THE CONSULTANT

The Newsletter of the IEEE Consultants Network of Long Island

Volume 25, Number 6 *June 2008*

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Chairman's Corner – *Jerry Brown, Essex Systems*

Eleven of our members filled out survey forms for their business in 2007. The results are summarized below.

It is unfortunate that we did not have more participation. This represents only about 25% of our membership. Although these results can hardly be considered representative, there are a few things worth mentioning.

About half are full-time consultants, 1/3 of the work was fixed-fee, the average rate was $95/Hr

Half are not interested in changing the organization. One-third thought we should do more marketing.

Look for the chart on Page 3, which follows the meeting announcements.

Meetings

April 2008

Topic: "What to Expect When Working on Projects Involving Manufacturing in China"
Speaker: John Weiss, Weiss Instruments

May 2008

Topic: "Introduction to LabVIEW and Computer-Based Measurements Hands-On Seminar"
Speaker: Robert E. Berger, National Instruments District Sales Manager for Long Island and New York City

June 4, 2008

Topic: "How I Design Switching Power Supplies"
A Pragmatic Approach for Wide Ranging Applications
Speaker: Martin Kanner, Kanner Electro-Medical Co. (KEMCO)

7:00 PM, Wednesday, June 4
6:30 PM Light Refreshments
Briarcliffe College, Great Room
1055 Stewart Avenue, Bethpage, NY.
CEU credits available for Professional Engineers.
0.2 CEU (2 PDH)
$ 20 Fee for CEU's payable at the meeting.
Admission is free (no charge) for those not receiving CEU's.
Guests are welcome.
Non-members please inform Irwin Weitman i.weitman@ieee.org or Jerry Brown jlbrown@essexsys.com so that we can order refreshments.
Directions: See our website www.consult-li.com.

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Other Meetings

Consult the Events Calendars on the Section website: www.ieee.li and the LICN site: www.consult-li.com

Remember to inform the members about seminars and other items that might be of interest. E-mail them at members@consult-li.com.

THE CONSULTANT is published monthly by the IEEE Long Island Consultants Network and is available free of charge to its members.
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Deadlines: Flexible
Articles for publication in ***THE CONSULTANT:*** Send them in. We need them.

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IEEE Long Island Consultants' Network Survey - data for 2007

1. Define your consulting practice (check one):

	TOTAL 11		1	2	3	4	5	6	7	8	9	10	11
a. Full-time consultant ____	55	%	1		1	1	1			1			1
b. Full-time employee ____	0	%											
c. employee and part-time consultant ____	18	%		1								1	
d. retired ____	0	%											
e. Retired - Part time consultant	18	%						1	1				
e. other _____	9	%									1		

2. In 2007, how many man-hours did you devote to: *(Blank spaces are not included in the averages)*

	MEAN	MEDIAN																	
a. Consulting (billable + non billable)_____	1131	1250	2600	200	2000	500	1300	1200	400	1600		10	1500						
b. Working as an employee for another company_____	1925	1925		1850								2000							
c. Other _____											2000								

3. What percentage of your consulting jobs are: *("Other" and blank spaces not included in the averages)*

a. Fixed Fee ____	36	%	85.0	100	25	10	0		0	0		100	0						
b. Time and Material _____	64	%	15.0	0	75	90	100		100	100		0	100						
c. Other _____		%						100			100								

4. What percentage of your consulting time is devoted to:

a. Billable work _____	68	%	75	70	80	50	80	90	60	65	0	95	80						
b. Looking for business _____	13	%	25	30	15	0	5	5	20	30	0	5	10						
c. Education and training _____	8	%	0	0	5	0	15	5	10	5	40	0	10						
d. Other _____	6	%	0	0	0	0	0	0	10	0	60	0	0						

5. At what hourly rate did you bill for your three most recent consulting jobs ? _____

			75	95	95	90	75	55	95	110		125	125						
			75	110															
			75	125															

AVG of MOST RECENT RATE	$94
AVG of ALL RATES	$95

MEDIAN of MOST RECENT RATE	$95
MEDIAN of ALL RATES	$95

6. What changes would you like to see in our group?

Increase dues to $500/yr and do some serious marketing
More aggressive marketing
List oceanic engineering, climate science & oceanography in services
Increased membership
More activity in getting new business
No change needed
More team-like participation
No comment (4)

Maximizing Brake Energy Recovery – *Carl E. Schwab*

Maximizing BER

The recent article entitled "Enhancing BER" included a **KE Table** that tabulated values of kinetic energy, KE, in both (ft-lbs) and Kwh and Drag in Kw as function of speed, mph, for a 3200 lb., series mode hybrid car. Using this **KE Table** examples clearly illustrate the importance of recovering braking energy.

