SPP
Southwest
Power Pool

System Impact Study for Generation Interconnection Request

GEN-2003-019

SPP Tariff Studies
(#GEN-2003-019)

July 2004

Executive Summary

<OMITTED TEXT> (Customer) has requested a System Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnection of up to a 250 MW wind powered generation facility in Lincoln and Ellsworth Counties, Kansas to the transmission system of Midwest Energy (MIDW) and Westar Energy (WERE). The wind powered generation facility will be comprised of 139 individual 1.8MW Vestas V80 wind turbines. The requested in-service date for the 250MW facility is November 1, 2005.

The proposed point of interconnection is in the existing Summit – Knoll 230kV line at a new switching station located about 25 miles west of Salina, KS and in Ellsworth County north of Ellsworth, KS. This 230kV line is owned by MIDW and WERE. The customer has indicated their desire, along with the transmission owners, to change the metering structure on this 230kV line such that the proposed generation interconnection is with WERE. Interconnection relationships have no effect on the results of the System Impact Study. The substation configuration will be finalized during the Facility Study if the customer elects to proceed.

Using the machine data and collection system one-line provided by the requestor and other information publicly available, the stability studies indicate that the MIDW and WERE systems will remain stable for all but one simulated fault when the 250MW wind powered generation facility is connected to the transmission system. All or a portion of the standard Vestas turbines were tripped offline for 10 of the 20 fault simulations studied. The Vestas optional Advanced Grid Option 4 package, which represents enhanced low voltage ride-through capability, enabled the 250MW wind farm to ride through 18 of the 20 fault simulations studied. These two critical faults (Faults 1_1PH and 1_3PH) result in loss of the Summit to Customer 230kV line. This line also showed up as a critical contingency in the power flow studies done as part of the feasibility study. Due to unstable operation of the Vestas turbines after loss of the Summit to Customer 230kV line, it is recommended that an automatic switching scheme be implemented to simultaneously open the Customer to Knoll 230kV line section if the Summit to Customer 230kV line is locked out. Normal fault clearing on the line does not cause instability, only extended loss of the line. This will serve to remove the wind farm from the grid in the event of loss of the Summit to Customer 230kV line. Automated tripping of the wind farm for the loss of the Summit to Customer 230kV line also results in removing requirements for a transformer upgrade and reactive requirements at Knoll specified in the Feasibility Study for this request.

Short circuit analysis for this wind powered generation facility will be performed by the transmission owner as part of the Facility Study if the customer elects to proceed.

The minimum total estimated cost of construction on the MIDW system for this interconnection is $3.5 million. The cost includes only construction of the 230kV interconnection substation tapping the Summit to Knoll line. This cost does not include any costs associated with customer facilities including the customer 230/34.5kV substation, line connecting the customer substation and the new 230kV substation, or associated right-of-way. This cost also does not include any costs associated with network upgrades required to alleviate overloads found during the feasibility study contingency analysis. These costs are outlined in section 5.0.

1. Introduction

<OMITTED TEXT> (Customer) has requested a System Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for interconnecting up to a 250 MW wind powered generation facility in Lincoln and Ellsworth Counties, Kansas to the transmission system of Midwest Energy (MIDW) and Westar Energy (WERE). The wind powered generation facility will be comprised of 139 individual 1.8MW Vestas V80 wind turbines. The requested in-service date for the 250MW facility is November 1, 2005.

The proposed point of interconnection is in the existing Summit – Knoll 230kV line at a new switching station located about 25 miles west of Salina, KS and in Ellsworth County north of Ellsworth, KS. This 230kV line is owned by MIDW and WERE. The customer has indicated their desire, along with the transmission owners, to change the metering structure on this 230kV line such that the proposed generation interconnection is with WERE. Interconnection relationships have no effect on the results of the System Impact Study. The substation configuration will be finalized during the Facility Study if the customer elects to proceed.

2. Purpose

The purpose of the Interconnection System Impact Study is to evaluate the impact of the proposed interconnection on the reliability of the Transmission System. The Interconnection System Impact Study will consider the Base Case as well as all Generating Facilities (and with respect to (iii) below, any identified Network Upgrades associated with such higher queued interconnection) that, on the date the Interconnection System Impact Study is commenced: (i) are directly interconnected to the Transmission System; (ii) are interconnected to Affected Systems and may have an impact on the Interconnection Request; (iii) have a pending higher queued Interconnection Request to interconnect to the Transmission System; and (iv) have no Queue Position but have executed an LGIA or requested that an unexecuted LGIA be filed with FERC.

Nothing in this System Impact Study constitutes a request for transmission service or confers upon the Interconnection Customer any right to receive transmission service.

3.0 Facilities

3.1 Generating Facility

The generating facility was studied with the assumption that it would be using the Vestas V80 wind turbines. The nameplate rating of each turbine is 1.8MW (1800kW) with a machine base of 2000kVA. The turbine output voltage is 690V. The Vestas turbines utilize an induction-generator with a wound rotor and slip rings. The turbines utilize onboard, switched capacitor banks to compensate for the reactive power requirements of the induction generator.

Vestas has provided optional equipment configurations that consist of enhanced low voltage ride through capability and improved power electronics that will improve efficiency and grid response to power fluctuations. This study was performed using the “standard” Vestas V80 wind turbine package available and optionally using the Advanced Grid Option 4 (AGO4) package available.

3.2 Interconnection Facility

The Customer has proposed an interconnection facility, which would connect to the MIDW and WERE transmission systems via a new substation located in Lincoln and Ellsworth Counties, Kansas on the existing Summit to Knoll 230kV line. The new substation would be configured to accept a terminal from an adjacent 230/34.5kV transformer substation that serves the wind powered generation facility. The substation configuration will be finalized during the Facility Study if the customer elects to proceed. The customer has indicated their desire, along with the transmission owners, to change the metering structure on this 230kV line such that the proposed generation interconnection is with WERE. Interconnection relationships have no effect on the results of the System Impact Study.

The 230kV Summit to Knoll line is approximately 100 miles long and connects west-central Kansas to the more heavily interconnected eastern Kansas region. There are no other substations along the line between these two points.

4.0 Analysis

4.1 Powerflow Analysis

A powerflow analysis was conducted for the facility using modified versions of the 2004 series SPP powerflow models. The output of the Customer's facility was offset in each model by a reduction in output of existing online SPP generation. The in-service date of the facility is proposed to be November 2005.

The analysis of the customer's project shows that the proposed location can handle the entire 250MW of output under steady state conditions without system upgrades in all seasons out to the end of SPP's planning horizon. However, powerflow and stability analysis will show that concerns exist for a loss of the Summit to Customer 230kV line. The feasibility study that was performed for this interconnection request showed that replacement of the Knoll 115/230kV transformer would be required for the loss of the Summit to Customer 230kV line. The powerflow analysis also required reactive support installation at the Knoll 230kV bus and at the windfarm on the 34.5kV bus. Sizing and specification requirements for the reactive support were to be analyzed during this stability analysis.

There are several other proposed generation additions in the general area of the Customer's facility. It was assumed in this preliminary analysis that all of these other projects within MIDW's and WERE's service territory will be in service.

4.1.1 Powerflow Analysis Methodology

The Southwest Power Pool (SPP) criteria states that: The transmission system of the SPP region shall be planned and constructed so that the contingencies as set forth in the Criteria will meet the applicable *NERC Planning Standards* for System Adequacy and Security – Transmission System Table I hereafter referred to as NERC Table I and its applicable standards and measurements.

Using the created models and the ACCC function of PSS\E, single contingencies in the SPP region were applied and the resulting scenarios analyzed. This satisfies the 'more probable' contingency testing criteria mandated by NERC and the SPP criteria.

4.2 Stability Analysis

The following fault simulations were used to analyze the effects on various transmission system facilities and the wind farm.

The 20 faults that were performed are as follows:

1. **FLT_1_1_PH - 1-phase Fault**
   Fault on the GEN-2003-019 (90000) – Summit (56873) 230kV line, near Summit.
2. **FLT_1_3_PH - 3-phase Fault**
   Fault on the GEN-2003-019 (90000) – Summit (56873) 230kV line, near Summit.
3. **FLT_2_1_PH - 1-phase Fault**
   Fault on the Knoll (56558) – GEN-2003-019 (90000) 230kV line, near Knoll.
4. **FLT_2_3_PH - 3-phase Fault**
   Fault on the Knoll (56558) – GEN-2003-019 (90000) 230kV line, near Knoll.
5. **FLT_3_1_PH - 1-phase Fault**
   Fault on the Circle (56871) – Mullergren (58779) 230kV line, near Circle.
6. **FLT_3_3_PH - 3-phase Fault**
   Fault on the Circle (56871) – Mullergren (58779) 230kV line, near Circle.
7. **FLT_4_1_PH - 1-phase Fault**
   Fault on the Manhattan (56861) – Concordia (58758) 230kV line, near Manhattan.
8. **FLT_4_3_PH - 3-phase Fault**
   Fault on the Manhattan (56861) – Concordia (58758) 230kV line, near Manhattan.
9. **FLT_5_1_PH - 1-phase Fault**
   Fault on the Jefferies Energy Center (56766) – Summit (56773) 345kV line, near Summit.
10. **FLT_5_3_PH - 3-phase Fault**
    Fault on the Jefferies Energy Center (56766) – Summit (56773) 345kV line, near Summit.
11. **FLT_6_1_PH - 1-phase Fault**
    Fault on the Morris (56863) – Summit (56873) 230kV line, near Summit.
12. **FLT_6_3_PH - 3-phase Fault**
    Fault on the Morris (56863) – Summit (56873) 230kV line, near Summit.
13. **FLT_7_1_PH - 1-phase Fault**
    Fault on the Knoll (56561) – Redline (56605) 115kV line, near Knoll.
14. **FLT_7_3_PH - 3-phase Fault**
    Fault on the Knoll (56561) – Redline (56605) 115kV line, near Knoll.

15. **FLT_8_1_PH - 1-phase Fault**
    Fault on the Hays (56562) – Vine (56591) 115kV line, near Hays.

16. **FLT_8_3_PH - 3-phase Fault**
    Fault on the Hays (56562) – Vine (56591) 115kV line, near Hays.

17. **FLT_9_1_PH - 1-phase Fault**
    Fault on the Knoll (56561) – South Hays (56553) 115kV line, near Knoll.

18. **FLT_9_3_PH - 3-phase Fault**
    Fault on the Knoll (56561) – South Hays (56553) 115kV line, near Knoll.

19. **FLT_10_1_PH - 1-phase Fault**
    Fault on the Knoll (56561) – Saline (56551) 115kV line, near Knoll.

20. **FLT_10_3_PH - 3-phase Fault**
    Fault on the Knoll (56561) – Saline (56551) 115kV line, near Knoll.

The above cases were run for the following conditions:

<u>2005 Summer Peak (Max loading conditions)</u>
System base case with Wind farm idled (0MW)
Wind farm output at 250MW with standard voltage ride-through package
Wind farm output at 250MW with AGO4 enhanced low-voltage ride through package
Wind farm output at 150MW with standard voltage ride-through package
Wind farm output at 150MW with AGO4 enhanced low-voltage ride through package
Wind farm output at 125MW with standard voltage ride through package
Wind farm output at 125MW with AGO4 enhanced low-voltage ride through package

Note: 125MW cases include 139 turbines at 50% rated power. 150MW cases include 83 turbines at 100% rated power.

The customer requested, in the Impact Study Agreement, that the Transmission Provider study the interconnection with the project maximum size of 190MW as an alternative. The customer then provided drawings for a wind farm installation of 250MW and alternatively 150MW with instructions to interpolate from the drawings to create a wind farm of 190MW maximum capability. In the interests of time, the 250MW and 150MW wind farms were investigated and the assumption was made that any stability issues still present at 150MW would be present at 190MW. Facility loadings at 190MW were outlined during the feasibility study and are again tabulated in section 5.0 Conclusion. It is assumed that stability results at 150MW are indicative of the wind farm behavior at 190MW.

Fault Locations

4.2.1 Dynamic Modeling of the Wind Powered Generation Facility

The rated output of the generation facility is 250MW, comprised of 139 Vestas V80 wind turbines. The base voltage of the Vestas turbine is 690 V, and a generator step up transformer (GSU) of 1.85MVA connects each unit to the high side of 34.5kV. The rated power output of each turbine is 1.8MW while the actual power output depends on the wind.

In performing a system impact study, existing on-line generation in the SPP region is displaced by the addition of the generator.

The generating facility substation will consist of two 34.5/230kV transformers. Each transformer will be connected on the high side to the 230kV bus and each transformer will be connected on the low side to its own 34.5kV bus. From the preliminary one-lines received from the customer, on the 34.5kV side of each transformer, feeder circuits of varying lengths will extend into the generating facility. Each feeder will connect to one or more junction substations that will in turn consist of one or more collection circuits. The collection circuits will be connected to the wind turbines with the wind turbines connected in series. Each turbine then has its own pad-mounted transformer rated 690V/34.5kV and 1.85MVA. Please see the one-line drawing (Figure 1) attached to this document.

The actual parameters (R, X and B) of the 34.5kV collector circuits are calculated based on the data provided by the customer and assumptions of typical conductor characteristics. This information is useful in estimating the impedance of the collection and feeder systems. The cable impedance characteristic table is as follows:

Ref: Kerite Cable Catalog

Conductor Size	**(Ohms/1000')**		
	R1	**X1**	**Capacitance (micro F/ft)**
1000 kcmil	0.016	0.036	0.000077
4/0 AWG	0.064	0.045	0.000045
1/0 AWG	0.128	0.05	0.00004

At rated power, power flow analysis at the point of interconnection shows that there is a real power injection of 245MW and a reactive power injection of –40.5Mvar resulting in a power factor at the point of interconnection of 0.987. The wind farm collection system, including both 34.5/230kV transformers and the wind turbines create a reactive draw of 40.5Mvar from the transmission system. It is recommended that the customer provide reactive compensation of approximately 40Mvar at the wind farm site in order to provide a power factor at the point of interconnection of 1.0 at rated power.

4.2.2 Machine Dynamics Data

The generating facility was studied with the assumption that it would be using the Vestas V80 wind turbines. The nameplate rating of each turbine is 1.8MW (1800kW) with a machine base of 1981kVA. The turbine output voltage is 690V. The generator synchronous speed is 1800 rpm, and a variable resistance power converter tied to the generator rotor dynamically adjusts the generator torque vs. slip characteristics. The turbines utilize onboard capacitor banks to compensate for the reactive power requirements of the induction generator.

Shaw Power Technologies Inc. (PTI) has produced a Vestas V80 turbine model package for use on their PSS/E simulation software. This package was obtained from PTI and was used exclusively in modeling this wind farm.

The PTI model package consists of an IPLAN program that creates the dynamic stability data for the wind farm based on inputs from the user. The user is able to choose how the wind farm is dispatched (via a wind speed data set or dispatched directly) and the protection schemes for the turbines (both frequency and voltage).

The wind farm was dispatched directly by the program to the level specified (100% rated power and 50% rated power). It was also assumed that all turbines located in the farm were in-service (50% rated power means that all 139 turbines were generating at 50% rated power). The standard protection schemes embedded in the PTI model package were utilized for the initial analysis. Improved protection schemes (AGO4) are a part of the new, improved Vestas wind turbine model package from PTI. This improved protection scheme was tested to determine if it would allow the wind turbines to ride through more of the fault situations simulated.

4.2.3 Turbine Protection Schemes

The Vestas turbines utilize an undervoltage/overvoltage protection scheme and an underfrequency/overfrequency protection scheme. The various protection schemes are designed to protect the wind turbines in the case of system disturbances that can cause damage to the mechanical systems or power electronics on board the turbine. Generally, the protection schemes will disconnect the generator from the electric grid if the sampled frequency or voltage is outside of a specified band for a specified amount of time.

The new Advanced Grid Option 4 (AGO4) option for the Vestas wind turbines was modeled in the analysis of this request. The new AGO4 option allows the wind turbines to experience grid voltages as low as 0.5pu for up to 0.2 seconds. The standard protection settings trip the wind turbines instantaneously at voltages equal to or less than 0.75pu.

The standard voltage protection scheme:

Voltage below 75%: 0.08 seconds, trip the generator and the power factor correction
Voltage below 85%: 0.40 seconds, trip the generator and the power factor correction
Voltage below 94%: 60 seconds, trip the generator and the power factor correction
Voltage 94% to 110%: continuous
Voltage above 110%: 60 second, trip the generator and the power factor correction
Voltage above 111%: 0.08 second, trip the power factor correction
Voltage above 113.5%: 0.2 second, trip the generator and the power factor correction
Voltage above 120%: 0.08 second, trip the generator and the power factor correction

The AGO4 voltage protection scheme:

Voltage below 50%: 0.20 seconds, trip the generator and the power factor correction
Voltage below 75%: 0.80 seconds, trip the generator and the power factor correction
Voltage below 80%: 2.00 seconds, trip the generator and the power factor correction
Voltage below 90%: 300 seconds, trip the generator and the power factor correction
Voltage 90% to 110%: continuous
Voltage above 110%: 60 second, trip the generator and the power factor correction
Voltage above 111%: 0.08 second, trip the power factor correction
Voltage above 115%: 30 second, trip the generator and the power factor correction
Voltage above 120% 2.00 second, trip the generator and the power factor correction
Voltage above 125%: 0.08 second, trip the generator and the power factor correction

The standard frequency protection scheme:

Frequency below 57.0 Hz: 0.2 seconds, trip the generator and the power factor correction
Frequency 57.0 to 62.0 Hz: continuous
Frequency above 62.0 Hz: 0.2 seconds, trip the generator and the power factor correction

The AGO4 frequency protection scheme:

Frequency below 55.5 Hz: 0.02 seconds, trip the generator and the power factor correction
Frequency below 56.5 Hz: 0.35 seconds, trip the generator and the power factor correction
Frequency below 57.0 Hz: 2.0 seconds, trip the generator and the power factor correction
Frequency 57.0 to 61.5 Hz: continuous
Frequency above 61.5 Hz: 90 seconds, trip the generator and the power factor correction
Frequency above 63.0 Hz: 0.02 seconds, trip the generator and the power factor correction

4.3 Stability Results

The wind farm and surrounding transmission system appear to remain stable for all faults applied except the single phase and three phase faults at Summit on the Summit to Customer wind farm 230kV line. Discussion of this fault and the instability occurs in section 4.3.1.

The wind farm experiences tripping in multiple scenarios due to voltage deviations from nominal values. This tripping occurs with both the standard voltage protection package and with the AGO4 voltage protection package. Changing the voltage protection scheme to the AGO4 option enables the wind farm to ride-through more of the fault simulations. However, it appears that the most critical fault is the fault at Summit on the Summit to Customer wind farm 230kV line. Tripping caused by other faults does not appear to create stability problems on the rest of the surrounding SPP transmission system.

Instability also appears to be worst when the wind farm is generating close to its nameplate rating of 250MW. When the wind farm is reduced in size to 150MW, tripping is eliminated by installing the AGO4 ride-through package. However, some instability is still present at the wind farm. When the 250MW wind farm is generating at 50% of its nameplate rating, there is still some voltage instability when the Summit to Customer line is tripped.

All cases and scenarios are tabulated below:

2005 Summer Peak Case:

Fault Case/Scenario	250MW	250MW and AGO4	150MW	150MW and AGO4	125MW	125MW and AGO4
FLT_1_1PH	X	@ 76% (high)	@ 84% (low)	---	---	---
FLT_1_3PH	X	@ 93% (high)	X	---	X	---
FLT_2_1PH	---	---	---	---	---	---
FLT_2_3PH	X	---	X	---	X	---
FLT_3_1PH	---	---	---	---	---	---
FLT_3_3PH	@ 46% (low)	---	X	---	---	---
FLT_4_1PH	---	---	---	---	---	---
FLT_4_3PH	---	---	---	---	---	---
FLT_5_1PH	---	---	---	---	---	---
FLT_5_3PH	X	---	X	---	X	---
FLT_6_1PH	@ 7% (low)	---	@ 19% (low)	---	---	---
FLT_6_3PH	X	---	X	---	X	---
FLT_7_1PH	---	---	---	---	---	---
FLT_7_3PH	@ 21% (low)	---	@ 81% (low)	---	---	---
FLT_8_1PH	---	---	---	---	---	---
FLT_8_3PH	---	---	---	---	---	---
FLT_9_1PH	---	---	---	---	---	---
FLT_9_3PH	@ 21% (low)	---	@ 82% (low)	---	---	---
FLT_10_1PH	---	---	---	---	---	---
FLT_10_3PH	@ 21% (low)	---	@ 81% (low)	---	---	---

O = wind farm tripped due to high voltage
X = wind farm tripped due to low voltage
--- = wind farm did not trip
@ = some of the farm tripped

All scenarios/faults were run to a period of 15.0 seconds to verify that the wind turbines achieved stable operation.

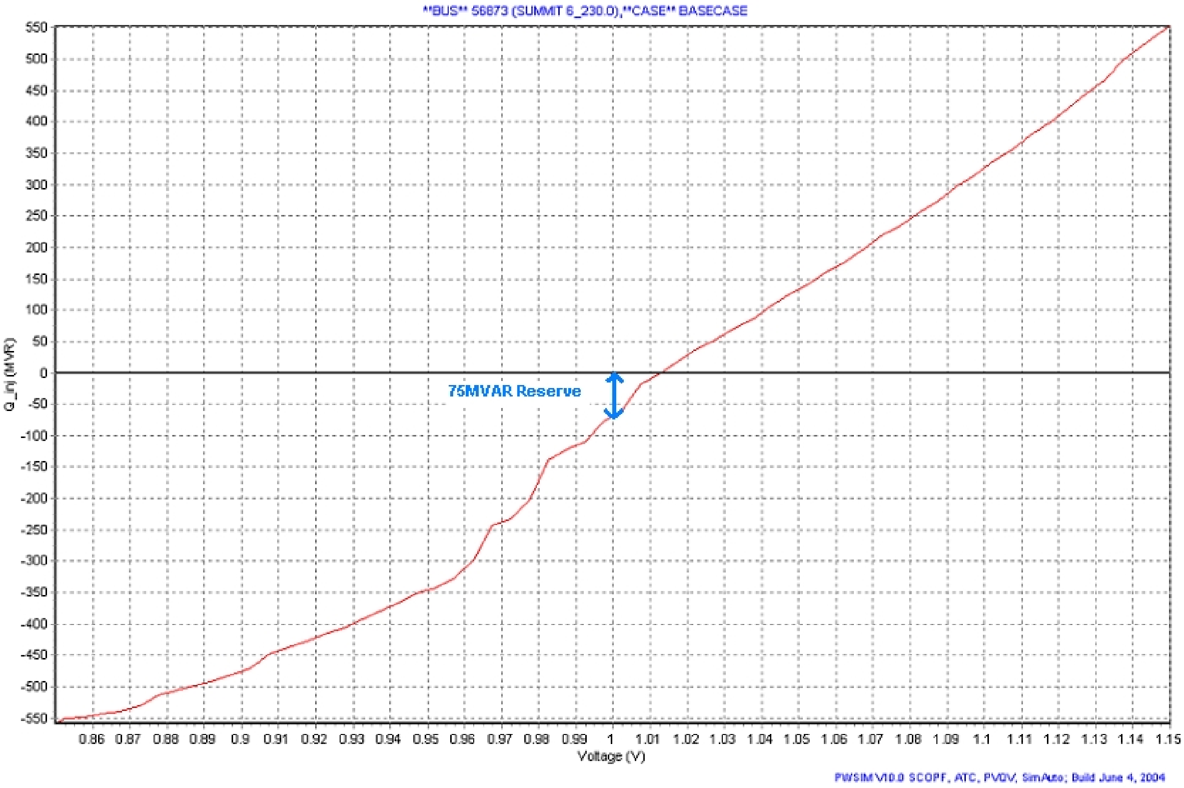
4.3.1 Instability for Fault 1 (Single and Three phase faults at Summit)

The stability of the wind farm and the surrounding transmission system appear to rely heavily on the tripping of the wind farm for a fault at Summit and loss of the Customer wind farm to Summit 230kV line. In the feasibility study phase, there were significant problems found during the loss of the Summit to Customer wind farm 230kV line. The loss of this line section results in all 250MW of wind farm output being forced back onto the 115kV system emanating from the Knoll 230/115kV substation. This power flow causes a significant voltage depression on the lower voltage system in western Kansas. Powerflow analysis also showed that the 115/230kV transformer at Knoll would need to be replaced with a higher capacity transformer if the wind farm were to be interconnected at 250MW nameplate capacity. In addition, reactive compensation would be required at both the wind farm site and the Knoll substation to avert voltage collapse.

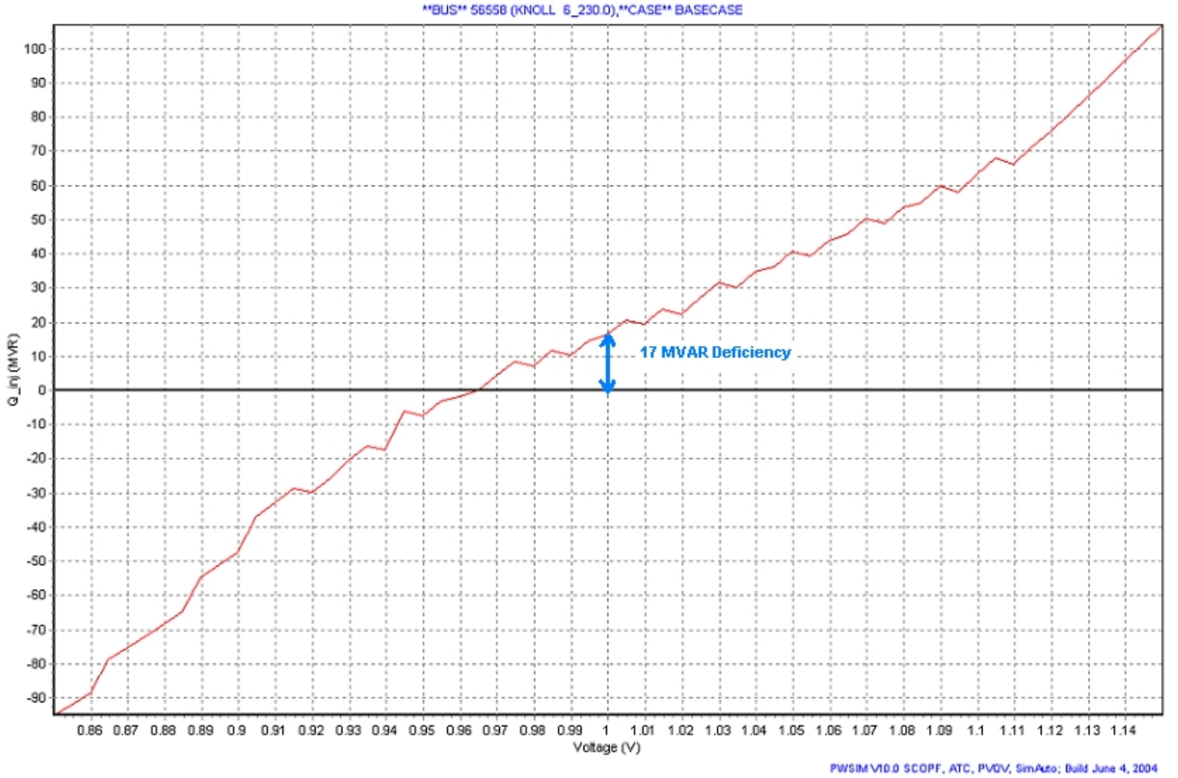
As has been seen in the past with other interconnections, the Vestas turbines do not react well to situations where they are subjected to a fault and are then left connected to a relatively weak transmission system via a long high voltage line. The reactive characteristics of this situation cause the Vestas turbines to enter an unstable voltage and power oscillation as its onboard power controls hunt for a new operating point. The Vestas wind turbines attempt to control the power and voltage output of the generator by adjusting the current flow in the generator rotor. This is done by means of an externally controlled resistor. Wind turbine voltages below 0.9pu trigger the rotor protection connecting the full external rotor resistance. In this case, the external rotor resistance is connected and disconnected alternatively as the voltage goes above and below 0.9pu. This variation in the rotor resistance causes variations in the voltage and power output of the generator. The addition of an SVC or other active dynamic reactive compensation device, in some cases, may be able to damp out the oscillation of the turbine controls. However, leaving the wind farm connected in this scenario causes significant voltage depression and oscillation on the 115kV and lower transmission system. In this situation, it is recommended that the wind farm be tripped to prevent these oscillations.

This instability is not seen when the other section of line emanating from the wind farm interconnection is faulted and tripped. This is due to the reactive “strength” of the transmission system to which the wind farm is left connected. A QV plot of the 230kV buses at Summit and Knoll below show that the Summit bus is much stronger than the Knoll bus. At steady state in the basecase with no contingencies, the Knoll bus has a reactive deficiency of approximately 17Mvar at 1.0pu voltage while the Summit bus has a reactive reserve of approximately 75Mvar at 1.0pu voltage. This demonstrates the reason for the unstable operation of the Vestas turbines when the Summit to Customer wind farm line is lost. As the power from the wind farm is forced across the Knoll 230kV bus, the reactive deficiency becomes even greater resulting in voltage decline.

