电源适配器测试方法
Testing methods for power supplies

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参照依据Reference

★中国节能产品认证管理委员会

单路输出式AC/DC外部电源适配器节能产品认证技术要求

★Test Method for Calculating the Energy Efficiency of Single-Voltage External Ac-Dc Power Supplies

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Arshad Mansoor, Power Electronics Application Center (EPRI-PEAC)

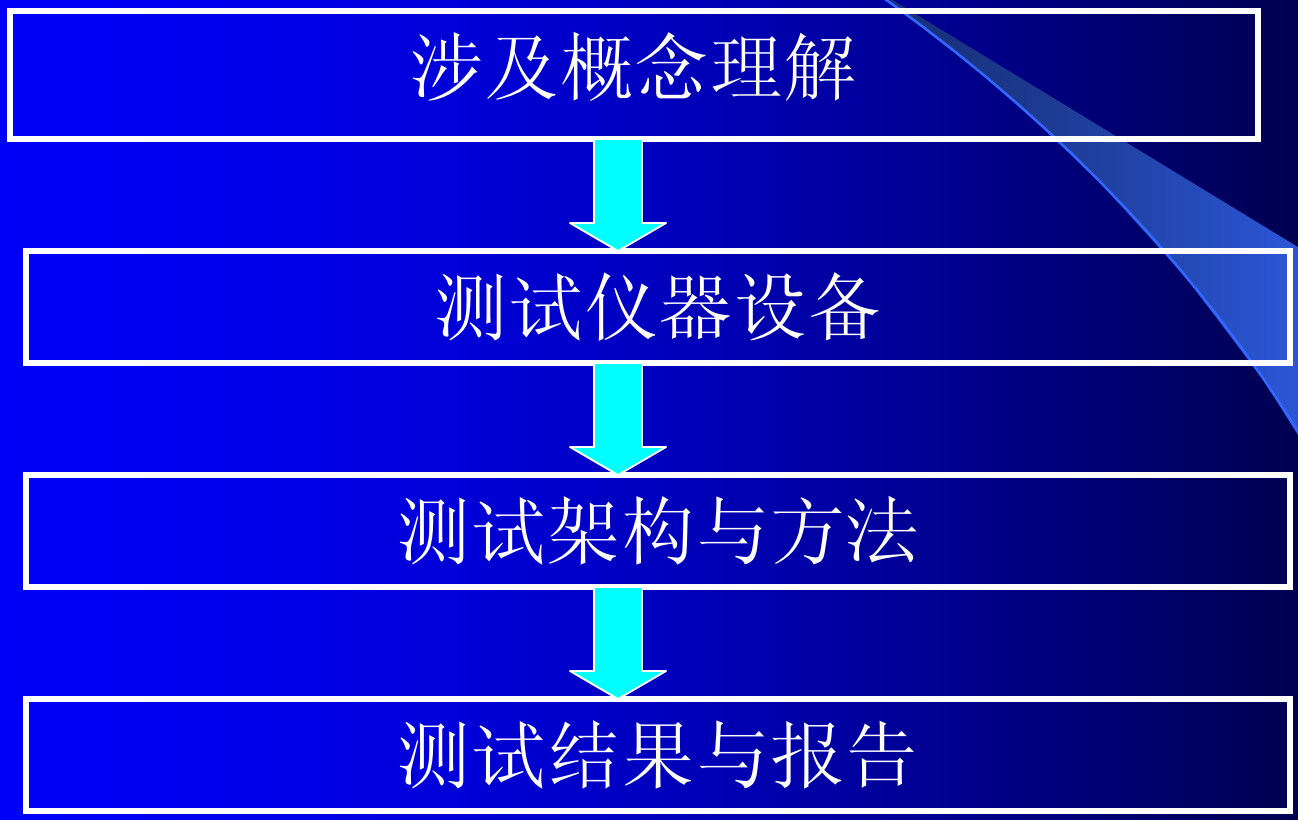
测试目标参数

电源适配器的能效限定值及节能评价的参数指标：

☆ 平均效率 Average Efficiency

☆ 空载功耗 No Load Power

讲义提纲



定义-1

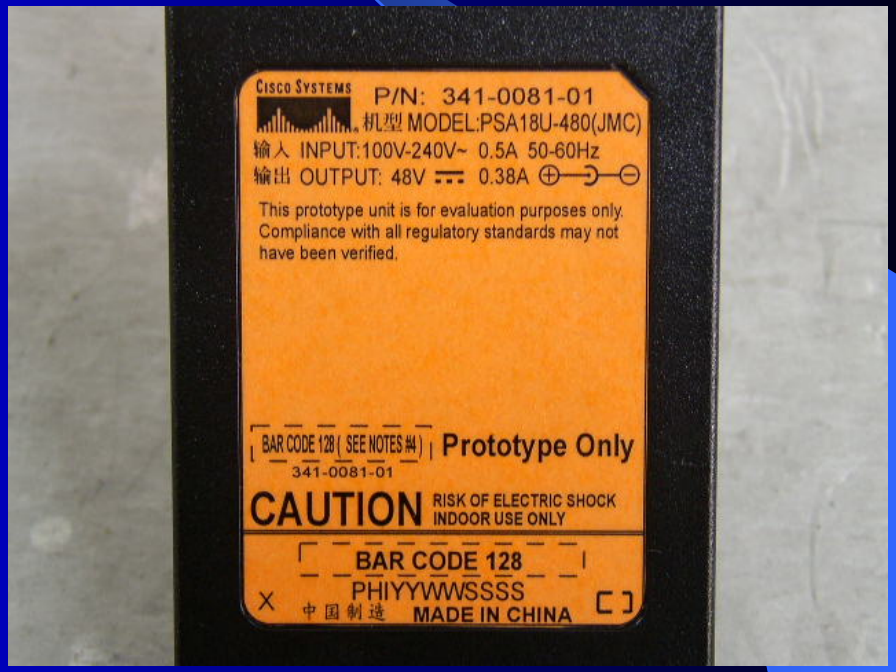
- 电源适配器：

Power Supply、 Power Adaptor

- 线性电源适配器 Linear Power Adaptor

- 开关电源适配器 Switching Mode power supply

开关电源适配器
Switching mode power supply



定义-2

- 视在功率（Apparent Power)---S：
- 有功功率(Real power)---P
- 无功功率(Reactive Power)---Q
- 功率因素（Power Factor)---PF

