Softstuf, Inc.

Line Groups and Fault Location

Technical Description Document, Revision 8 – 06/18/2018

<u>1.0 – Line Groups</u>

1.1) Definition:

A Line Group is a set of fields that identify the analog and digital channels of a specific line in a specific DME (Disturbance Monitoring Equipment) such as a Digital Fault Recorder (DFR), or a Sequence of Events Recorder (SOE) or a digital relay. The fields are used for identifying the line's three phase currents and voltages and associated events, and other related information such as line length, impedance, and remote end identification.

1.2) Purpose:

The process of preparing DME data for analysis is time consuming. The process includes selection, conversion, validation, alignment, calculation and merging of analog and digital data channels. Typically 45 minutes of each analysis hour is spent preparing data.

The purpose for Line Groups is to automate the process of preparing data by using templates and scripts as defined in this document. The successful use of Line Groups results in significant reductions in the time it takes to prepare data for analysis (from minutes to seconds), and enables automatic analysis and report generation features which include health checks and fault location reports.

1.3) Contents:

- Sections 1.4 thru 1.8: Format and filename details, examples, limitations, and software calculated channels
- Sections 1.9 and 1.10: Installation and usage
- Section 2: Scripts formats and report files (manual and automatic application)
- Section 3: Automatic processing and reporting architecture
- Section4: Contact information

1.4) Format:

For each DME, a text file is used to list all of the monitored lines/feeders. Each feeder in the list is a Line Group. The fields that define a Line Group are shown in Table 1.1.

Field	Description	Format
LINENAME	Line/Feeder Designation	Text (up to 12 Characters)
REMOTEDME	Remote DME Designation	Text (up to 24 Characters)
REMOTENAME	Remote Line/Feeder Designation	Text (up to 12 Characters)
VACHAN	VA Analog Channel Title	String (1 to 255)
VBCHAN	VB Analog Channel Title	String (1 to 255)
VCCHAN	VC Analog Channel Title	String (1 to 255)
IACHAN	IA Analog Channel Title	String (1 to 255)
IBCHAN	IB Analog Channel Title	String (1 to 255)
ICCHAN	IC Analog Channel Title	String (1 to 255)
INCHAN	Neutral Analog Channel Title	String (1 to 255)
BREAKER1	Digital Channel Title – Breaker 1 Status	String (1 to 1024)
BREAKER2	Digital Channel Title – Breaker 2 Status	String (1 to 1024)
EVENT1	Digital Channel Title – Event 1 Status	String (1 to 1024)
EVENT2	Digital Channel v – Event 2 Status	String (1 to 1024)
EVENTN	Digital Channel Title – Event N Status	String (1 to 1024)
VACOLOR	VA Channel Color	Text (Example: Red)
VBCOLOR	VB Channel Color	Text (Example: Blue)
VCCOLOR	VC Channel Color	Text (Example: Green)
IACOLOR	IA Channel Color	Text (Example: Red)
IBCOLOR	IB Channel Color	Text (Example: Blue)
ICCOLOR	IC Channel Color	Text (Example: Green)
INCOLOR	Neutral Channel Color	Text (Example: Fuchsia)
POSSEQR	Real POS SEQ Line Impedance (in ohms)	Real Num (5 Decimal Digits)
POSSEQX	Imaginary POS SEQ Line Impedance	Real Num (5 Decimal Digits)
ZEROSEQR	Real Zero SEQ Line Impedance (in ohms)	Real Num (5 Decimal Digits)
ZEROSEQX	Imaginary Zero SEQ Line Impedance	Real Num (5 Decimal Digits)
LINEMILES	Total Line Length in Miles	Real Num (2 Decimal Digits)
FROMBUS	CAPE From Bus Designation	String (up to 9999)
TOBUS	CAPE To Bus Designation	String (up to 9999)
CKTNUM	CAPE Circuit Number	String (up to 9999)

Table-1.1; Format of Line Groups File

1.5) Line Groups Filename:

The Line Groups filename is composed of the Substation name as specified in the COMTRADE configuration file (CFG) plus the extension ".LNG". For the CFG file shown in Figure 1.1 the Substation name is "West 49th Street" so the filename is "West 49th Street.LNG".