Summit 230kV QV Curve

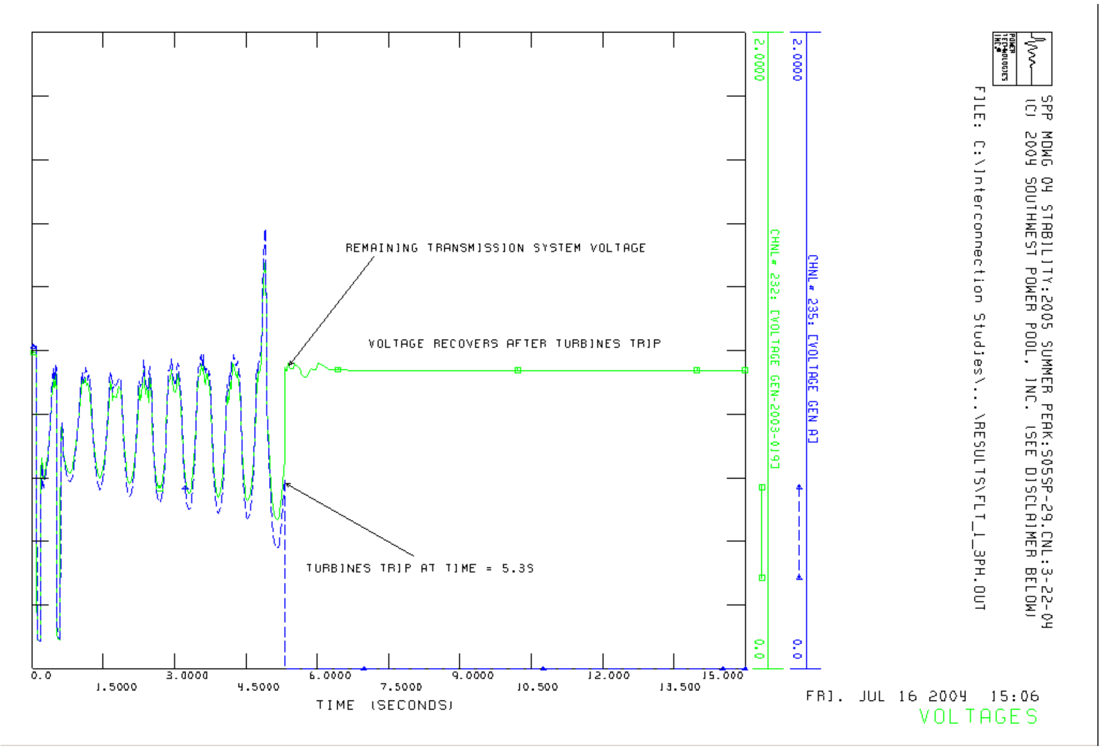


Knoll 230kV QV Curve



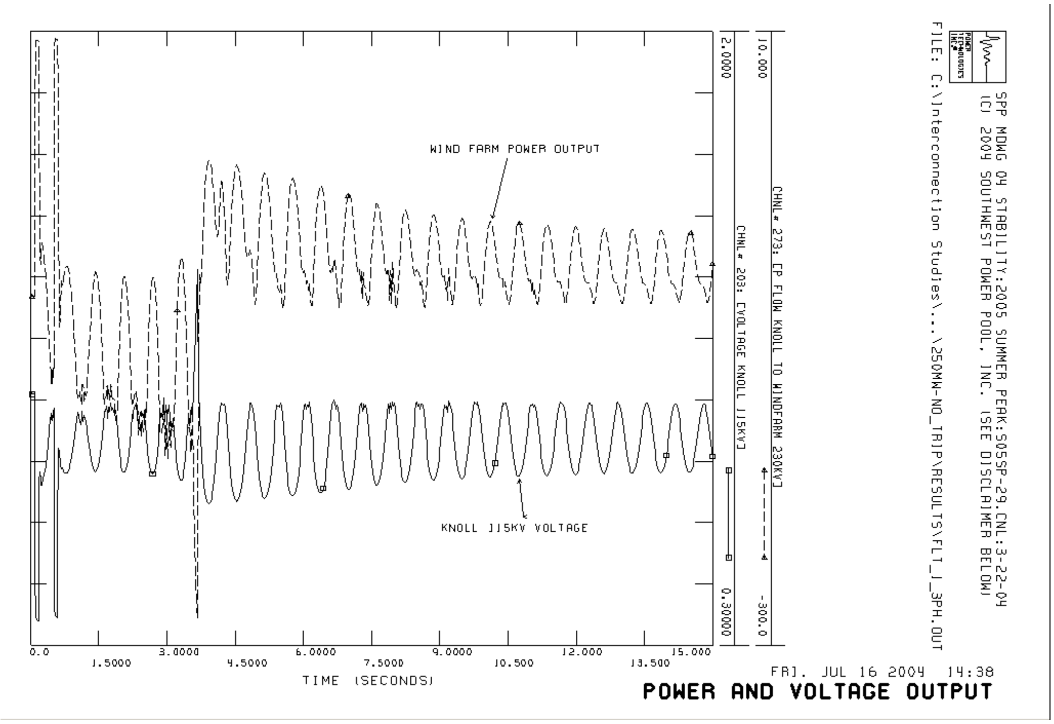
If the wind farm is allowed to remain connected after loss of the Summit to Wind Farm line, the voltage will stay low enough such that the wind farm will trip offline due to its protection settings (standard and AGO4 package). Once the wind farm trips offline, voltages recover and the system returns to stable operation. In this situation, tripping of the wind farm is desirable.

Tripping of the Wind Farm Due to Undervoltage After the Fault



If the wind farm is not allowed to trip or if the voltage protection system fails, simulated here by disabling the protection system altogether, the voltage in west central Kansas stays low and the Vestas wind turbines begin to oscillate in both power and voltage output significantly. The powerflow analysis was investigating this situation—continued operation of the wind farm after the loss of the Summit to Customer 230kV line. In this situation, the powerflow analysis showed that 60Mvar of capacitor banks along with a 20Mvar SVC (continuous operation) would be required at the wind farm 34.5kV bus and an additional 20Mvar capacitor bank would be required along with a transformer upgrade at the Knoll 115/230kV substation. This mirrors what was seen in the stability analysis. If the wind farm remains connected after loss of the Summit to Customer 230kV line, a severe reactive deficiency causes the wind farm to enter an unstable, oscillatory situation.

Power and Voltage Oscillation with Wind Farm Tripping Disabled



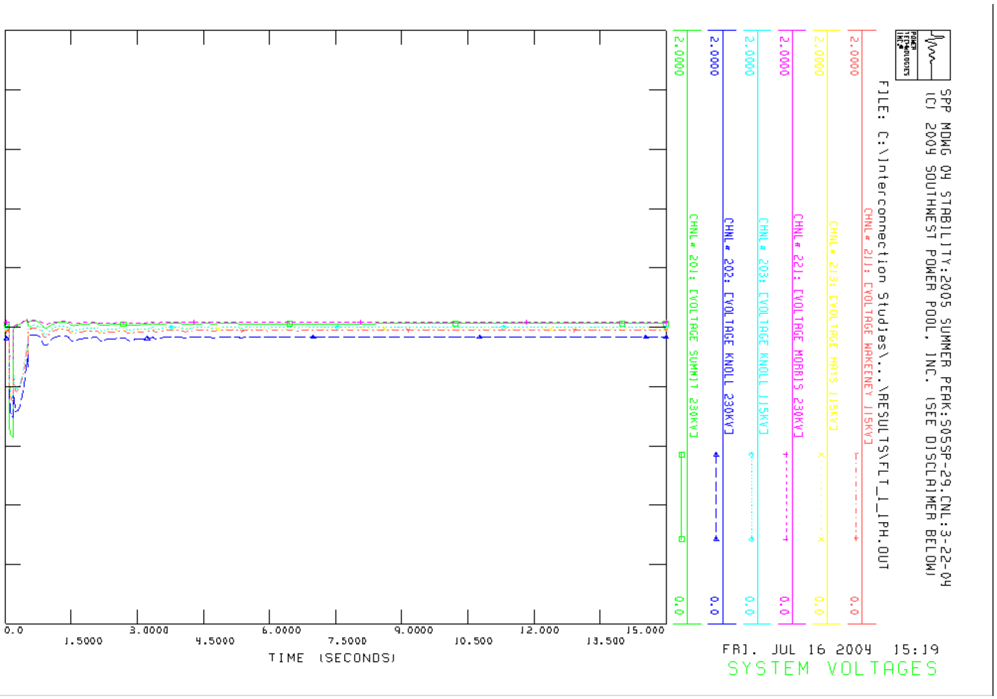
Capacitor installations at the wind farm site on the 34.5kV buses were implemented with automatic switching to attempt to alleviate the voltage decline. However, the capacitor banks were not enough to arrest the voltage decline and subsequent tripping of the wind farm with the standard voltage protection settings. It is recommended that capacitors be installed at the wind farm site to provide power factor correction at the point of interconnection such that the power factor is 1.0. However, the capacitor banks should be sized such that there are several steps to account for differing generation levels. An appropriate capacitor bank setup might be four 10Mvar capacitor banks to provide the 40Mvar at rated power and lower levels for corresponding generation levels.

In this situation, we find that if the wind farm remains connected after loss of the Summit to Customer 230kV line, a very large amount of reactive support is required to keep the wind farm in stable operation and keep the system voltages within criteria limits. In addition, for this contingency the transformer at Knoll is overloaded. In order to alleviate the requirements for the reactive devices and the transformer replacement at Knoll, it is recommended that a switching scheme be implemented that simultaneously opens the Knoll to Customer 230kV line if the Customer to Summit 230kV line is locked out.

It should be mentioned that the voltage instability and voltage decline are not present if there is a fault at Summit on the Summit to Wind Farm 230kV line and the fault is cleared normally and the line section is not locked out. Only in the situation where the line section is locked out is the voltage oscillation present. Implementation of the switching scheme mentioned above will eliminate any voltage or power oscillations due to the wind farm by removing it from the rest of the grid after loss of the Customer to Summit 230kV line.

Below is a plot of the surrounding system voltages after a normally cleared fault that doesn't result in lock out of the Customer to Summit 230kV line. After the fault is cleared, the line remains energized after reclosing. This would be analogous to the line experiencing a lightning strike.

System Voltages After Normally Cleared Fault with Wind Farm In-Service



5.0 Conclusion

Certain stability concerns presently exist for the GEN-2003-019 wind farm as proposed and studied. The loss of the Customer Wind Farm to Summit 230kV line results in an undesirable power and voltage oscillation from the Vestas wind turbines. This usually results in a low voltage condition at the wind farm, which in turn causes the protection systems to trip the turbines. If the turbines are not tripped offline, the reactive deficiency of the remaining transmission system connection causes the Vestas turbines to enter an oscillatory state. Removal of the wind farm from service in this situation corrects the reactive deficiency and stops the voltage and power oscillation. Voltage on the remaining transmission system recovers to nominal values after removal of the wind farm. Therefore, it is recommended that a switching scheme be implemented that simultaneously opens the Knoll to Customer 230kV line if the Customer to Summit 230kV line is locked out. It is not necessary to trip the wind farm if a fault clears normally on either of the 230kV line sections. Implementation of the switching scheme will also remove the requirements for the additional reactive requirements and the transformer replacement at Knoll.

The windfarm also trips offline for several other remote faults on the transmission system. This is due to the relatively weak voltage ride-through capability of the Vestas standard turbines. If the AGO4 option is implemented on the turbines, this nuisance tripping is corrected. Therefore, it is recommended that the customer install the AGO4 option on the wind turbines.

It is also recommended that the customer install reactive compensation at the wind farm site to enable the wind farm output at the point of interconnection to have a power factor of 1.0. This would require a capacitor installation of approximately 40Mvar. It is also recommended that the capacitors be sized with multiple steps to account for differing generation levels.

The minimum cost of interconnecting the Customer project is $3.5 million. These costs do not take into account any breaker duty ratings or settings. The short circuit analysis will be performed as part of the Facility Study by MIDW and WERE if the customer elects to have the study performed.

There are still upgrades required for other contingencies that were found during the powerflow analysis part of the feasibility study. The costs to alleviate these overloads are up to an additional $18.9 million for a total cost of up to $22.4 million.

Tables showing the required facilities are on the next page.

Network Upgrade Facilities Required at 250MW

Facility	ESTIMATED COST (2004 DOLLARS)
MIDW - Ellsworth 230kV 3 terminal ring switching station addition in existing Summit – Knoll 230kV line.	$3,500,000
WERE - Auburn 230-115 kV transformer #2 addition.	2,250,000
WERE - Exide Junction - Summit 115kV rebuild and reconductor 4.94 miles with 1192 ACSR.	1,100,000
WERE - Goodyear Junction - Northland 115kV rebuild of 3.44-mile line.	940,000
WERE – Jeffrey Energy Center - Hoyt 345 kV line upgrade to a minimum of 1,093MVA.	14,000,000 *
WERE - Northview - Summit 115kV uprating of line to 100oC and replace wave trap.	610,000
Total	**$22,400,000**

* Estimate of cost to be updated by the Transmission Owner based on the results of a sag analysis that may be completed during the development of the facility study. This estimate does not include re-dispatch expenses that may be required. Upgrading during the spring and fall seasons is assumed and only when the Jeffrey Energy Center is down for maintenance.

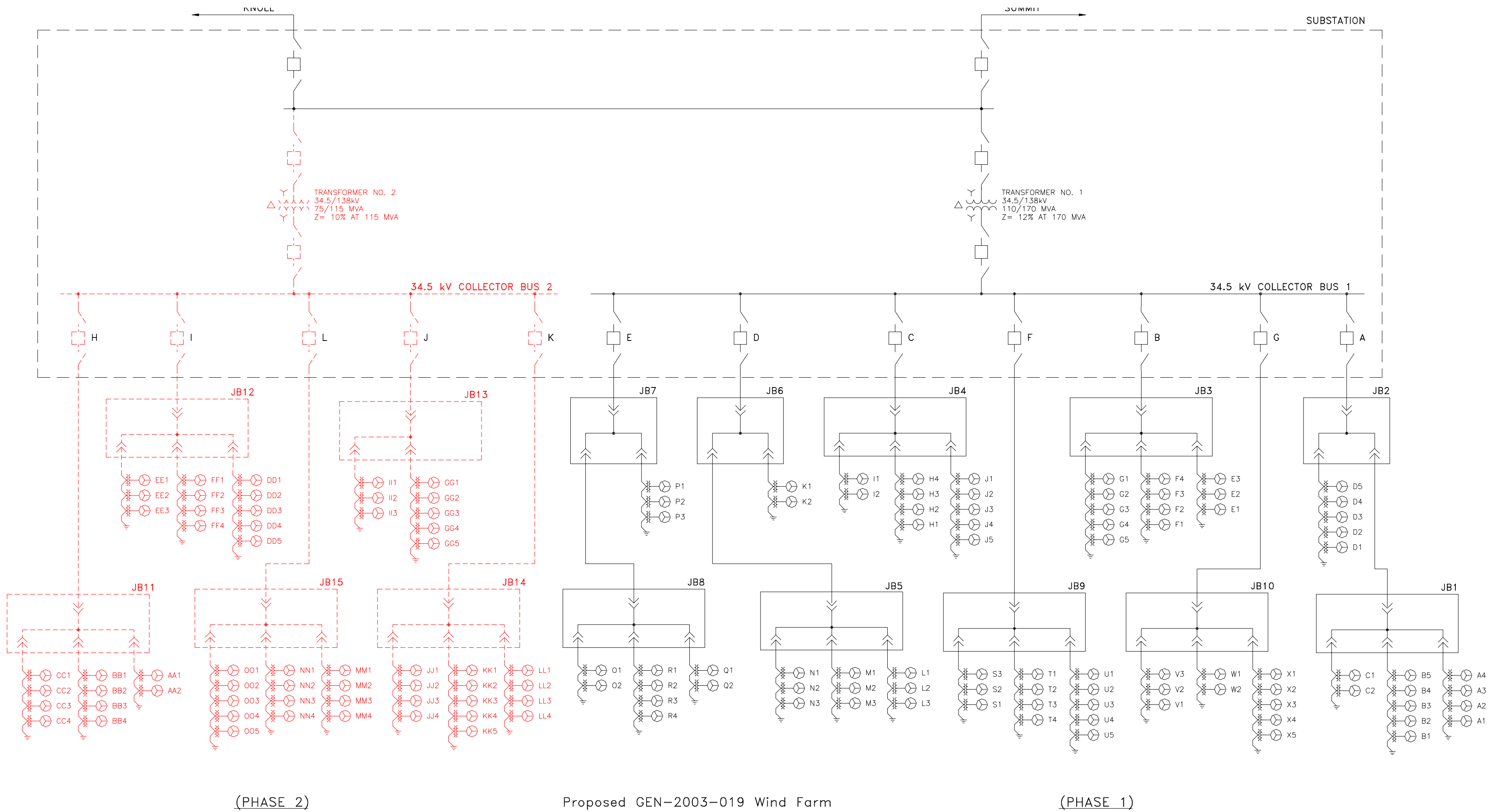
If the customer elects to reduce the size of the project to 190MW as requested during the feasibility study, the costs to alleviate the overloads are reduced to an additional $4.29 million for a total cost of $7.79 million.

Network Upgrade Facilities Required at 190MW

Facility	ESTIMATED COST (2004 DOLLARS)
MIDW - Ellsworth 230kV 3 terminal ring switching station addition in existing Summit – Knoll 230kV line.	$3,500,000
WERE - Auburn 230-115 kV transformer #2 addition.	2,250,000
WERE - Exide Junction - Summit 115kV rebuild and reconductor 4.94 miles with 1192 ACSR.	1,100,000
WERE - Goodyear Junction - Northland 115kV rebuild of 3.44-mile line.	940,000
Total	**$7,790,000**

Reduction of the customer wind farm to 190MW will not alleviate the requirement for the switching scheme that results in tripping the wind farm if the Summit to Customer wind farm 230kV line opens. This was investigated with the wind farm built to 150MW and the voltage and power oscillation would still occur with the reduced wind farm size.

The costs do not include any costs associated with the deliverability of the energy to final customers. These costs are determined by separate studies if the Customer requests transmission service through Southwest Power Pool’s OASIS.



Proposed GEN-2003-019 Wind Farm
ONE LINE DIAGRAM
(250 MW OPTION – VESTAS 1.8 TURBINES)

NOT TO BE USED
FOR CONSTRUCTION

Appendix A-1

Plots of Fault Simulations

Plots of selected bus voltage response during faults

Scenario:
2005 Summer Peak
Wind Farm at 250MW (100% rated power)
Standard Protection Settings

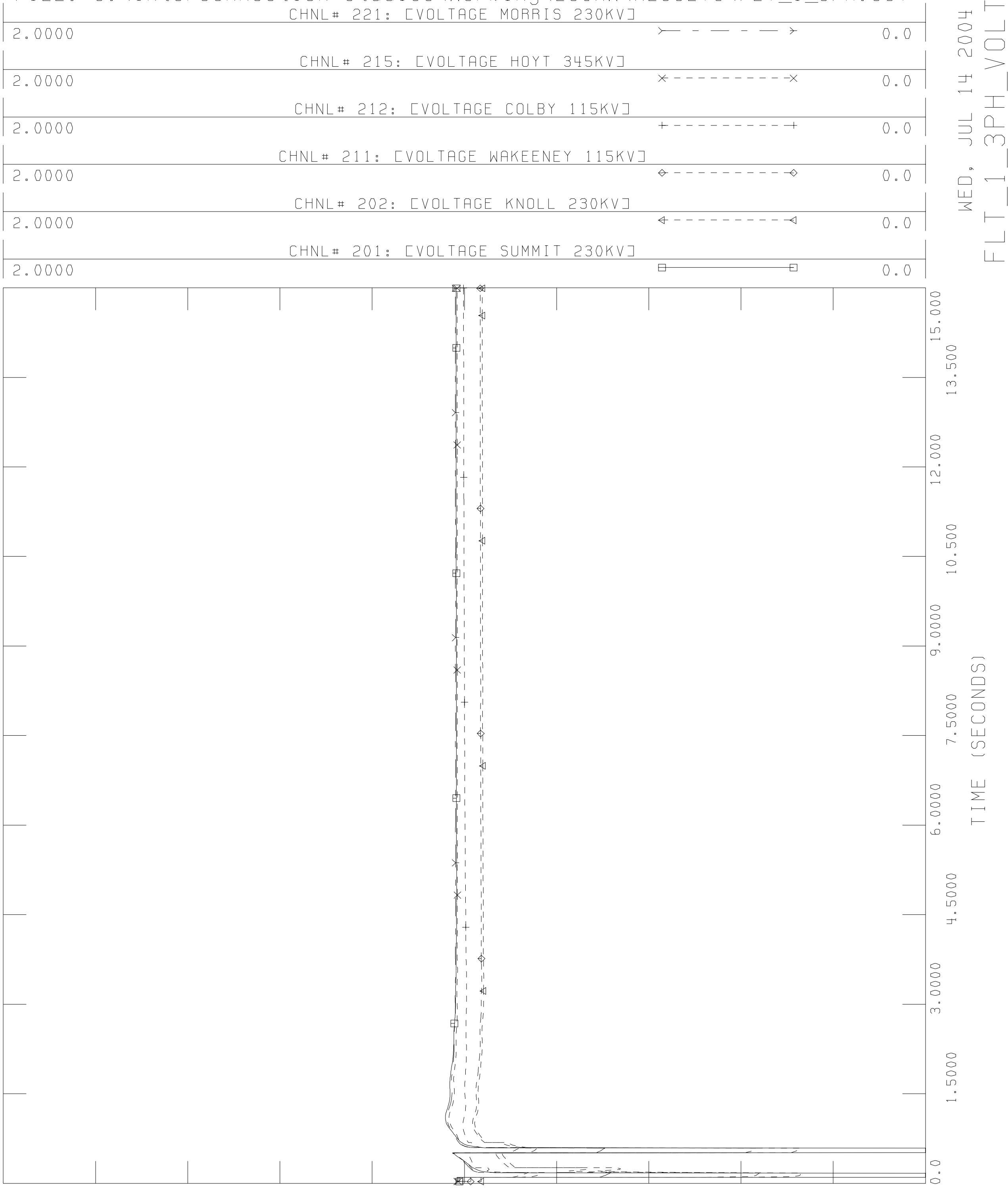
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_1_3PH.OUT

WED, JUL 14 2004 11:09

FLT_1_3PH_VOLTAGES

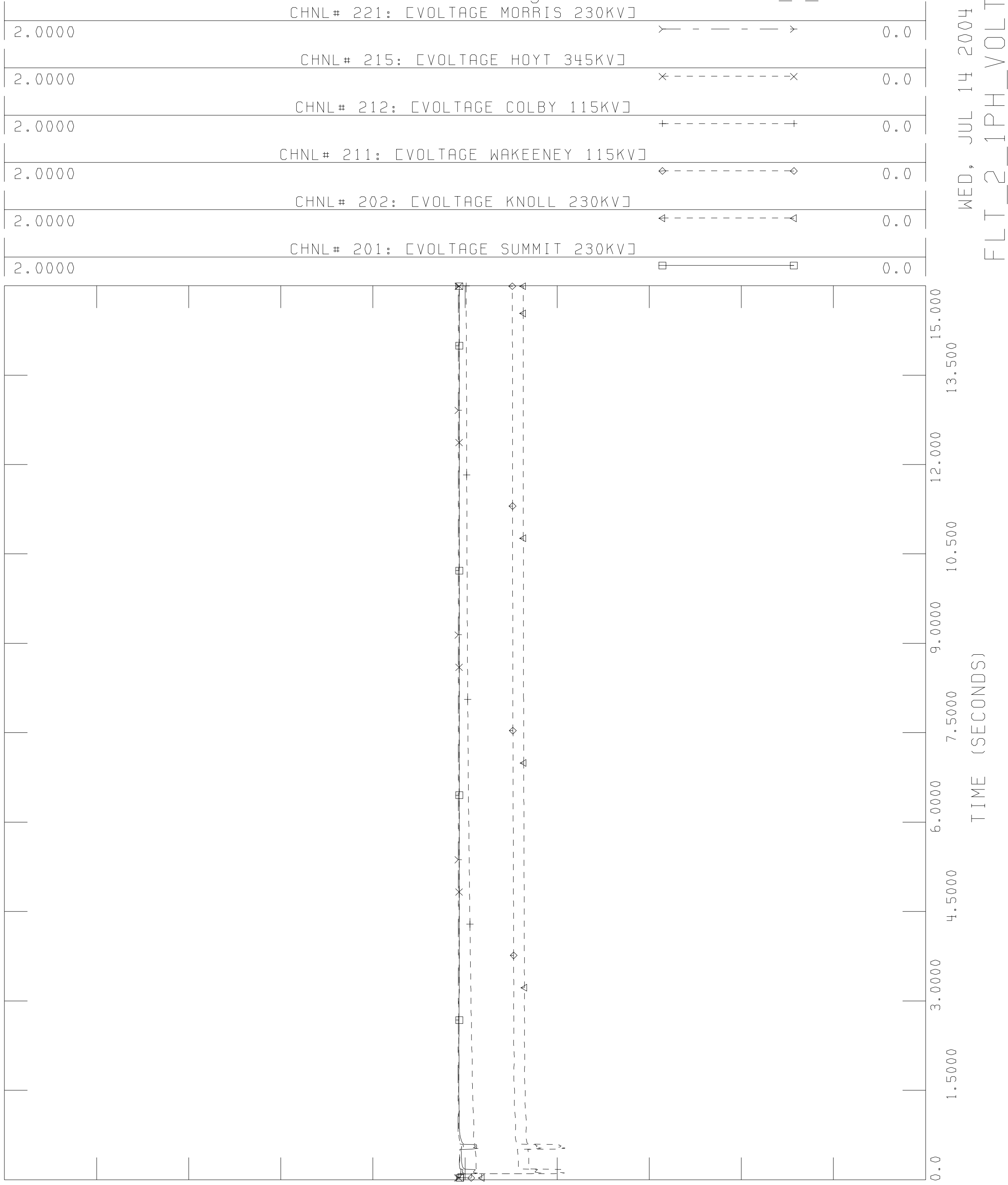


POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 11:09
FLT_2_1PH_VOLTAGES

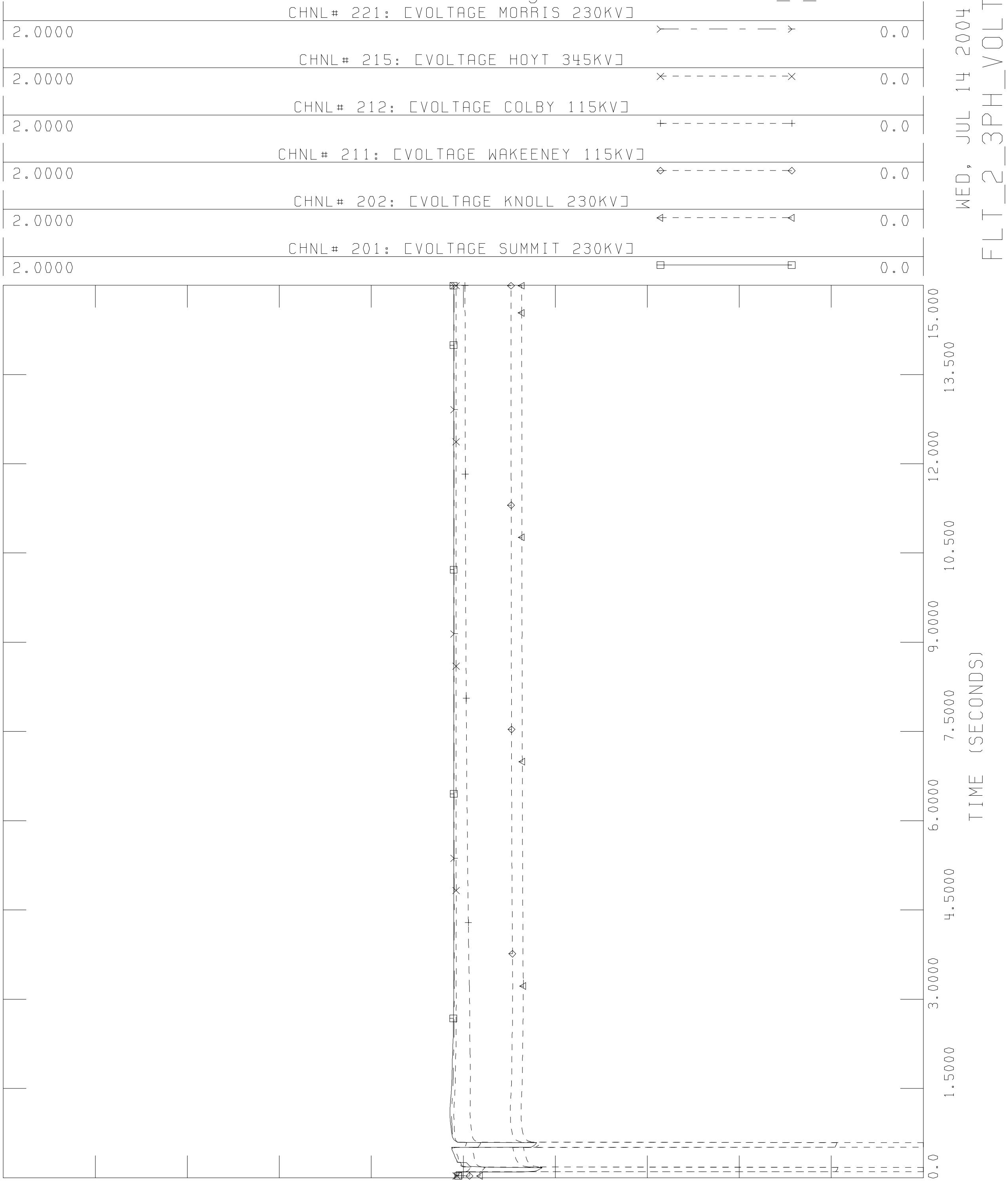
FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_2_1PH.OUT



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

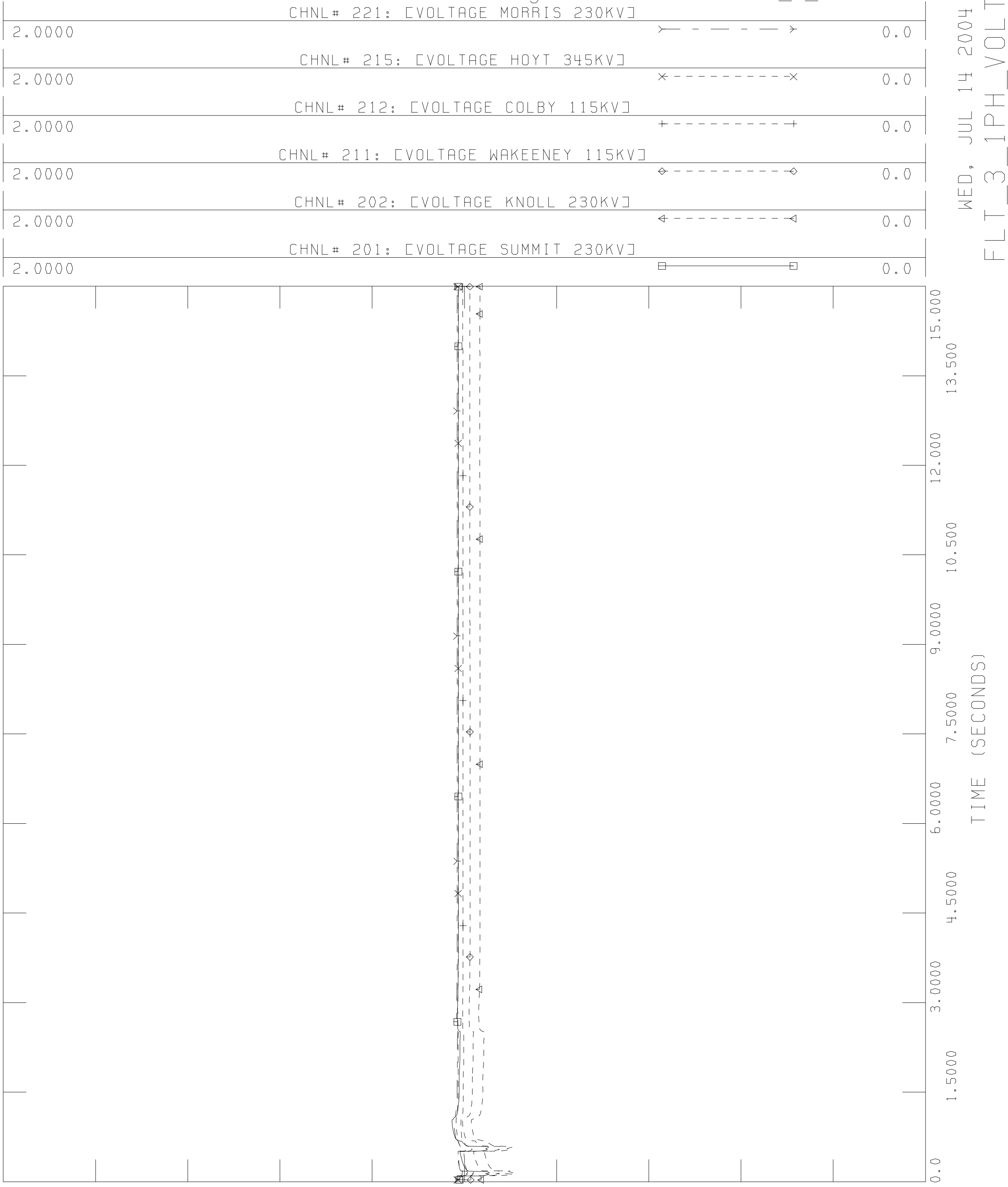
FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_2_3PH.OUT



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 11:09
FLT_3_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_3_1PH.OUT