定义-3

- 额定输出电压

Rated Output Voltage

- 额定输出电流

Rated Output Current

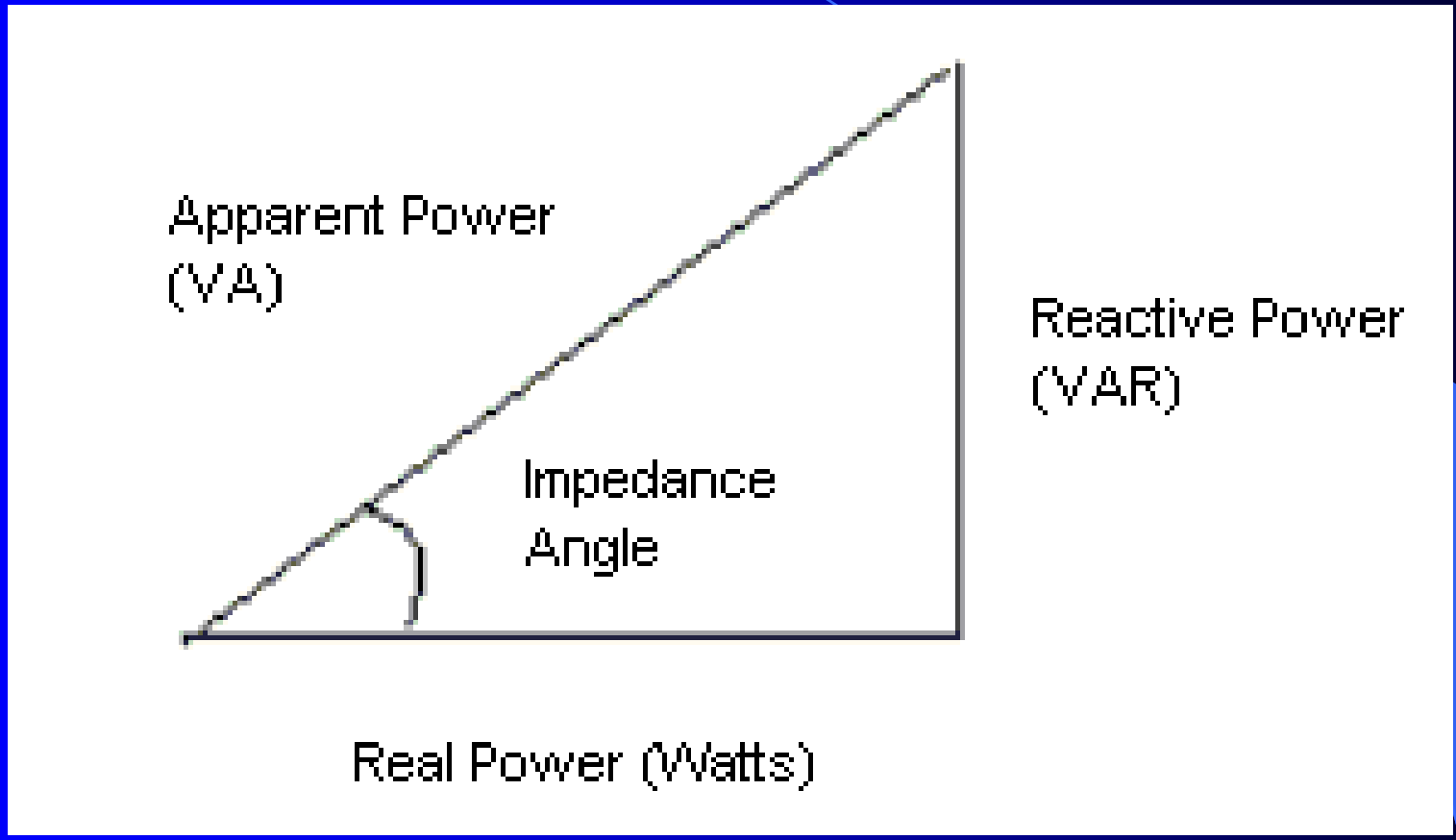
功率概念应用-1

the actual power calculation depends on the resistive and reactive components (capacitors and/or inductors) in the circuit. The power dissipation in a purely resistive circuit is always a function of the voltage drop and current draw through the circuit.

功率概念应用-2

Reactive circuits appear to function like resistive circuits because they produce voltage drops and draw current. However, reactive circuits actually store or return power. The reactive components cause a phase shift (up to 90 degrees) between the voltage and current waveforms which reduces the overlap between the two curves and effectively delivers less power to the loads. This phenomenon is represented by three different power measurements: reactive power, apparent power, and real power. These three power measurements have a phase relationship that can be visualized in the power triangle, shown below.

功率三角图



$$p = UI\cos\phi(1-\cos 2\omega t) + UI\sin\phi\sin 2\omega t$$
$$= P(1-\cos 2\omega t) + Q\sin 2\omega t$$

