Harmonic Analysis Program Instructions

NOTE: Specific details regarding Inputs, Outputs, and Assumptions are given in the "Equations and Explanations" TAB.

The Following Standard format has been created.

Inputs are listed in RED TYPE!

1. **There are 2 Program Tabs: %TDD** AND **%Vthd**! Enter **ALL** your Input Data into the program under the first tab - **%TDD.** This input data will transfer automatically to the **%Vthd** worksheet. The difference is as follows: PCC for **%TDD** is defined as the customer and user interface point; generally the T1 transformer Primary - the "utility"! **Voltage THD** is calculated on the transformer secondary; or the specific bus selected. To show the correct value for voltage; **T1** [secondary] is the default PCC for this worksheet!
2. Each required input is accompanied by a set of directions that appear as a comment.
3. The instruction comment is always to the cell directly to the LEFT of the required input; or on the TOP of the column if multiple inputs are possible.
4. The comment defines what input is required, with the command to **ENTER** the data in **RED**.
5. Comments to Clarify the instruction, or list a default value are listed in **BLUE!**
6. These comments are in the Yellow area of the worksheet. Yellow areas are locked to protect the program integrity. All **INPUT** Data from **%TDD** Tab is transferred to the **%Vthd** Tab & corresponding Cell. THAT Data is LOCKED!
7. Inputs like project number and other items to identify the project are displayed in **BLUE type**!
8. The default value for % Demand of t1 is set at **80%**. This value is the load placed on the transformer by both the NON-linear load (drives) and the linear load. To illustrate: start with an assumption that 1HP equals 1KVA. Using a 2500 KVA transformer that is loaded to 80%, there will be a **2000 KVA** load. Then, if the drive load is 500 HP (or 500 KVA); the balance of 1500kVA load is LINEAR.
9. To **Enter** Input Short Circuit for the Primary; adjust the Primary **MVA** in cell J3. The default value is **400**.
10. NOTE: System Voltage, Frequency and Transformer Data are required. Wire data may not available; and generally falls into the 'not significant' category!
11. ENTER all drive inputs. Pay careful attention to what internal and external (or additional reactors) are used in the system.
12. Selection of the CONVERTER TYPE is generally 6-Pulse. If specified as 12 or 18 Pulse, select the appropriate type code. Selecting Type 5: = MIRUS filter; Type 7= the HG-7 TCI filter.

REPORT OUTPUT:

1. The Spread Sheets are set up to **PRINT** as a single 11" x17" sheet. Columns of Formulas and Look - Up tables are hidden to make the printout readable.
   TABS: %TDD and **%Vthd** should both be printed for each study. The footer will identify each tab with title and page number.
2. The VALUE for **% Vthd** shows at CELL P30.
3. The VALUE for **% TDD** shows at CELL P28
4. Written RESULTS are displayed at CELLS O30 through P30 on page 2!
   Note: Results will show in **GREEN** text when the results pass; **RED** text will display as a failure when IEEE519 guidelines are exceeded.
5. Individual Harmonics Results are displayed in 2 formats. The bar graphs display the data in relative format; the actual data for each harmonic is also displayed!

Updated 10-28-11 by MAM

Harmonic Analysis Program inputs:

Rev: 10/1/2002 TJB

1) System frequency
2) Nominal primary and secondary voltages
3) Location of PCC (Point of Common Coupling)
4) The utility demand load,
5) Network configuration as "fed from" sources
6) All significant network impedances,
7) The total drive complement, the drive converter types
8) Average motor loading.

The most significant impedances are those from the transformers and reactors in the drives current paths. All of these should be included in the analysis. Wire impedances are usually less significant but wires with long runs and with significant voltage drops must be included.