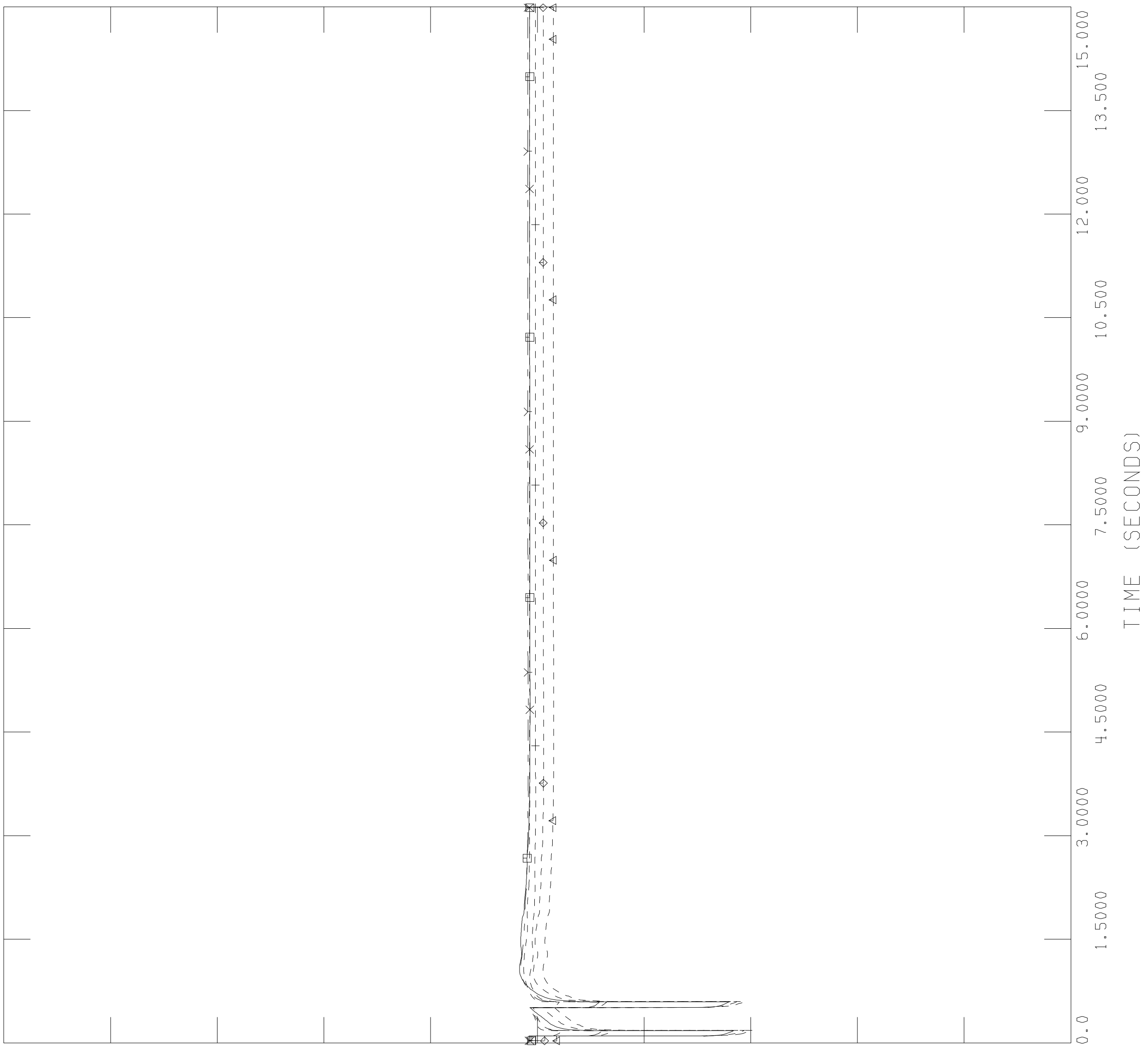
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_3_3PH.OUT

WED, JUL 14 2004 11:09
FLT_3_3PH_VOLTAGES

CHNL# 221: [VOLTAGE MORRIS 230KV]		
2.0000	≻— - — - — ≻	0.0
CHNL# 215: [VOLTAGE HOYT 345KV]		
2.0000	×- - - - - - - - - -×	0.0
CHNL# 212: [VOLTAGE COLBY 115KV]		
2.0000	+- - - - - - - - - -+	0.0
CHNL# 211: [VOLTAGE WAKEENEY 115KV]		
2.0000	◇- - - - - - - - - -◇	0.0
CHNL# 202: [VOLTAGE KNOLL 230KV]		
2.0000	◁- - - - - - - - - -◁	0.0
CHNL# 201: [VOLTAGE SUMMIT 230KV]		
2.0000	□————————□	0.0



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

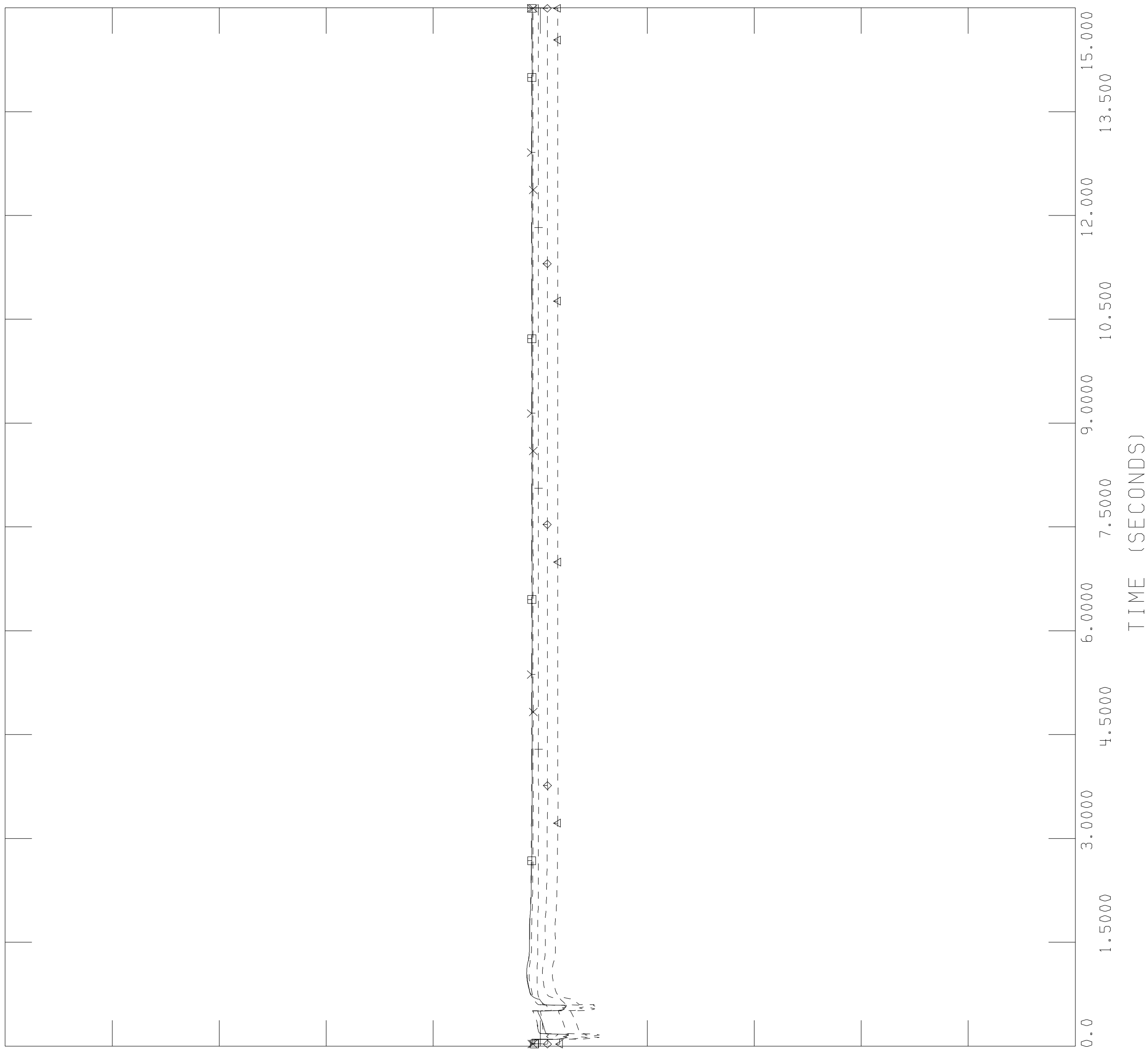
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 11:09

FLT_4_1PH_VOLTAGES

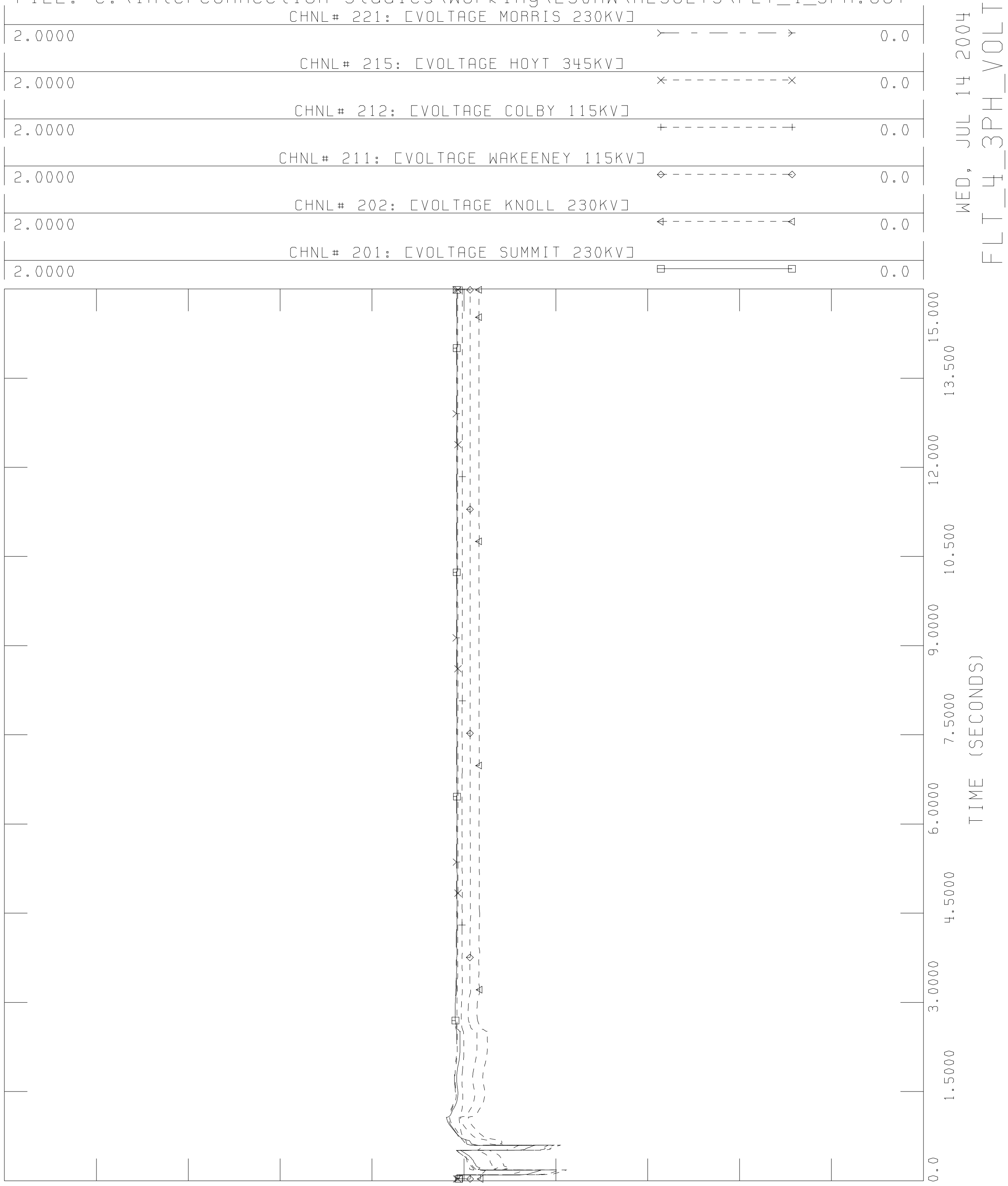
FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_4_1PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]		
2.0000	Y— - — - — Y	0.0
CHNL# 215: [VOLTAGE HOYT 345KV]		
2.0000	×- - - - - - - - - -×	0.0
CHNL# 212: [VOLTAGE COLBY 115KV]		
2.0000	+- - - - - - - - - -+	0.0
CHNL# 211: [VOLTAGE WAKEENEY 115KV]		
2.0000	◇- - - - - - - - - -◇	0.0
CHNL# 202: [VOLTAGE KNOLL 230KV]		
2.0000	◁- - - - - - - - - -◁	0.0
CHNL# 201: [VOLTAGE SUMMIT 230KV]		
2.0000	□———————□	0.0



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_4_3PH.OUT

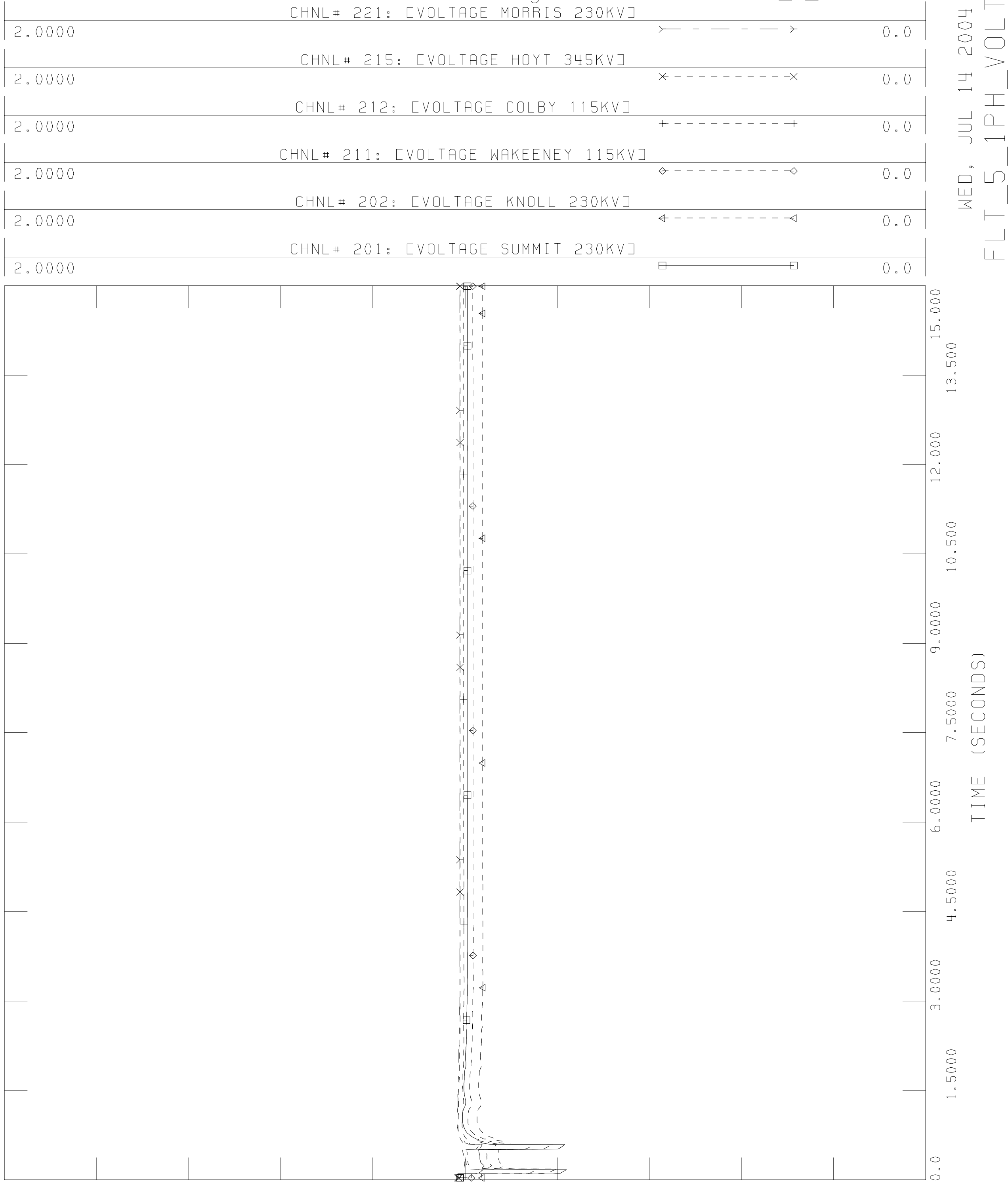


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER
TECHNOLOGIES
INC.®

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_5_1PH.OUT

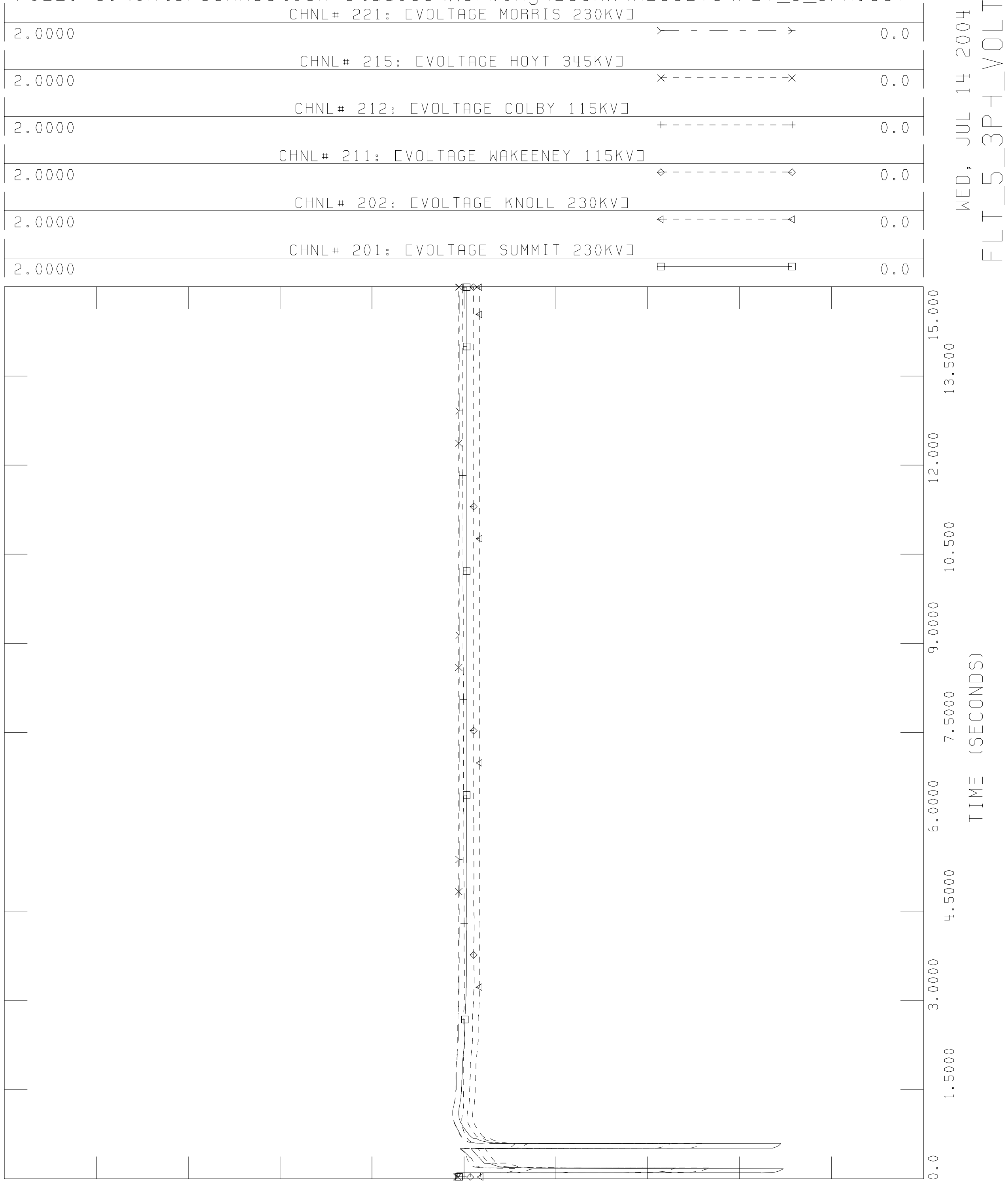
WED, JUL 14 2004 11:09
FLT_5_1PH_VOLTAGES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_5_3PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_6_1PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 0.0

CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 0.0

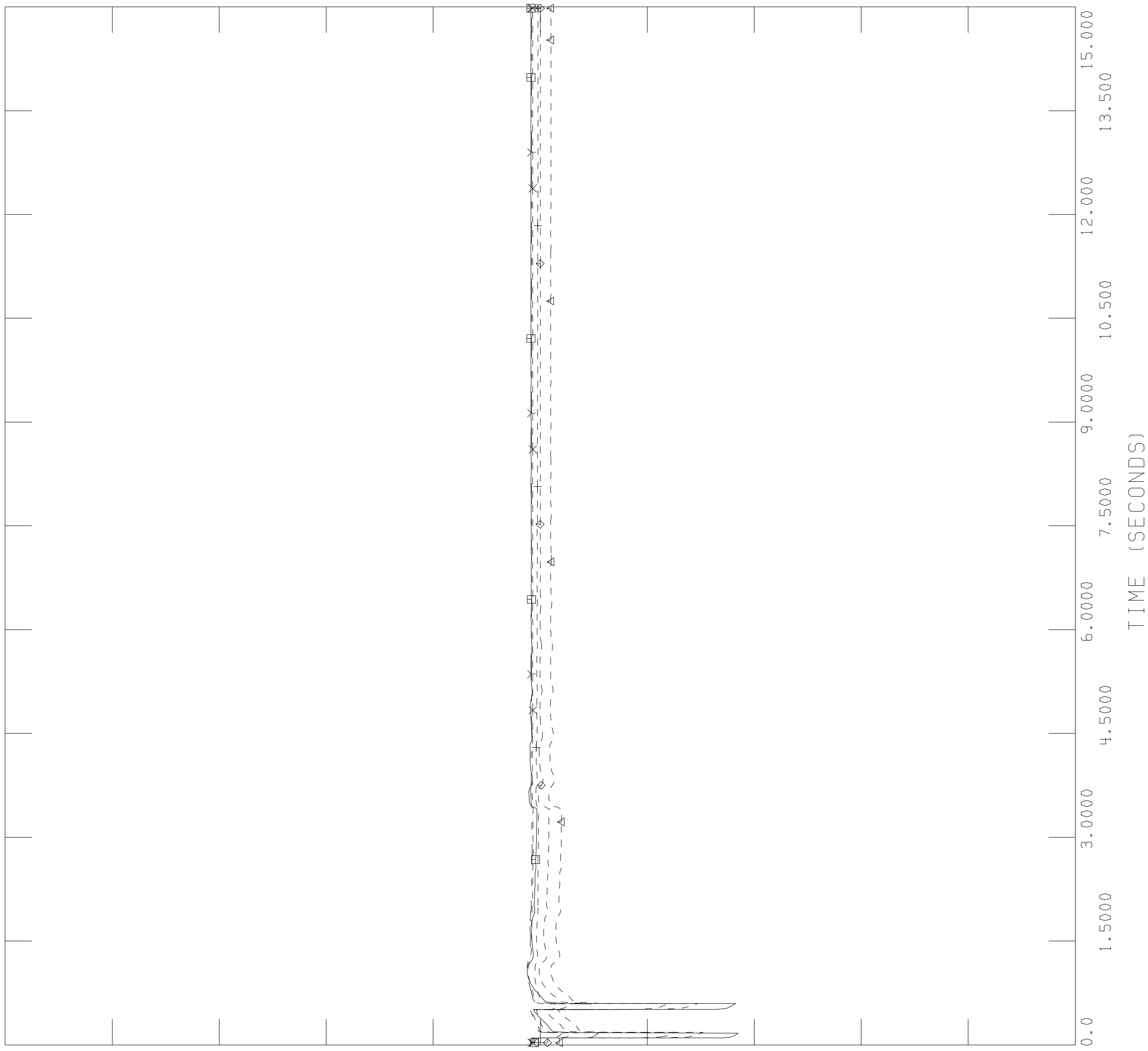
CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 0.0

CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 0.0

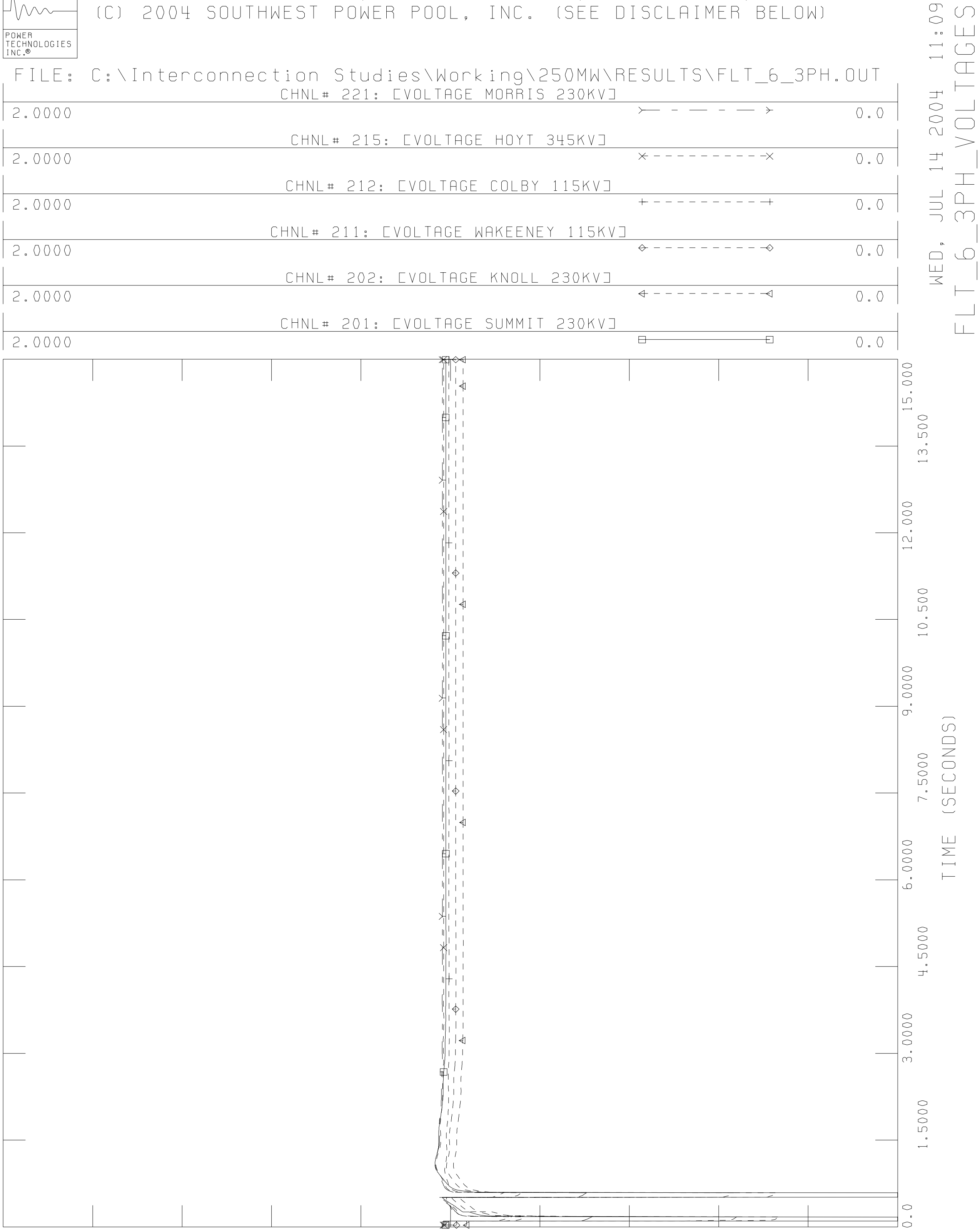
WED, JUL 14 2004 11:09
FLT_6_1PH_VOLTAGES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_6_3PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 11:09

FLT_7_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_7_1PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 0.0

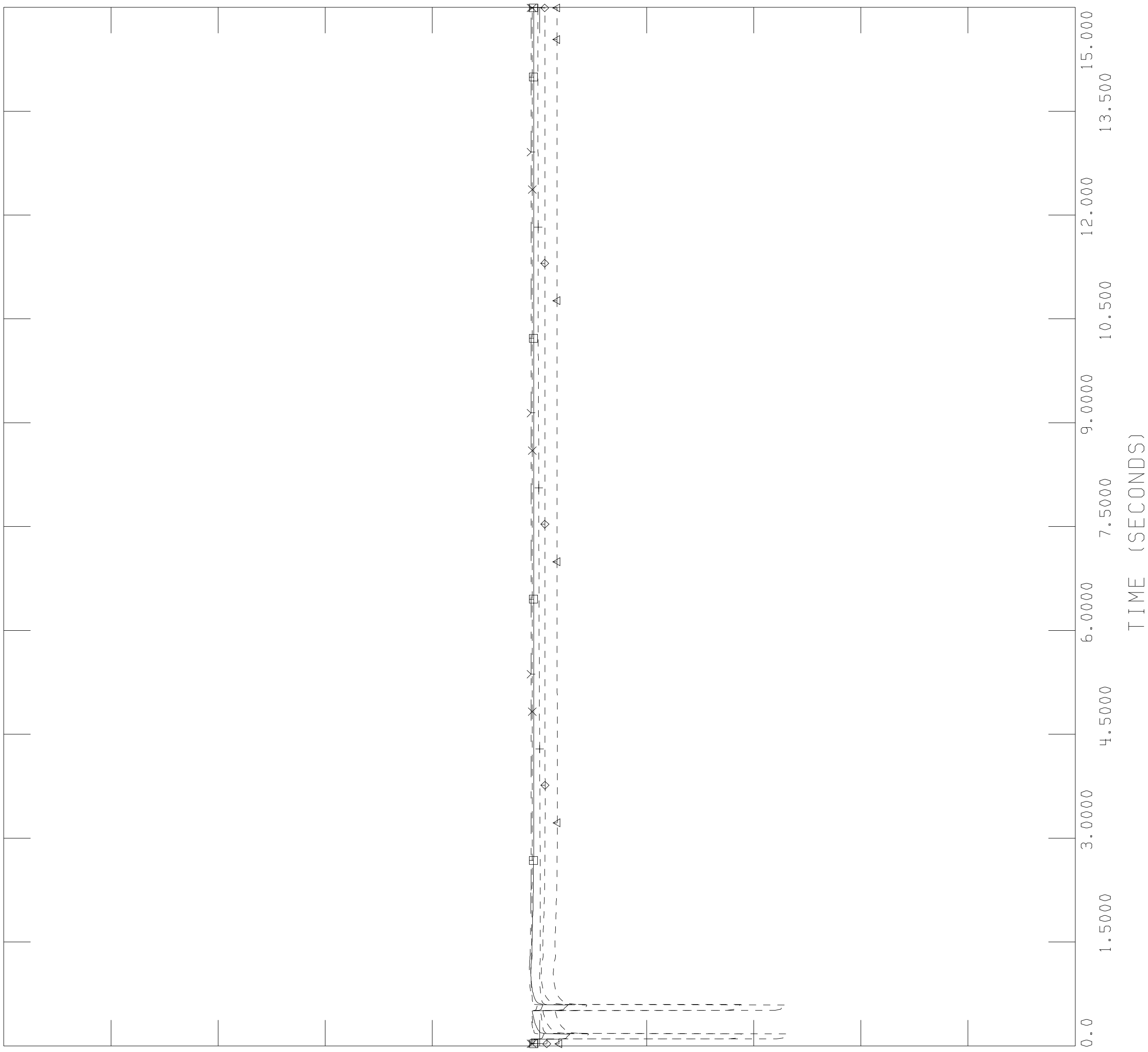
CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 0.0

CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 0.0

CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 0.0



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_7_3PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 0.0

CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 0.0

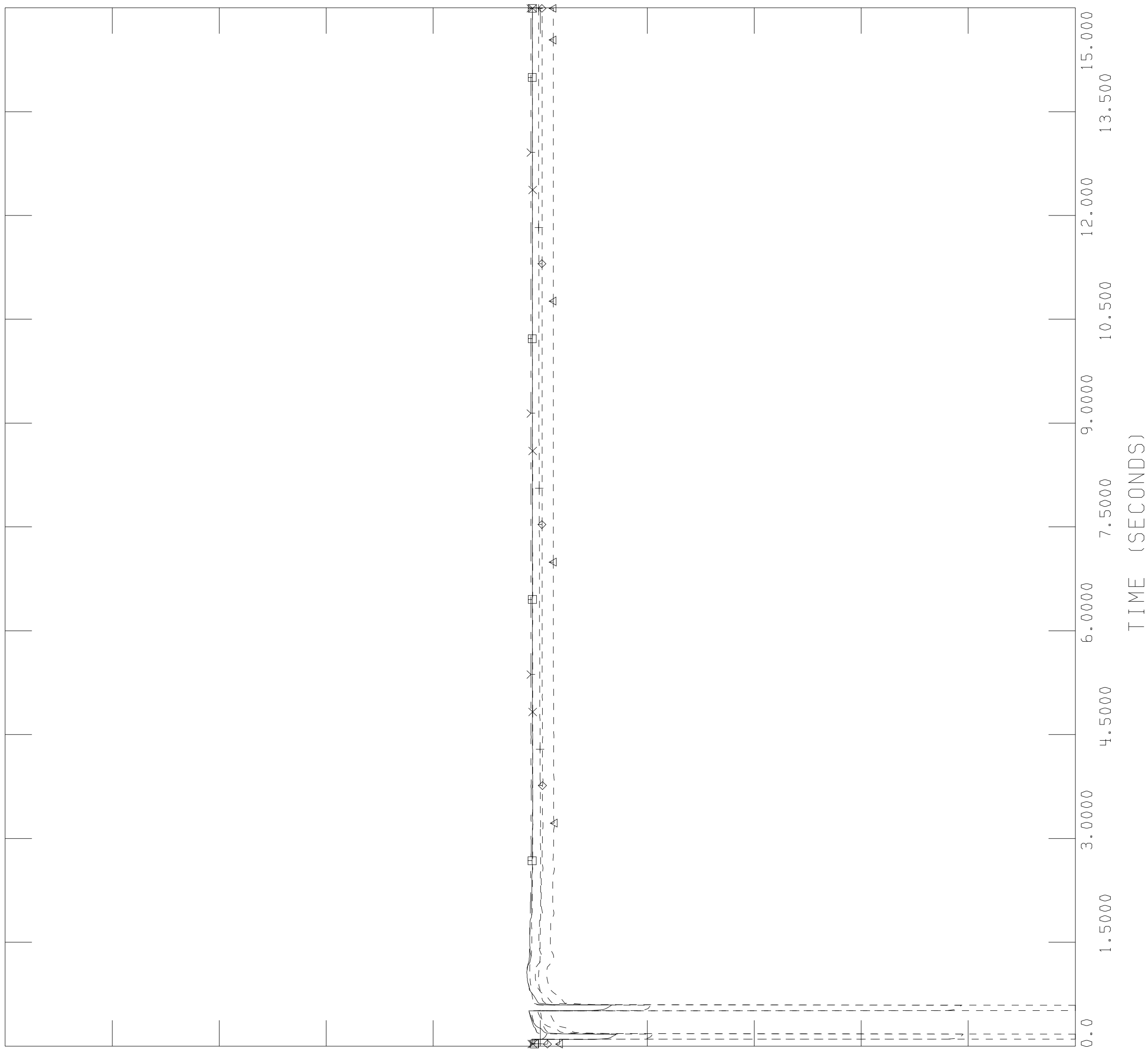
CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 0.0

CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 0.0

WED, JUL 14 2004 11:09
FLT_7_3PH_VOLTAGES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 11:09

FLT_8_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_8_1PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 ⋎— - — - — ⋎ 0.0

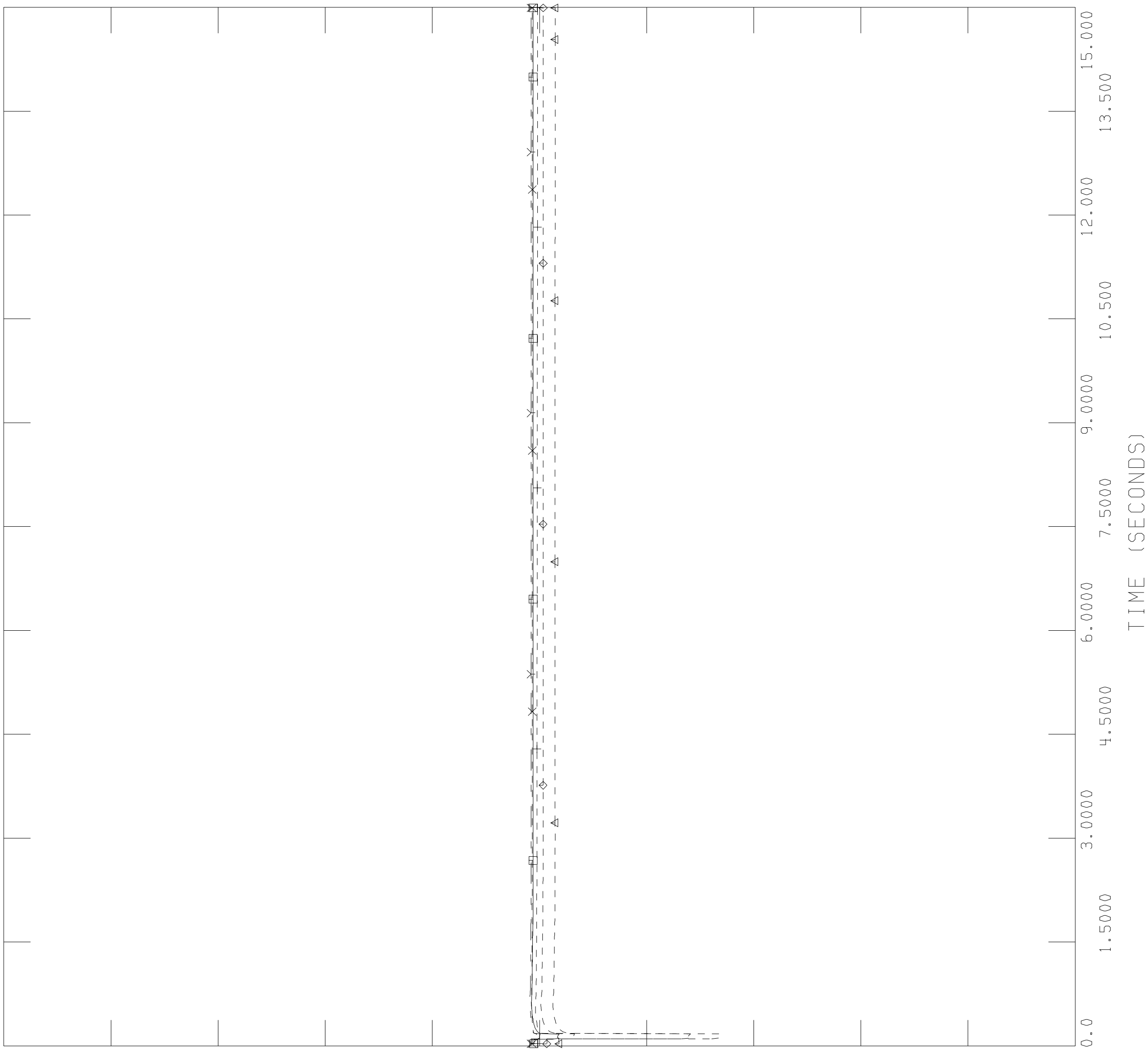
CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 ×----------× 0.0

CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 +----------+ 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 ◇----------◇ 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 ◁----------◁ 0.0

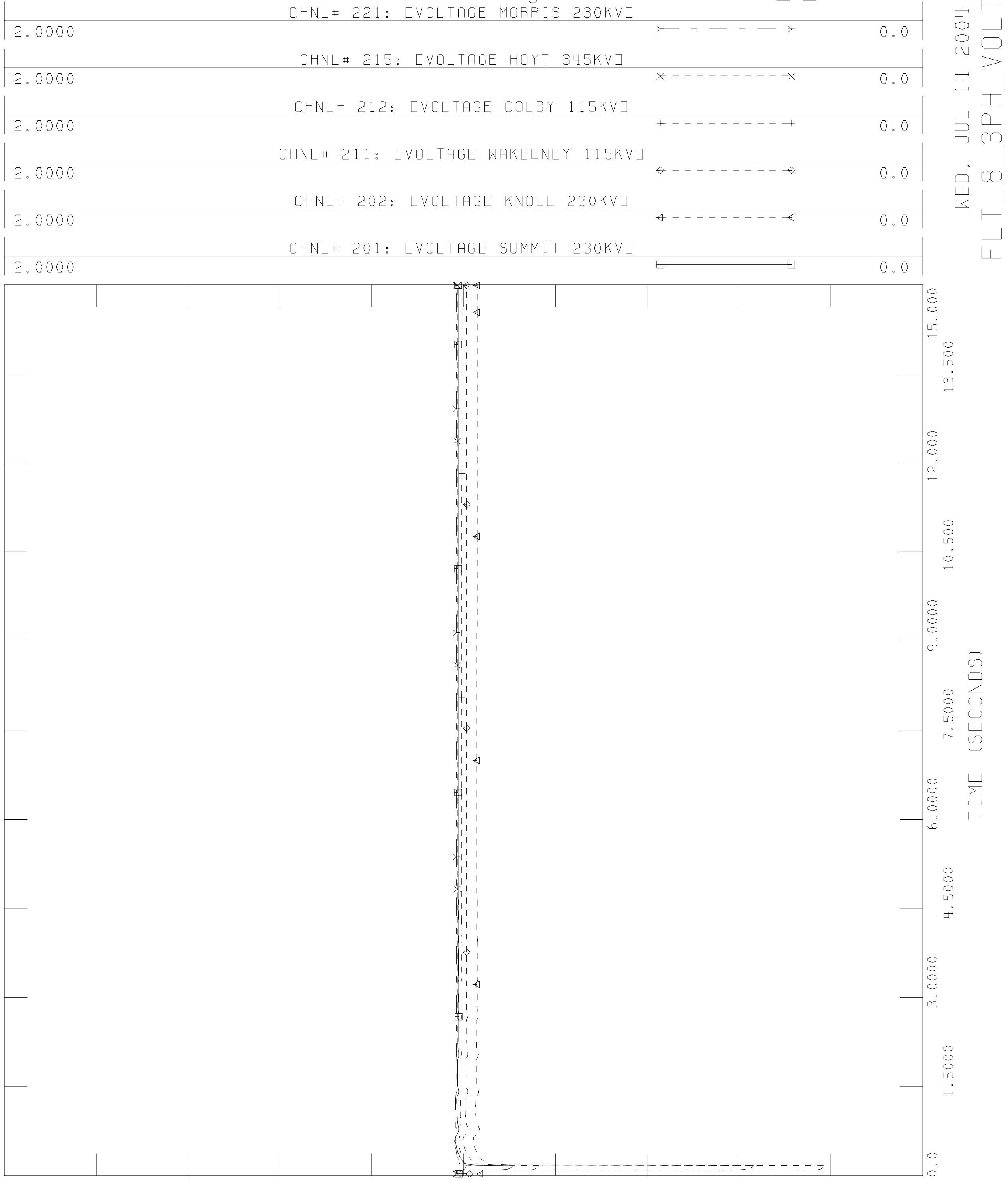
CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 □——————□ 0.0



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_8_3PH.OUT

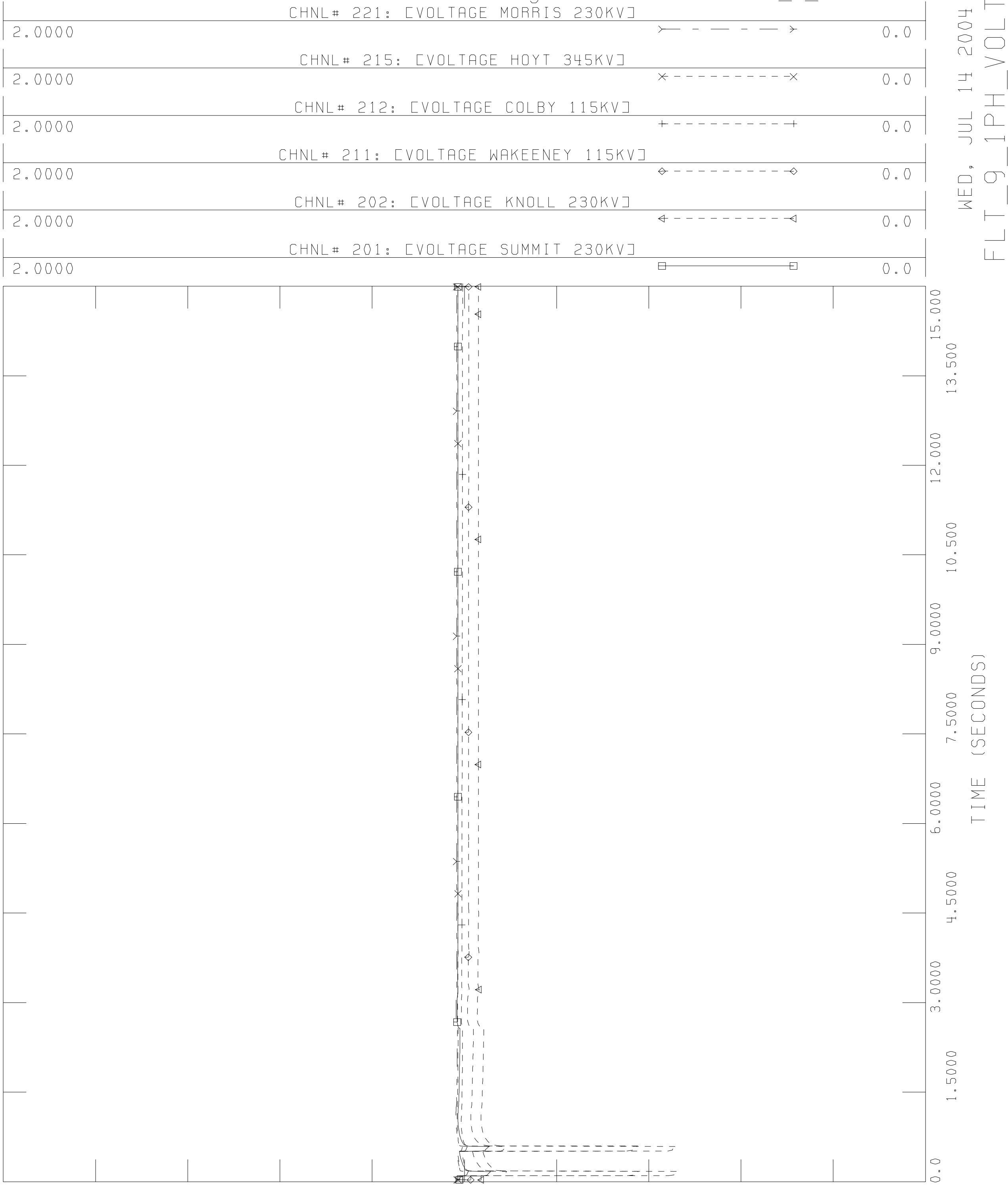


POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_9_1PH.OUT

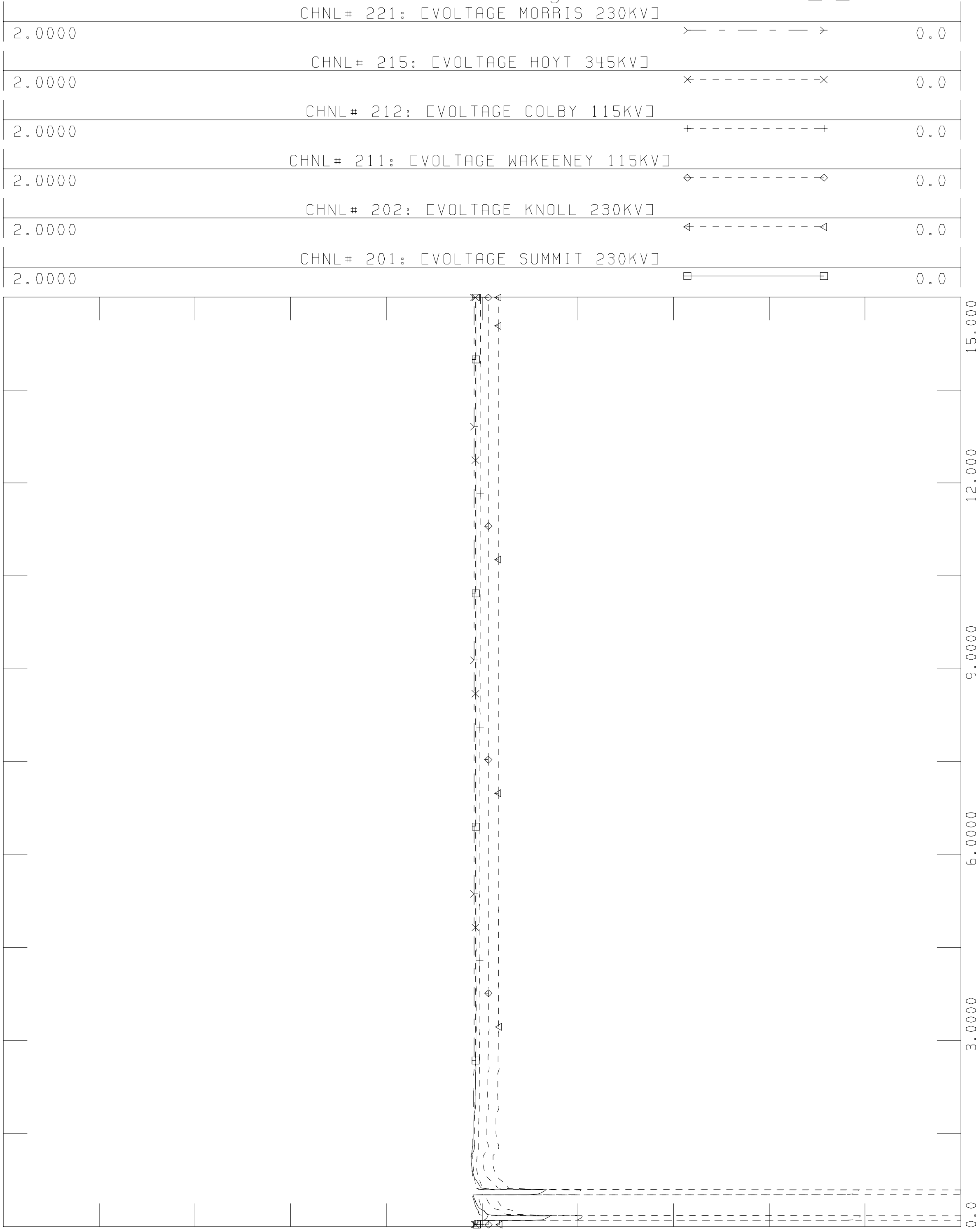
WED, JUL 14 2004 11:09
FLT_9_1PH_VOLTAGES



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_9_3PH.OUT



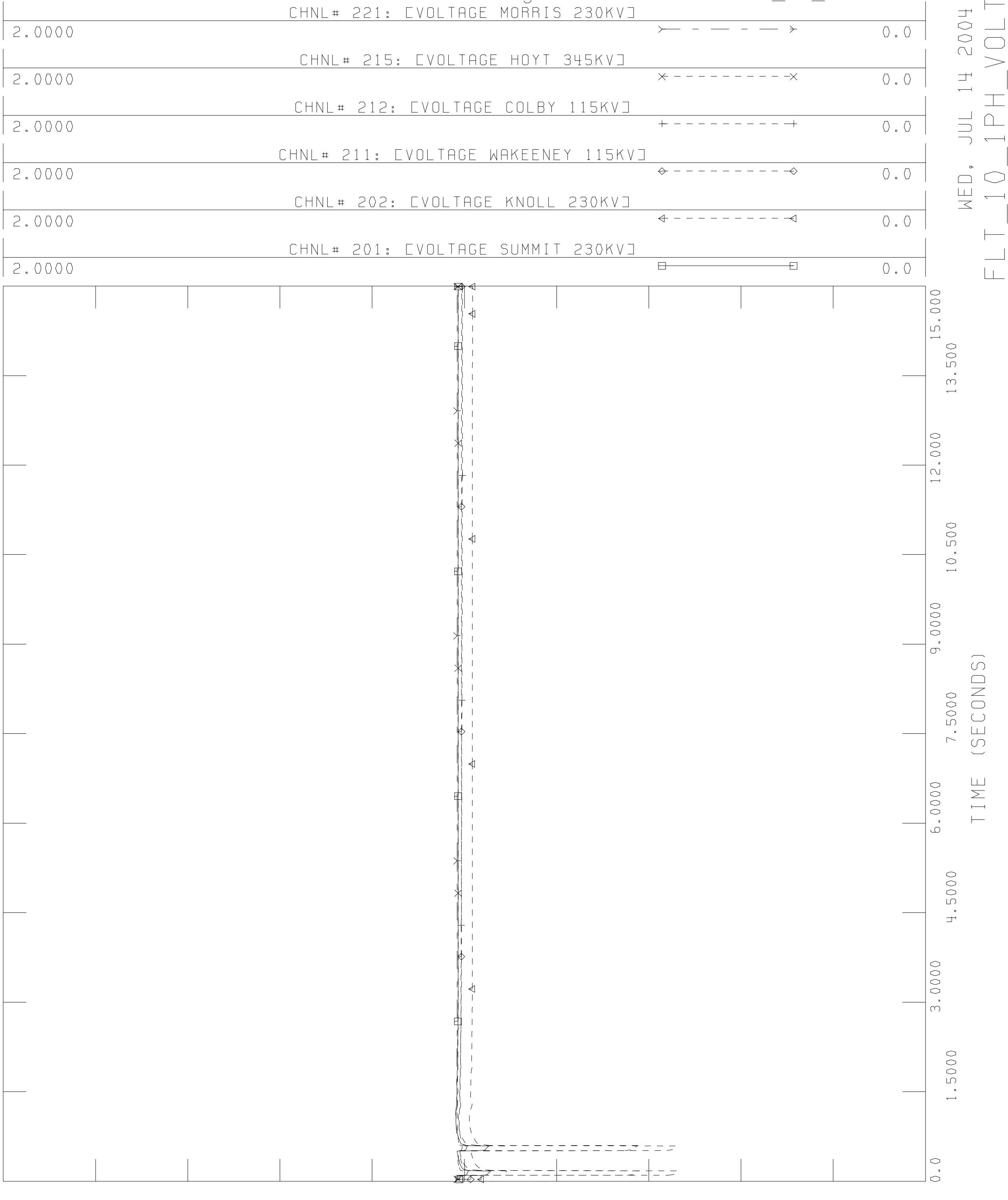
WED, JUL 14 2004 11:09
FLT_9_3PH_VOLTAGES

POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

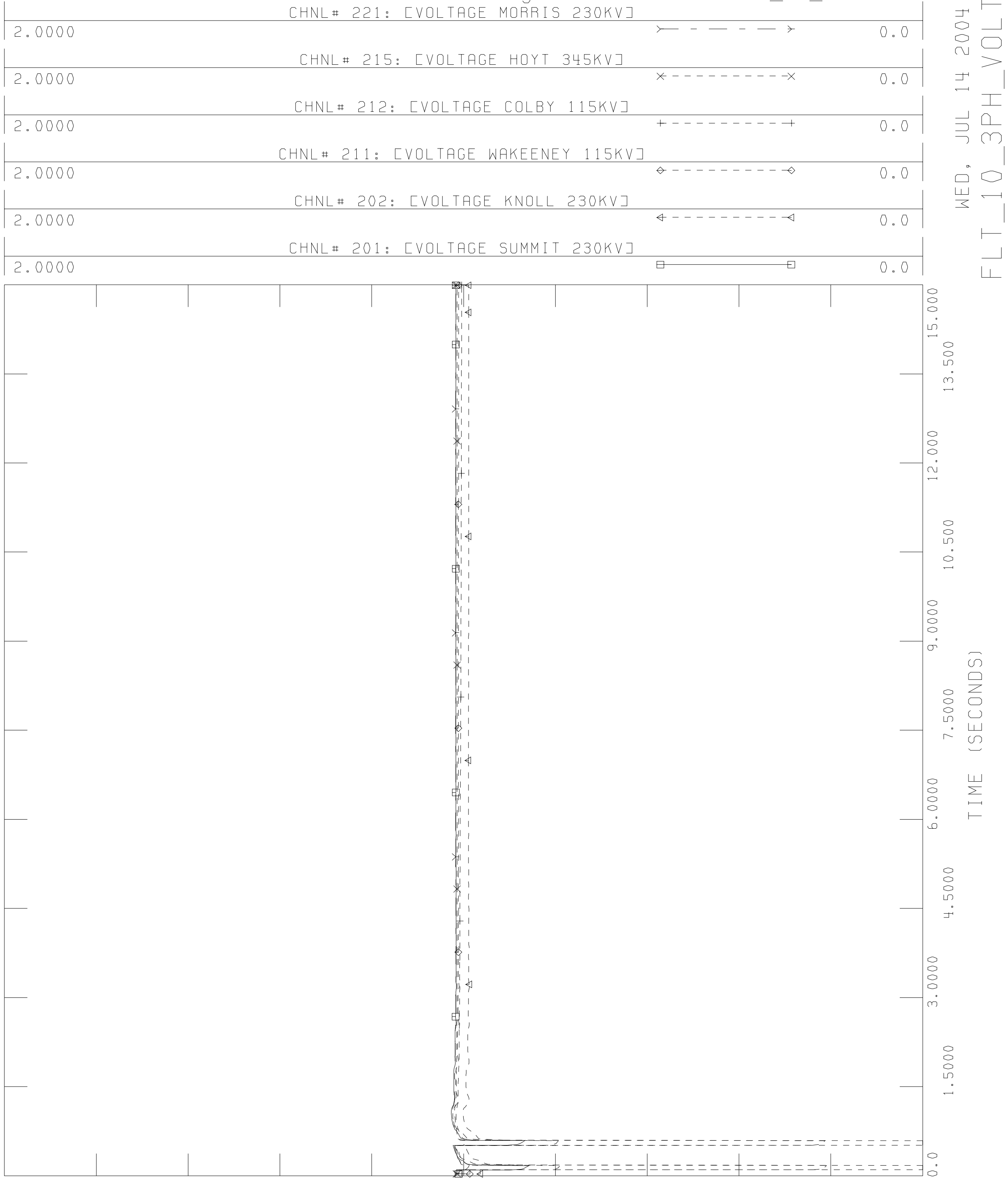
FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_10_1PH.OUT

WED, JUL 14 2004 11:09
FLT_10_1PH_VOLTAGES



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_10_3PH.OUT



Appendix A-2

Plots of Fault Simulations

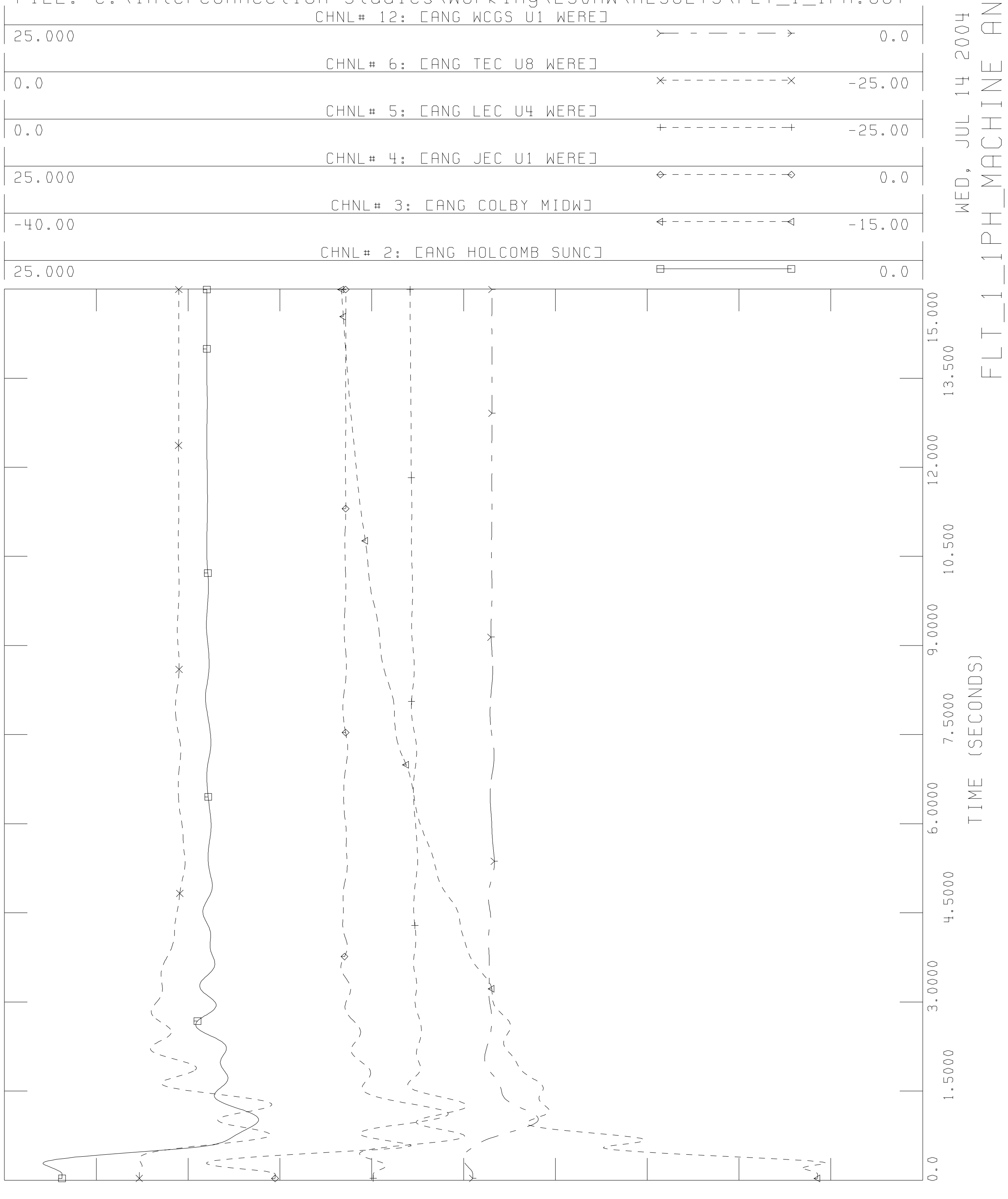
Plots of selected machine phase angles during faults