关系等式

- (Apparent Power)^2 =

  (Real Power)^2+(Reactive Power)^2

- Reactive Power = (Apparent Power)*Sin ϕ

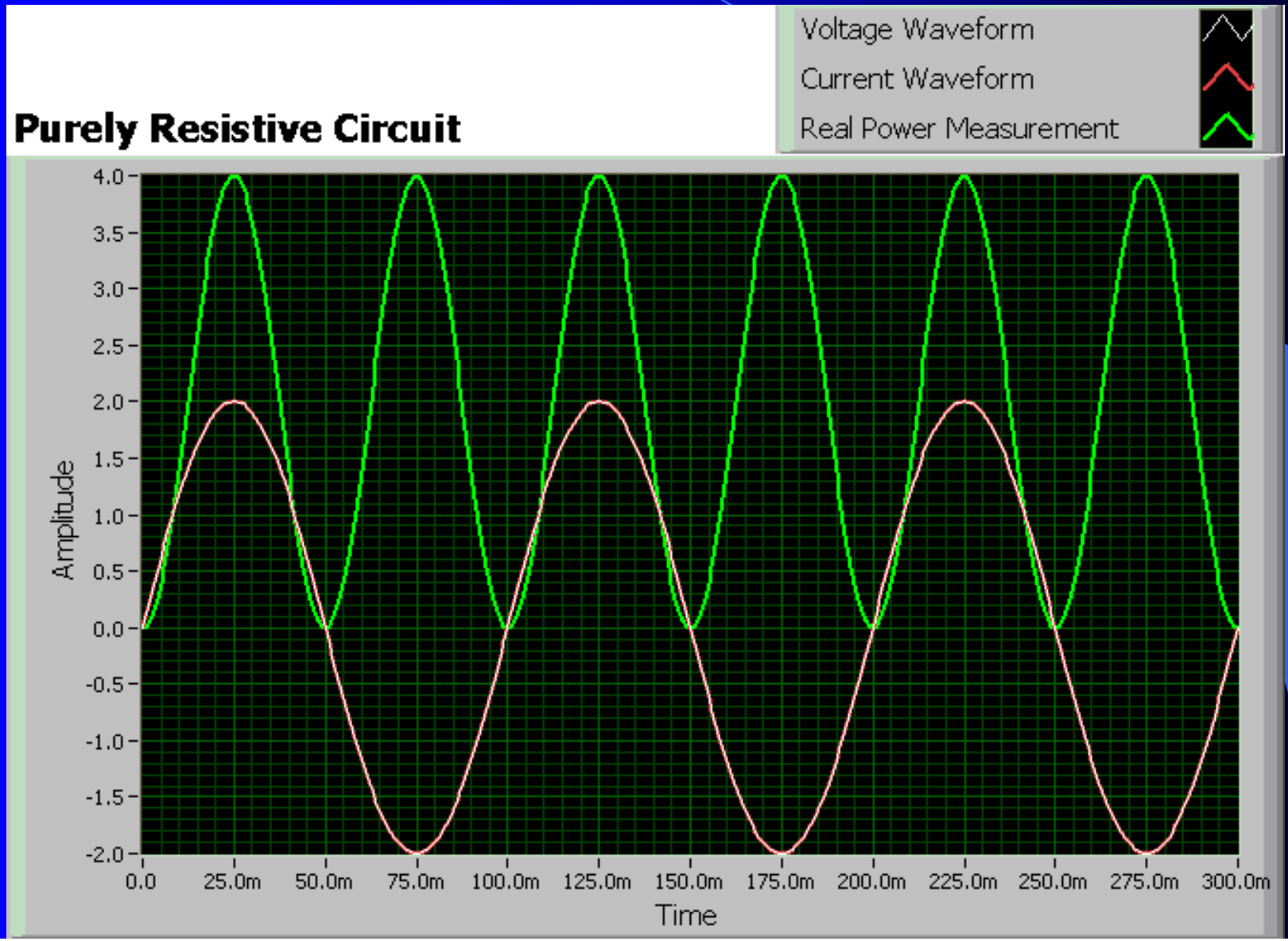
- Real Power = (Apparent Power)*(Power Factor)

  = (Apparent Power)* COS ϕ

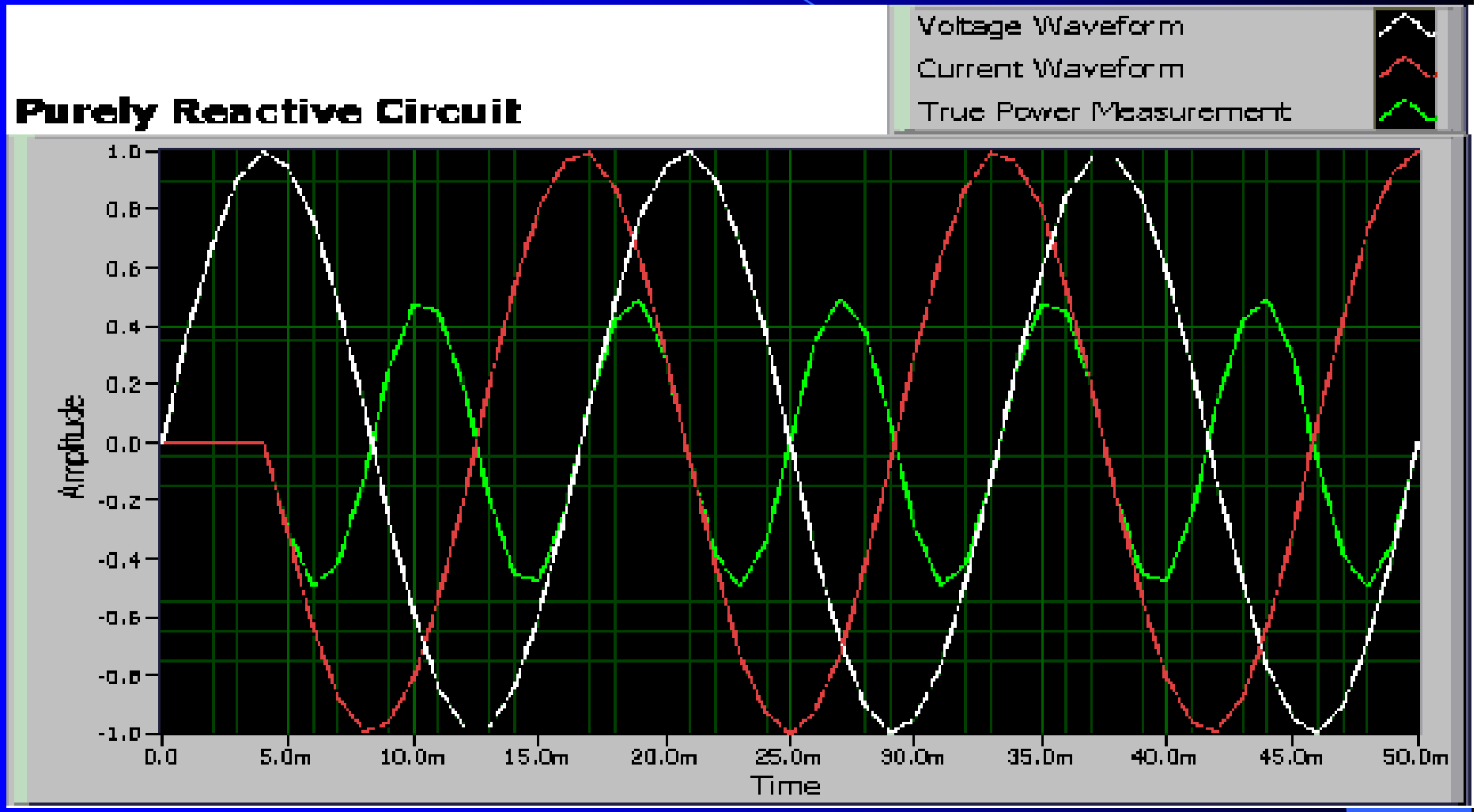
- Power Factor = Real Power / (Apparent Power)