📈 File: C:\Wavewin32\ConEd\Lin	eGroups\Records\West 49th Street\R10F421_150729,091006906,-4t,West 49th Street,USI_M9000,USI,WWD.CFG 💶 🔲 🗙
West 49th Street USI M9	000,1999
903, 30A, 929D	
1,1,A,Bus Section #1 VA	. 345 KV VOLTAGE,V,18.7506,0,0,-32768,32767,345000,115,P
2,2,A,Bus Section #6 VA	345 KV VOLTAGE, V, 18.7506, 0, 0, -32768, 32767, 345000, 115, P
3,3,A,Feeder M54	A Phase Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
4,4,B,Feeder M54	B Phase Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
5,5,C,Feeder M54	C Phase Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
6,6,N,Feeder M54	Ground Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
7,7,A,Feeder M55	A Phase Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
8,8,B,Feeder M55	B Phase Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
9,9,C,Feeder M55	C Phase Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
10,10,N,Feeder M55	Ground Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
11,11,B,Bus Section #1	VB 345 KV VOLTAGE, V, 18.7506, 0, 0, -32768, 32767, 345000, 115, P
12,12,B,Bus Section #6	VB 345 KV VOLTAGE, V, 18.7506, 0, 0, -32768, 32767, 345000, 115, P
13,13,A,Feeder M51	A Phase Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
14,14,B,Feeder M51	B Phase Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
15,15,C,Feeder M51	C Phase Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
16,16,N,Feeder M51	Ground Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
17,17,A,Bus Section #2	VA 345 KV VOLTAGE, V, 18.7506, 0, 0, -32768, 32767, 345000, 115, P
18,18,A,Bus Section #5	VA 345 KV VOLTAGE, V, 18.7506, 0, 0, -32768, 32767, 345000, 115, P
19,19,A,Feeder M52	A Phase Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
20,20,B,Feeder M52	B Phase Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P
21,21,C,Feeder M52	C Phase Current, A, 2.0834, 0, 0, -32768, 32767, 2000, 5, P

Figure-1.1; COMTRADE Configuration file showing the Substation Field is highlighted

1.6) Line Groups File Example:

Figure 1.2 shows the Line Group definition for one of the Feeders listed in the configuration file shown in Figure 1.1.

r	
File: C:\Wavewin32\ConEd\LineGroups\Records\West 49th Street\West 49th Street.LNG 💶 🔲	×
[M52]	-
LineName=M52	
RemoteDME=Sprainbrook 345kv	
RemoteName=M52	
VaChan=1	
VbChan=11	
VcChan=27	
IaChan=19	
IbChan=20	
IcChan=21	
InChan=+19/+20/+21/u=A/	
Breaker1=50	
Breaker2=54	
Event1=79	
Event2=80	
Event3=81	
Event4=82	
Event5=83	
Event6=84	
Event7=85	
Event8=89	
VaColor=Red	
VbColor=Blue	
VcColor=Green	
IaColor=Red	
IbColor=Blue	
IcColor=Green	
InColor=Fuchsia	
PosSeqR=0.9522	
PosSeqX=4.42773	
ZeroSeqR=9.59342	
ZeroSeqX=13.0927	
LineMiles=17.6	
FromBus=1400	
ToBus=1000	
Cktnum=29	-
1:1 Modified Insert Copyright © 2016, Softstuf, Inc.	
,, ,,	

Figure-1.2; Line Groups File Contents Example

1.7) Structural Limits:

For Wavewin, up to 16 Line Groups can be defined for each DME. Each Line Group can have up to 10 digital channels (Breakers and other Event fields) and 10 calculated channels.

1.8) Calculated Channels:

If a group contains an unmonitored neutral or current phase, or if the currents are not monitored but can be calculated from the vector sum of breaker currents, then the definitions may include script instructions to reproduce the unmonitored phases:

- *Example 1:* If the phase currents are channels 1, 2, and 3 then the INCHAN field can be calculated using the script instruction +1/+2/+3/u=Amps/.
- *Example 2:* If the breaker channels for A phase currents are 7 and 24 then the IACHAN field can be calculated using the script instruction +7/+24/u=Amps/.

1.9) Installation:

To install Line Groups files:

- **Step-1)** Save: Create a folder (preferably a shared folder on a network drive for access by other users) and then copy the Line Groups files to it.
- **Step-2) Point:** Run Wavewin and select "Driver Configuration" from the "Options" menu in the file manager as shown in Figure 1.3, then select COMTRADE from the Drivers list and point to the new folder in the Header Directory field as shown in Figure 1.4.

