Technical Guide
“Power Factor Basics”

Small and Medium Enterprises Development Authority

Ministry of Industries & Production
Government of Pakistan

www.smeda.org.pk

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2 Introduction to SMEDA

The Small and Medium Enterprises Development Authority (SMEDA) was established in October 1998 with an objective to provide fresh impetus to the economy through development of Small and Medium Enterprises (SMEs).

With a mission "to assist in Employment Generation and Value Addition to the national income, through development of SME sectors, by helping increase the number, scale and competitiveness of SMEs", SMEDA has carried out 'sectoral research' to identify Policy, Access to Finance, Business Development Services, strategic initiatives and institutional collaboration & networking initiatives.

Preparation and dissemination of prefeasibility studies in key areas of investment has been a successful hallmark of SME facilitation by SMEDA.

Concurrent to the prefeasibility studies, a broad spectrum of Business Development Services is also offered to the SMEs by SMEDA. These services include identification of experts and consultants and delivery of need-based capacity building programs of different types in addition to business guidance through help desk services.

2.1 Industry Support Program

In order to enhance competitiveness of SMEs and achieve operational excellence, SMEDA established an Industry Support Cell (ISC) for provision of foreign technical support and knowledge transfer in collaboration with International Development Organizations. SMEDA's Industry Support Program (ISP) initially launched with Japan International Cooperation Agency (JICA) and actively engaged in reducing energy inefficiencies and improving production and quality of products with the support of Japanese Experts. Later on, similar activities with other international partner organizations like German Corporation for International Cooperation (GIZ), Training and Development Centers of the Bavarian Employers' Association (bfz), Germany, and United Nations Industrial Development Organization (UNIDO) were also successfully implemented.

3 What Is Power Factor?

Power factor is one of the most important feature of electrical distribution system and the efficiency of whole electrical distribution system highly depends upon power factor.

We can define power factor as

'' Power Factor is the ratio of Active Power to Apparent Power''

Now in order to understand the concept of Power Factor we will first have to understand some basic terms like active power (kW), reactive power (kVAR) and apparent power (kVA)

We will define each one of them below

3.1 Active Power (kW)

Active Power (also known as real power or actual power) is the power that actually powers the equipment and performs useful work). It is represented by kW in technical literature.

3.2 Reactive Power (kVAR)

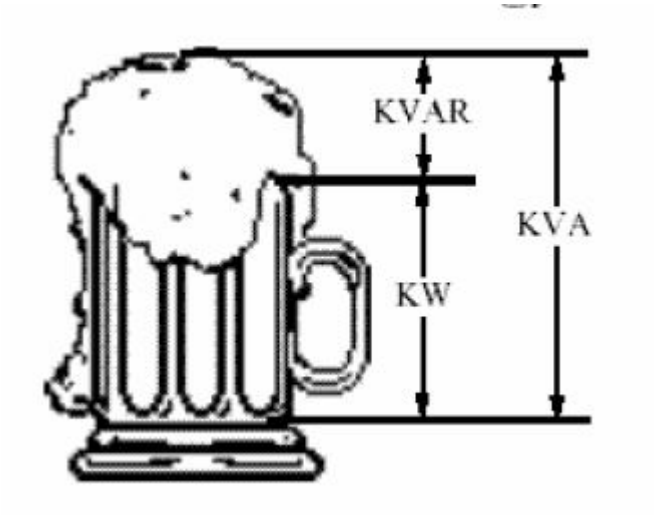
The power required by the magnetic equipment (Transformer, Motor and Relay) to produce the magnetic flux, is known as reactive power. It is represented by kVAR in technical literature.

3.3 Apparent Power (kVA)

Apparent Power is the vector sum of active power and reactive power. It is represented by kVA in technical literature. Most of the electrical equipment are rated in kVA.

3.4 Coffee-Mug Analogy

Now let's look at a simple analogy in order to better understand these terms. The most popular analogy to understand these terms is the coffee-mug analogy. You order a mug of coffee and when your order arrives the third portion of your mug is filled with coffee and the remaining portion is froth as shown in following figure



The frothy portion is representing the reactive power (kVAR) because it will not soothe your coffee craving while the coffee portion represents active power (kW) which will be actually responsible for satisfying your coffee needs. Total contents of the mug will represent apparent power (kVA) (Sum of coffee and frothy portion).