  = COS ϕ

纯电阻电路功率波形


Purely Resistive Circuit
Voltage Waveform
Current Waveform
Real Power Measurement
Amplitude
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
0.0
25.0m
50.0m
75.0m
100.0m
125.0m
150.0m
175.0m
200.0m
225.0m
250.0m
275.0m
300.0m
Time

纯电感性电路


Purely Reactive Circuit
Voltage Waveform
Current Waveform
True Power Measurement
Amplitude
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
0.0
5.0m
10.0m
15.0m
20.0m
25.0m
30.0m
35.0m
40.0m
45.0m
50.0m
Time

更多...

电压

电流

视在功率

有功功率

无功功率

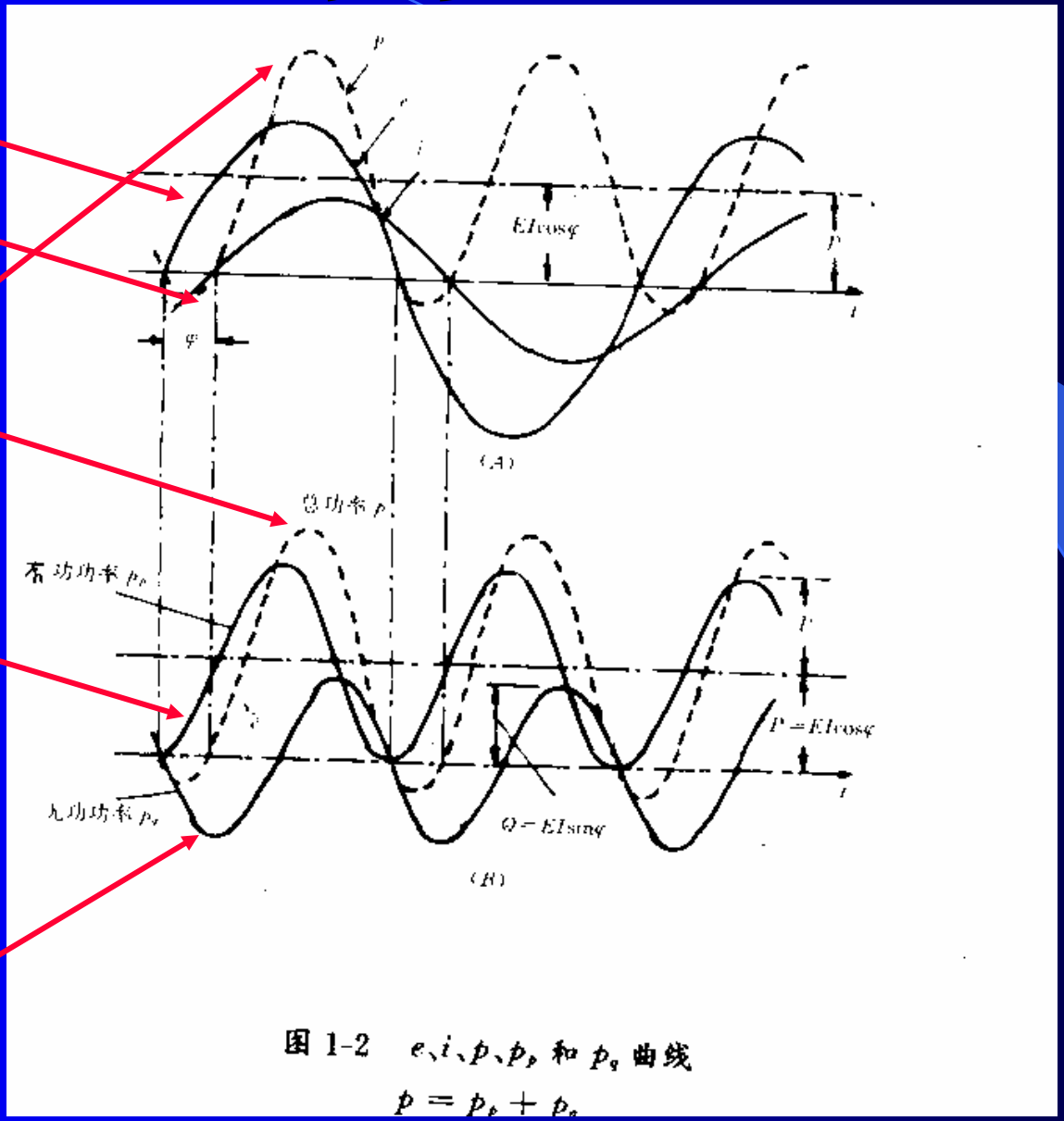


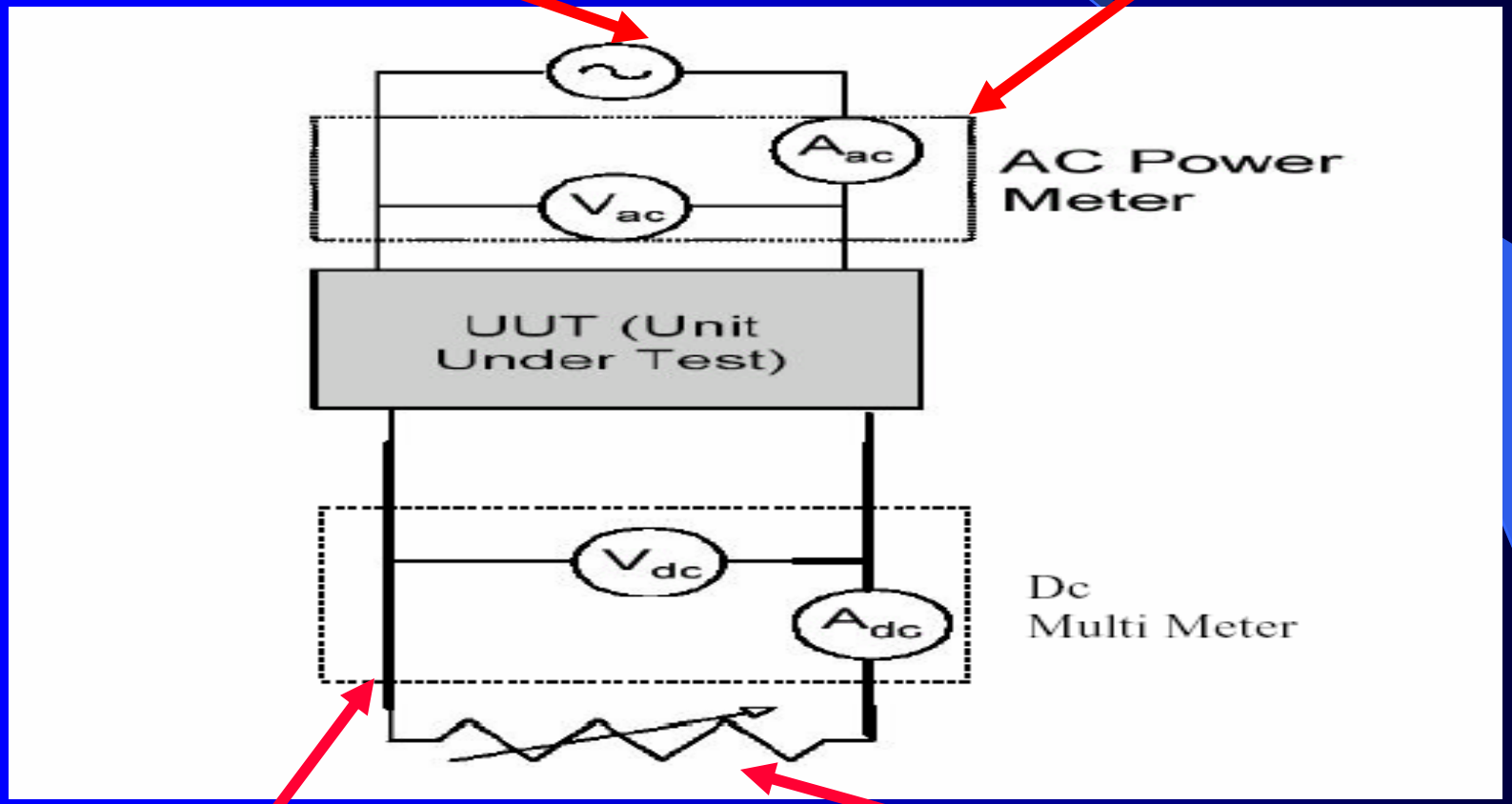
图 1-2　e、i、p、p_p 和 p_q 曲线

$p = p_p + p_q$

测试仪器

电源

功率计



万用表

负载

测试仪器-调频电源
Ac Power Source

☆调频电源：

★电压、频率可调，容量足够大（10×Input power)