WAVEWIN H.3									a	×
Files Edit Sort Mark	Options Drivers Query Window	Help	_	_						~
Evit Quetore	Display	The Devices A Stations	/ Foult					09/2	9/2015 03:40:15 D	
	Display		-> raun	>				0.5/2	0/2013 03.43.13 P	141
Files: 🔛 🖓 🔸	Driver Conliguration		🥴 ·	× •						
C:\Wavewin32\Cor	Query Tab								_ _ >	×I
Foldoro	Show/Hide Channel Titles	File Name	E-Type	Size	Fault Date	Fault Time	Save Date	Save Time	Driver	2
	Waveform File(s)		1.1264	0.00			00 / 10 / 0015	00.005.004	DeatDis	-1
	Waveform Summaries			0			08 / 16 / 2015	23 : 35 : 34	Previous Dir	
Nev.	Complex Calculator	Sprainbrook 345kV ,USI_M9000,U	CFG	35319	07 / 10 / 2015	11 : 52 : 02 . 283	07 / 12 / 2015	00 : 31 : 54	ASCII	
- 🔁 Geoma		Bprainbrook 345kV ,USI_M9000,U	dat	3379200	07 / 10 / 2015	11 : 52 : 02 . 283	07 / 12 / 2015	00 : 31 : 54	Comtrade	
🖻 🗁 Line Gr	ASCII Display F2	Dunwoodie 345kV/USI_M9000/US	CFG	30374	07 / 10 / 2015	09 : 57 : 17 . 751	07 / 12 / 2015	00:31:54	ASCI	
- 🛅 Des	Hexadecimal Display F3	-5 Pleasant Valley (DEB) LISL 20	CEG	1620	10 / 02 / 2004	13 : 00 : 08 531	10 / 02 / 2004	13 - 00 - 08		
📄 📄 LNC	DAU Station Information	-5.Pleasant Valley (DFR).USI 20	DAT	173884	10 / 02 / 2004	13 : 00 : 08 . 531	10 / 02 / 2004	13 : 00 : 08	Comtrade	
	Edit DAU-DEF File	-5,Pleasant Valley (DFR),USI_20	HDR	1403	10 / 02 / 2004	13 :00 :08 .531	07 / 07 / 2015	20 : 58 : 22	ASCI	
🛅 Ter		5,LEED,Transcan1991,NGRID,T	CFG	1679	10 / 02 / 2004	13 :00 :08 .523	09 / 03 / 2014	00 : 42 : 50	ASCI	
🖻 🖨 USI	Reports	 P5,LEED, Transcen1991, NGRID, T ELEED Transcen1991 NGRID T 	UAT	542168	10 / 02 / 2004	13 : 00 : 08 . 523	10 / 02 / 2004	13 : 00 : 08	Comtrade	
	Save As Comtrade	tion - Template EMT	EMT	676	10 / 02 / 2004	13 . 00 . 00 . 323	07 / 14 / 2015	17 48 08	ASCIL	
	Auto Convert to Comtrade	ation - Values.CSV	CSV	1499			07 / 15 / 2015	10 : 42 : 04	CSV File	
	Compress Comtrade Files	mmary - Template.FMT	EMT	521			07 / 27 / 2015	14 : 26 : 24	ASCII	
	Davies Menseen	mmary-Values.CSV	CSV	524			07 / 27 / 2015	14:26:24	CSV File	
	Device Manager	ectors - Lemplate.FM L	CEV	218			08 / 14 / 2015	13 : 22 : 20	ASUI CRVEIA	
	BroadCast Mode		/dr	0			09 / 28 / 2015	00 : 14 : 32	Directory	
	Dispatcher Table		Ing	2551			07 / 13 / 2015	22 : 40 : 38	ASCII	
	Fault Data Manager		/dr	0			09 / 07 / 2015	17 : 16 : 56	Directory	
	SOE Manager	• p	Ing	3235			07 / 13 / 2015	22 : 40 : 40	ASCI	
	TO TRANSPORT		1/or				109 7 21 7 2015	21 41 54	LUIRCION	

Figure-1.3; Selecting the Driver Configuration Dialog



Figure-1.4; Pointing to the Line Groups files (Driver's Header Directory)

1.10) Using Line Groups:

Run Wavewin and open a fault record from a DME. Click on the list indicator of the ALL icon as shown in Figure 1.5, and then select a Feeder designation to view its channels as shown in Figure 1.6. Mouse-over the ALL icon to see the designation of the selected Feeder.