So to maximize BER, what rules do you follow?

Rule 1: Load the mot/gen at an "appropriate" load current to produce the braking torque desired. This converts into Kwh energy.

Rule 2: Convert this KWH energy to an "appropriate" voltage/current levels to apply to the drive battery to efficiently store the Kwh energy.

Notice in Rule 1 and Rule 2 the use of the word "appropriate". In the case of the mot/gen "appropriate" means keeping within the efficient torque/current range, keeping in mind as deceleration (braking) takes place, although the torque/current remain relatively constant, the voltage generated as bemf is linearly decreasing as rpm decreases.

In the case of the battery this Kwh energy has to be presented to the battery at a proper voltage/current level to be efficiently chemically stored as charge.

To better understand what's involved VOLTS and RPM columns have been added to the **KE Table** and the speed range extended from 5 to 100 mph. The RPM column represents a Krpv of 6.92 rpm/volt and 30 rpm/hz for a PMSM. The driving electronics for the moment is comprised of a 201 Vdc pack, and a 299 volt hi-efficiency boost to produce 500 Vdc to power a VVVF drive. By PWM, pulse width modulation, the VVVF produces a sine wave current in the 3-phase winding of the mot/gen. The leakage inductance the mot/gen combined with the bemf efficiently converts the battery stored energy to mechanical torque from the PMSM.

But now let's put on the brakes.

The shunt diodes across each of the 6-IGBT switches form an efficient 6-diode full wave package producing DC from the 3-phase mot/gen winding.

Explanation About VOLTS, RPM Columns

The RPM is simply the mot/gen rotor rpm as a function of the ground speed in mph. The VOLTS column is Vdc but actually directly relates to the line-to-line AC voltage of the mot/gen using the equation –

VOLTS = (line-to-line Vrms)/0.74=RPM /6.92

Now it works out that VOLTS value driving the VVVF can produce the line-to-line Vrms required by the mot/gen up to that VOLTS value. That is, it can also produce lower RPM values as well.

KE Table

VOLTS	RPM	Speed(Mph)	KE (ft-lbs)	KE (Kwh)	Drag(Kw)
500	3458	100	1,075,555	.4951	54.35
450	3114	90	871,200	.3281	39.62
400	2766	80	688,355	.2595	27.83
350	2420	70	527,022	.1984	18.64
300	2075	60	387,200	.1458	11.74
250	1730	50	268,888	.1013	6.79
225	1556	45	217,800	.0820	4.95
200	1383	40	172,088	.0648	3.48
150	1037	30	96,800	.0364	1.47
100	692	20	43,022	.0162	.435
75	519	15	24,200	.0091	.183
50	346	10	10,755	.0040	.054
25	173	5	2,688	.0010	.007

Conversions

Hp-hr= 1,980,000 ft-lbs Kwh=2,655,223 ft-lbs=3.6 megaJ
Energy in 1 gal of gasoline=132 megaJ=36.67 Kwh J=watt-sec
Energy in 1 gal of diesel = 148 megaJ=41.11Kwh

Efficiency of conversion

Gasoline Eff=2.84/36.37/0.4=.194 or 19.4%
Diesel Eff=3.18/41.11/.254=.305 or 30.5%

Back emf

Before diving into the discussion about maximizing BER, I want to recap bemf (Back ElectroMotive Force) as it applies to both DC and AC motors. In the case of permanent magnet DC motors and AC (PMSM) motors, if you spin the armature (rotor) at a specific rpm the motor will produce it's bemf directly at its terminals. This is a simple way to verify the Krpv (or its inverse) numerical values.

In the case of the VFSM, VF shunt DC and induction motors, it is necessary to provide field excitation i.e. if the field excitation is not provided when the rotor spins the terminal voltage will be small and/or erratic. In the case of VFSM and VF shunt DC the excitation for the field is a dc current of a specific amount. In the case of the induction motor it's a bit different.

We are only going to consider a 3-phase VVVF (Variable Voltage Variable Frequency) solid-state source; also referred to as a VFD (Variable Frequency Drive). The 3-phase winding of the induction motor strongly resembles the primary of a 3-phase transformer bank and in both, to prevent excessive (maybe damaging) current you must vary the applied voltage linearly with the frequency applied. For example if you are using a 220 vac, 3-phase, delta connected, 60 cycle induction motor, shaft speed 1775 rpm, then the scale factor is 220/60 = 3.67 ac volts per hertz. To operate this motor at ¼ speed (1775/4) then the frequency would be 60/4=15hz and the voltage will be 15 x 3.67= 55vac. This is precisely what you have to do to operate a transformer at a different than 60-cycle line frequency. In a like manner you can operate the motor at a higher line frequency, say 120hz but with the proviso that although the voltage will double i.e. 120 x 3.67 = 440vac, the power rating of the motor will not double and conservatively is kept the same. There is some latitude here.