★负载稳定度好

★谐波失真小（2%），利用功率计或音频信号分析仪测试其谐波失真

调频电源Ac Power Source —15kVA

功率计 Power Meter

作用：

☆空载或带载状态下输入功率测试

☆带载输出功率测试

要求：

★准确度高

★电压测试电路的输入阻抗高

★电流测试电路的输入电阻低

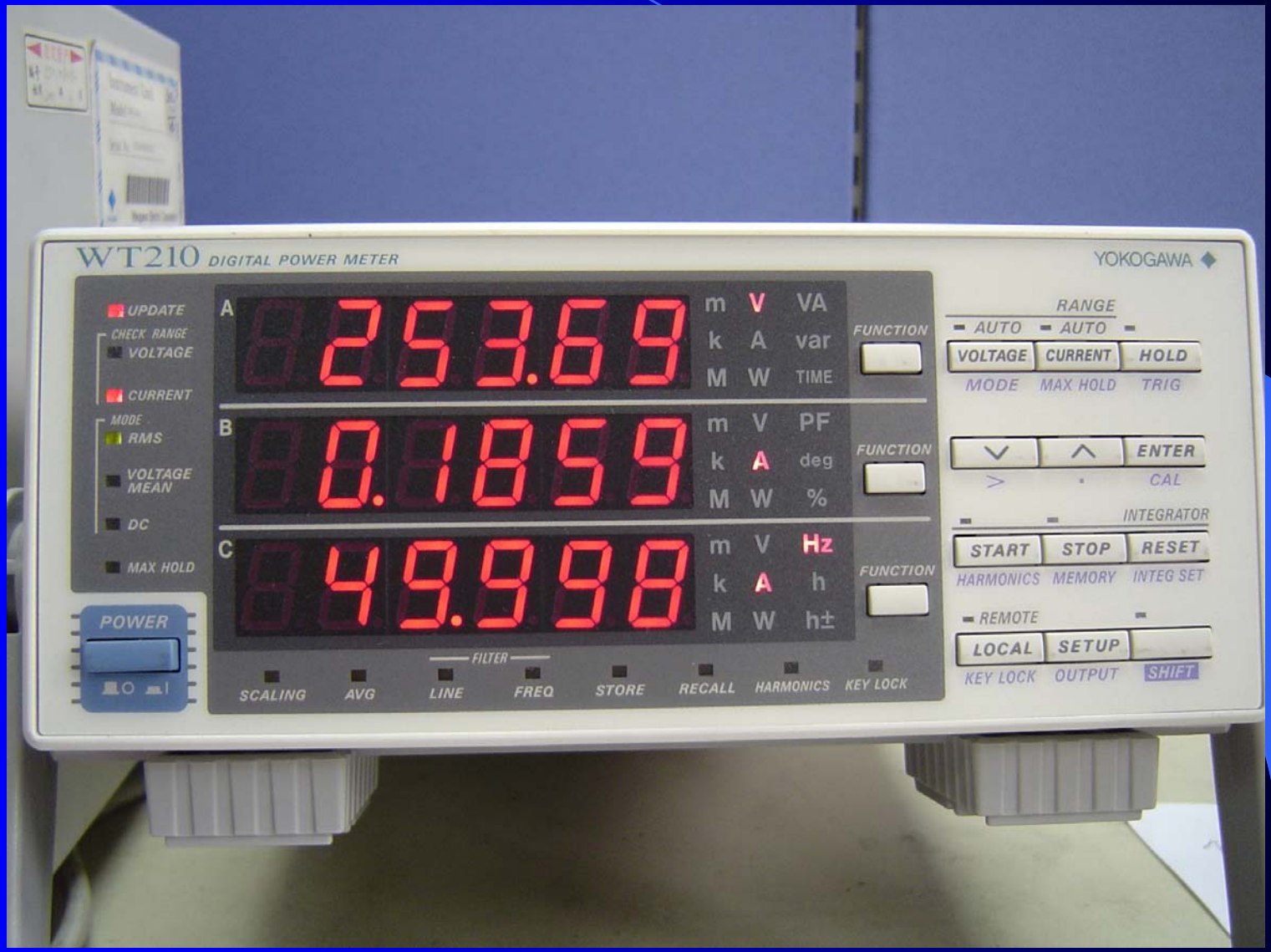
★最好带谐波失真分析功能

YOKOGAWA WT210功率计

Basic power accuracy Basic voltage and current accuracy	0.1% of reading +0.1% of range
The input resistance of the voltage measurement circuit	Approximately 2MΩ
The input resistance of the current measurement circuit	Approximately 6mΩ

功率计

—输入功率或输出功率测试



功率计—接线端子


20A≂
MAX
EXT
CURRENT
10V≂ MAX /
200mV≂ MAX
ALL TERMINALS
600V MAX TO ⏚
CAT II

Improving the measurement accuracy

☆ When the measurement current is relatively large, the voltage measurement circuit is connected to the load side.

☆ When the measurement current is relatively small, the current measurement circuit is connected to the load side.