Figure-1.5; Selecting a Line Group to View for Manual Analysis



Figure-1.6; Waveform Display Showing the Selected Line Group

2.0 – Scripts and Report Files

2.1) Format:

Multiple types of report files can be created including for example health checks and fault location reports. To simplify the process of creating various types of reports, script instructions are used for defining and formatting reports. This allows users to modify or create new reports without having to upgrade the Software.

Script instructions are enclosed in reserved characters: < > []. The instructions are inserted in user created text files. The < > characters are used to define fault quantities and [] are used to define prefault quantities. For example, the following script sequence:

- DME Name: <Station>
- Feeder: <Line>
- Fault Time: <Date> <Time>
- VA Prefault: [^1:R][^1:U] at [^1:P] Degrees
- VA Fault: <^1:R><^1:U> at <^1:P> Degrees

Produces the following text sequence:

• DME Name: Mott Haven

- Feeder Name: 71
- Fault Time: 07/27/2015 10:31:41.383333
- VA Prefault: 342206.042 V at 243.004 Degrees
- VA Fault: 299962.322 V at 248.203 Degrees

Files containing such script instructions are template files that are used with Line Groups to produce custom reports.

2.2) Manual Application:

Here are the steps to manually apply a script template to a selected DME record:

- **Step-1) Select Feeder:** Run Wavewin and open a DME fault record and then select the desired Feeder from the Line Groups list as shown in Figures 1.4 and 1.5.
- **Step-2)** Select Template: Select the "Mark and Save" window from the "Values" menu option as shown in Figure 2.1 and then use the highlighted browse button as shown in Figure 2.2 (red circle) to select the desired template containing the user script instructions. If the template has not been created yet, then specify a filename in the top window, create the script template, and then click the Save button.
- **Step-3**) **Apply Template:** To apply the template, position the solid black data bar in the fault area, then position the dashed blue reference bar in the prefault area, and then click on the Mark button at the bottom of the "Mark and Save" window (red circle) to create the custom report as shown in Figure 2.3.



Figure-2.1; Selecting the Mark and Save Window for Creating Custom Reports



Figure-2.2; Selecting the Desired Template for Creating Custom Reports



Figure-2.3; Resulting Custom Report from the Mark and Save Window

2.3) Automatic Application:

Command line parameter are used to invoke Wavewin to open a DME record, select a Feeder from its Line Groups, select a user template with script instructions, and then create the custom report (all automatically).

The command line parameters are included in a text file named "FLREPORT.RUN". The contents of the parameters file are shown in Table 2.1:

Field	Description	Format
DME Record	Path and filename of DME record	Text (up to 128 Characters)
/Line	Feeder from the DME Line Groups	Text (up to 12 Characters)
/ Template	Path and filename of template file	Text (up to 128 Characters)
/Exit	Command to close when complete	Text (Fixed)

Table-2.1; FLREPORT.RUN Contents for Automatic Creation of Custom Reports

Once the parameters file is created, Wavewin can be invoked with the following command line:

Drive:\Program Path\Wavewin32.exe "Template Path\FLREPORT.RUN" /Batch

Where,

Drive: Is the drive letter where Wavewin is located.

Program Path: Is the path where Wavewin is located.

Template Path: Path where the template is located and where the custom report is saved. Batch: Command that tells the system to process multiple sets of line parameters.

Once Invoked with the /Batch command, Wavewin will open the FLREPORT.RUN file and iterate through all of the listed sets of command line parameters. For each set, Wavewin will perform the following steps (automatically):

- Open the specified DME record.
- Select the specified Feeder.
- Open the specified template with script instructions.
- Apply the specified template and save the resulting custom report.
- Proceed to the next set of command line parameters and repeat the above steps.
- Close Wavewin when complete.

The resulting custom report is saved as a text file in the template path. The report file is named in line with IEEE Std. C37.232 (COMNAME) with a DIG extension:

Date Report was Created, Time Report was Created, Name of Template File.DIG

2.4) Automatic Application Example:

An example of the FLREPORT.RUN command parameters file is shown in Figure 2.4.