Scenario:
2005 Summer Peak
Wind Farm at 250MW (100% rated power)
Standard Protection Settings

POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_1_1PH.OUT



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER
TECHNOLOGIES
INC.®

WED, JUL 14 2004 10:50

FLT_1_3PH_MACHINE ANGLES

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_1_3PH.OUT

CHNL# 12: [ANG WCGS U1 WERE]
25.000 ⟶ 0.0

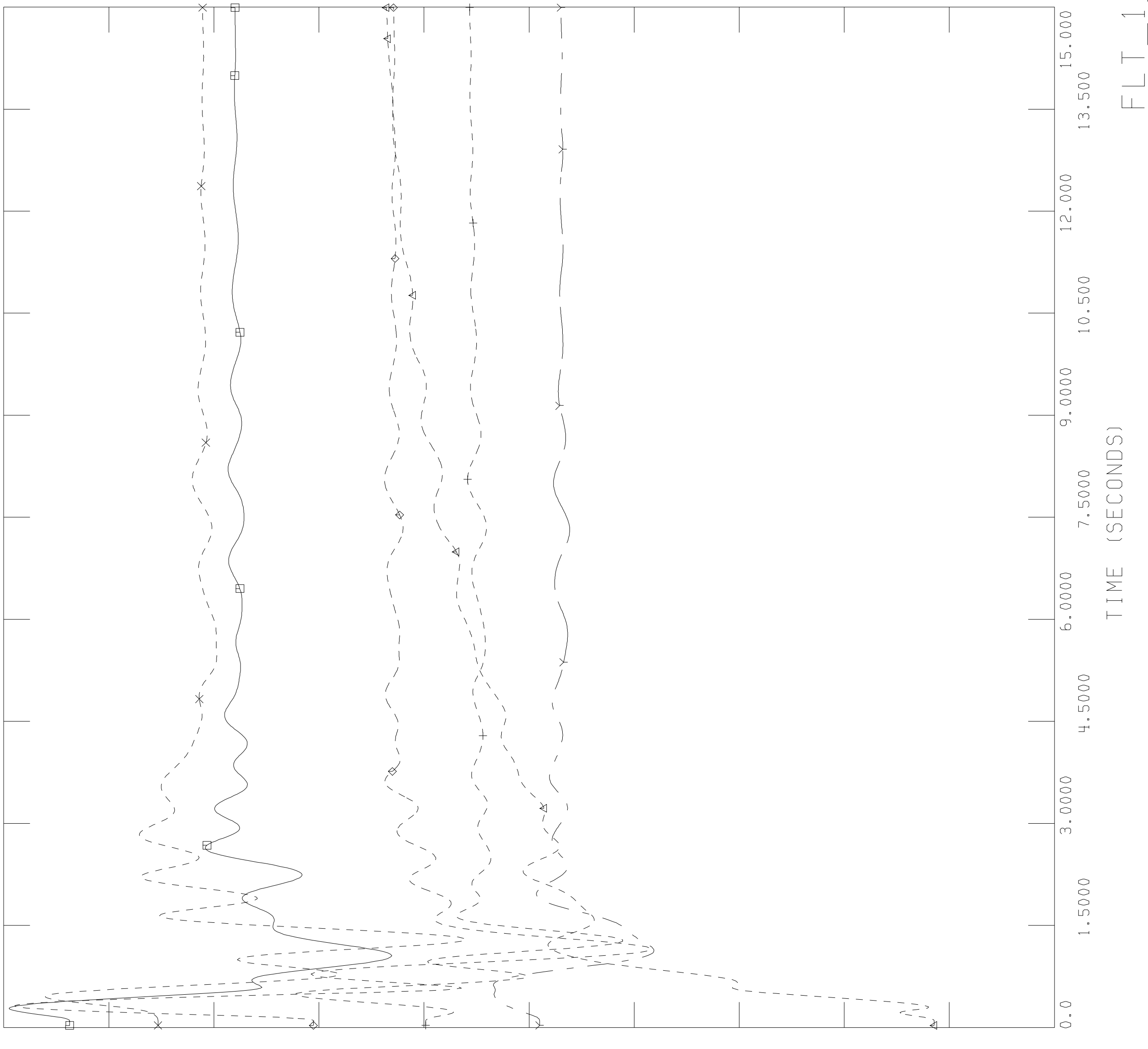
CHNL# 6: [ANG TEC U8 WERE]
0.0 ⟶ -25.00

CHNL# 5: [ANG LEC U4 WERE]
0.0 ⟶ -25.00

CHNL# 4: [ANG JEC U1 WERE]
25.000 ⟶ 0.0

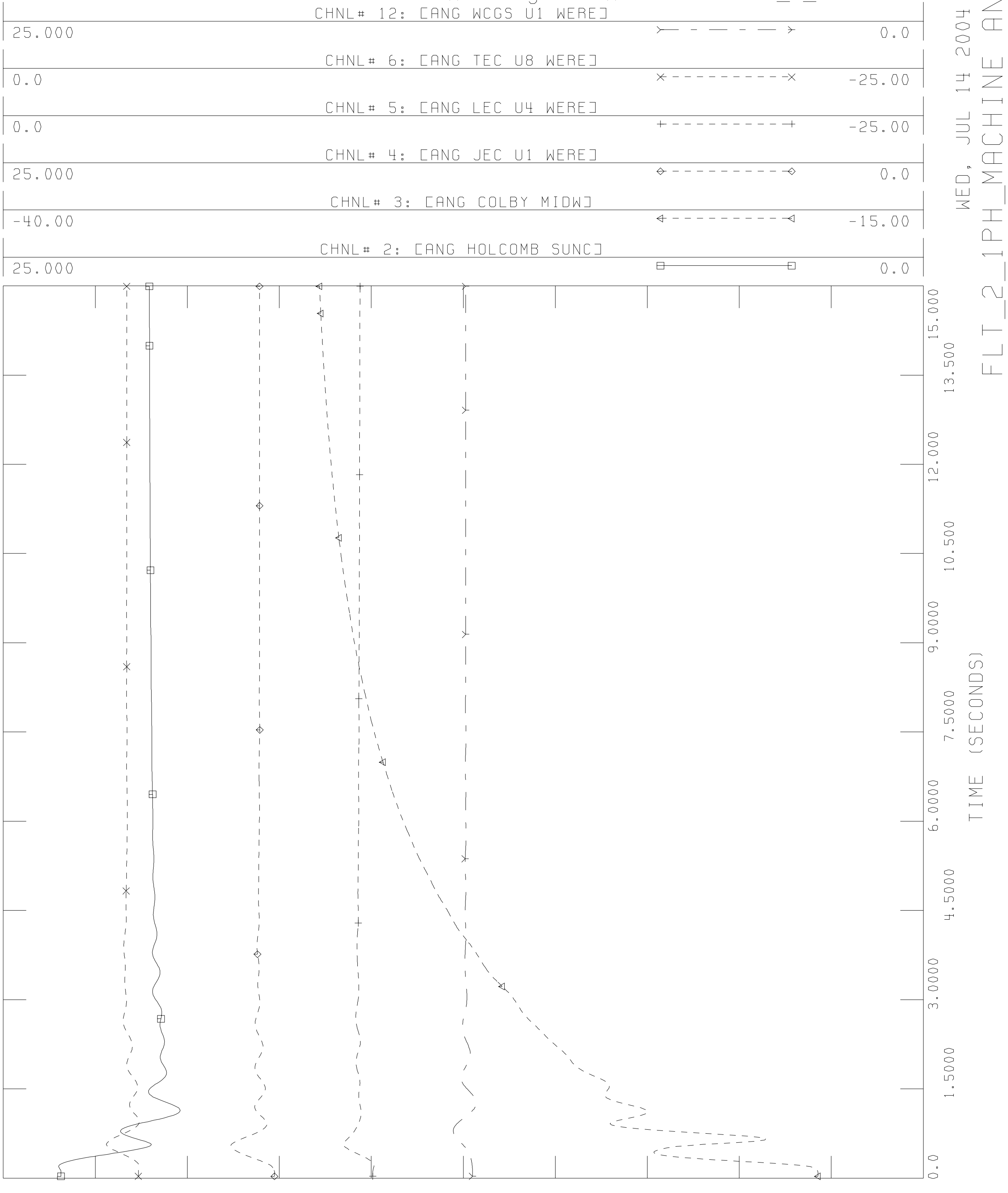
CHNL# 3: [ANG COLBY MIDW]
-40.00 ⟶ -15.00

CHNL# 2: [ANG HOLCOMB SUNC]
25.000 ⟶ 0.0



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_2_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_2_3PH.OUT

CHNL# 12: [ANG WCGS U1 WERE]
25.000 0.0

CHNL# 6: [ANG TEC U8 WERE]
0.0 -25.00

CHNL# 5: [ANG LEC U4 WERE]
0.0 -25.00

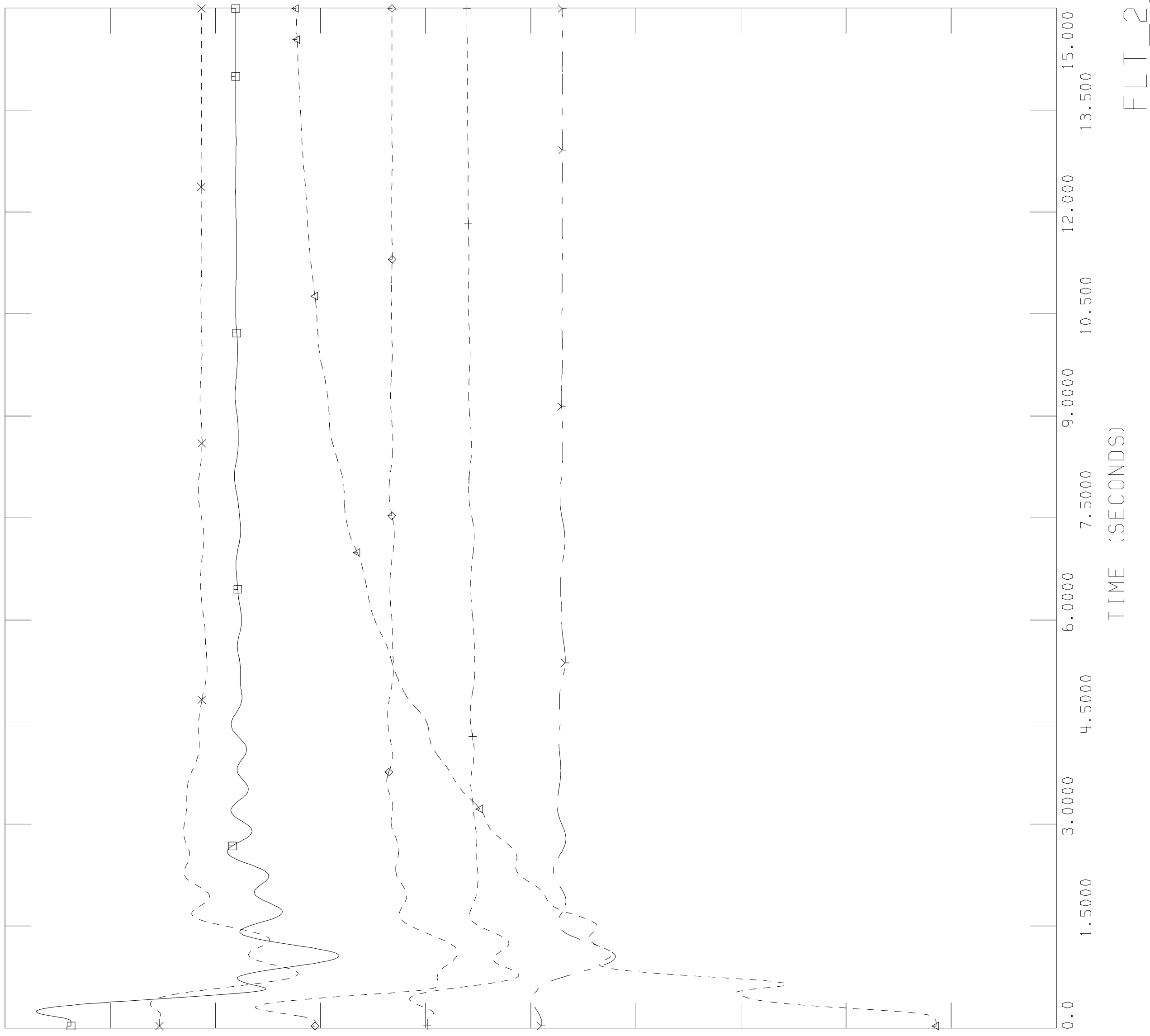
CHNL# 4: [ANG JEC U1 WERE]
25.000 0.0

CHNL# 3: [ANG COLBY MIDW]
-40.00 -15.00

CHNL# 2: [ANG HOLCOMB SUNC]
25.000 0.0

WED, JUL 14 2004 10:50

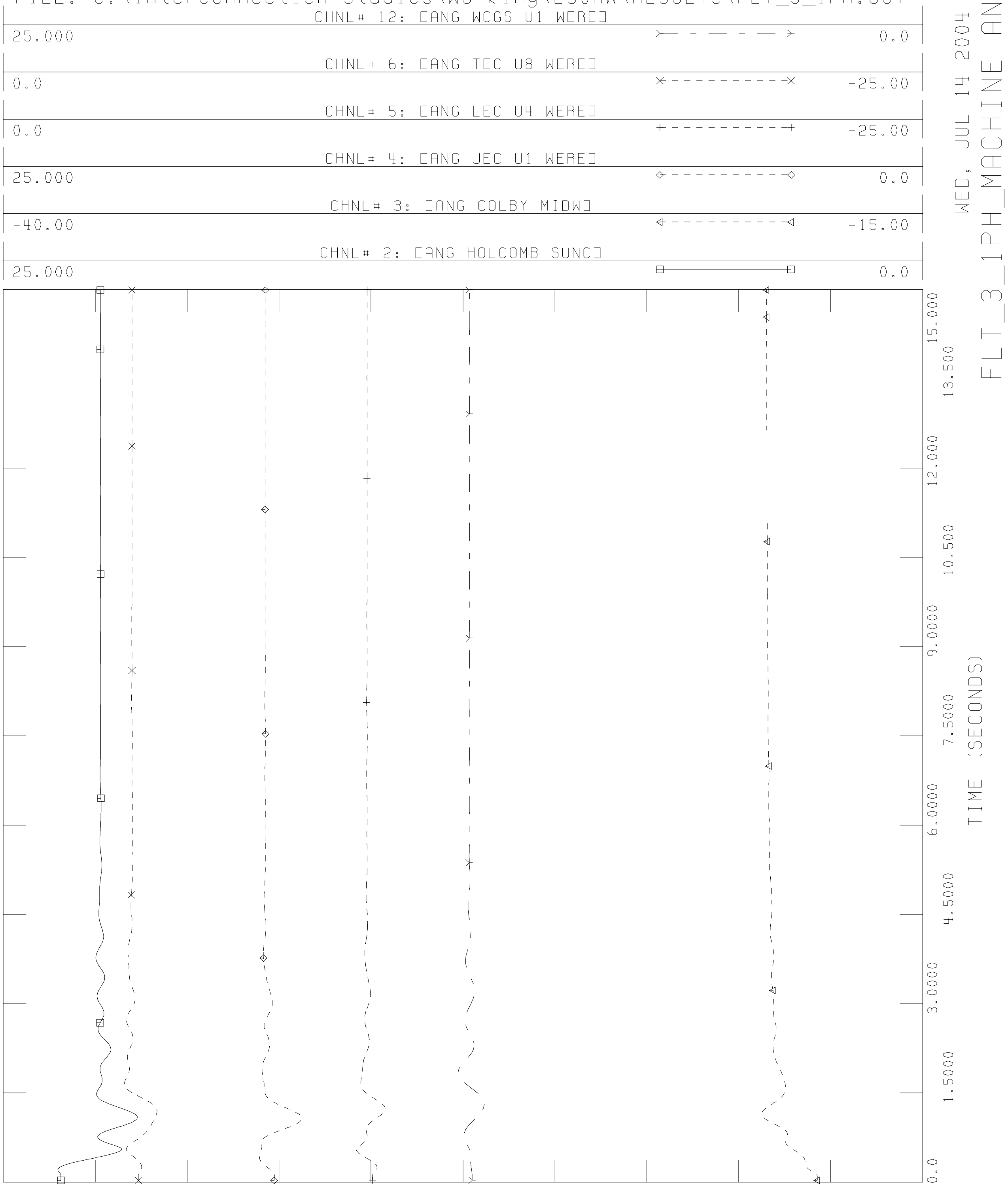
FLT_2_3PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_3_1PH.OUT



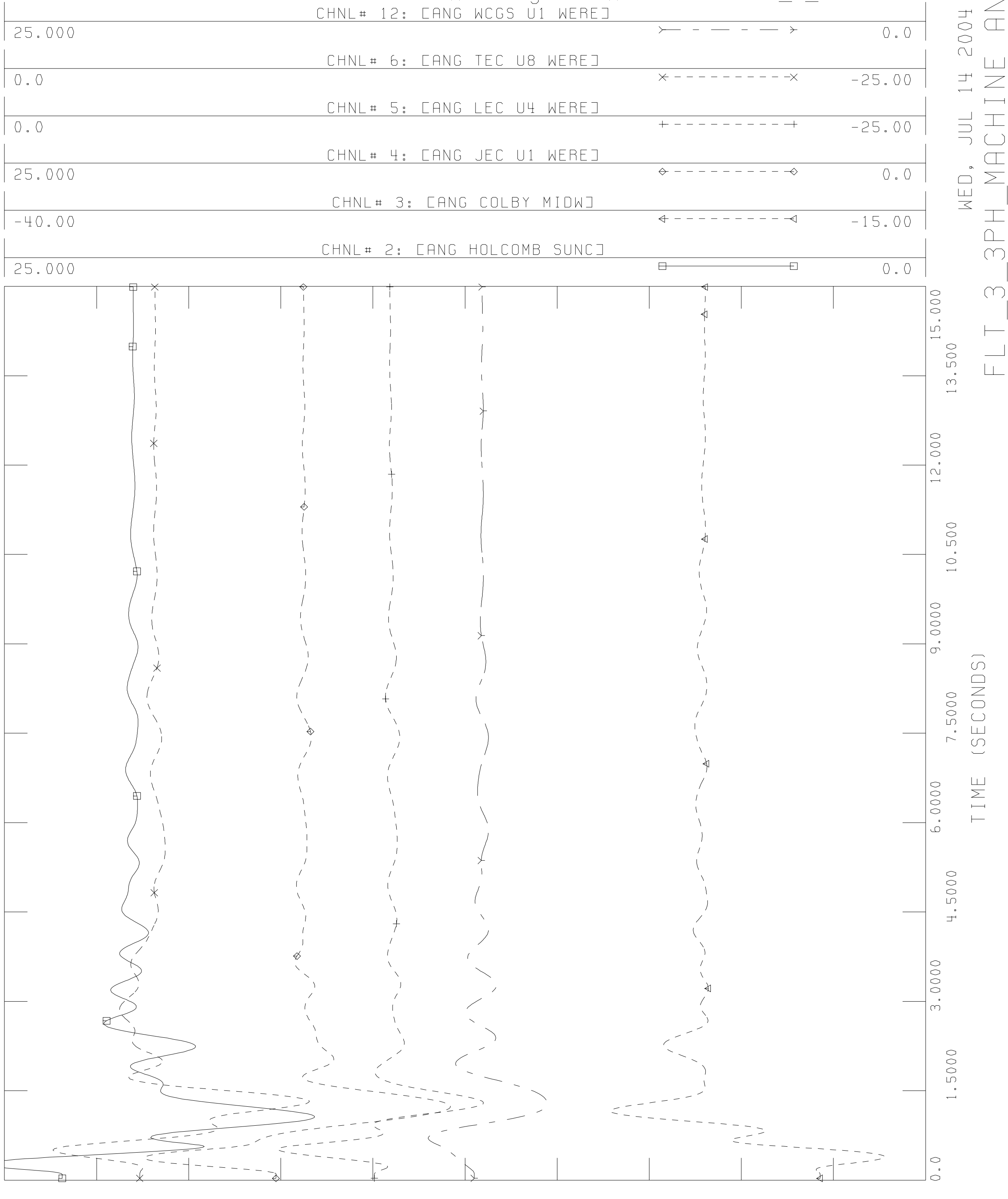
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_3_3PH.OUT

WED, JUL 14 2004 10:50

FLT_3_3PH_MACHINE ANGLES



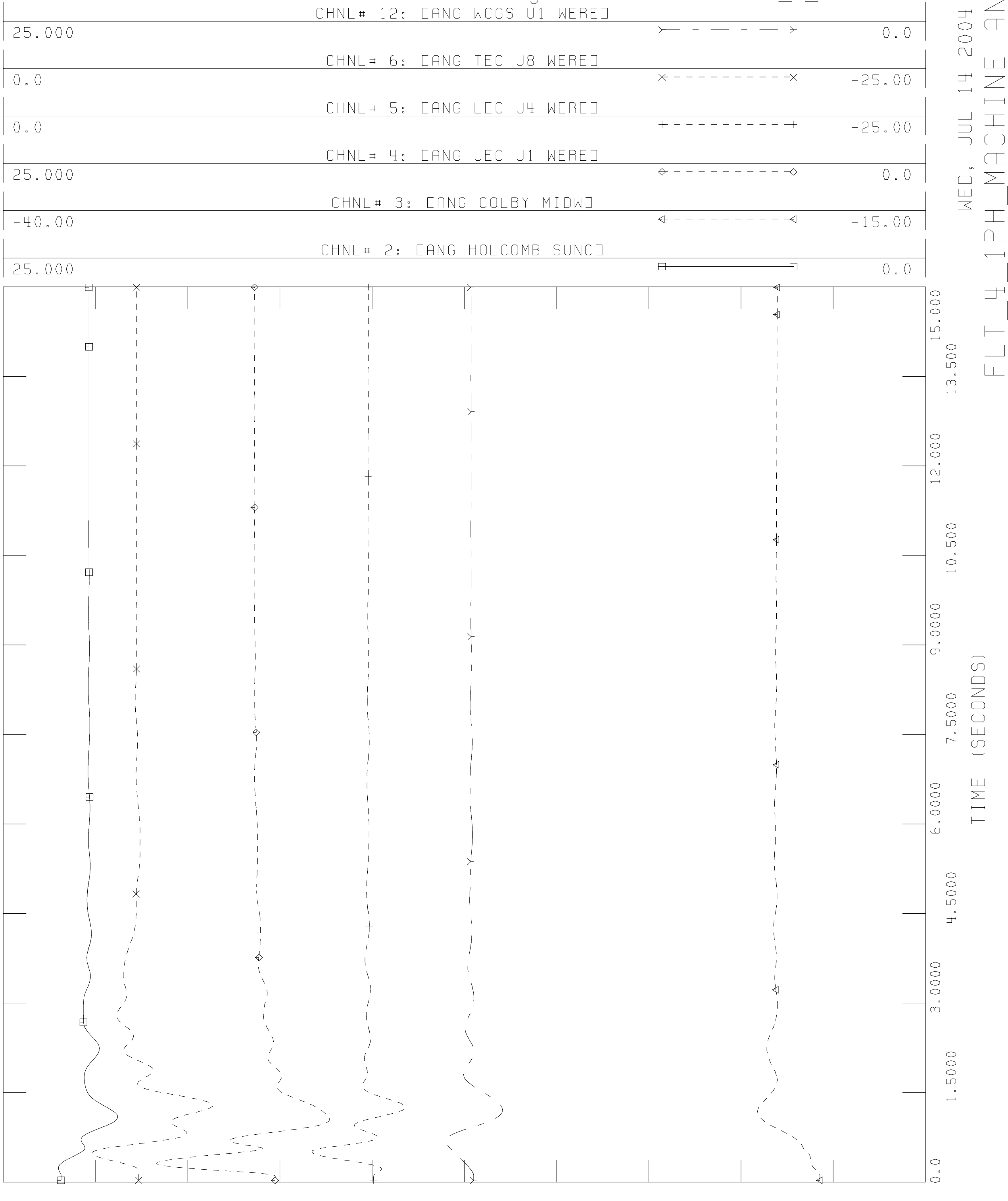
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_4_1PH.OUT

WED, JUL 14 2004 10:50

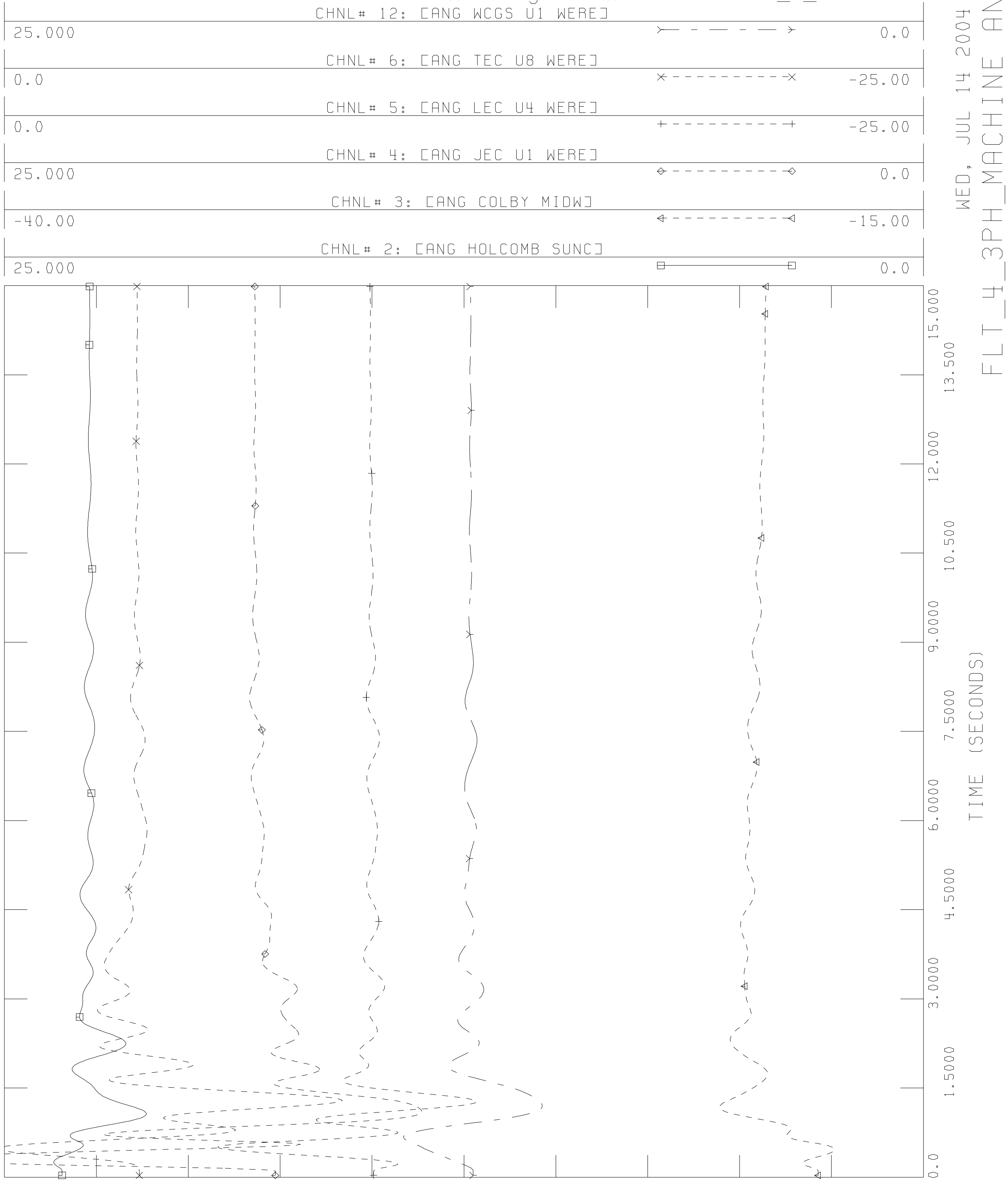
FLT_4_1PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_4_3PH.OUT



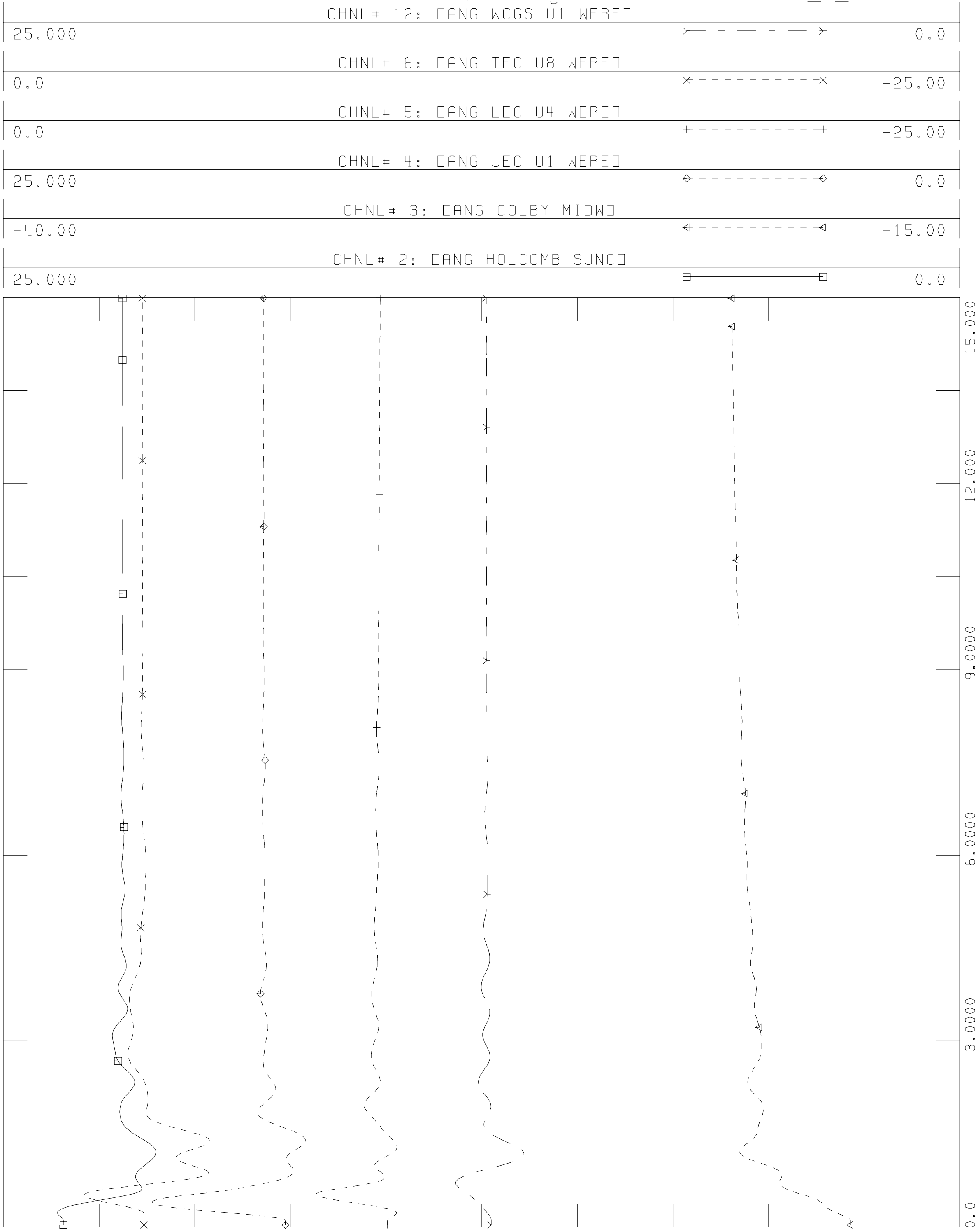
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_5_1PH.OUT