Now as we know that power factor is the ratio of active power to apparent power

$$P.F. = \frac{Active\ Power}{Apparent\ Power}$$

Thus,

$$P.F. = \frac{kW}{kVA}$$

Looking at our coffee-mug analogy we can further elaborate this equation as

$$P.F. = \frac{Coffee}{Coffee + Froth}$$

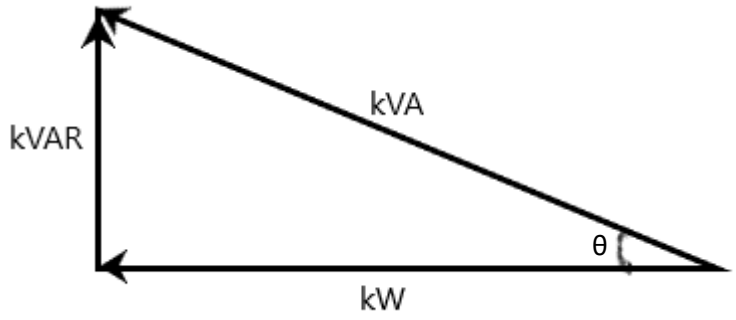
Furthermore,

$$P.F. = \frac{kW}{kW + kVAR}$$

In simple words, we can say that higher the value of kVAR lower will be the value of power factor and vice versa.

Coffee-mug analogy is a bit simple. In reality, apparent power (kVA) is the vector sum of active power and reactive power. Therefore, for this purpose we have to consider the power triangle and the angle (Theta θ) between active power and reactive power.

3.5 The Power Triangle



As we know that

$$P.F. = \frac{kW}{kVA}$$

Thus from the power triangle

$$\cos\theta = \frac{Base}{Hypotenuse}$$

Here

Base = kW

Hypotenuse – kVA

$$\cos\theta = \frac{kW}{kVA}$$

Which implies that

$$\boldsymbol{P.F. = \cos\theta}$$

Now in simple words we can write as

$$\boldsymbol{Power\ Factor = P.F. = cos\theta = \frac{kW}{kVA}}$$

4 Types of Power Factor

Mainly power factor is categorized into two types

A. Lagging Power Factor
B. Leading Power Factor

4.1 Lagging Power Factor

The term ‘’Lagging Power Factor’’ is used where the load current lags behind the supply voltage. This property of current lagging the voltage belongs to inductive loads, meaning inductive loads will cause a lagging power factor.

Lagging power factor values are shown by positive‘’ + ‘’ sign.

4.2 Leading Power Factor

The term ‘’Leading Power Factor’’ is used where the load current leads the supply voltage. This property of current leading the voltage belongs to capacitive loads, meaning capacitive loads will cause a leading power factor.

Leading power factor values are shown by negative ‘’ - ‘’ sign.

4.3 Disadvantages of Leading Power Factor

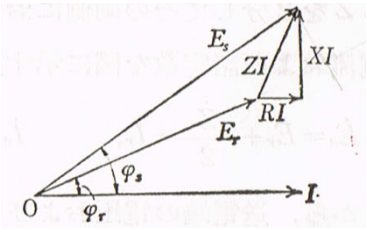
Power Factor of the system should always be lagging because leading power factor causes some problems in the electrical distribution system which are mentioned below

1) Leading reactive current generates unnecessary energy losses

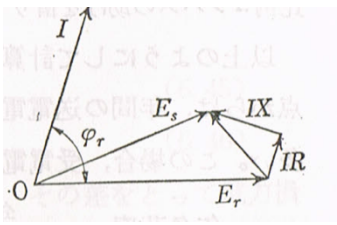
2) Leading power factor (negative “-“ values) seems to be converted into lagging power factor (positive “+” same values) in Pakistan. In this case higher leading power factor is equivalent to lower lagging power factor. Absolute values may be considered by power companies. Low power factor penalty is imposed if total power factor is less than 90%

3) High leading power factor may cause higher receiving end voltage (E_r) as compared to source/sending voltage (E_s), which may damage electrical equipment in factories.