Transformer impedances are defined in term of rated KVA and % Impedance at that KVA
%Zxfmr@PCC = %Zxfmr@KVA * (sqrt3 * Idrvs@PCC * Vll@PCC) / (KVAxfmr*1000)
Wire impedance is determined from a look up table giving ohms per foot for the wire size times the cable length divided by number of cables in parallel.
%Zwire@PCC = 100 * (sqrt3 * Idrvs@PCC * Vll@PCC) / Vll@wire^2
* ohms/foot from lookup table for wire size * wire length / number of cables in parallel
Individual drive reactor or transformer impedances are input as %Z with respect to that drive

The **Zsource, Ishort_circuit, Idemand Calculator** inputs source impedance in 4 forms:
Primary Short Circuit MVA; If Short Circuit Current is known adjust MVAsc until current is correct
Primary R + jX
Primary Wire Size, Length, & Number in Parallel
Disrtibution Transformer KVA & %Impedance

The program assumes that all of these impedances are in series.
If any of these are not known or are insignificant: leave inputs blank.
If the impedance is not significant it will not be shown on the Harmonic Report

The program allows input for: up to nine transformers in any configuration, and ten busses with input wires; and for twenty-five drives with input wires and with internal and external series impedance. And for: 6, 12, or 18 pulse or active converters, harmonic trap or coupled filter or user harmonic data.

Demand is highest 15 or 30 minute average utility current in a month or year and is inputed as % of distribution transformer KVA. This % can be adjusted to a desired demand current. **If unknown; 80% is assumed**.

Idemand includes both drive currents and sinusoidal currents. The ratio Idemand/Idrives is assumed the same at all points in network
Program assumes a balanced system, X/R of 5 for transformers, X/R of 20 for reactors, all drives equally loaded.

The quality of the output report is related to the accuracy of all these inputs.

The program determines the %Ithdh for each harmonic for each drive from a lookup table giving %Ithdh at each harmonic for the drive equivalent %loop impedance determined from the configuration inputs. **The lookup table data was derived by pspice analysis program runs for different loop impedances.**
To obtain the total %Ithdh for each harmonic for each drive in the PCC path, each drive's individual %Ithdh times drive HP, are summed and divided by the total HP in the PCC path.

The Harmonic Analysis Report outputs: PCC location, Source impedance data, Demand data, Motor loading, Voltage, HP, Current at PCC (Isc, Idemand, Idrives), Equivalent %Z before and after PCC, total Z, Analysis Results: meets or fails IEEE-519 requirements, %Ithd, %TDD, %Vthd and IEEE-519 limits, If, Ih, Irms, Kfactor, Disp PF, Actual PF, Vrms, Vbus, Individual harmonic %Vthd & %TDD

Report Map:

Report Inputs:	Report Outputs:	Harm Table Data Line#s	Indiv Drive Harm Data:	Harmonic Tables:
A1:L51	M1:Z51	AA1:AA51	AB1:AZ51	CC1:cu420
Guarantees:		%Zloop Calculator:		
A54:K61	Limit Calculator	AA52:AZ97	Data for Charts:	index
Mitagation Methods:	N53:W60		BE1:BH51	6 pulse data
A63:K79	L55:M62		Data for Kfactor	%Zloop
	Wire Table:		BC1:BC51	Kfactor
	N64:S93			%Ithd
				Irms/If
			BA58:CB79	Ih/If
				DispPF
Load Calculator:	Path Calculator			ActPF
B101:AU149	AX102:BS127			%Vthd
				Vrms/Vs
%ZloopCalculator				Vbus/Vs
H150:AV156	AX128:BT150			%I2nd
				%I3rd
				%I4th
				%I5th
				%I6th
				%I7th
				%I8th
				%I9th
				%I10th
				%I11th
				%I12th
				%I13th
				%I14th
				%I15th
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				%I30th
				%I31th
				%I32th
				%I33rd
				%I35th
				%I37th
				%I39th
				%I41th
				%I43th
				%I45th
				%I47th
				%I49th
				index

