Appendix A

Solutions for Self-Assessment Problems

Segment 1 – Solutions

1. The BMS System at a truck assembly plant, that operates 365 days a year, is displaying following electrical power and energy consumption data:

> Billing Days in the Current Month: 30
> On Peak Energy Consumption: 2,880,000 kWh
> Off Peak Energy Consumption: 11,520,000 kWh
> Three highest 30 minute energy usages for the billing month are
> (i) 12,500 kWh,
> (ii) 12,300 kWh and
> (iii) 12,290 kWh.

Assuming this facility is on OPT, Time of Use, contract with 30 minutes demand interval, determine the following:
(a) Average demand.
(b) Peak demand.
(c) The load factor for the current month.
(d) Average annual demand

Solution:
(a) Average demand can be calculated by applying Eq. 1.1 as follows:

$$\text{Average Demand, in kW}$$
$$= \frac{\text{Energy (kWh or MWh) consumed during the billing Month}}{\text{Total number of hours in the billing month}}$$
$$= \frac{\text{On Peak Energy + Off Peak Energy Consumption}}{\text{Total number of hours in the billing month}}$$
$$= \frac{2{,}880{,}000 \text{ kWh} + 11{,}520{,}000 \text{ kWh}}{(24 \text{ hrs/Day}).(30 \text{ Days/Month})}$$
$$= 20{,}000 \text{ kW or } 20 \text{ MW}$$

(b) Peak Demand can be calculated by applying Eq. 1.2 to the 30 minute interval during which the highest energy consumption is recorded. In this problem, three high 30 minute kWh consumptions are stated. However, we are interested in the "highest" kWh recorded; and that is 12,500 kWh. Therefore, the peak demand would be:

$$\text{Peak Demand} = \frac{\text{Peak Energy in kWh}}{\text{Time in hours}} = \frac{\text{Peak Energy in kWh}}{\frac{1}{2}\text{hour}}$$

$$= \frac{12{,}500\ \text{kWh}}{0.5\ \text{h}} = 25{,}000\ \text{kW or } 25\ \text{MW}$$

(c) Load factor can be calculated by applying Eq. 1.3 as follows:

$$\text{Load Factor} = \frac{\text{Average Demand for the Month, in kW or MW}}{\text{Peak Demand for the Billing Month, in kW or MW}}$$

Using the Average Demand, calculated in part (a) as 20 MW, and the Peak Demand calculated in part (b) as 25 MW:

$$\text{Load Factor} = \frac{20\ \text{MW}}{25\ \text{MW}} = 0.80 \text{ or } 80\%$$

2. A 200 kVA transformer has been tested by the manufacturer to safely and continuously sustain a load of 230 kVA. What service factor should the manufacturer include on the nameplate of this transformer?

Solution:

$$\text{Service Factor} = \frac{\text{Safe or Continuous Load, in kW, kVA or hp}}{\text{Nameplate rating of equipment, in kW, KVA or hp}}$$

$$= \frac{\text{Safe Operating Load}}{\text{Full Load Rating of the Transformer}} = \frac{230\ \text{kVA}}{200\ \text{kVA}} = 1.15$$

3. A 5 hp single phase AC motor, rated at a service factor of 1.10, is being tested at maximum safe load, powered by 230 V_{AC} source. Determine the amount of current drawn by this motor, from the power source if the motor efficiency is 90% and the power factor is 0.85.

Solution:

The 5 hp motor, with a service factor of 1.10, operating at its maximum safe load is, essentially, delivering energy or performing work at the rate of:

P = (5 hp) .(Service Factor) = (5 hp).(1.10) = 5.5 hp.

Also note that in most current computations the power, in hp, must be converted to power in watts or kW's.