Lagging power factor : $E_r < E_s$



Leading power factor : $E_r > E_s$



5 How to realize Power Factor and Low Power Factor Penalty from Electricity Bill?

Most of the SME's in Pakistan are not able to study their electricity bills and they are not aware of the fact that they are being charged with low power factor penalty. For this purpose an electricity bill with highlighted marks have been added below for their convenience

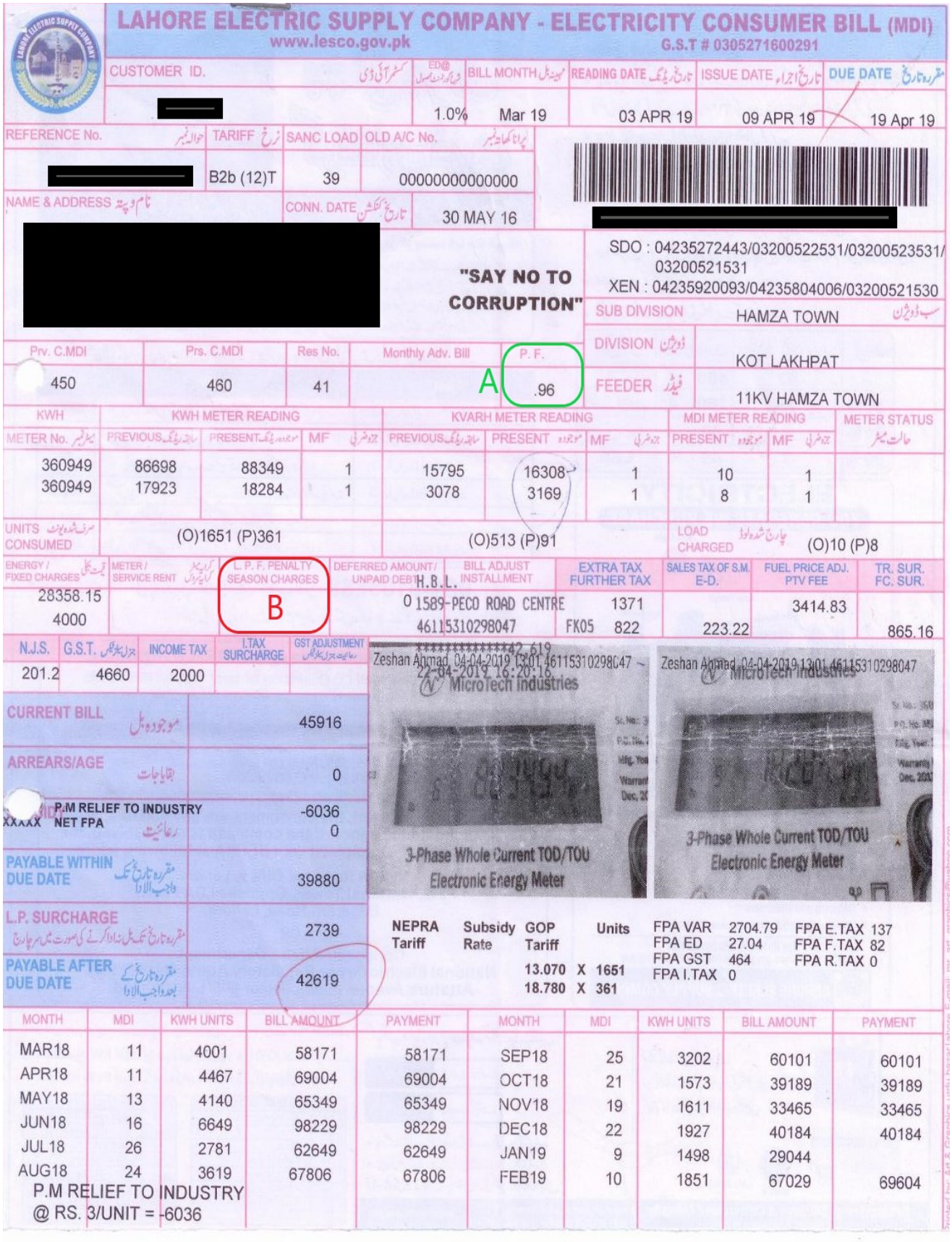
5.1 How to read Power Factor Value

Power Factor of a month can be clearly seen in the green rectangle which has been marked by alphabet A. In this case the power factor is 0.96 (96%) as can be clearly seen in the below attached electricity bill picture. If this value falls below 0.90 (90%) then low power factor penalty will be charged.