REPORT EQUATIONS

Inputs:	Primary Z:	MVAsc (H3)(O11)	R (F3)(O12)	X (F4)(O13)	Wire: Size (F5)(O15)	Length (H5)(O16)	#inP (J5)(O17)
	LnFrq (C4)(S10)	Vpri (C5)	Kvat1 (C6)(O19)(C1	Vsec (C7) (E12)	%Z (F6)(D12)(O20)		
		PCC (F9)(P10)	Applic (F8)	Ave%MtrLoading (C9)(O24)		Dmd%KVAt1(F7)(O22)	
		t2-t9:	Kva (C13-20)	Vsec(D13-20)	%Z (E13-20)	FedFrom(B13-20)	
		b1-b10:	Wire:	Size (I11-20)	Length (J11-20)	#inP (K11-20)	
	Drive:	HP (D22-46)		CnvTyp(C22-46)	%Zint (E22-46)	%Zext (F22-46)	FedFrom(B22-46)
				Wire:	Size (G22-46)	Length (I22-46)	#inP (H22-46)

Calcs:
(S11) = (H9) = Vll@PCC = Vlookup(PCC,Table1,6,0) = Vsecinput for tx or Vlookup(fedfrom,Table3,6) for bx
(S12) = (L9) = HPdrv@PCC = Vlookup(PCC,Table1,3,0) = sum all HPs fed from tx or bx fed from … fed from PCC
(S13) = (L8) = Hpdrvtotal = (D148) = (D129) = sum(J129:J147) = sum all HPs ultimately fed from utility
(S16) = (J9) = Idrvs@PCC = 584 * HPdrvs@PCC / Vll@PCC Table1 = B129:I148

Primary Z:
(J3) = Isc from MVAsc@pri = MVAsc * 10^6 /sqrt3 / Vpri
(K3) = Isc from MVAsc@VPCC = MVAsc * 10^6 /sqrt3 / Vll@PCC
(L3) = %Z from MVAsc = 100 * Idrvs@PCC / Isc from MVAsc@PCC

(H4) = (O14) = Z = sqrt(R^2 + X^2)
(J4) = X / R
(K4) = Isc from R+jX@PCC = Vpri^2 / Vll@PCC / sqrt3 / Z
(L4) = %Z from R+jX@PCC = 100 * Idrvs@PCC / Isc from R+jX@PCC

Z from wire = Vlookup(Size, Table, 4) * Length / #inP
(K5) = Isc from wire@PCC = Vpri^2 / Vll@PCC / sqrt3 / Z from wire
(L5) = %Z from wire @PCC = 100 * Idrvs@PCC / Isc from wire@PCC

Iscpri@PCC = 1 / (1 / Isc from MVAsc@PCC + 1 / Isc from R+jX@PCC +1 / Isc from wire@PCC)
%Ztotalpri = %Z from MVAsc@PCC + %Z from R+jX@PCC + %Z from wire@PCC

(I6) = (O21) = Idistxfmr rating@PCC = KVAt1 * !000 / sqrt3 /Vll@PCC
(J8) = Idmd@PCC = Idistxfmr rating * %Xfmrdmd / 100 but not less than Idrvs = I6 * F7 / 100
(S15) = (F22) = Idmd = Max(I7 * S12 / S13, S16)
(H7) = KVAdmd =KVAt1*Dmd%KVAt1/100 =C6*F7/100
(K6) = Isc from t1@PCC = Idistxfmr rating *100 / %Zt1
(L6) = %Z from t1 = 100 * Idrvs@PCC / Isc from t1@PCC

(K7) = Isc@t1sec@PCC = 1 / (1 / Iscpri@PCC + 1 / Isc from t1@PCC)

(L7) = %Ztotal@t1sec@PCC = 100 * Idrvs@PCC / Isc@t1sec@PCC
(S20) = %Z before PCC = Sum[all%Z*HPthruZin path from PCC to utility] / HP@PCC = AV156

(S21) = %Z after PCC = (Vlookup(PCC,Table,5,0) - Hlookup(PCC,Table2,27,0)) / HPdrvs@PCC
(S14) = Isc@PCC = Idrvs@PCC *100 / %Zs before PCC = S16 * 100 /S20
(S22) = %Zloop = %ZbeforePCC + %ZafterPCC