But now back to the field excitation of the induction motor. If the motor is free shaft (no mechanical load), the current drawn by the motor IS the field excitation current and is lagging by approximately 90 degrees just like the transformer primary.

Now at any shaft speed set by the VVVF, if you mechanically load the shaft the current drawn by the motor will be an in-phase current that increases nearly linearly with the rotor "slip" rpm. Equally (and really more interesting), if you mechanically power the rotor shaft ABOVE the free-shaft speed, the rotor current again increases, BUT it is an out-of-phase current and actually delivers power back towards the VVVF source. SO if you maintain the field current component, then the induction motor produces a bemf much like the PMSM and PM DC motors. It is this bemf energy that is used for regenerative braking or BER.

A Little More About "slip"

In the induction motor discussed here, the "slip" at rated load is 1800-1775=25 rpm. Now the mechanics of "slip" is that the torque generated in term of ft-lbs/amp does NOT change as the VVVF varies the voltage with the frequency in our ratio of 3.67 volts/hz. So a 10rpm "slip" at 10hz produces the same torque as 10rpm "slip" at 60hz and the current drawn will be the same.

Mot/gen shaft position sensor

For the VVVF to perform its function it needs to know the rotation position of the rotor/armature. This is most commonly done by using Hall effect devices or sin-cos optical encoder coupled as a shaft position sensor. In either case these devices must work down to and through "0" rpm and provide signal to the VVVF circuits. These devices are particularly critical in maintaining the field drive to the induction motor.

The "Slippery Slope" While Braking

The reason for the two added columns, VOLTS and RPM now becomes evident. While braking, with a PMSM (or any motor), the RPM will reduce. As the RPM reduces the corresponding VOLTS also reduces. If we were to use a 300vdc battery pack, once the speed drops below approximately 50mph the mot/gen volts is insufficient to charge the 300vdc battery pack directly. What is required is a dc-dc converter to match to the mot/gen voltage and current into a voltage and current to charge back (regenerative) into the battery pack. This dc-dc converter/controller is, in fact, the BER braking controller.

What Are The Trades?

If one could have a "perfect" dc-dc converter/controller there would be no need for trades, BUT, efficiency becomes an issue because the device is not "perfect". Specifically, as the required "step up" ratio increases the conversion efficiency decreases to the extent losses equal or exceed savings. So in early hybrids much of the mot/gen braking was dynamic because of the dc-dc converter inefficiency. This prevented them from achieving better mileage.

More recently Toyota in revising the Prius to make the Prius III, has done two things. First they have increased the system voltage from 273vdc to 500vdc and second, they have reduced from 273vdc to about 200vdc. In addition to the increase to 500vdc the bigger PMSM (the Prius has two) has been increased from 35Kw to 50Kw. This has improved acceleration to 60mph by some 3 seconds.

Equally important the dc-dc converter/controller now has a better range of voltage difference over which it must transform the BER energy. The immediate question is how did they gain because now they have the efficiency loss of an additional dc-dc converter? The answer is that the dc-dc converter boosting 300vdc to 500vdc is quite efficient since it is fixed ratio and efficiency better than 95%. For the still remaining dc-dc BER converter/controller while still variable ratio, the bulk of its conversions for LOCAL driving are at more efficient ratios. So the Prius III has improved LOCAL mileage.

What Toyota appears to have done in their Camry hybrid is raise the system voltage to 650vdc while keeping the battery pack voltage at 245vdc.

Is VFSM Worth A Re-look?

The biggest single negative about Variable Field Synchronous Motor is the life of the brush/slip-ring required to permit dc current into the rotating field winding. As far as cost of manufacturer is concerned it is very competitive to PMSM or induction motors. When considering “Maximizing BER” the ability to smoothly vary field strength has advantages that will improve efficiency of the BER operation. In particular at LOCAL speeds the field can be strong for better torque for initial acceleration and better torque for BER braking in the regenerative mode. Truly a win-win situation.

So far as efficient high-speed operation is concerned a weaker field produces a lower bemf so the system voltage can be retained. So all advantages if the brush slip-ring life can be solved.