$\therefore \quad P_{Motor\text{-}watts} = (5.5 \text{ hp}).(746 \text{ W/hp}) = 4103 \text{ W}$

As introduced in earlier segments:

$$\text{Magnitude of apparent power S} = |S| = \frac{P_{Motor-Watts}}{PF} = |V||I|_{Motor}$$

And magnitude of apparent power drawn from the source =

$$\frac{P_{Motor-Watts}}{(PF).(Eff.)} = |V||I|_{Source}$$

$$\therefore \quad |I|_{Source} = \frac{P_{Motor-Watts}}{(PF).(Eff.).(|V|)} = \frac{4103W}{(0.85).(0.9).(230V_{RMS})} = 23.32 \text{ A}$$

4. Consecutive electrical power meter readings at a home in Hawaii are listed below. Determine the total electrical power bill for the month of this residence if the flat \$/kWh cost rate is¢ 21/kWh. The renewable energy rider is \$15 and the energy sales tax rate is 4%.
Previous reading: 45000
Current or present reading: 46000

Solution:
According to Eq. 1.6,

$$\text{Baseline Charge} = (46000 - 45000).(\$0.21 \text{ /kWh})$$
$$= (1000).(\$0.21/\text{kW}) = \$210$$

$$\text{Total Bill} = (\$210 + \$15).(1 + 4\%) = (\$225).(1 + 0.04)$$
$$= (\$225).(1.04) = \$234.00$$

Note that the 4% sales tax is applied to the subtotal comprising of the baseline cost plus the renewable rider.

5. If the peak demand in Case Study 1.2 is reduced by 10% through implementation of peak shaving measures, what would be the baseline cost for the demand portion of the bill?

Solution:
According to Spreadsheet 1.1, the original peak demand for the month is 26,000 kW.

$$\therefore \text{ New, reduced, demand} = \left(26{,}000 \text{ kW}\right).\left(1 - 0.01\right)$$

$$= (26{,}000 \text{ kW}).(0.9) = 23{,}400 \text{ kW}$$

Then, revise the demand portion of Spreadsheet 1.1 for the reduced peak demand of 23,400 kW as shown below:

Description	Demand and Energy Parameters	Rates	Line Item Charge
On-Peak Billing Demand	**23,400 kW**		
On-Peak Billing Demand Charge			
For the First 2,000 kW	2,000 x	$7.64 per kW =	$15,280.00
For the Next 3,000 kW	3,000 x	$6.54 per kW =	$19,620.00
For Demand Over 5,000 kW	**(23,400 – 5,000) x**	**$5.43 per kW =**	**$99,912**
Total Demand Cost for the Billing Month			$15,280.00 +$19,620.00 +$99,912 = **$134,812**

Segment 2 – Solutions

1. A gas powered prime mover is rotating the rotor of a single phase alternator at a speed of 1200 rpm. The alternator consists of six pole construction. The effective diameter of the coil is 0.15m and the length of the coil loop is 0.24m. The coil consists of 20 turns. The magnetic flux density has been measured to be 1.2T. Calculate the power delivered by this generator across a resistive load of 10Ω.

Solution:
The RMS, effective or DC voltage produced through an alternator or generator can be computed by applying Eq. 2.6:

$$V_{DC} = V_{RMS} = V_{eff} = \frac{V_P}{\sqrt{2}} = \frac{\pi np\text{NAB}}{(60).\left(\sqrt{2}\right)}$$

Given:

n = 1200 rpm
p = 6
N = 20
B = 1.2T
A = (Eff. diameter of the coil conductor) x (Eff. length of the coil)
= (0.24m) x (0.15m) = 0.036m^2

$$V_{DC} = V_{RMS} = \frac{\pi np\text{NAB}}{(60).\left(\sqrt{2}\right)}$$

$$= \frac{(3.14)(1200rpm)(6)(20)(0.036\text{m}^2)(1.2\text{T})}{(60).\left(\sqrt{2}\right)} = 230.2\text{V}$$

$$P = \frac{V^2}{R} = \frac{(230.2)^2}{10} = 5{,}299\text{ W} = 5.3\text{kW}$$

2. A four pole alternator/generator is producing electrical power at an electrical frequency of 50 Hz.
(a) Determine the angular speed corresponding to the generated electrical frequency.
(b) Determine the rotational (synchronous) speed of the armature/rotor.