(AB-AZ52) = %Zloopdrv = sum(%Z of each t and b in path from drive to utility) + %Ztipri + %Ztotaldrv
Index = hline# + 52*(ConvTypedrv - 1) = [AA2-51 + 52 * (C27-51 - 1)]
(AB-AZ2-51) = %Ithdhdrv = Hlookup(%Zloopdrv,Table,index,1) + Interpolation
(AB-AZ59) = PathFactor = 1 if PCC is in path from drive to utility else 0
(Y3:Y51) = %TDDh = [sum for each drive (Path factor * HPdrv * %Ithdhdrv)] / HP@PCC / (Idmd/Idrv)

%Zpath =
(X2:X51) = %Vthdh = h/130 * sum(%Ithdhdrv * %Zpath)

(N28) = %TDD = sqrt(sum(%TDDh^2))
(N26) = %Ithd = %TDD * (Idmd/Idrvs) /.91
(N30) = %Vthd = sqrt(sum(%Vh^2))

(S23) = If = .91 * Idrvs@PCC
(S24) = Ih = %Ithd / 100 * If
(S25) = Irms = sqrt(If^2 + Ih^2)

(S26) = Kfactor = Summation [h^2 * (%TDD/100)^2] * (Idmd/Irms)^2 * .934

Inputs:	
Application=	D5
PCC Location=	D9
Current Factor=	G10
%Ave Mtr Loadin	G9
Line Freq=	J9,U10
MVAsc pri=	J3
R pri=	G3
X pri=	G4
Wire Size pri=	G5
Wire Length=	J5
Wire #P=	L5
KVA t1=	D6
%Z t1=	D7
Vll t1 pri=	G6
Vll t1 sec=	G7
%Dmd t1KVa=	D8
Xfmr t1/9	
Fed From=	C13/20
KVA=	D13/20
%Z=	E13/20
Vll sec=	F13/20
Bus b1/10	
Fed From=	J11/20
Wire Size=	K11/20
Wire #P=	L11/20
Wire Length=	M11/20
Drives d1/25	
Fed From=	C22/46
Conv Type=	D22/46
HPdrv=	E22/46
%Zf int=	F22/46
%Zf ext=	G22/46
%Loading=	H22/46
Wire Size=	I22/46
Wire #P=	J22/46
Wire Length=	K22/46

Calculations:		
Vll PCC=	K7,U11	Hlookup(D9,BM1:CG65,65,0)
HP drv PCC=	N9,U12	Hlookup(D9,BM1:CG65,62,0)
Hpused PCC=	N8,U13	Hlookup(D9,BM1:CG65,63,0)
Isc PCC=	U14	100*U16/U20
		Max(I8*G7/U11,
Idmd PCC=	K8,U15	430/G10/U11*Hlookup(D9,BM1:CG65,60,0)
Idrv PCC=	L9,U16	430/G10*U13/U11 430=746/sqrt3
Isc pri=	L3	M3*K7/G6
Z pri=	J4	sqrt(G3^2+G4^2)
X/R=	L4	G4/G3
Isc/Idmd=	U17	U14/U15=G2
Idmd/Idrv=	U18	U15/U16=J2
Isc/Idrv=	U19	U14/U16=L2
Irated t1=	K6,Q21	D6*1000/1.732/K7
Idmd ti pri=	I7	G8*1000/1.732/G6
Idmd ti sec=	I8	G8*1000/1.732/G7
KVA dmd=	G8,Q23	D6*D8/100
%Zs PCC=	U20	Hlookup(D9,BM1:CG70,68,0)
%Zf PCC=	U21	Hlookup(D9,BM1:CG70,69,0)
%Zloop=	U22	U20+U21
Irated=	G13/20	D13/20*1000/1.732/F13/20
If PCC=	U23	sqrt(U25^2-U24^2)
Ih PCC=	U24	U15*P28/100
Irms PCC=	U25	U16
Ampacity=	N11/20	Vlookup(K11/20,N65:S96,6)*L11/20
Kfactor PCC=	U26	sum(EO2:EO51)*(U15/U25/100)^2
PFdispPCC=	U27	Hlookup(U22,
PFactPCC=	U28	if(U27=0,1,U27)*U23/U25
VrmsPCC=	U29	Hlookup(U22,
VbusDrv1=	U30	Hlookup(AF69,
Ampacity=	L22/46	
%Z total=	M22/46	
Vll drv input=	N22/46	
%Ithdf=	P26	100*U24/U23
%TDD=	P28	sqrt(Sumsq(AA3:AA51))
%Vthdf=	P30	sqrt(Sumsq(Z3:Z51))