ELEPORT.RUN - Notepad		_ 8 ×
File Edit Format View Help		
"C:\Wavewin32\ConED\Line Groups\Records\Academy*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\Buchanan*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\East Fishkills*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\East Fishkills*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\East Fishkills*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\East Fishkills*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\Gowanus*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\Gowanus*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\Gowanus*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\Gowanus*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\Vetasantville*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\Pleasantville*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\Pleasantville*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\Pleasantville*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:Wavewin32\ConED\Line Groups\Records\Pleasantville*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:\Wavewin32\ConED\Line Groups\Records\Pleasantville*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:\Wavewin32\ConED\Line Groups\Records\Pleasantville*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:\Wavewin32\ConED\Line Groups\Records\Pleasantville*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "C:\Wavewin32\ConED\Line Groups\Records\Pleasantville*.DAT" /Line=All /Template="C:\Wavewin32\ConED\Reports\ "	Vectors.FMT" Vectors.FMT" Vectors.FMT" Vectors.FMT" Vectors.FMT" Vectors.FMT" Vectors.FMT" Vectors.FMT" Vectors.FMT" Vectors.FMT" Vectors.FMT" Vectors.FMT" Vectors.FMT"	/Exit /Exit /Exit /Exit /Exit /Exit /Exit /Exit /Exit /Exit /Exit /Exit /Exit /Exit /Exit /Exit



The file lists multiple folders with DME records. The "*.DAT" wild card at the end of the first parameter tells Wavewin to process all of the COMTRADE DME records in that folder. The "/Line=ALL" parameter tells Wavewin to apply all of the Line Groups for each DME record. The "/Template=" parameter points Wavewin to the path and filename of the script template to apply. The "/Exit" parameter tells Wavewin to close the DME record when complete.

The name of the template file is up to the user and a different template may be used with each entry in the FLREPORT.RUN file. The template file used in this example is named "Vectors.FMT". The contents of the template file are shown in Figure 2.5.



Figure-2.5; Example of the Template File with Script Instructions

Once invoked with the command line parameter:

C:\Wavewin32\Wavewin32.exe "C:\Wavewin32\ConED\Reports\FLREPORT.RUN" /Batch

Wavewin will automatically iterate through all of the specified DME records and Line Groups and apply the specified templates. A snap shot of one step in the process is shown in Figure 2.6.



Figure-2.6; Snap Shot of Wavewin Iterating through DME Records and Feeders

When all of the specified DME records and Line Groups have been processed, Wavewin will save the resulting custom report to the same path where the FLREPORT.RUN file was specified. Figure 2.7 shows the resulting custom report.