(c) Determine the angular velocity of the armature/rotor (rads/sec).

Solution:

(a) Angular speed, **ω**, corresponding to the generated electrical frequency, f, can be calculated using Eq. 2.8:

$$\omega = 2\pi f = (2).(3.14).(50\text{Hz}) = 314 \text{ rad/s}$$

(b) The rotational or synchronous speed of the armature/rotor is given by Eq. 2.7:

$$n_s = \frac{120f}{p} = \frac{(120)(50 \text{ Hz})}{4} = 1500 \text{ rpm}$$

(c) Angular velocity of the armature/rotor is simply the rotational speed, in rpm, converted into rad/s. Since there are 2π radians per revolution:

$$\omega_s = 1500 \text{ rev./min} = \left(\frac{1500 \text{ rev.}}{\text{min}}\right).\left(\frac{2\pi \text{ rad./rev}}{(60\text{sec/min})}\right) = 157 \text{ rad/sec}$$

3. A four pole single phase AC generator consists of windings constituting 80 series paths and is driven by a diesel engine. The effective or mean length of the armature is 18 cm and the cross-sectional radius of the armature is 5 cm. The armature is rotating at 1800 rpm. Each armature pole is exposed to a magnetic flux of 1.0 T. The efficiency of this generator is 90% and it is rated 2 kW. Determine the following:

(a) The maximum voltage generated.
(b) The RMS voltage generated.
(c) The horsepower rating of the generator
(d) The horse power output of the prime mover.

Solution:

The maximum voltage, $\mathbf{V_m}$, generated by this alternator is given by Eq. 2.7.

$$V_m = V_P = \left(\frac{\pi}{2}\right).\left(\frac{n}{30}\right).\, p\text{NAB} = \frac{\pi n p \text{NAB}}{60} \qquad \textbf{Eq. 2.7}$$

Given:

n = 1800 rpm
p = 4
N = Number of series paths = 80
B = 1.0 T

A = (Eff. diameter of the coil conductor) x (Eff. length of the coil)
= (2 x 5cm) x (18cm) = (0.1m) x (0.18m) = 0.018m^2

(a)

$$V_m = \frac{\pi np\text{NAB}}{60} = \frac{(3.14).(1800rpm)(4)(80)(0.018\text{m}^2)(1.0\text{T})}{60}$$

$$= 543\text{V}$$

(b) The RMS voltage could be calculated by using Eq. 2.6, or simply by dividing V_m, from part (a), by the square root of 2 as follows:

$$V_{RMS} = V_{eff} = \frac{V_m}{\sqrt{2}} = \frac{543}{\sqrt{2}} = 384 \text{ V}$$

(c) The horsepower rating of this generator is the power ***output*** rating specified in hp, premised on the stated ***output capacity*** of 2.0 kW. Therefore, application of the 0.746 kW/hp conversion factor yields:

$$P_{hp} = \frac{P_{kW}}{0.746\text{kW/hp}} = \frac{2.0\text{kW}}{0.746\text{kW/hp}} = 2.68\text{hp}$$

(d) The horsepower rating of the prime mover – or the propane fired engine – would need to offset the inefficiency of the AC generator. Therefore, based on the given 90% efficiency rating of the generator:

$$P_{hp\text{ - Prime Mover}} = \frac{P_{hp\text{ - Gen.}}}{\text{Eff.}_{Gen}} = \frac{2.68 \text{ hp}}{0.90} = 2.98 \text{ hp}$$

4. A three phase, four pole, AC induction motor is rated 170 hp, is operating at full load, 60 Hz, 460 V_{rms}, efficiency of 90%, power factor of 80%, and a slip of 4%. Determine the following:
(a) motor shaft speed, in rpm
(b) torque developed, in ft-lbf.
(c) line current drawn by the motor and
(d) the amount of reactive power, Q, sequestered in the motor under the described operating conditions.