.001, G6, F12 to F20, Hlookup(BX53to CG53, BM1:CG65,65,0) BX toCG53=Fed From

AD135 to AD154

AC135 to AC154

Y135 to Y154

Sumproduct(AF132:BD132, AF133:BD133, Af135/154:BD135/154) +

Isc MVA=	M3	If(J3=0,10^15,J3*10^6/1.732/K7
%Z MVA=	N3	100*U16/M3
Isc R+jX=	M4	If(J4=0,10^15,G6/J4/1.732/K7
%Z R+jX=	N4	100*U16/M4
		If(L5=0,10^15,G6^2/K7/1.732/
Isc Wire pri=	M5	Vlookup(G5,n65:R94,4)*L5/J5
%Z wire pri=	N5	100*U16/M5
Isc t1 only=	M6	D6*10^5/1.732/K7/D7
%Z t1=	N6	100*U16/M6
Isc t1 sec=	M7	1/(1/M3+1/M4+1/M5+1/M6)
%Z total=	N7	sum(N3:N6)

BF127 to BY127 Sum [AB107/AA107*Bf/BY107 +… +]*BF/BY130 + AB107/126

AD107 to AD126

EO2/O51 = sum[(X3 to 51 * AA3 to 51)^2]

AF165/211

%Ithdhdrv

Hpuseddrvall

Drvs in PCC path

%TDDh= AA3/51 [AF103*AF56*(AF3/51+AF163/211)+…+BD$103*BD$56*(BD3/51+BD163/211))]/(N8*U18)

Sum for all drvs[(1 if Drv in PCC path else 0) Hpuseddrvall %Ithdhdrv] + AF165/211] / (HPusedPCC Idmd/Idrvs)

%Vthdf= 100 sum h=2 to 50 sqrt[[Vh / Vf]^2} = 100

Vh s to n = h sum over all nodes in PCC path [Znode Ihnode]

Znode = %Z node/100 * Vllnode / Inode / sqrt3 = Vfnode / Ifnode / sqrt3

Inode = 430/G10*HPnode

Ihnode = %Ih/100 node Ifnode

%Vh/Vf= Z3:Z51 X3/51/130*Sum[BJ80/100*Hlookup(BK80/100,BM1:CG65,X3/51+1,0)] + BK163/21

h/130 * Sum for all nodes in PCC path[%Znode * %Ithdnode] + BK163/211

%Znode= BJ80/100 HLOOKUP(BK80/100,$BM$1:$CG$75,66,0)*BI80/100/$N$8

0.134=100/sqrt3/430 Hpat node BI80/100= VLOOKUP(BK80/100,$Z$135:$AE$155,3,0)

Nodes in PCC BK80/100 D9, HLOOKUP(BK80/100,$BK$1:$CG$53,53,0)