5.2 How to read Low Power Factor Penalty

When power factor of an electricity consumer falls below 90 % then low power factor penalty is charged on that connection. The low power factor penalty box is shown by red rectangle with label B as shown in below electricity bill. If there is any low power factor penalty being charged then it will show at this location. In our case no low power factor penalty is being charged, therefore this box is empty

5.3 Sample Electricity Bill



LAHORE ELECTRIC SUPPLY COMPANY - ELECTRICITY CONSUMER BILL (MDI)

www.lesco.gov.pk

G.S.T # 0305271600291

CUSTOMER ID.	ED@	BILL MONTH	READING DATE	ISSUE DATE	DUE DATE
[redacted]	1.0%	Mar 19	03 APR 19	09 APR 19	19 Apr 19

REFERENCE No.	TARIFF	SANC LOAD	OLD A/C No.
[redacted]	B2b (12)T	39	00000000000000

NAME & ADDRESS: [redacted]

CONN. DATE: 30 MAY 16

"SAY NO TO CORRUPTION"

SDO : 04235272443/03200522531/03200523531/03200521531

XEN : 04235920093/04235804006/03200521530

SUB DIVISION: HAMZA TOWN

DIVISION: KOT LAKHPAT

FEEDER: 11KV HAMZA TOWN

Prv. C.MDI	Prs. C.MDI	Res No.	Monthly Adv. Bill	P. F.
450	460	41	A	.96

KWH METER READING				KVARH METER READING			MDI METER READING		METER STATUS
METER No.	PREVIOUS	PRESENT	MF	PREVIOUS	PRESENT	MF	PRESENT	MF	
360949	86698	88349	1	15795	16308	1	10	1	
360949	17923	18284	1	3078	3169	1	8	1	

UNITS CONSUMED: (O)1651 (P)361 | (O)513 (P)91

LOAD CHARGED: (O)10 (P)8

ENERGY / FIXED CHARGES	METER / SERVICE RENT	L. P. F. PENALTY SEASON CHARGES	DEFERRED AMOUNT / UNPAID DEBT	BILL ADJUST INSTALLMENT	EXTRA TAX FURTHER TAX	SALES TAX OF S.M. E-D.	FUEL PRICE ADJ. PTV FEE	TR. SUR. FC. SUR.
28358.15		B	H.B.L. 0	1589-PECO ROAD CENTRE 1371			3414.83	
4000			46115310298047	FK05 822		223.22		865.16

N.J.S.	G.S.T.	INCOME TAX	I.TAX SURCHARGE	GST ADJUSTMENT
201.2	4660	2000		

CURRENT BILL موجودہ بل	45916
ARREARS/AGE بقایاجات	0
P.M RELIEF TO INDUSTRY	-6036
XXXXX NET FPA رعائیت	0
PAYABLE WITHIN DUE DATE مقررہ تاریخ تک واجب الادا	39880
L.P. SURCHARGE مقررہ تاریخ تک بل نہ ادا کرنے کی صورت میں سرچارج	2739
PAYABLE AFTER DUE DATE مقررہ تاریخ کے بعد واجب الادا	42619

NEPRA Tariff	Subsidy Rate	GOP Tariff	Units
		13.070 X	1651
		18.780 X	361

FPA VAR	2704.79	FPA E.TAX	137
FPA ED	27.04	FPA F.TAX	82
FPA GST	464	FPA R.TAX	0
FPA I.TAX	0		

MONTH	MDI	KWH UNITS	BILL AMOUNT	PAYMENT	MONTH	MDI	KWH UNITS	BILL AMOUNT	PAYMENT
MAR18	11	4001	58171	58171	SEP18	25	3202	60101	60101
APR18	11	4467	69004	69004	OCT18	21	1573	39189	39189
MAY18	13	4140	65349	65349	NOV18	19	1611	33465	33465
JUN18	16	6649	98229	98229	DEC18	22	1927	40184	40184
JUL18	26	2781	62649	62649	JAN19	9	1498	29044	
AUG18	24	3619	67806	67806	FEB19	10	1851	67029	69604

P.M RELIEF TO INDUSTRY @ RS. 3/UNIT = -6036

6 Conclusion

CEO / Owner of every factory should check PF value and Low Power Factor Penalty in electricity bill of each month because most of them are unaware of the fact that they are paying extra rupees in terms of low power factor penalty. With the help of above sample electricity bill anyone can check their monthly power factor, the value of low power factor penalty, if any and make efforts to improve it.