Solution
Given:

$\mathbf{P_{L,3\text{-}\square}}$ = Real power or rate of work performed by the motor = 170 hp
= (170 hp).(746 W/hp) = 126,820 W

p = 4 poles

$\mathbf{V_L}$ = 460 V_{RMS}

Pf = 80% or 0.80

Eff. = 90% or 0.90

n_s = Synchronous speed, in rpm = ?

Slip, s = 4%

f = Frequency of operation = 60 Hz

(a) **Shaft or motor speed:** Rearrange and apply Eq. 2.10:

$$\text{Slip} = s = \left(\frac{n_s - n}{n_s}\right)$$

And, by rearrangement: $n = n_s(1-s)$

Next, we must determine the synchronous speed of the motor by applying Eq. 2.9:

$$n_s = \text{Synchronous speed} = \frac{120f}{p} = \frac{(120).(60)}{4} = 1800 \text{ rpm}$$

$$\therefore\ n = (1800 \text{ rpm})(1-0.04) = 1728 \text{ rpm}$$

(b) **Torque developed, in ft-lbf:** There are multiple methods at our disposal for determining the torque developed. Formulas associated with two common methods are represented by Eq. 2.12, Eq. 2.13 and Eq. 2.14. Since the power is available in hp and the rotational speed in rpm, apply Eq. 2.12:

$$\text{Torque}_{(\text{ft}-\text{lbf})} = \frac{5250 \text{ x } P_{(\text{horsepower})}}{n_{(\text{rpm})}} = \frac{5250 \text{ x } 170 \text{ hp}}{1728 \text{ rpm}} = 516 \text{ ft-lbf}$$

(c) **Line current drawn by the motor:** Full load line current is the current the motor draws from the power source or utility in order to sustain the full load. Application of Eq. 2.22 takes this into account in the computation of 3-phase motor line current, after the motor hp rating (or actual load) is converted into watts:

$$\text{The 3-}\phi \text{ phase line curent, } |I_L| = \frac{|S_{L,3\text{-}\phi}|}{\sqrt{3}(|V_L|)} = \frac{P_{L,3\text{-}\phi} \text{ (in Watts)}}{\sqrt{3}(|V_L|)(\text{Pf}).(\text{Eff.})}$$

Three phase (total) real power was converted into watts under "Given" as **$P_{L,3-}$**□ = 126,820 W

Therefore,

The 3-ϕ phase line curent, $\left|I_L\right| = \dfrac{126,820 \text{ Watts}}{\sqrt{3}\left(460 \text{ V}_{RMS}\right)(0.90).(0.80)} = 221 \text{ A}$

(d) **Reactive power, Q**: There are multiple approaches available to us for determination of reactive power Q for this motor application. We will utilize the power triangle or apparent power component vector method:

$$S = P + jQ, \text{ and } S^2 = P^2 + Q^2,$$

$$\text{or, } Q^2 = S^2 - P^2$$

$$\text{and } Q = \sqrt{S^2 - P^2}$$

Real power "P" was computed earlier as 126,820 W, and apparent power S can be assessed using Eq. 2.20:

$$\left|S_{L,3-\phi}\right| = \frac{P_{3-\phi} \text{ (in Watts)}}{(\text{Pf}).(\text{Eff.})} = \frac{126,820\text{W}}{(0.90).(0.80)} = 176,139 \text{ VA}$$

Therefore,

$$Q = \sqrt{S^2 - P^2} = \sqrt{176,139^2 - 126,820^2} = \sqrt{14,941,595,779}$$

$$= 122,236\text{VAR}$$

5. A three phase, four pole, AC induction motor is tested to deliver 200 hp, at 900 rpm. Determine the frequency at which this motor should be operated for the stated shaft speed. Assume the slip to be negligible.

Solution

Given:

p = 4 poles

n_s = Synchronous speed, in rpm = 900 rpm = Shaft speed, since slip is zero

f = Frequency of operation = ?