%Ithdnode=

BK163/211

$X3/130*(BJ$80*HLOOKUP($BK$80,$BM$1:$CG$51,$X3+1,0)+BJ$81*HLOOKUP($BK$81,$BM$1:$CG$51,$X3+1,0)+BJ$82*HLOOKUP($BK$82,$BM$1:$CG$51,$X3+1,0)+BJ$83*HLOOKUP($BK$83,$BM$1:$CG$51,$X3+1,0)+BJ$84*HLOOKUP($BK$84,$BM$1:$CG$51,$X3+1,0)+BJ$85*HLOOKUP($BK$85,$BM$1:$CG$51,$X3+1,0)+BJ$86*HLOOKUP($BK$86,$BM$1:$CG$51,$X3+1,0)+BJ$87*HLOOKUP($BK$87,$BM$1:$CG$51,$X3+1,0)+BJ$88*HLOOKUP($BK$88,$BM$1:$CG$51,$X3+1,0)+BJ$89*HLOOKUP($BK$89,$BM$1:$CG$51,$X3+1,0)+BJ$90*HLOOKUP($BK$90,$BM$1:$CG$51,$X3+1,0)+BJ$91*HLOOKUP($BK$91,$BM$1:$CG$51,$X3+1,0)+BJ$92*HLOOKUP($BK$92,$BM$1:$CG$51,$X3+1,0)+BJ$93*HLOOKUP($BK$93,$BM$1:$CG$51,$X3+1,0)+BJ$94*HLOOKUP($BK$94,$BM$1:$CG$51,$X3+1,0)+BJ$95*HLOOKUP($BK$95,$BM$1:$CG$51,$X3+1,0)+BJ$96*HLOOKUP($BK$96,$BM$1:$CG$51,$X3+1,0)+BJ$97*HLOOKUP($BK$97,$BM$1:$CG$51,$X3+1,0)+BJ$98*HLOOKUP($BK$98,$BM$1:$CG$51,$X3+1,0)+BJ$99*HLOOKUP($BK$99,$BM$1:$CG$51,$X3+1,0)+BJ$100*HLOOKUP($BK$100,$BM$1:$CG$51,$X3+1,0))+BK163

$X51/130*(BJ$80*HLOOKUP($BK$80,$BM$1:$CG$51,$X51+1,0)+BJ$81*HLOOKUP($BK$81,$BM$1:$CG$51,$X51+1,0)+BJ$82*HLOOKUP($BK$82,$BM$1:$CG$51,$X51+1,0)+BJ$83*HLOOKUP($BK$83,$BM$1:$CG$51,$X51+1,0)+BJ$84*HLOOKUP($BK$84,$BM$1:$CG$51,$X51+1,0)+BJ$85*HLOOKUP($BK$85,$BM$1:$CG$51,$X51+1,0)+BJ$86*HLOOKUP($BK$86,$BM$1:$CG$51,$X51+1,0)+BJ$87*HLOOKUP($BK$87,$BM$1:$CG$51,$X51+1,0)+BJ$88*HLOOKUP($BK$88,$BM$1:$CG$51,$X51+1,0)+BJ$89*HLOOKUP($BK$89,$BM$1:$CG$51,$X51+1,0)+BJ$90*HLOOKUP($BK$90,$BM$1:$CG$51,$X51+1,0)+BJ$91*HLOOKUP($BK$91,$BM$1:$CG$51,$X51+1,0)+BJ$92*HLOOKUP($BK$92,$BM$1:$CG$51,$X51+1,0)+BJ$93*HLOOKUP($BK$93,$BM$1:$CG$51,$X51+1,0)+BJ$94*HLOOKUP($BK$94,$BM$1:$CG$51,$X51+1,0)+BJ$95*HLOOKUP($BK$95,$BM$1:$CG$51,$X51+1,0)+BJ$96*HLOOKUP($BK$96,$BM$1:$CG$51,$X51+1,0)+BJ$97*HLOOKUP($BK$97,$BM$1:$CG$51,$X51+1,0)+BJ$98*HLOOKUP($BK$98,$BM$1:$CG$51,$X51+1,0)+BJ$99*HLOOKUP($BK$99,$BM$1:$CG$51,$X51+1,0)+BJ$100*HLOOKUP($BK$100,$BM$1:$CG$51,$X51+1,0))+BK211