WED, JUL 14 2004 10:50

FLT_5_1PH_MACHINE ANGLES

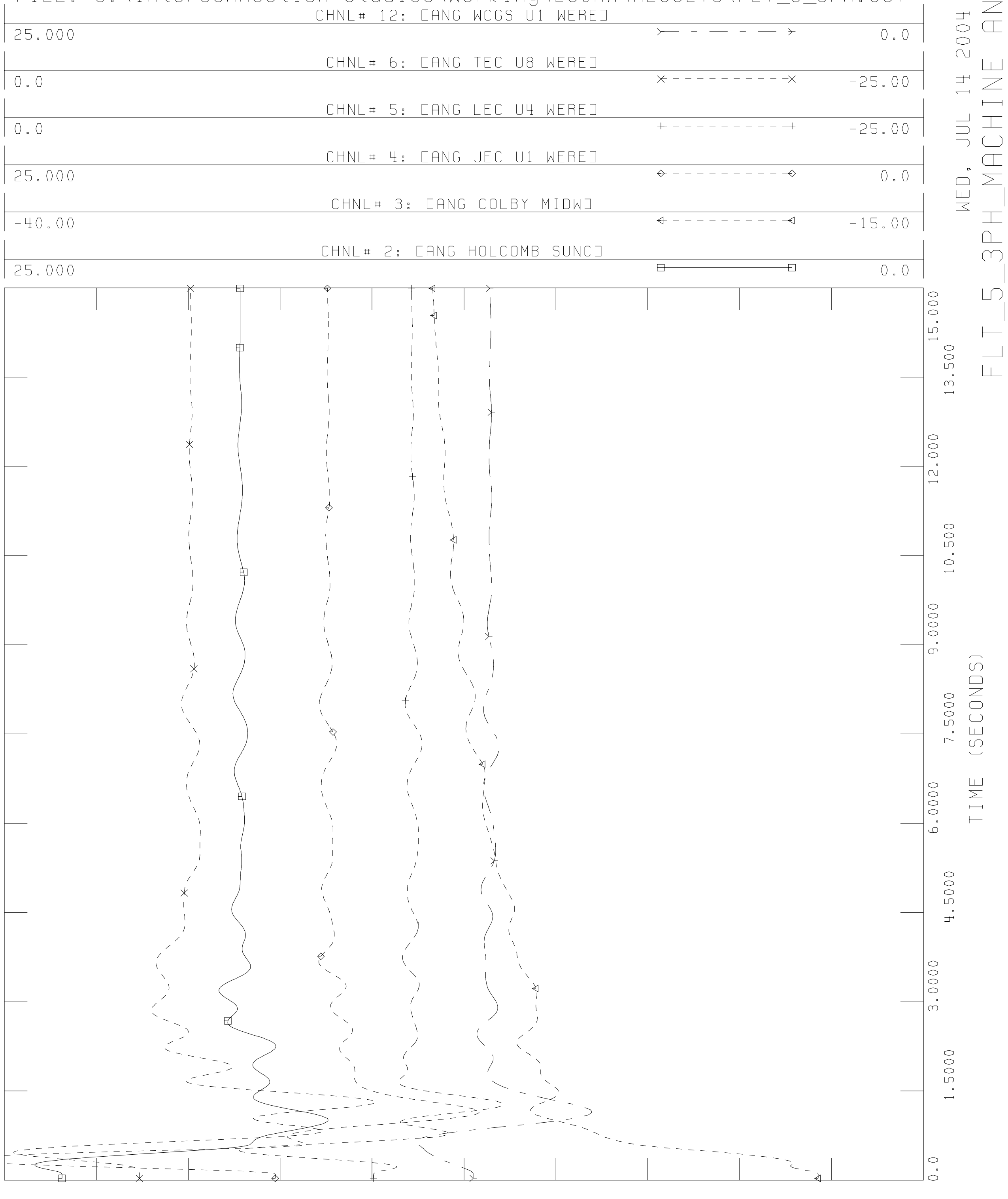


TIME (SECONDS)

POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

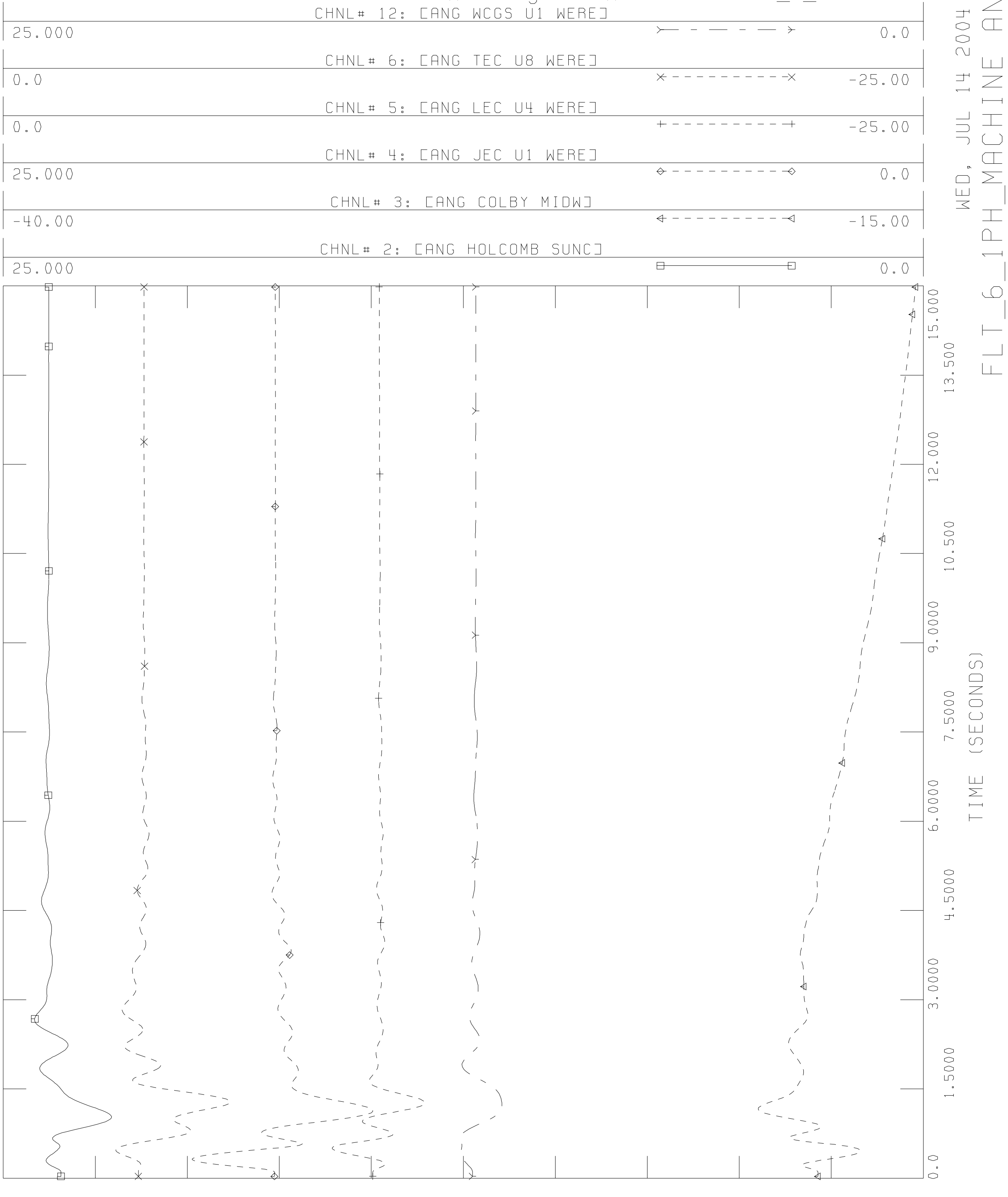
FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_5_3PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_6_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_6_3PH.OUT

CHNL# 12: [ANG WCGS U1 WERE]
25.000 ⟶ 0.0

CHNL# 6: [ANG TEC U8 WERE]
0.0 ⟶ -25.00

CHNL# 5: [ANG LEC U4 WERE]
0.0 ⟶ -25.00

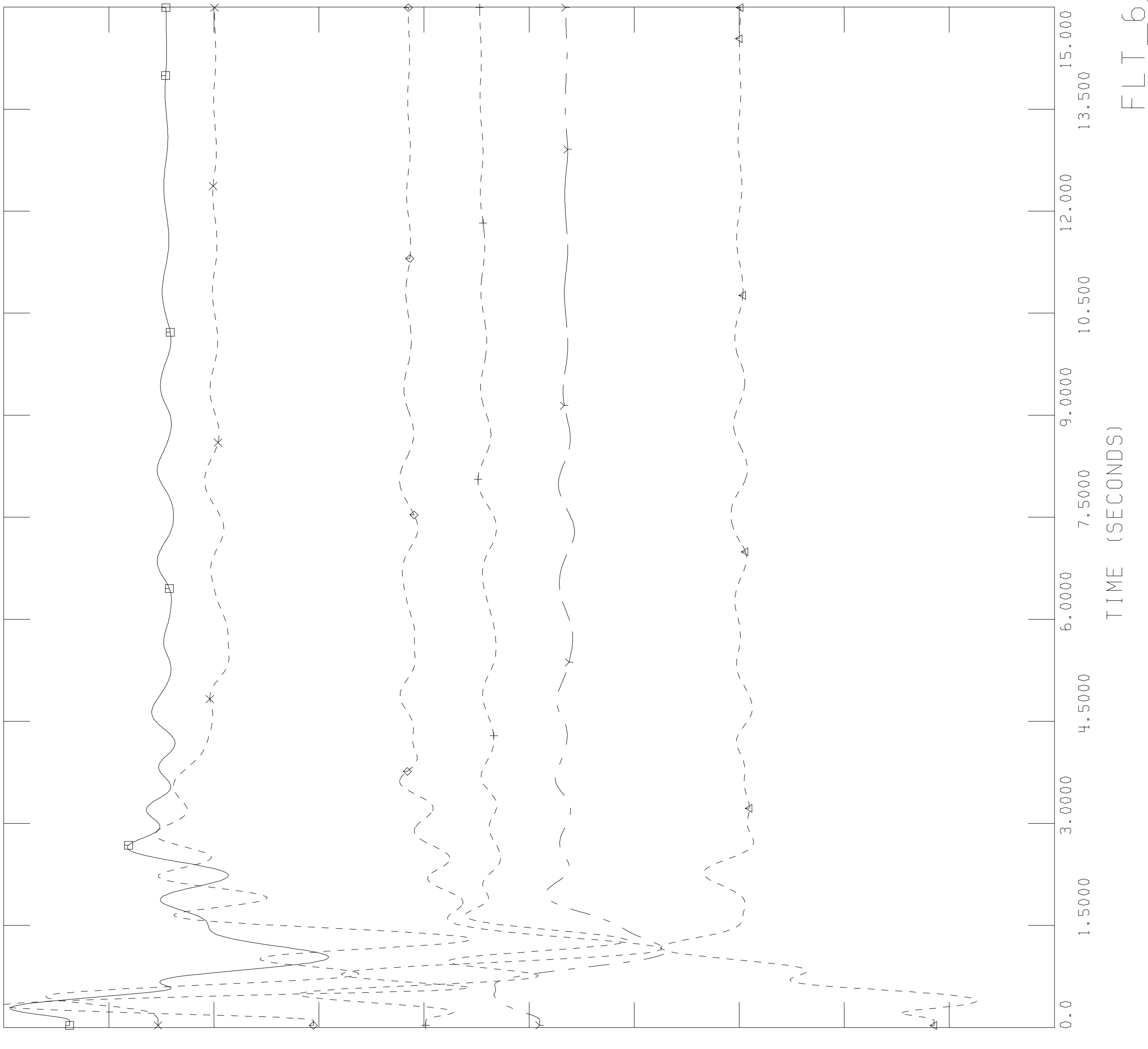
CHNL# 4: [ANG JEC U1 WERE]
25.000 ⟶ 0.0

CHNL# 3: [ANG COLBY MIDW]
-40.00 ⟶ -15.00

CHNL# 2: [ANG HOLCOMB SUNC]
25.000 ⟶ 0.0

WED, JUL 14 2004 10:50

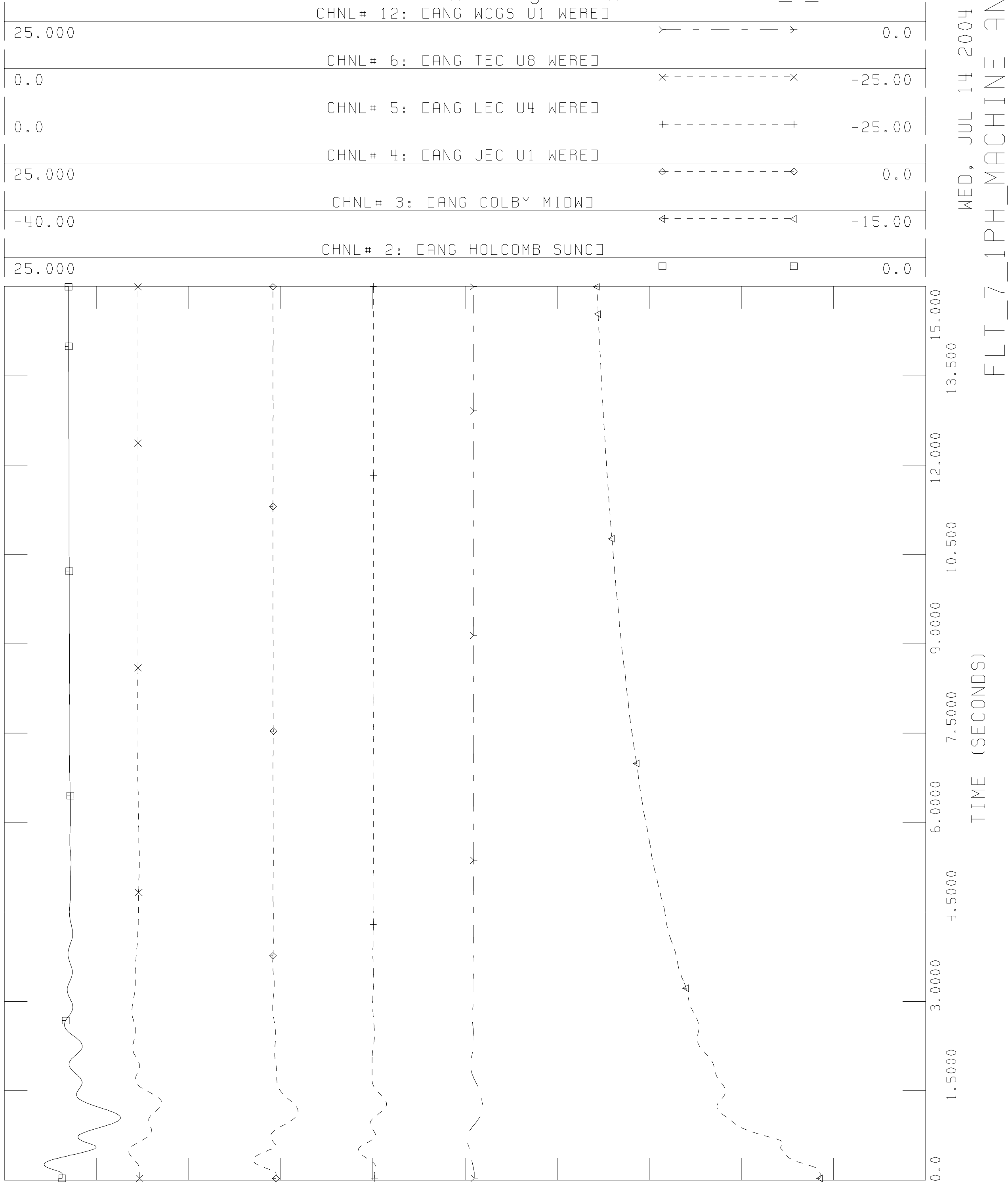
FLT_6_3PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_7_1PH.OUT



WED, JUL 14 2004 10:50

FLT_7_1PH_MACHINE ANGLES

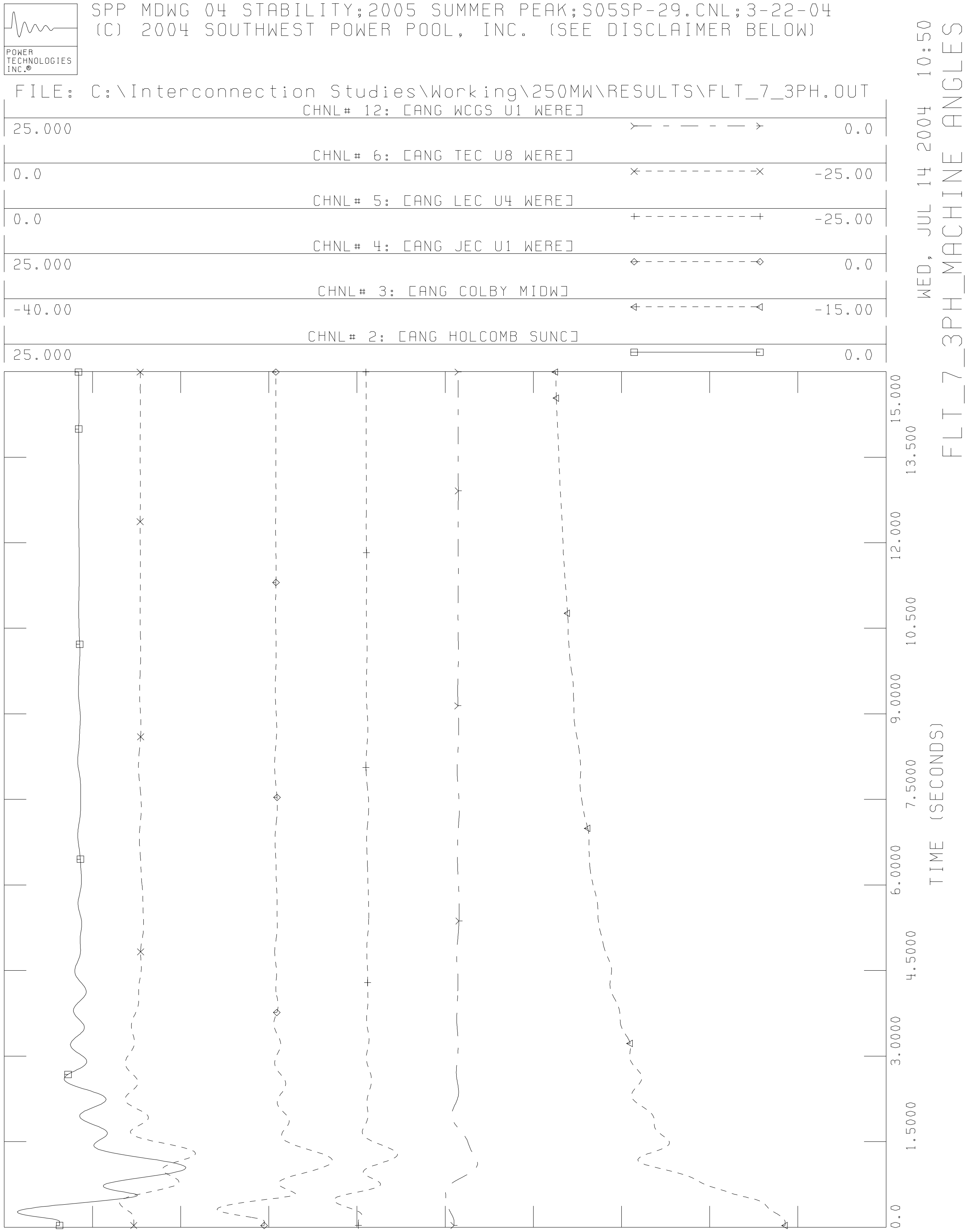
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_7_3PH.OUT

WED, JUL 14 2004 10:50

FLT_7_3PH_MACHINE ANGLES



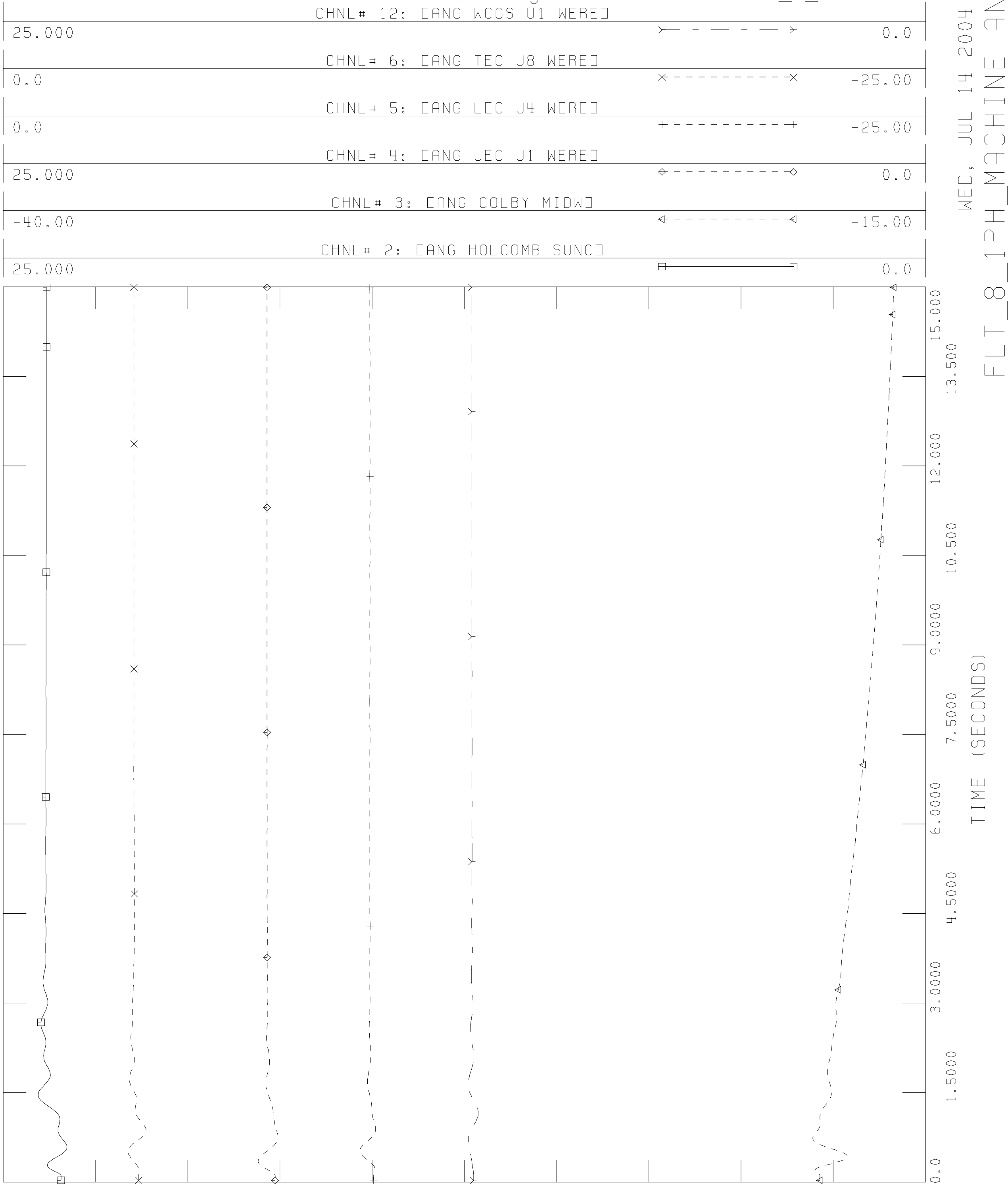
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_8_1PH.OUT

WED, JUL 14 2004 10:50

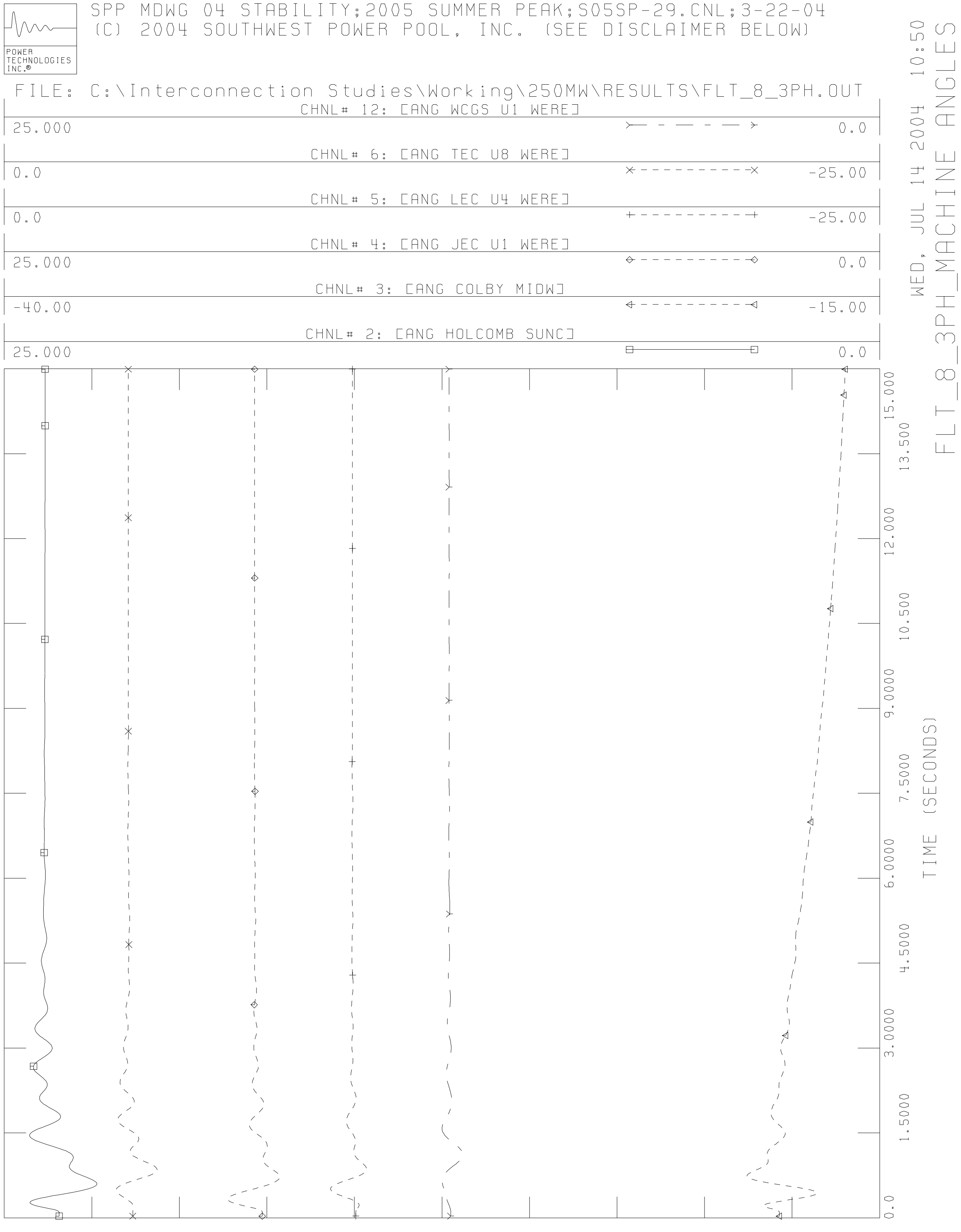
FLT_8_1PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

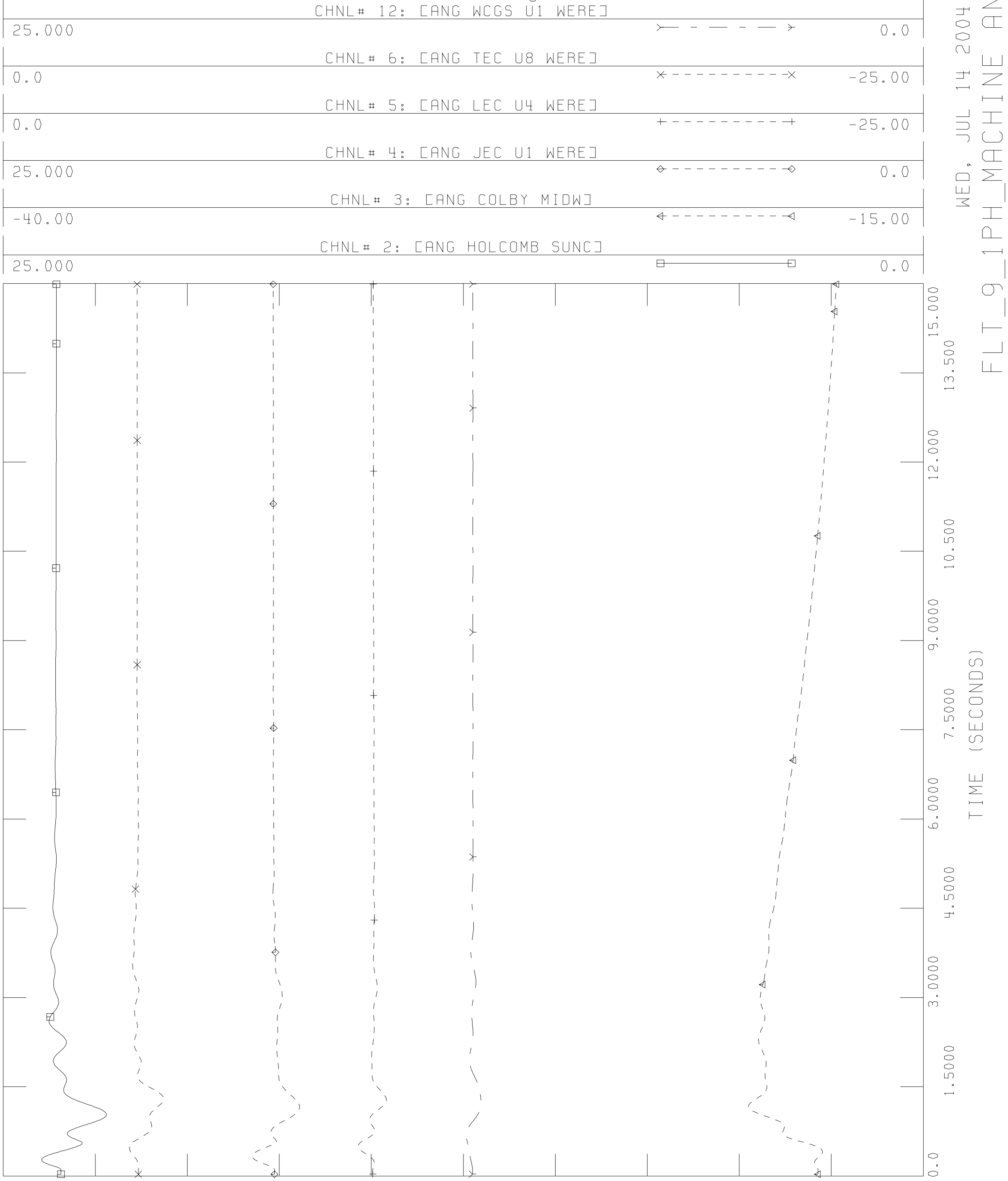
FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_8_3PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