Rearrange and apply Eq. 2.9

$$n_s = \text{Synchronous speed} = \frac{120f}{p},$$

$$\text{Or, } f = \frac{(n_s).(p)}{120} = \frac{(900).(4)}{120} = 30 \text{ Hz}$$

6. A three phase induction motor delivers 600 kW at a power factor of 80%. In lieu of installing power factor correction capacitors a synchronous motor is being considered as a power fact correction measure. Determine the apparent power size of the synchronous motor – in kVA - that should be installed to carry a load of 300 hp and raise the (combined) power factor to 93%. The source voltage is 230 V_{rms}.

Solution:
Given:

P_I = Real power delivered by the 3-□ induction motor = 600 kW
P_S = Real power contributed by the synchronous motors = 300 hp = (300 hp) x (0.746 kW/hp) = 223.8 kW
Pf_i = Initial Power Factor = 80% = 0.80
Pf_f = Final Power Factor = 93% = 0.93
V_s = Source voltage = 230 Vrms. However, the voltage information is not needed to solve this problem.

This problem is similar to Example 2.6. So, the strategy for solving it is the same as the one employed for Example 2.6. Overall, we need to determine the reactive power, Q_S, contributed by the synchronous motor. Then, by applying the Pythagorean Theorem to Q_S and P_S, we can derive the apparent power (kVA) of the synchronous motor.

$$\text{Since } S_T^2 = P_T^2 + Q_T^2, \quad Q_T = \sqrt{S_T^2 - P_T^2}$$

The combined real power of the induction motor and the synchronous motor:

P_T = 600 kW + 223.8 kW = 824 kW

$$\text{Since } S_T \text{Cos}\theta = P_T, \quad S_T = \frac{P_T}{\text{Cos}\theta},$$

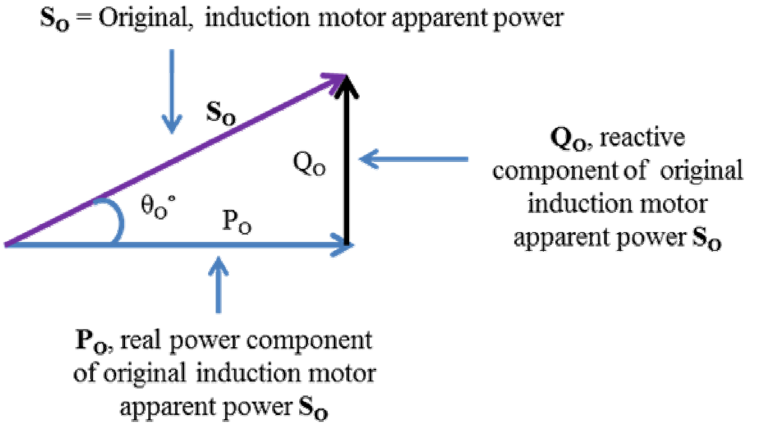
And since θ_T, the final power factor angle = $\text{Cos}^{-1}(0.93) = 21.58°$,

$$S_T = \frac{P_T}{\cos\theta_T} = \frac{824\text{ kW}}{\cos(21.58°)} = 886\text{ kVA}$$

Therefore,

$$Q_T = \sqrt{S_T^{\ 2} - P_T^{\ 2}} = \sqrt{886^2 - 824^2} = \sqrt{106{,}058} = 326\text{ kVAR}$$

Now, in order to determine Q_S, the reactive power contributed by the synchronous motor, we must subtract the original reactive power, Q_O, from the final, total, reactive power, Q_T. However, Q_O is unknown and can be determined through the power triangle as follows:



$$\text{Since } \tan(\theta_O) = \frac{Q_O}{P_O}\text{, or, } Q_O = P_O \tan(\theta_O) = 600\text{ kW}\tan(\theta_O)$$

$$\text{And, } \theta_O = \cos^{-1}(Pf_O) = \cos^{-1}(0.80) = 36.87°$$

Therefore,

$$Q_O = 600\text{ kW}\tan(36.89°) = 600\text{ kW}(0.75) = 450\text{ kVAR}$$

And, reactive power contributed by the synchronous motor would be:

$$Q_S = Q_O - Q_T = 450\text{ kVAR} - 326\text{ kVAR} = 124\text{ kVAR}$$

Therefore,

$$S_S = P_S + jQ_S\text{, and } S_S^{\ 2} = P_S^{\ 2} + Q_S^{\ 2}\text{, or, } S_S = \sqrt{P_S^{\ 2} + Q_S^{\ 2}}$$

$$\text{Or, } S_S = \sqrt{(224\text{ kW})^2 + (124\text{ kVAR})^2} = 256\text{ kVA}$$

Segment 3 Answers/Solutions:

1. A substation in a manufacturing facility is being fed from a 13kV transformer secondary. This switchgear in this substation would be categorized as:

A. Medium voltage
B. Low voltage
C. High voltage
D. Medium voltage
E. None of the above

2. Power transmission lines would be categorized as:

A. Medium voltage
B. Low voltage
C. High voltage
D. Medium voltage
E. None of the above

3. The breakers installed in residential breaker panels are:

A. OCB's
B. Thermal magnetic circuit breakers
C. Low voltage thermal magnetic circuit breakers
D. None of the above
E. Both B and C

4. The vacuum circuit breakers tend to offer longer service spans between overhauls than do air circuit breakers.

A. True
B. False

5. The SF_6 type high voltage circuit breakers are not preferred due to environmental concerns.

A. True

B. False

6. MCC’s are not designed to accommodate PLC’s and VFD’s.

A. True
B. False

7. The bus bars in MCC’s are commonly constructed out of:

A. Aluminum
B. Silver plated copper
C. Silver
D. Iron

8. Pilot devices on MCC’s:

A. Control circuit breakers
B. Indicate the status of MCC
C. Indicate the status of motor/load
D. Include “Start” and “Stop” controls
E. Both (C) and (D).

9. Power control cubicles in MCC’s are fixed and cannot be removed while the main fusible disconnect switch of the MCC is ON.

A. True
B. False

10. A control transformer, in a given MCC compartment:

A. Steps down the voltage for control circuit operation.
B. Provides power for MCC cabinet lighting.
C. Is seldom needed.
D. Serves as an isolation transformer.
E. Both (C) and (D).

Appendix B

Common Units and Unit Conversion Factors

Power

In the SI or Metric unit system, DC power or “real” **power** is traditionally measured in watts and:

kW = 1,000 Watts
MW = 1,000,000 Watts = 10^{6} W
GW = 1,000,000,000 Watts = 10^{9} W
TW = 10^{12} W

Where k = 1000, M = 1000,000, G = 1 billion, and T = 1 trillion.

Some of the more common **power conversion factors** that are used to convert between SI System and US system of units are listed below:

1.055 kJ/s = 1.055 kW = 1 BTU/s
1–hp = One hp = 746 Watts
= 746 J/s
= 746 N-m/s
= 0.746 kW
= 550 ft-lbf/sec

Energy

In the SI or Metric unit system, DC energy or “**real” energy** is traditionally measured in Wh, kWh, MWh, GWh, TWh (10^{12} Wh).

kWh = 1,000 Watt-hours
MWh = 1,000,000 Watt-hour = 10^{6} Wh
GWh = 1,000,000,000 Watt-hours = 10^{9} Wh
TWh = 10^{12} Wh

Some mainstream conversion factors that can be used to convert electrical energy units within the SI realm or between the SI and US realms are referenced below:

1000 kW x 1h = 1 MWh
1 BTU = 1055 J = 1.055 kJ
1 BTU = 778 ft-lbf

Energy, Work and Heat Conversion Factors:

Energy, Work or Heat		
Btu	1.05435	kJ
Btu	0.251996	kcal
Calories (cal)	4.184	Joules (J)
ft-lbf	1.355818	J
ft-lbf	0.138255	kgf-m
hp-hr	2.6845	MJ
KWH	3.6	MJ
m-kgf	9.80665	J
N-m	1	J