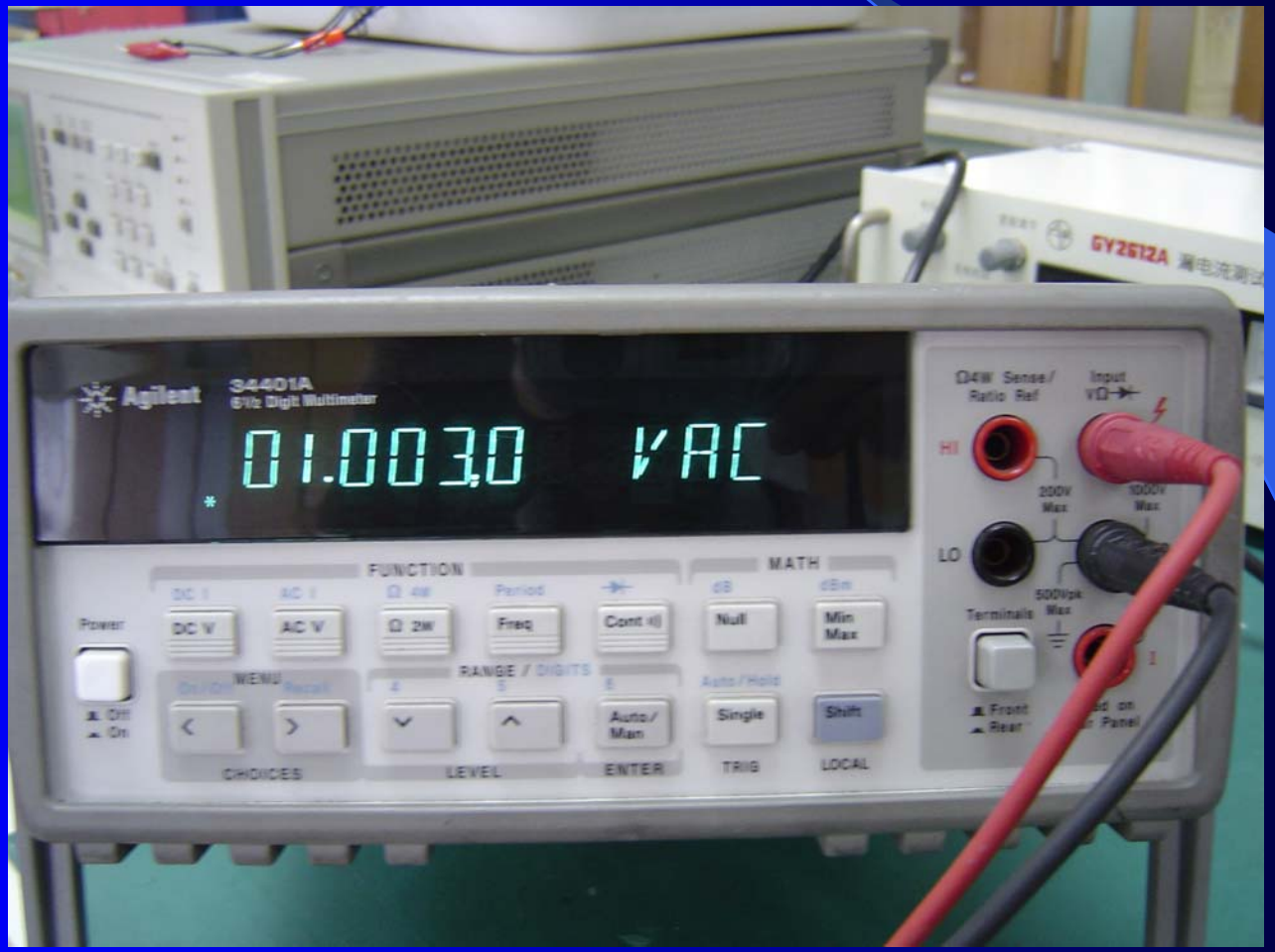
功率计—测试示例

验证1： $P^2+Q^2=S^2$ （ G=LAG , d=lead)

验证2： $P=S*\cos\phi$, $PF = \cos\phi$

数字万用表 Multi-meter

---输出电压与电流测试



Agilent 34401A multi-meter

Measuring Characteristics

DC Voltage	
Measurement Method:	Continuously integrating, multi-slope III A/D converter.
A/D Linearity:	0.0002% of reading + 0.0001% of range
Input Resistance:	
0.1 V, 1 V, 10 V ranges	Selectable 10 MΩ or >10 GΩ [11]
100 V, 1000 V ranges	10 MΩ ±1%
Input Bias Current:	< 30 pA at 25°C
Input Terminals:	Copper alloy
Input Protection:	1000 V on all ranges
Resistance	
Measurement Method:	Selectable 4-wire or 2-wire ohms. Current source referenced to LO input.