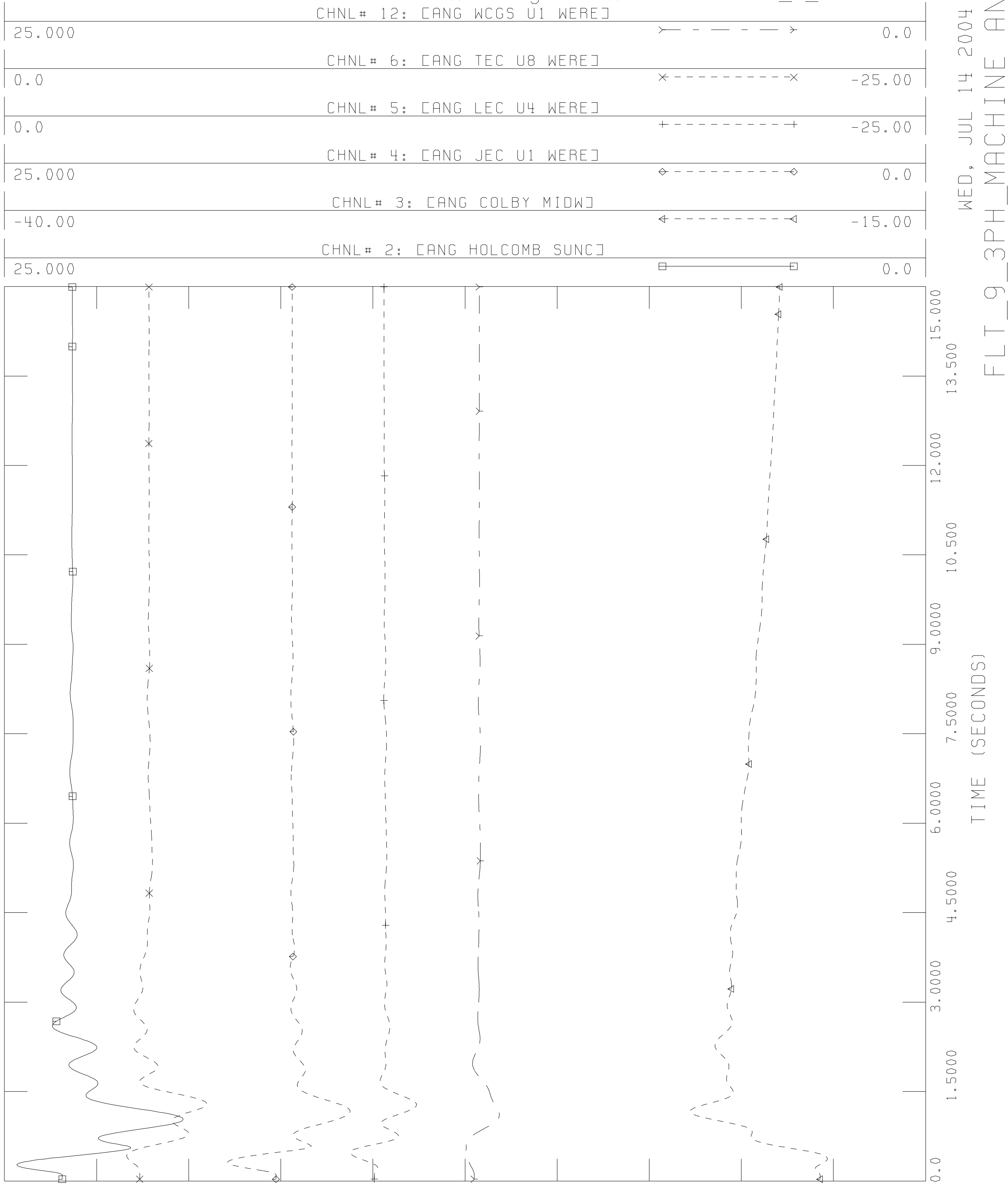
FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_9_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_9_3PH.OUT



WED, JUL 14 2004 10:50

FLT_9_3PH_MACHINE ANGLES

POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_10_1PH.OUT

CHNL# 12: [ANG WCGS U1 WERE]
25.000 0.0

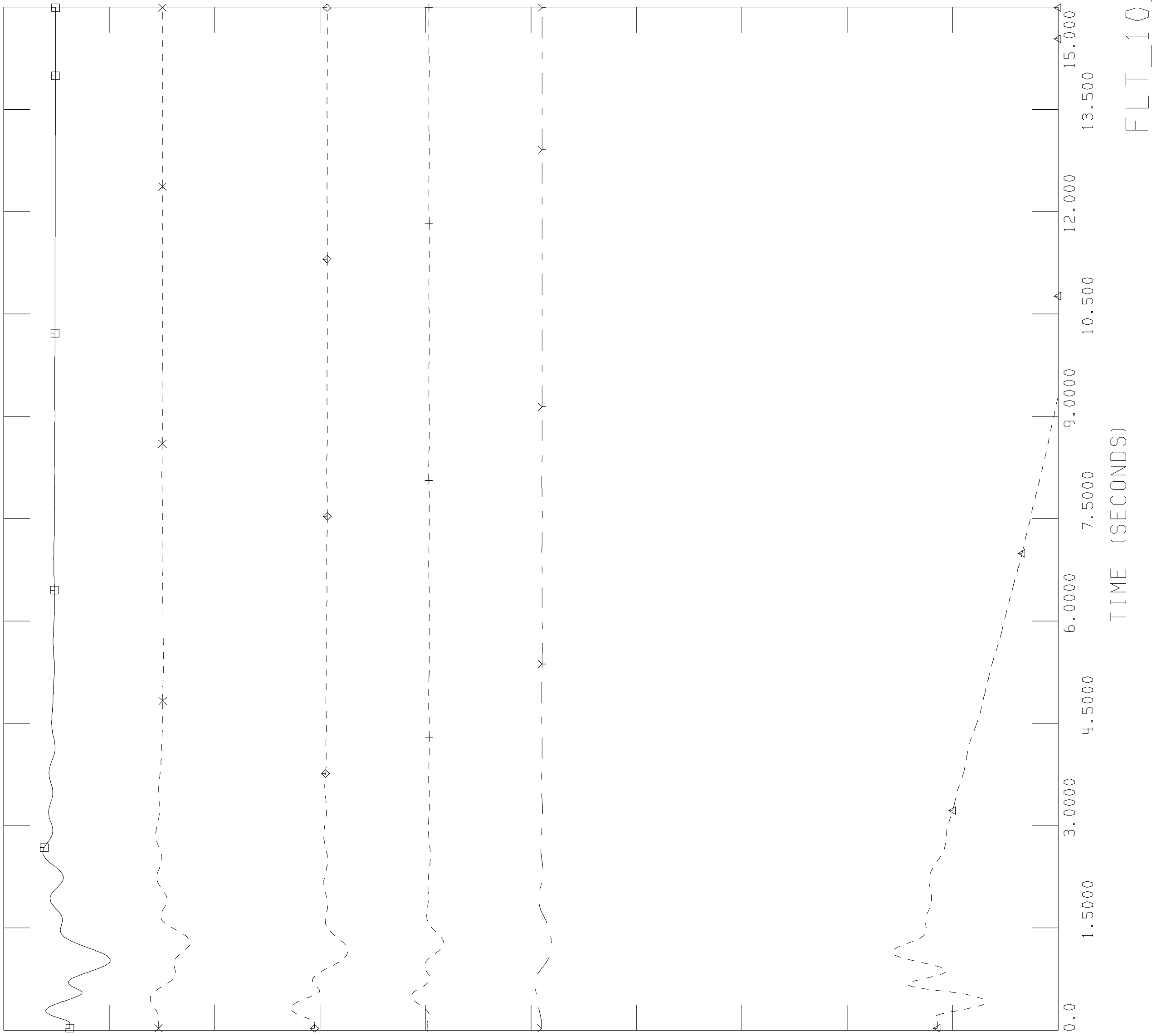
CHNL# 6: [ANG TEC U8 WERE]
0.0 -25.00

CHNL# 5: [ANG LEC U4 WERE]
0.0 -25.00

CHNL# 4: [ANG JEC U1 WERE]
25.000 0.0

CHNL# 3: [ANG COLBY MIDW]
-40.00 -15.00

CHNL# 2: [ANG HOLCOMB SUNC]
25.000 0.0



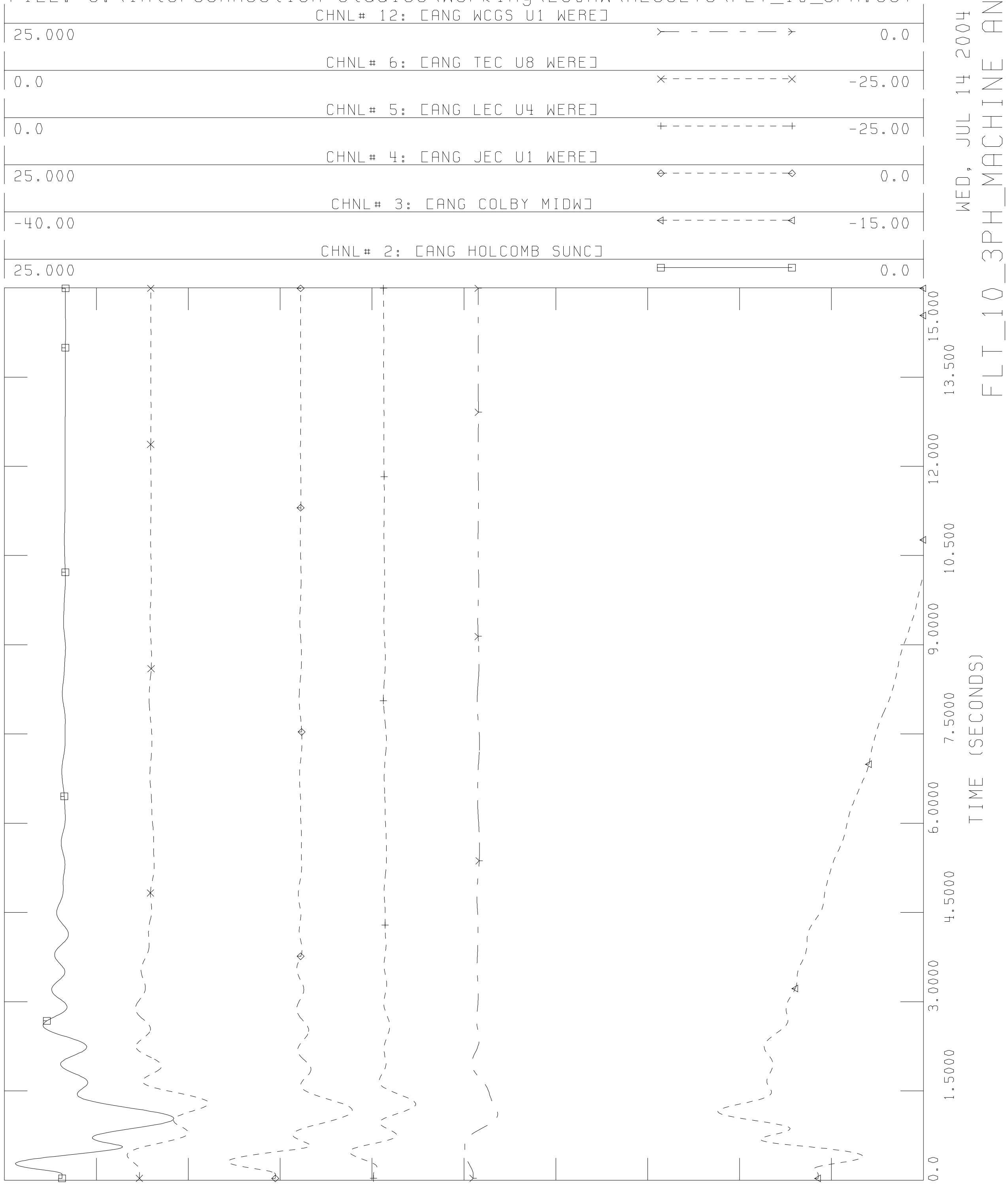
WED, JUL 14 2004 10:50

FLT_10_1PH_MACHINE ANGLES

POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW\RESULTS\FLT_10_3PH.OUT



Appendix B-1

Plots of Fault Simulations

Plots of selected bus voltage response during faults

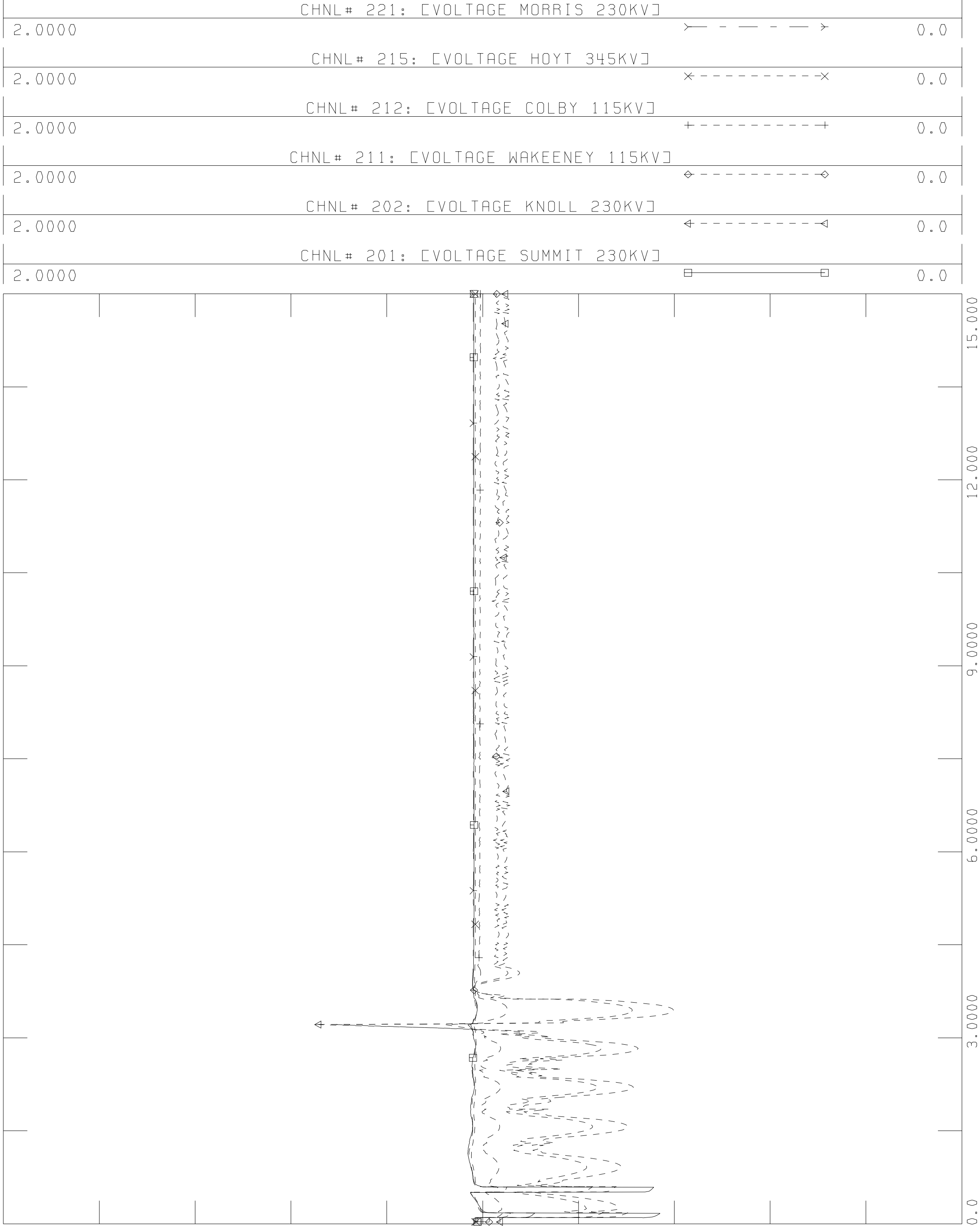
Scenario:
2005 Summer Peak
Wind Farm at 250MW (100% rated power)
AGO4 Protection Settings

POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_1_1PH.OUT

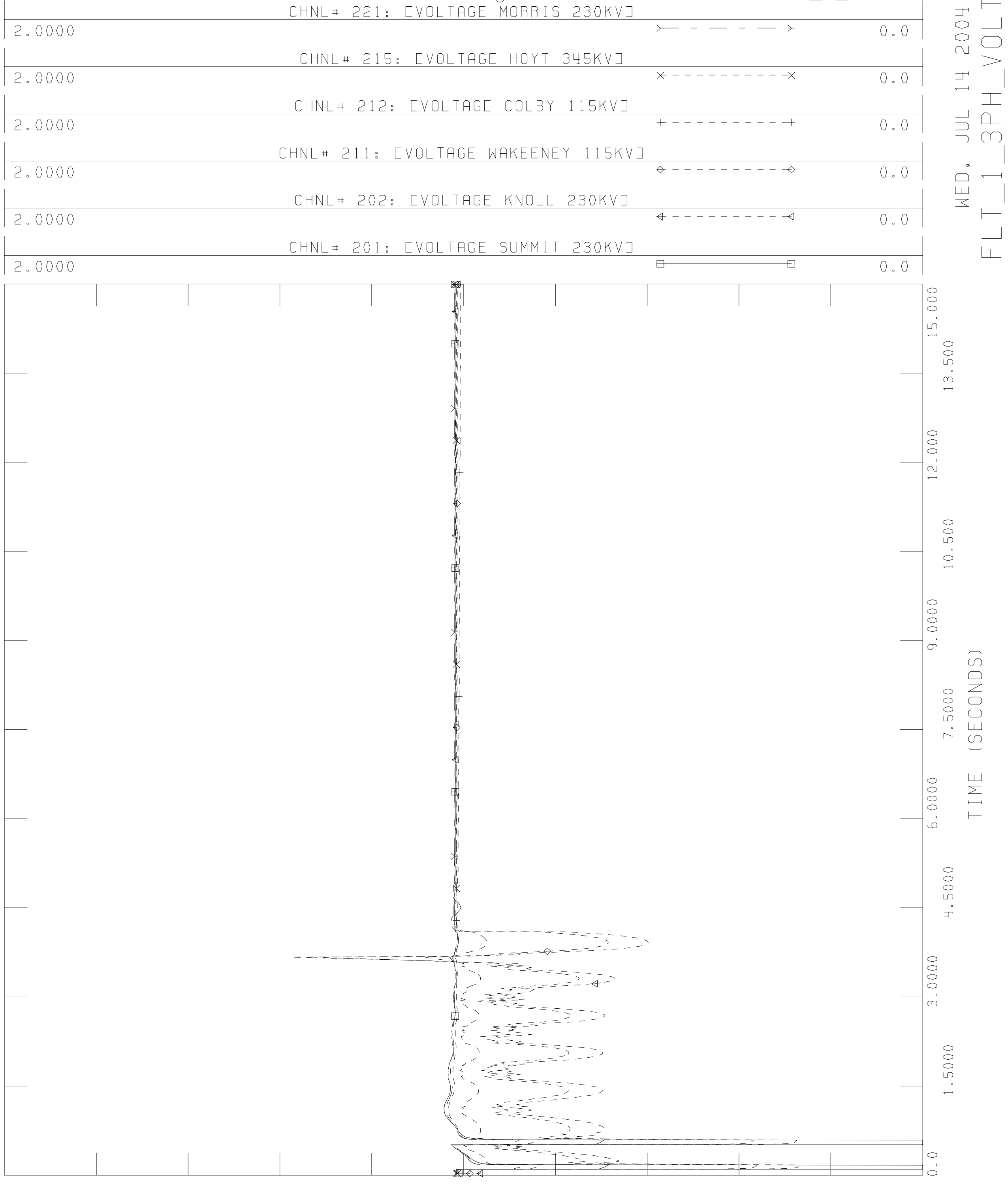
WED, JUL 14 2004 10:58
FLT_1_1PH_VOLTAGES



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_1_3PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:58
FLT_2_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_2_1PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 ≻— - — - —≻ 0.0

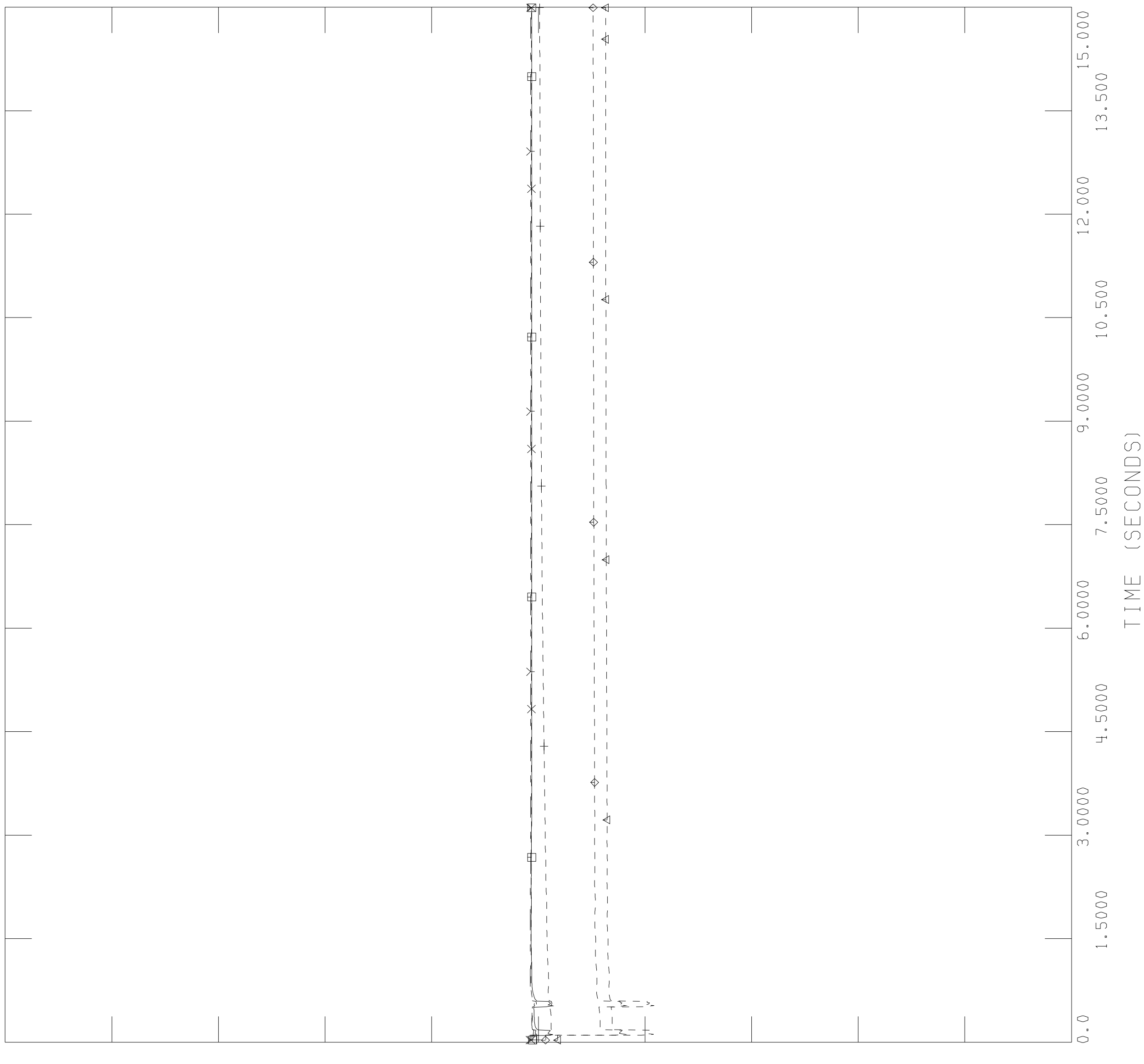
CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 ×----------× 0.0

CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 +----------+ 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 ◇----------◇ 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 ◁----------◁ 0.0

CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 □——————□ 0.0



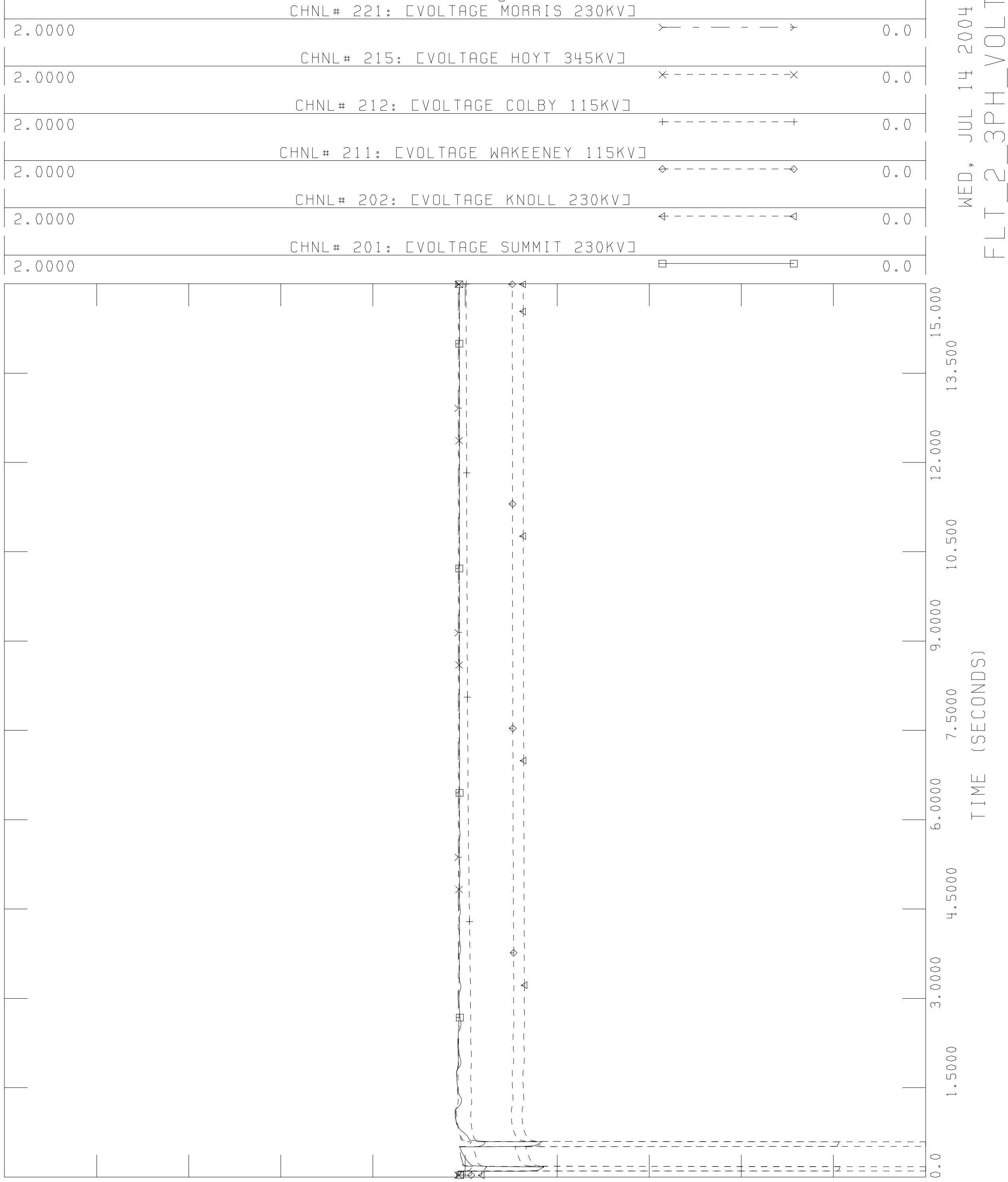
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_2_3PH.OUT

WED, JUL 14 2004 10:58

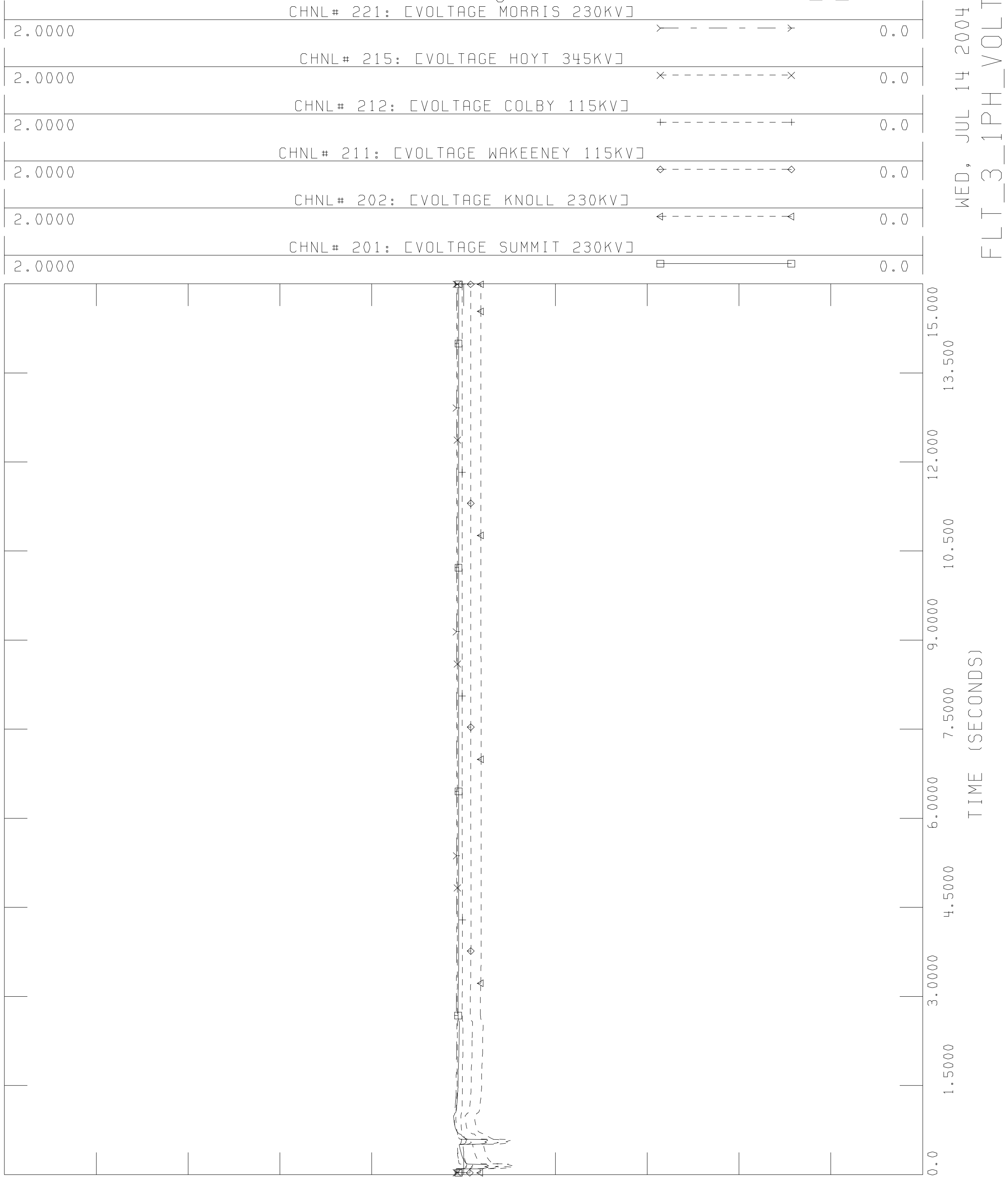
FLT_2_3PH_VOLTAGES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_3_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY:2005 SUMMER PEAK:S05SP-29.CNL:3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:58
FLT_3_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_3_3PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 0.0