		T. M. A.									
150924,110751442000	J, Vectors. I X	I - Notepad									
rie Eult Pormat view r	heip	D. t.		1/1	1/4	1/0	1/0	1.0	Long and	- •	
Station,	Line,	Date,	11me,	VA-rms,	VA-ph,	VB-rms,	VB-ph,	VC-rms,	VC-ph,	IA-rms,	1A- A
Duriwoodie 345kV,	150,	0//25/2015,	02:01:00.875833,	201317.093,	0.000,	202525.480,	-119./32,	204341.0/4,	119.880,	0.830,	1.20
Dunwoodie 345kV,	^{/1} ,	07/25/2015, $07/25/2015$	02:01:00.8/5833,	201208.105,	0.000,	202044.280,	-119./41,	204519.804,	119.852,	630,021	2
Dunwoodio 245kV	w72,	07/25/2015, $07/25/2015$	02.01.00.875833	201317.095,	0.000,	202323.400,	-110 741	204541.0/4,	110,852	120 781	-71
Dunwoodie 345kV	w73,	07/25/2015	02.01.00.875833,	201208.103,	0.000,	202044.200,	-110 722	204319.604,	110 890	240 155	-/1
Dupwoodie 345kV	w75L/M	07/25/2015	02:01:00.875833	201317.093,	0.000,	202323.480,	-110 7/1	204541.074,	110 852	612 071	177
Dunwoodie 345kV	W/ JL/M,	07/25/2015	02:01:00.875833	201208.105,	0.000,	202644.286	-110 741,	204519.804,	110 852	30 182	8/
Dunwoodie 345kV	w00,	07/25/2015	02:01:00.875833	201208.105,	0.000,	202523 486	-110 732	204311 674	110 880	810 270	-173
Sprainbrook 345kV	M29	07/29/2015	02.11.38 392083	202018 494	0.000	199398 175	128 672	206219 817	9 782	481 080	-164
Sprainbrook 345kV	M51	07/29/2015	02.11.38 392083	202018 494	0.000	199398 175	128 672	206219 817	9 782	805 969	-78
Sprainbrook 345kV.	M52.	07/29/2015.	02:11:38.392083.	202018,494,	0.000.	199398.175.	128,672	206219.817.	9,782	627.394.	ŏ
Sprainbrook 345kV.	W64.	07/29/2015.	02:11:38.392083.	203527.833.	0.000.	196859.617.	-119.757	197539.231	8.057.	947.144.	67
Sprainbrook 345kV.	W65.	07/29/2015.	02:11:38.392083.	203527.833.	0.000.	196859.617.	-119.757.	197539.231.	8.057.	935.927.	1
Sprainbrook 345kV,	W75,	07/29/2015,	02:11:38.392083,	202018.494,	0.000,	199398.175,	128.672,	206219.817,	9.782,	237.729,	-123
Sprainbrook 345kV,	W78,	07/29/2015,	02:11:38.392083,	203527.833,	0.000,	196859.617,	-119.757,	197539.231,	8.057,	913.970,	2
Sprainbrook 345kV,	W79,	07/29/2015,	02:11:38.392083,	203527.833,	0.000,	196859.617,	-119.757,	197539.231,	8.057,	1102.350,	179
Sprainbrook 345kV,	X28,	07/29/2015,	02:11:38.392083,	202018.494,	0.000,	199398.175,	128.672,	206219.817,	9.782,	619.028,	-123
Academy,	м29,	07/22/2015,	06:06:14.333333,	203439.577,	0.000,	204902.246,	-119.729,	206460.140,	119.991,	440.716,	167
Buchanan,	Y88,	07/20/2015,	15:47:18.865833,	200483.300,	0.000,	200362.138,	-119.785,	201082.114,	120.192,	316.250,	-178
Buchanan,	Y94,	07/20/2015,	15:47:18.865833,	198742.050,	0.000,	198907.000,	-119.511,	200262.876,	120.219,	153.700,	-12
Buchanan,	W93,	07/20/2015,	15:47:18.865833,	198646.247,	0.000,	199405.074,	-120.167,	196718.133,	121.618,	1281.798,	-2
Buchanan,	W95,	0//20/2015,	15:4/:18.865833,	195592.520,	0.000,	1996/5.251,	-120.282,	200/4/.125,	119.746,	1600.954,	1/6
Buchanan,	W96,	0//20/2015,	15:4/:18.865833,	198/42.050,	0.000,	198907.000,	-119.511,	200262.8/6,	120.219,	1669.938,	-1/9
Buchanan,	W97,	0//20/2015,	15:4/:18.865833,	200483.300,	0.000,	200362.138,	-119.785,	201082.114,	120.192,	840.495,	170
Buchanan,	w98,	0//20/2015, $07/20/2015$	15:4/:18.805833,	200483.300,	0.000,	200302.138,	-119./85,	201082.114,	120.192,	980.192,	1/9
E FISHKIII,	F 50,	07/29/2015, $07/20/2015$	08:04:09.418740	204/03.330,	0.000,	204/29.100,	-119.346,	203939.030,	110.024	628 520	-103
E FISHKIII,	E38.V8	07/29/2013, $07/20/2015$	08:04:09:418749,	204083.713,	0.000,	204090.249,	-110 342	2018/9.800,	120 077	048 882	-10/
E Fishkill	F 30±V8	07/29/2015, $07/29/2015$	08:04:09:418749,	203174 756	0.000,	201445 710	-110 100	204987 550	120.077,	1056 156	-0
E Fishkill	REK 305	07/29/2015	08.04.09 418749	204723 172	0.000	204831 264	-119 442	206309 182	119 972	1013 422	173
Farragut 345kV	41	07/29/2015	09.58.30 877708	196755 031	0.000	205551 171	-119 664	189335 436	119 862	317 125	165
Farragut 345kV	42,	07/29/2015	09.58.30 877708	207336 159	0.000	207567 926	7 395	184268 845	-114 034	313 368	-70
Farragut 345kV.	45.	07/29/2015.	09:58:30.877708.	198389.309.	0.000.	198772.181.	-119,716,	191580.930.	120.301.	312,954,	-43
Farraout 345kV.	46.	07/29/2015.	09:58:30.877708.	198198.117.	0.000.	203941.921.	-123.903.	197205.270.	119.822.	293.151.	145
Farragut 345kV,	в47,	07/29/2015,	09:58:30.877708,	196755.031,	0.000,	205551.171,	-119.664,	189335.436,	119.862,	84.176,	-154
Farragut 345kV,	48,	07/29/2015,	09:58:30.877708,	198198.117,	0.000,	203941.921,	-123.903,	197205.270,	119.822,	95.951,	-115
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Figure-2.7; Resulting Custom Report





