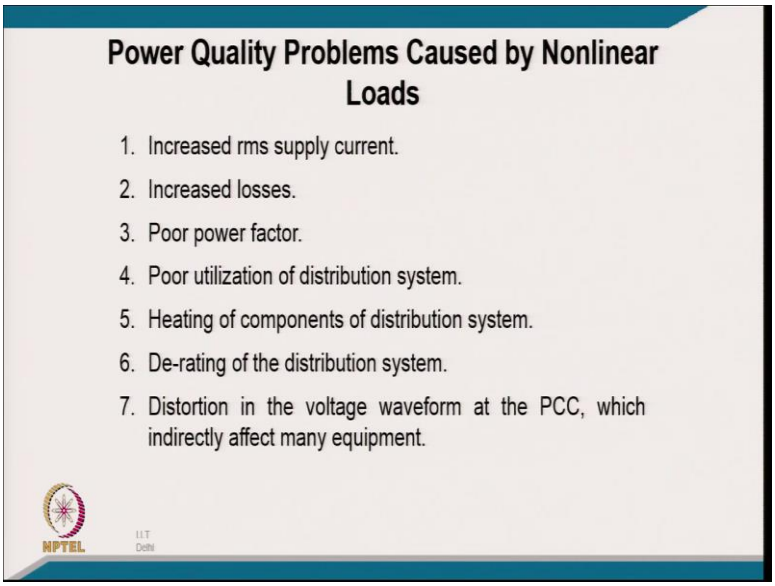

The power quality problems due to nonlinear loads are listed in the pasted slides.

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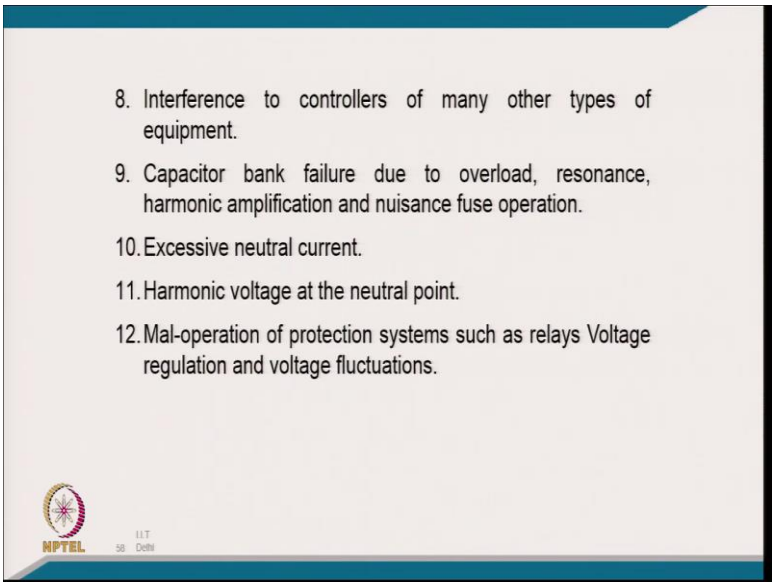

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