$X3/130*(BJ$80*HLOOKUP($BK$80,$BM$1:$CG$51,$X3+1,0)+BJ$81*HLOOKUP($BK$81,$BM$1:$CG$51,$X3+1,0)+BJ$82*HLOOKUP($BK$82,$BM$1:$CG$51,$X3+1,0)+BJ$83*HLOOKUP($BK$83,$BM$1:$CG$51,$X3+1,0)+BJ$84*HLOOKUP($BK$84,$BM$1:$CG$51,$X3+1,0)+BJ$85*HLOOKUP($BK$85,$BM$1:$CG$51,$X3+1,0)+BJ$86*HLOOKUP($BK$86,$BM$1:$CG$51,$X3+1,0)+BJ$87*HLOOKUP($BK$87,$BM$1:$CG$51,$X3+1,0)+BJ$88*HLOOKUP($BK$88,$BM$1:$CG$51,$X3+1,0)+BJ$89*HLOOKUP($BK$89,$BM$1:$CG$51,$X3+1,0)+BJ$90*HLOOKUP($BK$90,$BM$1:$CG$51,$X3+1,0)+BJ$91*HLOOKUP($BK$91,$BM$1:$CG$51,$X3+1,0)+BJ$92*HLOOKUP($BK$92,$BM$1:$CG$51,$X3+1,0)+BJ$93*HLOOKUP($BK$93,$BM$1:$CG$51,$X3+1,0)+BJ$94*HLOOKUP($BK$94,$BM$1:$CG$51,$X3+1,0)+BJ$95*HLOOKUP($BK$95,$BM$1:$CG$51,$X3+1,0)+BJ$96*HLOOKUP($BK$96,$BM$1:$CG$51,$X3+1,0)+BJ$97*HLOOKUP($BK$97,$BM$1:$CG$51,$X3+1,0)+BJ$98*HLOOKUP($BK$98,$BM$1:$CG$51,$X3+1,0)+BJ$99*HLOOKUP($BK$99,$BM$1:$CG$51,$X3+1,0)+BJ$100*HLOOKUP($BK$100,$BM$1:$CG$51,$X3+1,0))+BK163

$X51/130*(BJ$80*HLOOKUP($BK$80,$BM$1:$CG$51,$X51+1,0)+BJ$81*HLOOKUP($BK$81,$BM$1:$CG$51,$X51+1,0)+BJ$82*HLOOKUP($BK$82,$BM$1:$CG$51,$X51+1,0)+BJ$83*HLOOKUP($BK$83,$BM$1:$CG$51,$X51+1,0)+BJ$84*HLOOKUP($BK$84,$BM$1:$CG$51,$X51+1,0)+BJ$85*HLOOKUP($BK$85,$BM$1:$CG$51,$X51+1,0)+BJ$86*HLOOKUP($BK$86,$BM$1:$CG$51,$X51+1,0)+BJ$87*HLOOKUP($BK$87,$BM$1:$CG$51,$X51+1,0)+BJ$88*HLOOKUP($BK$88,$BM$1:$CG$51,$X51+1,0)+BJ$89*HLOOKUP($BK$89,$BM$1:$CG$51,$X51+1,0)+BJ$90*HLOOKUP($BK$90,$BM$1:$CG$51,$X51+1,0)+BJ$91*HLOOKUP($BK$91,$BM$1:$CG$51,$X51+1,0)+BJ$92*HLOOKUP($BK$92,$BM$1:$CG$51,$X51+1,0)+BJ$93*HLOOKUP($BK$93,$BM$1:$CG$51,$X51+1,0)+BJ$94*HLOOKUP($BK$94,$BM$1:$CG$51,$X51+1,0)+BJ$95*HLOOKUP($BK$95,$BM$1:$CG$51,$X51+1,0)+BJ$96*HLOOKUP($BK$96,$BM$1:$CG$51,$X51+1,0)+BJ$97*HLOOKUP($BK$97,$BM$1:$CG$51,$X51+1,0)+BJ$98*HLOOKUP($BK$98,$BM$1:$CG$51,$X51+1,0)+BJ$99*HLOOKUP($BK$99,$BM$1:$CG$51,$X51+1,0)+BJ$100*HLOOKUP($BK$100,$BM$1:$CG$51,$X51+1,0))+BK211

[N7-N6, N6, E13/20/(D13/20+0.001)*BP/BW55, VLOOKUP($K11,$N$65:$R$94,4,0)*$M11/($L11+0.001)*173.2*584*BX55/(BX64+0.001)^2]*BI80/100/$N$8

BK1:CG53 line 53 = Node Fed From = 0, utility, C13/20, J11/20