Figure-3.1; High Level Architecture of the 3D Automation System Design

For each DME a number of Feeders are defined and for each Feeder a number of Reports are defined. This provides a many to many, three-dimensional (3D) architecture where: The first dimension is the DME, the second dimension is the Feeder, and the third dimension is the Report (a graphical depiction is provided in Figure 3.1).

The main function of Wavewin in this project is to automatically navigate the 3D architecture as an assembly line, meaning:

- *Step 1:* Recognize that a new DME record has been received.
- *Step 2:* Read/open the DME record (using COMTRADE format).
- *Step 3:* Apply the first/next defined Feeder for that DME.
- *Step 4:* Apply the first/next defined Report for that Feeder.
- *Step 5:* Repeat Step 4 until all of the Reports have been applied for that Feeder.
- Step 6: Repeat Step 3 until all of the Feeders have been applied for that DME.
- *Step 7:* Save/Archive all of the resulting Reports.
- *Step 8:* Mark the DME record as being processed (using COMNAME user fields).
- Step 9: Repeat (restarting at Step 1).

The objective is to unlock Giga Bytes of DME data and reduce to Kilo Bytes of information by extracting/calculating a sufficient set of key measurements to enable automation. The sufficient set of key measurements is defined by the default Report. The default Report includes script

commands to extract prefault and fault vectors, calculate unbalances, and save the resulting key measurements as a spreadsheet. The script commands provided with the default Report template are detailed in Table 3.1.

Script Command	Description	Format
<station:17></station:17>	DME Station Name	Text (up to 17 Characters)
<line:7></line:7>	DME Feeder Name	Text (up to 7 Characters)
[Date]	Date of Prefault Vectors	Date (Standard Format)
[Time]	Time of Prefault Vectors	Time (Standard Format)
[^1,^2,^3:B:6]	Prefault Voltages – Magnitude Unbalance	Numeric (6 digits)
[^4,^5,^6:B:6]	Prefault Currents – Magnitude Unbalance	Numeric (6 digits)
[^1,^2,^3:S:6]	Prefault Voltages – Phase Unbalance	Numeric (6 digits)
[^4,^5,^6:S:6]	Prefault Currents – Phase Unbalance	Numeric (6 digits)
[^1:R:10]	Prefault Vectors – VA RMS Magnitude	Numeric (10 digits)
[^1:P:6]	Prefault Vectors – VA Phase Angle	Numeric (6 digits)
[^2:R:10]	Prefault Vectors – VB RMS Magnitude	Numeric (10 digits)
[^2:P:8]	Prefault Vectors – VB Phase Angle	Numeric (8 digits)
[^3:R:10]	Prefault Vectors – VC RMS Magnitude	Numeric (10 digits)
[^3:P:8]	Prefault Vectors – VC Phase Angle	Numeric (8 digits)
[^4:R:8]	Prefault Vectors – IA RMS Magnitude	Numeric (8 digits)
[^4:P:8]	Prefault Vectors – IA Phase Angle	Numeric (8 digits)
[^5:R:8]	Prefault Vectors – IB RMS Magnitude	Numeric (8 digits)
[^5:P:8]	Prefault Vectors – IB Phase Angle	Numeric (8 digits)
[^6:R:8]	Prefault Vectors – IC RMS Magnitude	Numeric (8 digits)
[^6:P:8]	Prefault Vectors – IC Phase Angle	Numeric (8 digits)
[^7:R:8]	Prefault Vectors – IN RMS Magnitude	Numeric (8 digits)
[^7:P:8]	Prefault Vectors – IN Phase Angle	Numeric (8 digits)
<date></date>	Date of Fault Vectors	Date (Standard Format)
<time></time>	Time of Fault Vectors	Time (Standard Format)
<^1,^2,^3:N:6>	Fault Voltages – Negative Sequence	Numeric (6 digits)
<^4,^5,^6:N:6>	Fault Currents – Negative Sequence	Numeric (6 digits)
<^1:R:10>	Fault Vectors – VA RMS Magnitude	Numeric (10 digits)
<^1:P:6>	Fault Vectors – VA Phase Angle	Numeric (6 digits)
<^2:R:10>	Fault Vectors – VB RMS Magnitude	Numeric (10 digits)
<^2:P:8>	Fault Vectors – VB Phase Angle	Numeric (8 digits)