Well maybe it can. Recent nano-engineering efforts have made big gains in fabricating materials effectively increasing the “effective areas” of electrodes etc., and just maybe these techniques can be used to generate brushes with greatly improved wear characteristics. Currently life on auto-alternator brush/slip-rings is near 100,000 miles. Perhaps the nano-engineering can get the number up to 500,000 miles. Were this so then VFSM would be the choice for “Maximizing BER”.

FWIW, VFSM are made in about 5Kw steps up to 500Kw by several companies world-wide. SO I think the brush/slip-ring life will be solved.

SuperCaps Again?

In “Enhancing BER” I made a calculation of a BER cycle assuming 85% efficiency of the mot/get each way and 85% efficiency of the battery pack charge and discharge. The result was we could recover (.85)^4 = .522 or 52.2% of the KE.

For short-term energy storage SuperCaps have the advantage of very low series impedance so can absorb and deliver large surge currents. This eventually can be helpful in further increasing the 52% recovery of the KE. It appears that the efficiency could become (.85)^2 x (.98)^2 = .694 = 69.4% and would allow a significant improvement in LOCAL driving mileage to about 55mpg.

Just now the nano-engineering improvements are in line to help SuperCaps become smaller while increasing capacitance in Farads AND reduce manufacturing cost. FORWARD and ONWARD !!

Mountain Drought – *Dr. Richard LaRosa, sealevelcontrol.com*

INTRODUCTION

Humidity and precipitation have increased on our warming planet. Unfortunately, the fresh water either falls uselessly in the ocean, or floods coastal land and quickly runs off into the ocean. Mountain areas, which depend on orographic precipitation, are literally being left high and dry. Orographic precipitation is produced when moist air is lifted as it moves over a mountain range (definition from Britannica Online). The rain and snow considered here is caused by water vapor from the ocean being carried by winds to mountains. In rising over the mountains, the air expands, cools, water vapor condenses, coalesces on airborne nucleation centers, and precipitation results. This has been happening in many places, such as the USA western states, Australia's New South Wales, China, and North Africa's Atlas Mountains. Now this precipitation is insufficient and we have drought. Disease is spreading and people are starving.

AUSTRALIA

The Great Divider Range is located near the southeast coast of Australia. On one side of its crest line, water flows toward the Pacific coast. On the inland side, water flows into the Murray - Darling river basin, which was a fertile agricultural

area used to grow rice among other crops. Now their rice mill is shut down and the rice land has been converted to grape cultivation because grapes can survive in the drier climate. This may be good for farmers and wine makers, but rice is a basic food for many people, and wine cannot take its place. Some people are paying more for rice, and the rest are starving.

One reason for the drought could be insufficient humidity in the air that is pulled in from the sea to replace the air that rises over the central deserts when they are heated during the day. But the generally accepted view is that the humidity of the air coming from the ocean has increased due to global warming. This agrees with the idea that more water is expected to evaporate from the ocean due to its increased surface temperature.

Another reason for the drought is that the water vapor is not being recovered as precipitation when the air is lifted over the mountains on its way from the coast to the interior deserts. Examination of Australia's topography is instructive. The mountain range on the southeast coast has tall peaks at the southern end, tapering off to lower heights toward the north. Air that rises to pass over these mountains cools at the dry adiabatic lapse rate of 9.8 °C per kilometer of altitude. Suppose the dry bulb temperature at ground level is 27°C and the relative humidity (RH) is 60%. From a psychrometric chart we learn that the vapor content is 0.0135 kg water vapor per kg of dry air. The dew point is 18.5°C, so the temperature must decrease 8.5°C and the altitude of the air mass must increase to 870 meters in order to start condensing out the water. Above 870 meters, the temperature drops at the moist adiabatic lapse rate of 5°C per km. Near the border between Victoria and New South Wales there are four mountain peaks with altitudes of 1640, 1802, 1984, and 2230 meters, respectively. The air could rise another km to pass over these mountains and the temperature would decrease another 5°C to 13.5°C. At this dew point the vapor content is 0.00975 kg water per kg dry air, so 0.00375 kg water per kg air will precipitate if all other conditions are favorable. This is 28% of the water vapor carried inland from the ocean. The existing drought indicates that they are getting far less than 28% recovery.

A likely reason for inadequate precipitation is that the mountains are absorbing solar energy and heating up more than the lower altitude terrain. These high mountains and their many neighbors are known as the Australian Alps. If their snow cover is decreasing, the high solar reflectivity of the snow is being replaced by the lower reflection and greater solar absorption of the bare ground. The mountain peaks are also broad and flat, so there is adequate time for radiative and convective heat transfer from terrain to the air mass as it passes over the mountains. Perhaps the air temperature does not drop to 13.5°C, which would result in less precipitation.