Max. Lead Resistance: (4-wire ohms)	10% of range per lead for 100 Ω, 1 kΩ ranges. 1 kΩ per lead on all other ranges.
Input Protection:	1000 V on all ranges
DC Current	
Shunt Resistor:	0.1Ω for 1A, 3A. 5Ω for 10 mA, 100 mA
Input Protection:	Externally accessible 3A, 250 V fuse Internal 7A, 250 V fuse

仪器比较

数字万用表： 异步时钟

a traditional digital multimeter has asynchronous clocks and does not provide waveform acquisition capability

数字功率计：同步时钟

Measurement synchronization source

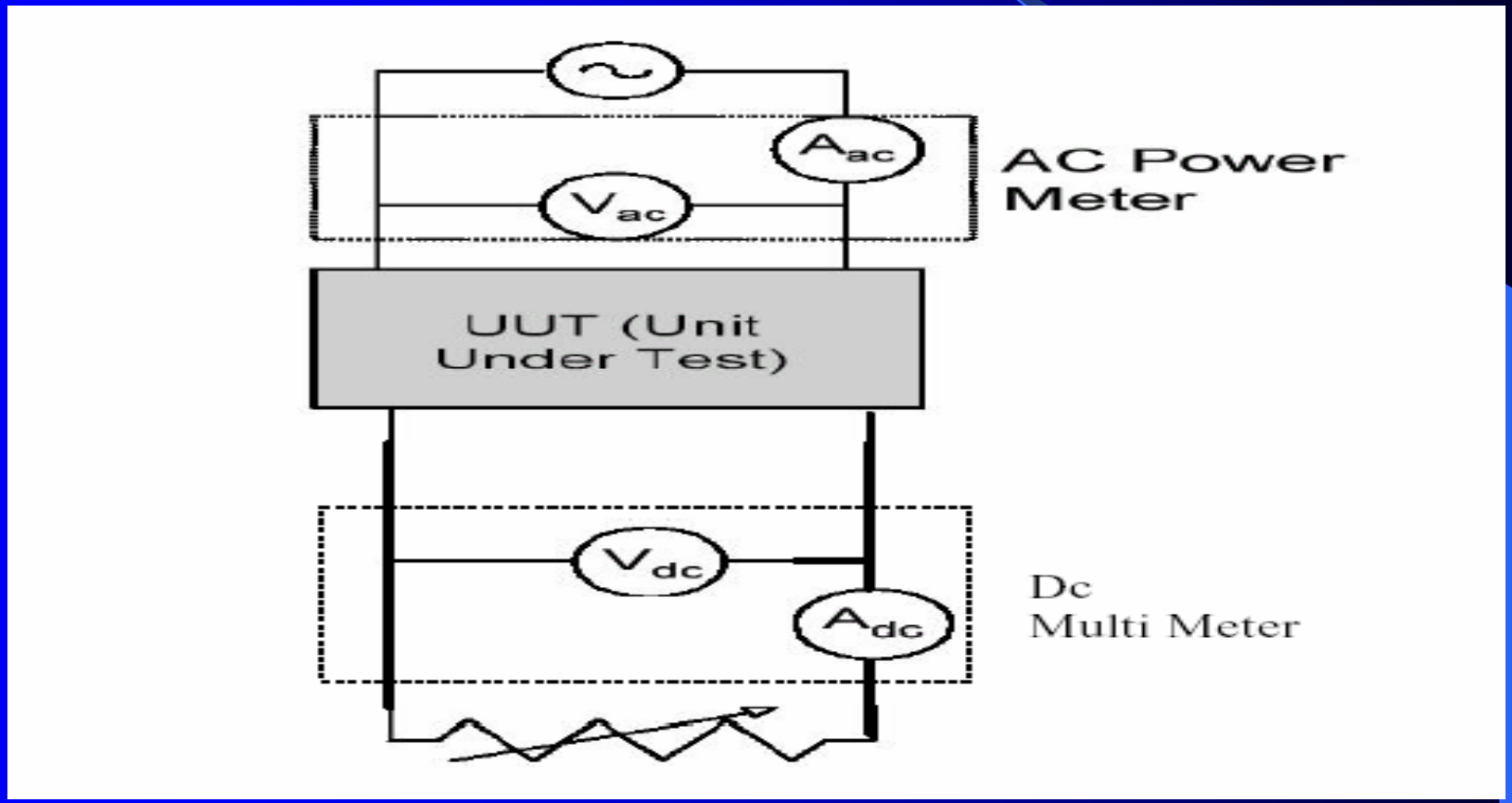
负载

☆可调电阻器 Variable Resistive Loads

☆电子负载 Electronic Load

Adjusted in Constant Current (CC) mode rather than in Constant Power mode

测试连接
Building Measurement System



测试环境

★置于非导热表面. The UUT shall be tested on a thermally non-conductive surface.