Power Conversion Factors:

Power		
Btu/hr	0.292875	Watt (W)
ft-lbf/s	1.355818	W
Horsepower (hp)	745.6999	W
Horsepower	550.*	ft-lbf/s

Temperature Conversion Factors/Formulas:

Temperature		
Fahrenheit	(°F-32) /1.8	Celsius
Fahrenheit	°F+459.67	Rankine
Celsius	°C+273.16	Kelvin
Rankine	R/1.8	Kelvin

Common Electrical Units, their components and nomenclature:

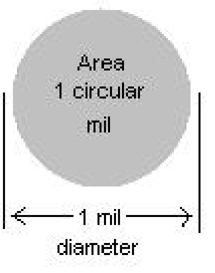
Force	Newton	**N**	**kg m s^{-2}**
Energy	joule	**J**	**kg m^2 s^{-2}**
Power	watt	**W**	**kg m^2 s^{-3}**
Frequency	hertz	**Hz**	**s^{-1}**
Charge	coulomb	**C**	**A s**
Capacitance	farad	**F**	**C^2 s^2 kg^{-1} m^{-2}**
Magnetic Induction	tesla	**T**	**kg A^{-1} s^{-2}**

Common Unit Prefixes:

1.00E-12	**pico**	**p**
1.00E-09	**nano**	**n**
1.00E-06	**micro**	**µ**
1.00E-03	**milli**	**m**
1.00E+03	**kilo**	**k**
1.00E+06	**mega**	**M**
1.00E+09	**giga**	**G**
1.00E+12	**tera**	**T**

Wire Size Conversions:

A circular mil can be defined as a unit of area, equal to the area of a circle with a diameter of one mil (one thousandth of an inch), depicted as:



1 circular mil is approximately equal to:

- 0.7854 square mils (1 square mil is about 1.273 circular mils)
- 7.854×10^{-7} square inches (1 square inch is about 1.273 million circular mils)
- 5.067×10^{-10} m^2
- 506.7 μm^2

1000 circular mils = 1 MCM or 1 kcmil, and is (approximately) equal to:

- 0.5067 mm^2, so 2 kcmil ≈ 1 mm^2

AWG to Circular Mil Conversion

The formula to calculate the circular mil for any given AWG (American Wire Gage) size is as follows:

.$\boldsymbol{A_n}$ represents the circular mil area for the AWG size $\boldsymbol{n}$.

$$A_n = (5 \times 92^{\frac{36-n}{39}})^2$$

For example, a AWG number 12 gauge wire would use **n = 12**; and the calculated result would be 6529.946789 circular mils

Circular Mil to mm^2 and Dia (mm or in) Conversion:

kcmil or, MCM	mm²	Diameter	
		in.	mm
250	126.7	0.5	12.7
300	152	0.548	13.91
350	177.3	0.592	15.03
400	202.7	0.632	16.06
500	253.4	0.707	17.96
600	304	0.775	19.67
700	354.7	0.837	21.25
750	380	0.866	22
800	405.4	0.894	22.72
900	456	0.949	24.1
1000	506.7	1	25.4
1250	633.4	1.118	28.4
1500	760.1	1.225	31.11
1750	886.7	1.323	33.6
2000	1013.4	1.414	35.92

Appendix C

Greek Symbols Commonly Used in Electrical Engineering

Greek Alphabet			
Αα	Alpha	Νν	Nu
Ββ	Beta	Ξξ	Xi
Γγ	Gamma	Οο	Omicron
Δδ	Delta	Ππ	Pi
Εε	Epsilon	Ρρ	Rho
Ζζ	Zeta	Σσς	Sigma
Ηη	Eta	Ττ	Tau
Θθ	Theta	Υυ	Upsilon
Ιι	Iota	Φφ	Phi
Κκ	Kappa	Χχ	Chi
Λλ	Lambda	Ψψ	Psi
Μμ	Mu	Ωω	Omega