<^3:R:10>	Fault Vectors – VC RMS Magnitude	Numeric (10 digits)
<^3:P:8>	Fault Vectors – VC Phase Angle	Numeric (8 digits)
<^4:R:8>	Fault Vectors – IA RMS Magnitude	Numeric (8 digits)
<^4:P:8>	Fault Vectors – IA Phase Angle	Numeric (8 digits)
<^5:R:8>	Fault Vectors – IB RMS Magnitude	Numeric (8 digits)
<^5:P:8>	Fault Vectors – IB Phase Angle	Numeric (8 digits)
<^6:R:8>	Fault Vectors – IC RMS Magnitude	Numeric (8 digits)
<^6:P:8>	Fault Vectors – IC Phase Angle	Numeric (8 digits)
<^7:R:8>	Fault Vectors – IN RMS Magnitude	Numeric (8 digits)
<^7:P:8>	Fault Vectors – IN Phase Angle	Numeric (8 digits)
<bx:s></bx:s>	Breaker X Status (Normal/Abnormal)	Text (1 characters)
<bx:d></bx:d>	Breaker X Start Time (with Milliseconds)	Time Tag (27 characters)
<bx:e></bx:e>	Breaker X End Time (with Milliseconds)	Time Tag (27 characters)
<bx:t></bx:t>	Breaker X Report (Name, Time, Duration)	Summary (up to 80 Chars)
<ex:s></ex:s>	Event X Status (Normal/Abnormal)	Text (1 characters)
<ex:d></ex:d>	Event X Start Time (with Milliseconds)	Time Tag (27 characters)
<ex:e></ex:e>	Event X End Time (with Milliseconds)	Time Tag (27 characters)
<ex:t></ex:t>	Event X Report (Name, Time, Duration)	Summary (up to 80 Chars)
<z1m:8></z1m:8>	Magnitude Positive Seq Line Impedance	Numeric (8 digits)
<z1p:8></z1p:8>	Angle Positive Seq Line Impedance	Numeric (8 digits)
<z0m:8></z0m:8>	Magnitude Zero Seq Line Impedance	Numeric (8 digits)
<z0p:8></z0p:8>	Angle Zero Seq Line Impedance	Numeric (8 digits)
<ll:8></ll:8>	Total Line Length in Miles	Numeric (8 digits)
<fbus></fbus>	CAPE From Bus Designation	Integer (up to 9999)
<tbus></tbus>	CAPE To Bus Designation	Integer (up to 9999)
<cktn></cktn>	CAPE Circuit Number	Integer (up to 9999)
<rdme></rdme>	Remote DME Station Name	Text (up to 24 Characters)
<remote></remote>	Remote Feeder Name	Text (up to 12 Characters)

Table-3.1; Script Commands of the Default Report Template

All of the values needed for automation are defined by the above 58 script commands. The commands provide measurements of prefault and fault vectors for both voltage and current phases. They also include impedance and length values needed for running the single and double ended fault location algorithms.

The commands also provide functions for calculating imbalances and negative sequence, and triggers can be set for any of the calculations using L for less than or G for greater than. For example the command ^7:RG1250 will produce the text Alarm if the neutral current magnitude is over 1250 Amps RMS otherwise it will produce the text Normal.

The values resulting from running the script commands are saved to a text file. The text file format is comma separated (the script values are separated by commas and the last value is followed by a <CR/LF> as shown in Figure 2.7). With this format the key measurements for each line appear in a separate row.

4.0 – Contact Information

For questions and/or additional information, please contact:

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