★无强制、直接通风冷却,不外加散热器There shall be no intentional cooling of the UUT by use of separately powered fans, air conditioners, or heat sinks.

★环境温度为20±5℃， The ambient temperature shall be maintained at 20 ± 5° C throughout the test， Products intended for outdoor use may be tested at additional temperatures

负载连接

Power supplies that are packaged for consumer use to power a product must be tested with the dc output cord supplied by the manufacturer. There are two options for connecting metering equipment to the output of this type of power supply: cut the cord immediately adjacent to the dc output connector, or attach leads and measure the efficiency from the output connector itself. If the power supply is attached directly to the product that it is powering, cut the cord immediately adjacent to the powered product and connect dc measurement probes at that point.

测试准备

☆ 连接导线应足够粗，尽量短。

☆ 带开关时，应将开关置于“ON ”位置

输入电源测试点

★ 230V，50Hz

Euro: 240V/50Hz

China and UK: 220V/50Hz

★ 115V，60Hz

USA: 120V/60Hz

Japan: 110V/50Hz/60Hz

测试顺序

预热30min

↓

额定电流100%±2%条件下

↓

额定电流75%±2%条件下

↓

额定电流50%±2%条件下

↓

额定电流25%±2%条件下

↓

额定电流0%条件下

结果评定

☆效率

Active Mode Efficiency=(Real output power) / (Real input power)*100%

☆平均效率

Average Efficiency

Arithmetic Average of Efficiency at four kind of different Load Conditions

☆空载功率 No Load Power

结果示例

Summary of EPS Testing at Ecos, PEAC, and CEPREI							
		115 V, 60 Hz			230 V, 50 Hz		
Power Supply	Test Lab	No Load (ac watts)	Average Active Efficiency	Average Active Efficiency of all Labs	No Load (ac watts)	Average Active Efficiency	Average Active Efficiency of all Labs
8.25W, 1A	Ecos	0.38	65.9%	66.3%	0.91	59.7%	61.1%
	PEAC	0.39	65.8%		0.88	60.7%	
	CEPREI	0.39	67.1%		0.94	62.9%	
5W, 0.5A	Ecos	1.18	60.3%	60.1%	2.42	51.4%	51.8%
	PEAC	1.18	59.9%		2.33	52.7%	
	CEPREI	1.22	60.1%		2.45	51.3%	
8.5W, 0.26A	Ecos	0.24	75.0%	74.9%	0.40	69.0%	69.2%
	PEAC	0.24	73.8%		0.39	68.8%	
	CEPREI	0.26	75.8%		0.45	69.8%	
24W, 1A	Ecos	0.95	78.2%	80.3%	1.08	80.4%	79.7%
	PEAC	0.92	81.2%		0.98	78.7%	
	CEPREI	0.98	81.4%		1.13	80.0%	
10W, 400mA	Ecos	0.08	76.8%	77.5%	0.30	71.3%	71.0%
	PEAC	0.09	77.0%		0.32	70.7%	
	CEPREI	0.09	78.7%		0.34	71.0%	
22.5W , 1A	Ecos	0.83	79.4%	79.2%	1.64	68.3%	69.6%
	PEAC	0.79	78.9%		1.62	69.8%	
	CEPREI	0.61	79.3%		1.47	70.8%	

测试报告Test Report —Sample Information

- ☆ UUT manufacturer,
- ☆ UUT model number,
- ☆ UUT dc cord length (± 1 cm),
- ☆ whether a built-in switch is present on the UUT,
- ☆ product powered by the UUT if known,
- ☆ photo of UUT that a) clearly shows nameplate information and b) displays the size of the entire UUT with a centimeter rule for scale, UUT country of manufacture

Test Report—Lab information

- ☆ name of test lab, name of technician performing the test,
- ☆ ambient temperature immediately surrounding the UUT (± 1 ° C),
- ☆ date and location of test,

Test Report-Test Equipment

- ☆ Equipment Name, Model
- ☆ Equipment serial No.
- ☆ and a description of test equipment used with most recent calibration date

仪器信息示例

序号	仪器、设备名称	型号、规格	计量有效期
1	数字功率计 power meter	WT200(SN:12A506038E) used for input measurement	2003.12.31-2004.12.31
2	数字功率计 power meter	WT200(SN:12A506036E) used for output measurement	2004.01.17-2005.01.17
3	数字多用表multi-meter	34401A（SN：US36140477）	2004.01.17-2005.01.17
4	调频电源 Ac power supply	AFC-15KB（SN：F20107022）	2004.04.27-2005.04.27

Test Report—test data

- ☆ The key data (measured and calculated) to report for each input voltage and frequency combination at which was test conducted.

Test Report—Test Data

Table 2 – Required Reported Data (Measured and Calculated)

Reported Quantity	***Description***
Dc Output Current (mA)	Measured at Load Conditions 1 – 4
Dc Output Voltage (V)	
Dc Output Power (W)	
Ac Input Voltage (V)	Measured at Load Conditions 1 – 5
Ac Input Power (W)	
Total Harmonic Distortion (THD)	
True Power Factor	
Power Consumed by UUT (W)	Calculated at Load Condition 1 – 4, Measured at Load Condition 5
Efficiency	Calculated at Load Conditions 1 – 4
Average Efficiency	Arithmetic Average of Efficiency at Load Conditions 1 – 4

感谢您*Thank You*