There are other reasons for low precipitation lurking in my murky understanding of the molecular basis of latent heat of vaporization. I know that when water vapor condenses into a fine mist of liquid water, the latent heat is released and the air and remaining water vapor and the newly-formed liquid water are warmed. This means that the temperature of this ensemble increases. Why?

I can picture individual water molecules vibrating, rotating, and colliding with air molecules and other water vapor molecules. Suppose the temperature of the gas is lowered, say by rising to a higher altitude and expanding. The air parcel does work on its surroundings and its internal energy is lowered. Temperature is a measure of internal energy so it decreases. Now a pair of water molecules might not have enough energy to bounce away from each other, so they are attracted to each other by some kind of force. They move in the direction of the force, so the force does work on them. The potential energy of the attractive force is converted into kinetic energy of vibration, rotation, and maybe translation of the resulting liquid mist particle. Certainly, if two combined water molecules snap onto a single water molecule, there will be translational kinetic energy of the three-molecule clump due to the asymmetry. Perhaps this is a valid molecular explanation of the release of latent heat of vaporization when condensation takes place. The latent heat release causes the temperature to decrease less rapidly as the air mass rises in altitude. This interferes with the condensation process.

There is an interesting complication that arises in condensation. As the mist particle accumulates more water molecules it has many more modes of vibration, so it becomes a broadband absorber/emitter and can gain more infrared energy from the broadband emitter/absorbers in the mountain terrain. Individual water vapor molecules are narrow-band absorber/emitters and gain less energy in the infrared exchange with the terrain. This may inhibit condensation, especially if the ground has attained a high temperature as a result of global warming.

BARCELONA

Barcelona has a severe drought. It is located on the Mediterranean coast and depends on orographic precipitation in the Pyrenees Mountains, which form a natural border between Spain and France. The Pyrenees run from the Bay of Biscay to

the Mediterranean, with low altitudes at the Biscay end, increasing to peaks of about 3000 m at the Mediterranean end. The Llobregat River collects water at 1259 m altitude from the slopes on the Spanish side of the 3000 m peaks and delivers it to Barcelona. The Pyrenees are in the prevailing westerlies, so the winds bearing moisture must travel about 350 km over mountainous land to reach the peaks that supply Barcelona. The warming and drying have reduced the snow cover on this path, so there is much warming from the terrain. This reduces the amount of condensation and precipitation.

News reports speak of recent rain, but they don't say whether the rain is on the tall mountain peaks or somewhere in the lowlands near Barcelona. City dwellers may not be aware of the distinction as long as they have enough water for their needs. Their awareness will increase if the mountains are warming and drying in accord with my hypothesis.

SAHARA DESERT

The area of Africa south of the Atlas Mountain Range was once a fertile oasis. In modern times it is familiar to us as the Sahara Desert. The soil is now dust that is blown in huge clouds toward Europe and onto the North Atlantic. Dust deposited on the ocean surface supplies iron needed by phytoplankton. The airborne dust affects hurricane formation in the North Atlantic. I am guessing that the change from oasis to desert is the result of a gradual decline of orographic precipitation on the Atlas Mountains. In ancient times, snow melt and rain came down both the north and south slopes of the mountains. The south slope fed the fertile Sahara region and charged aquifers which have now been pumped dry. The Atlas range extends from 30° to 36° North latitude, so the south face receives more solar energy and would tend to warm up first. This would decrease the amount of precipitation and shift it toward the north.

There are many other deserts that need to be studied and matched up with mountain ranges that might have provided orographic precipitation in the past. The Sahara Desert provides a glimpse of what may happen to the western U.S. and many other areas. It seems quite possible for all mountains and lower terrain dependent on orographic precipitation to dry out while coastal and low-lying areas are flooded and increased rain falls on the ocean.

ALPS and BEYOND

The European Alps extend through many countries and I have barely studied them. Then there are deserts or desertifying areas like Outer and Inner Mongolia, and the Himalayas. This will be an interesting lesson in Geography and Topology. I expect to find decreased orographic precipitation caused by solar heating of mountains throughout the world.

If my hunch is correct, and the humidity has increased due to global warming, solar-heated evaporators floating in coastal waters may not provide as much benefit as I had thought. Too bad, because I think I have solved a lot of raft design and deployment problems. Evaporator rafts must be put aside until the world view of mountain warming and drought is further along. In the meantime, does anybody know how to cool a mountain?