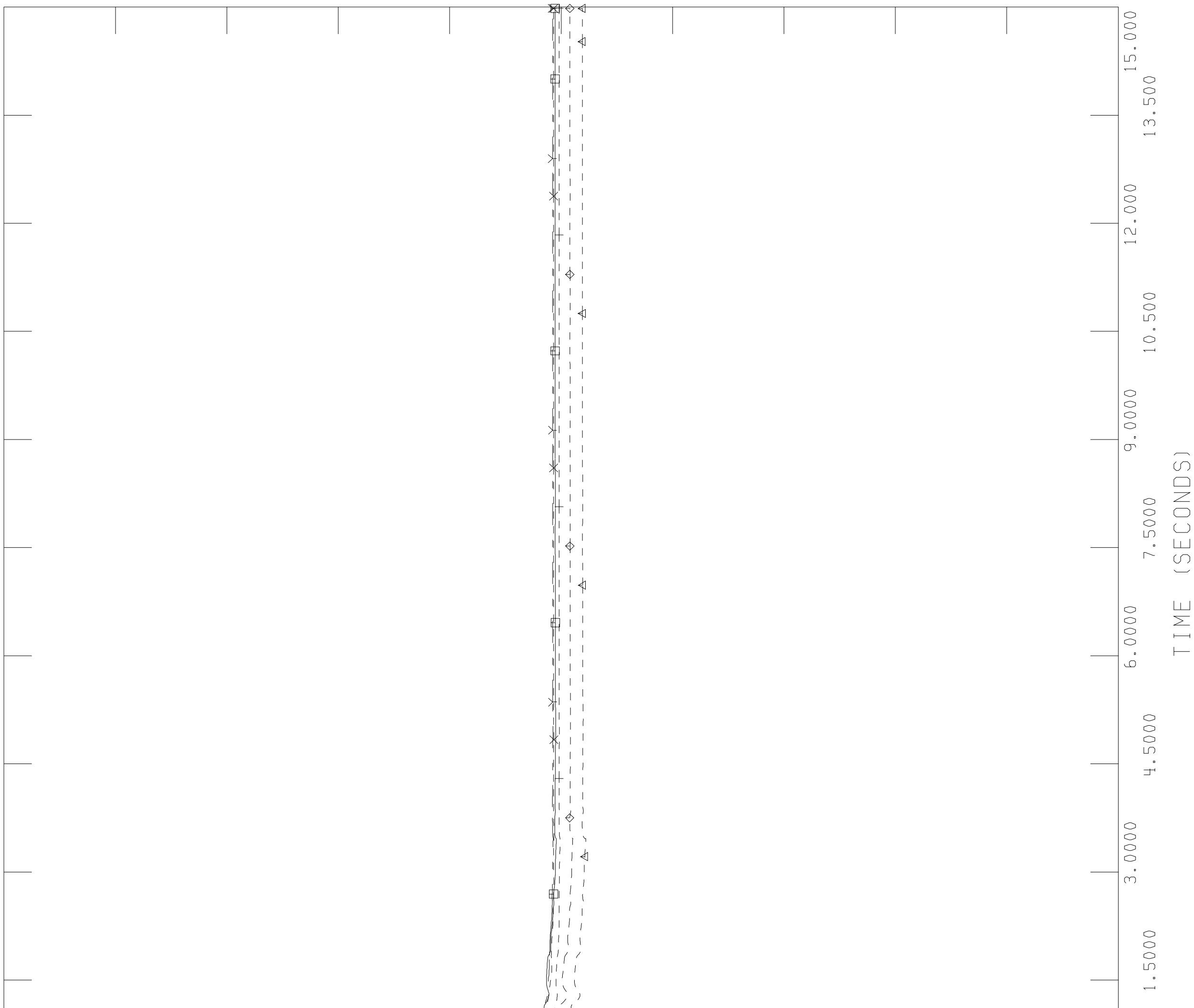
CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 0.0

CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 0.0

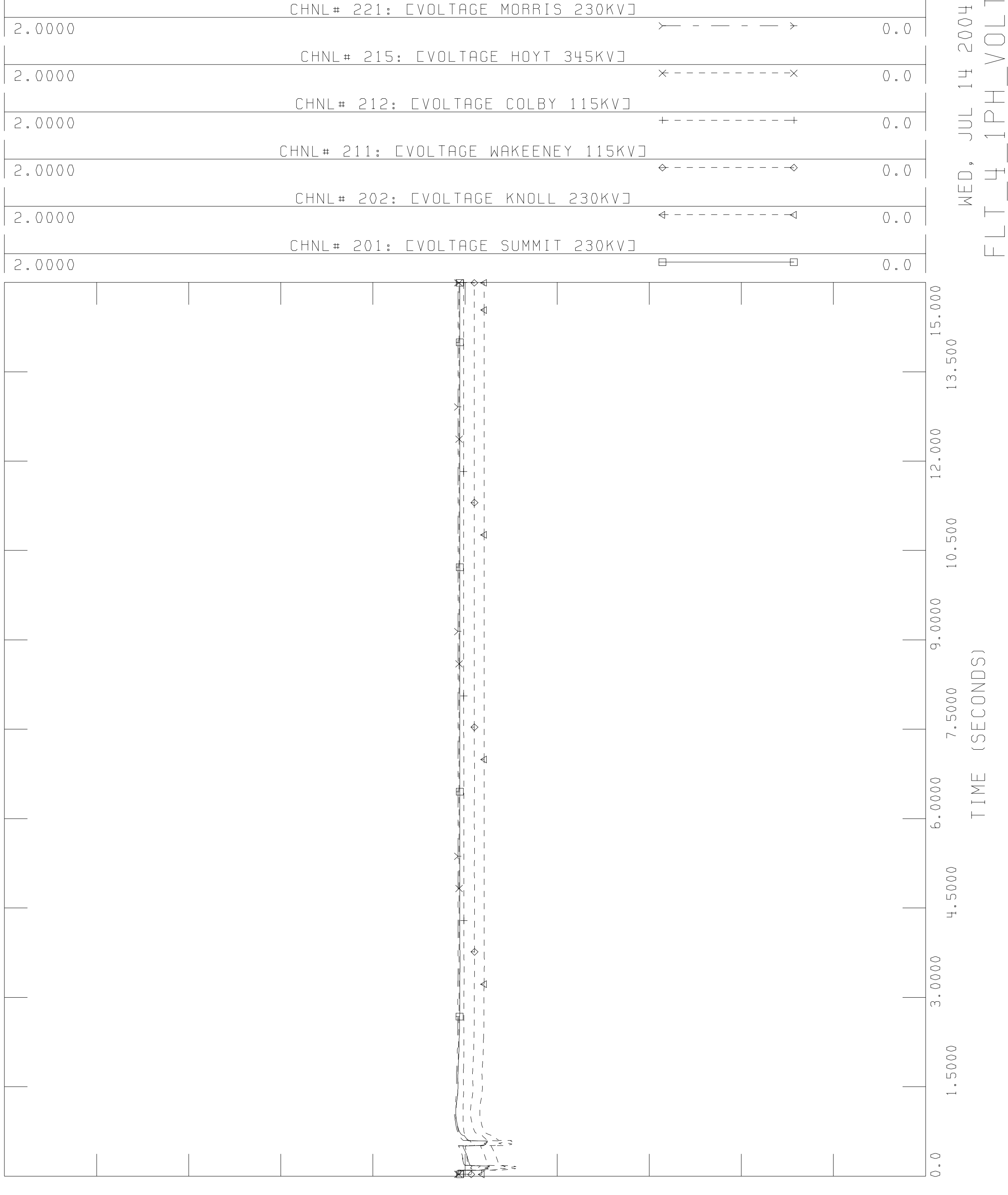
CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 0.0



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:58
FLT_4_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_4_1PH.OUT



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER
TECHNOLOGIES
INC.®

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_4_3PH.OUT

WED, JUL 14 2004 10:58
FLT_4_3PH_VOLTAGES

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 0.0

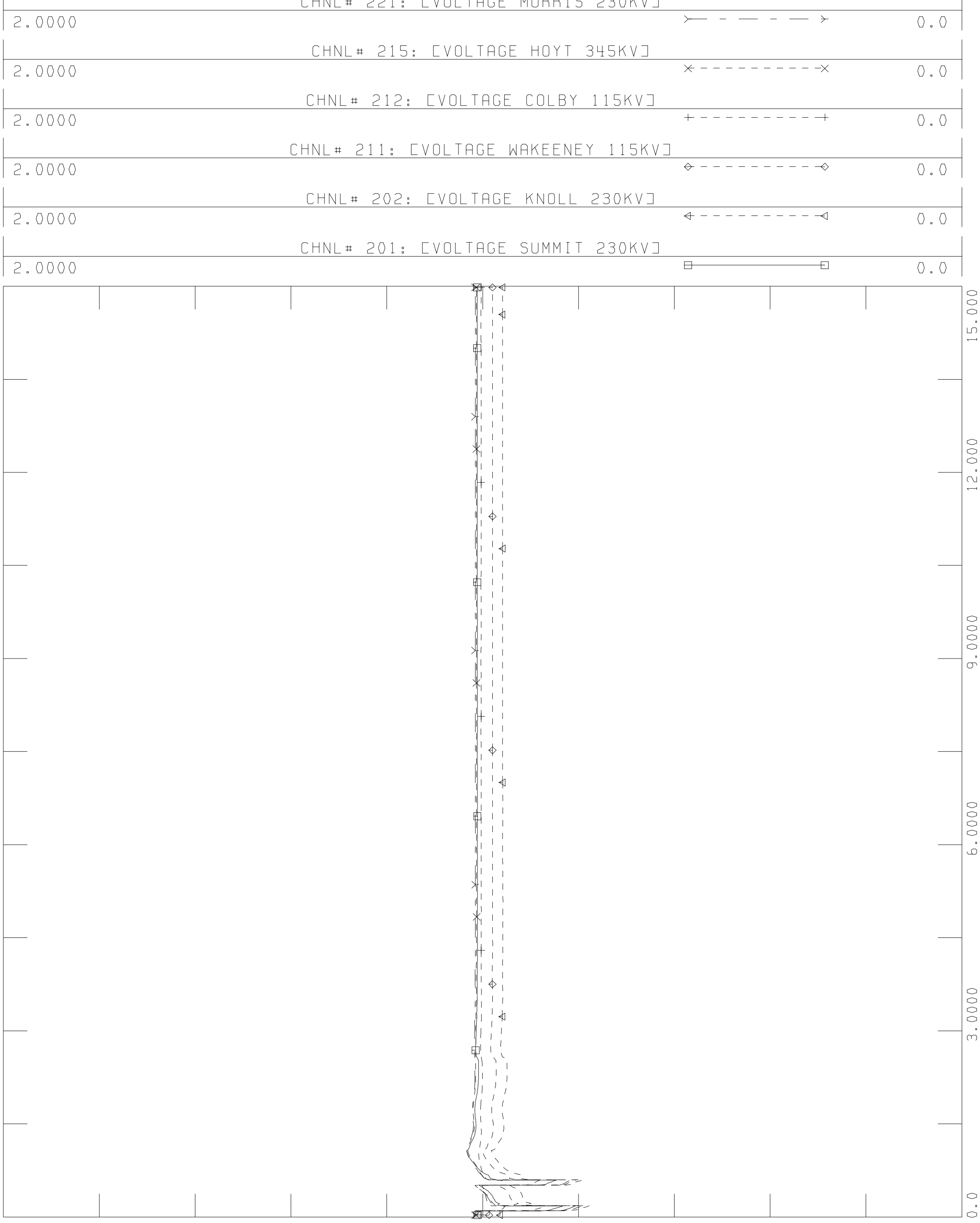
CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 0.0

CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 0.0

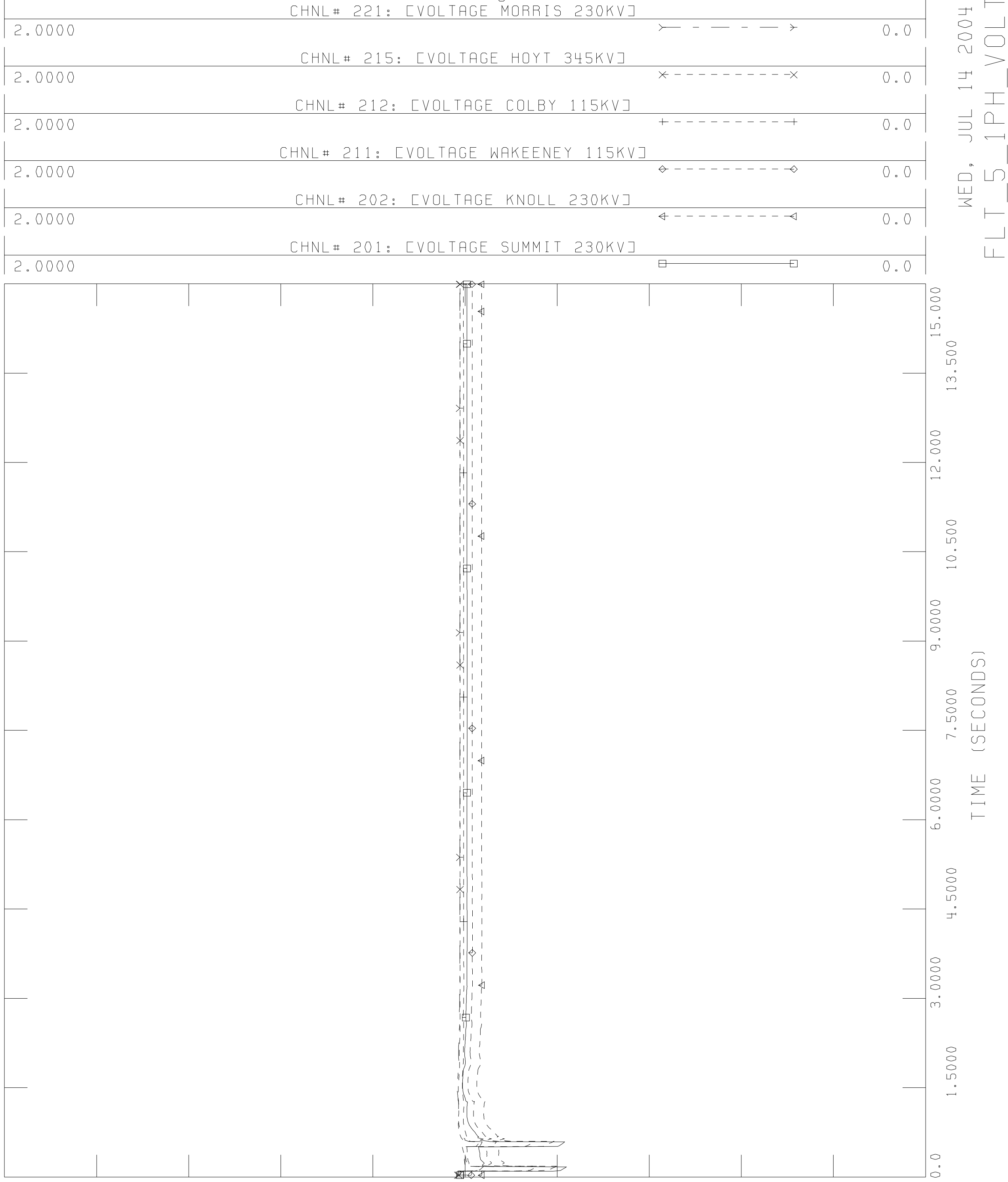
CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 0.0



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_5_1PH.OUT



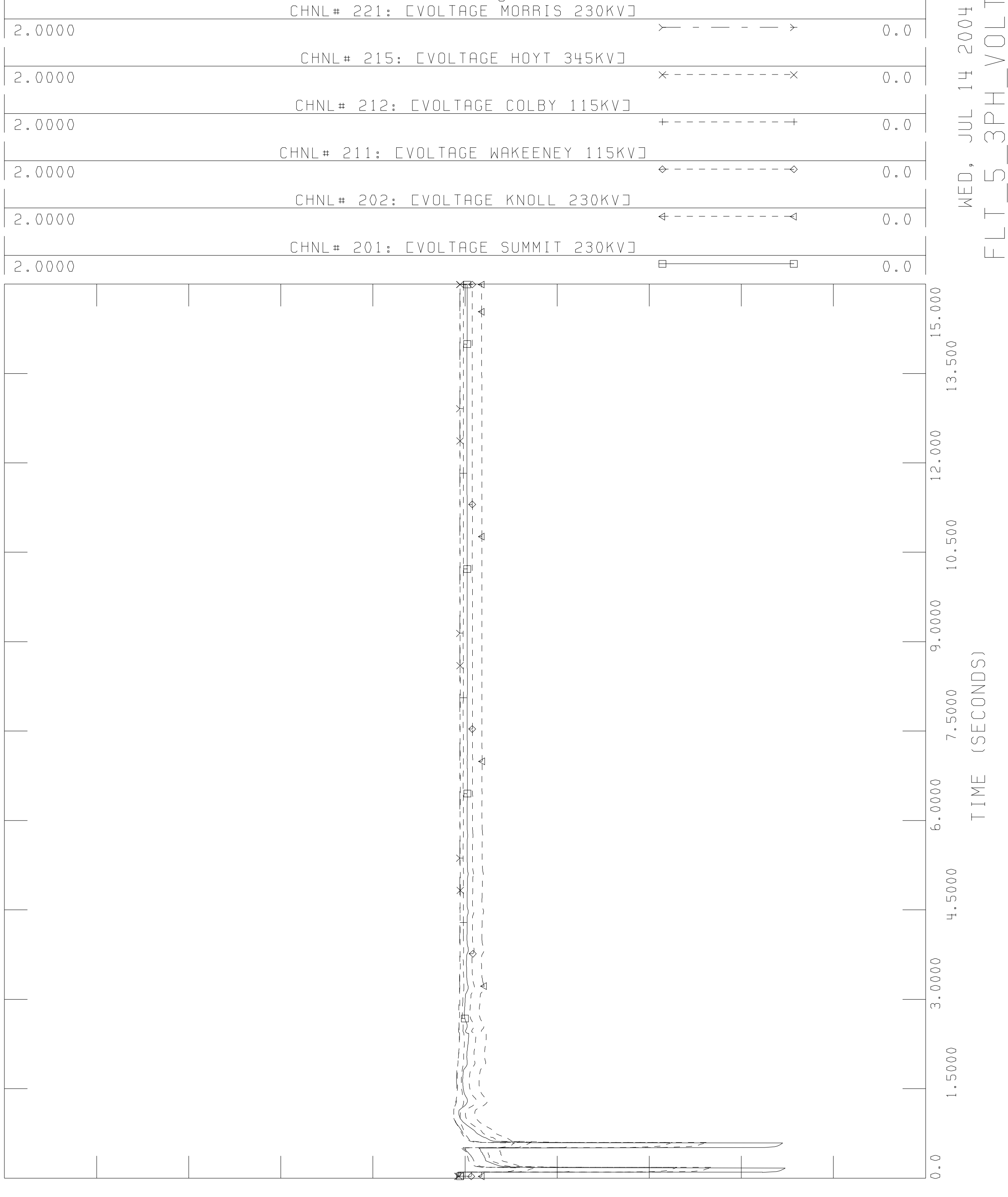
WED, JUL 14 2004 10:58

FLT_5_1PH_VOLTAGES

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_5_3PH.OUT

WED, JUL 14 2004 10:58
FLT_5_3PH_VOLTAGES

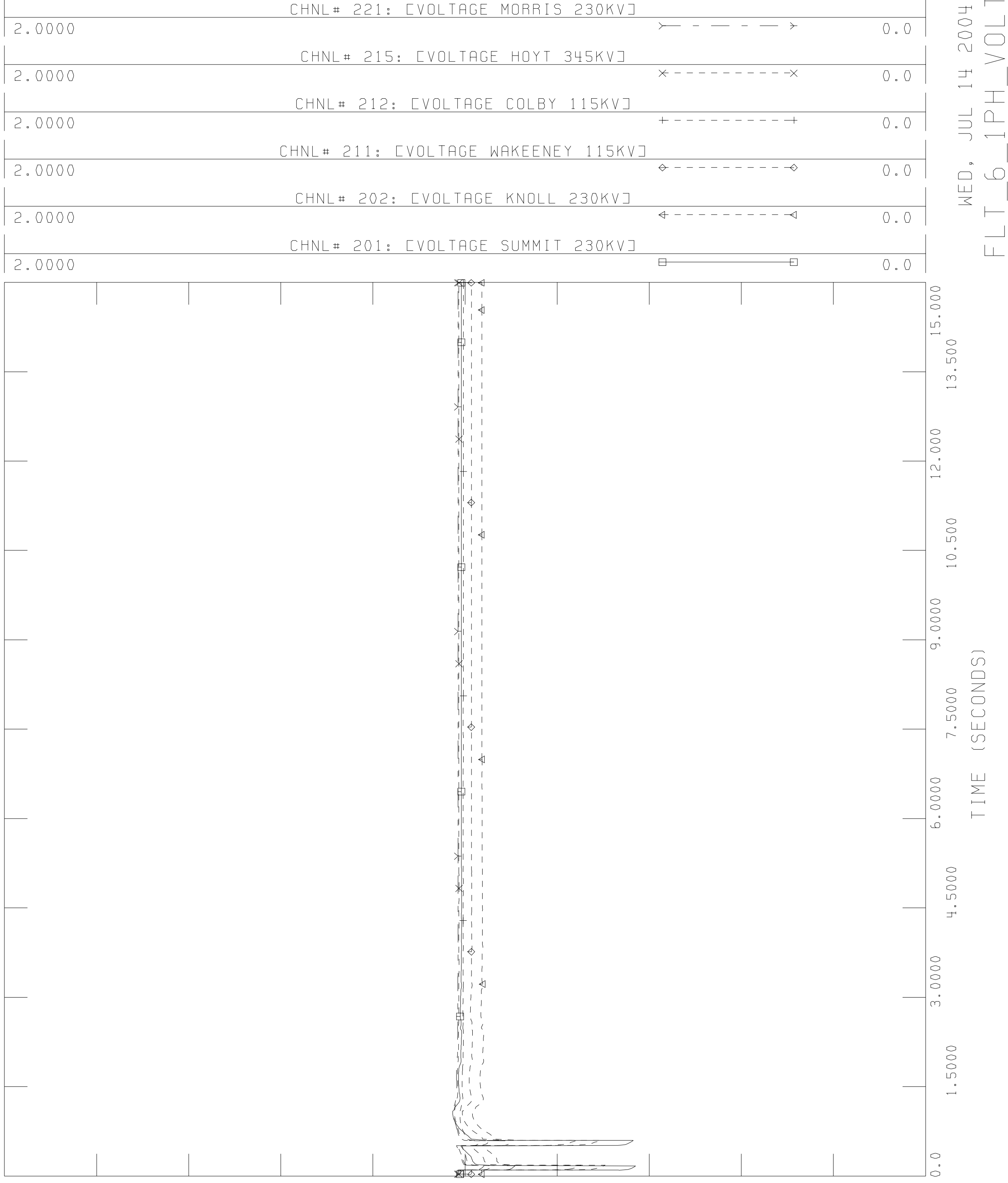


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_6_1PH.OUT

WED, JUL 14 2004 10:58

FLT_6_1PH_VOLTAGES



POWER TECHNOLOGIES INC.®

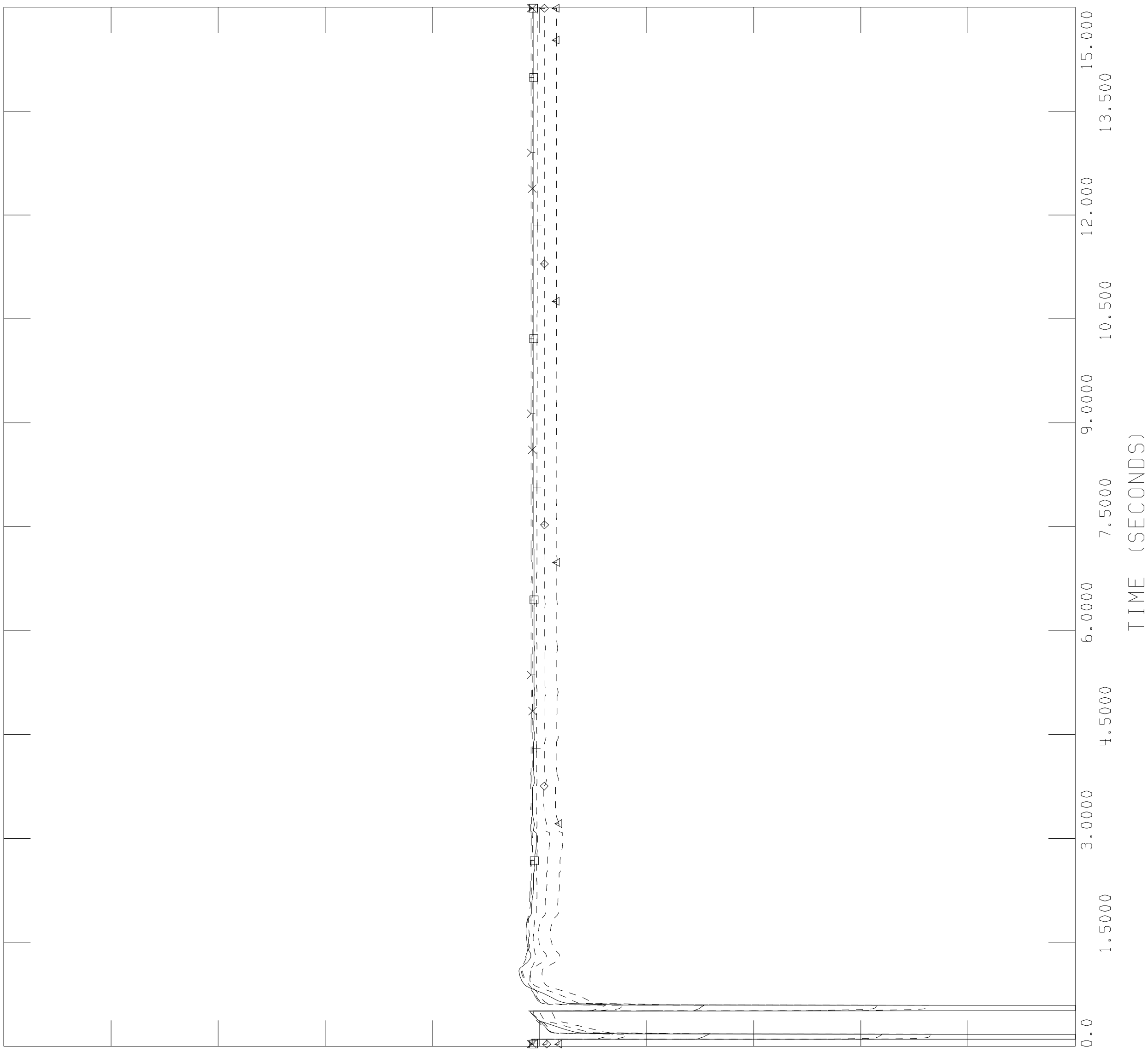
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:58

FLT_6_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_6_3PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]		
2.0000	≻ - — - — ≻	0.0
CHNL# 215: [VOLTAGE HOYT 345KV]		
2.0000	× - - - - - - - - - ×	0.0
CHNL# 212: [VOLTAGE COLBY 115KV]		
2.0000	+ - - - - - - - - - +	0.0
CHNL# 211: [VOLTAGE WAKEENEY 115KV]		
2.0000	◇ - - - - - - - - - ◇	0.0
CHNL# 202: [VOLTAGE KNOLL 230KV]		
2.0000	◁ - - - - - - - - - ◁	0.0
CHNL# 201: [VOLTAGE SUMMIT 230KV]		
2.0000	□——————□	0.0



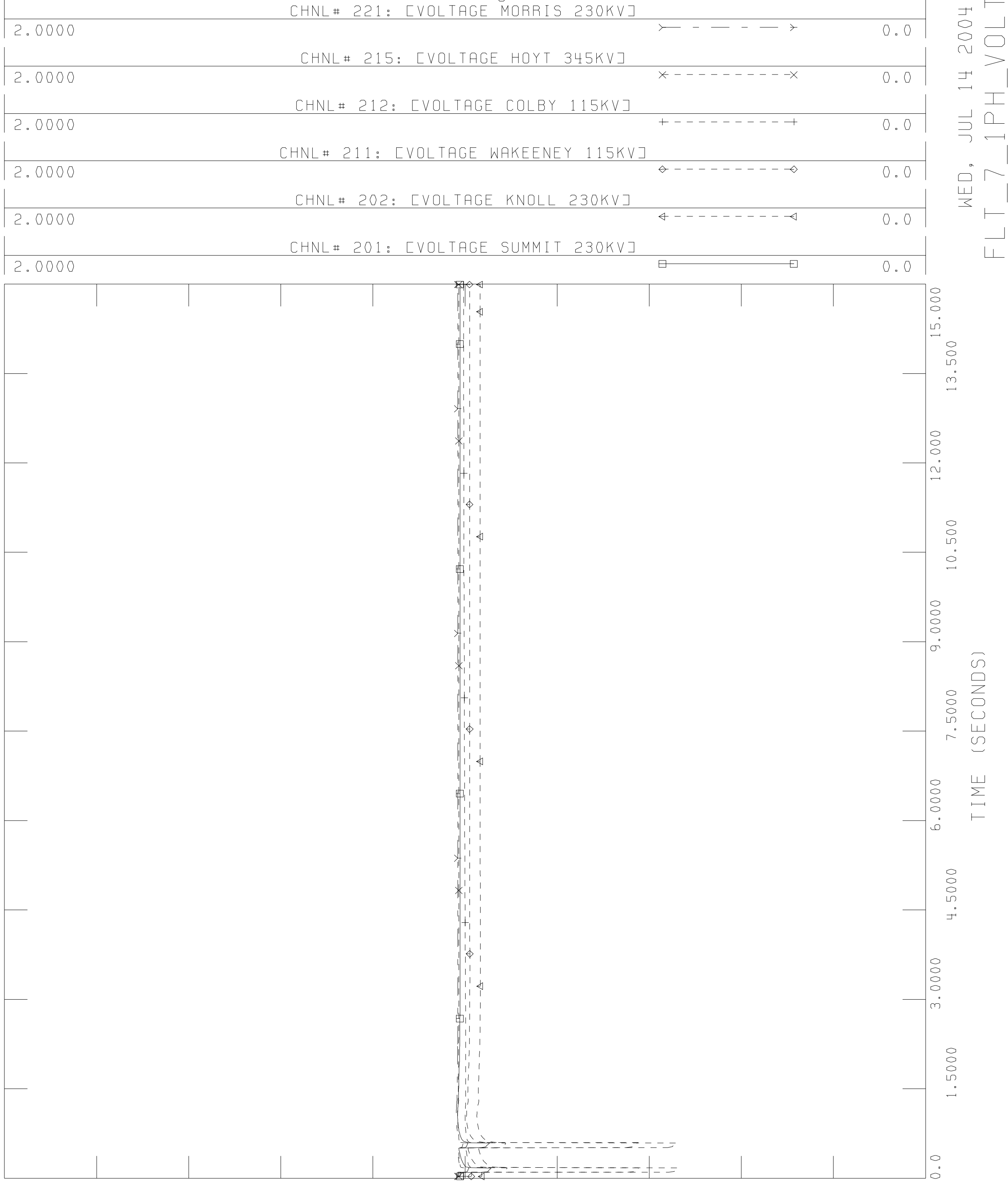
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER
TECHNOLOGIES
INC.®

WED, JUL 14 2004 10:58

FLT_7_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_7_1PH.OUT

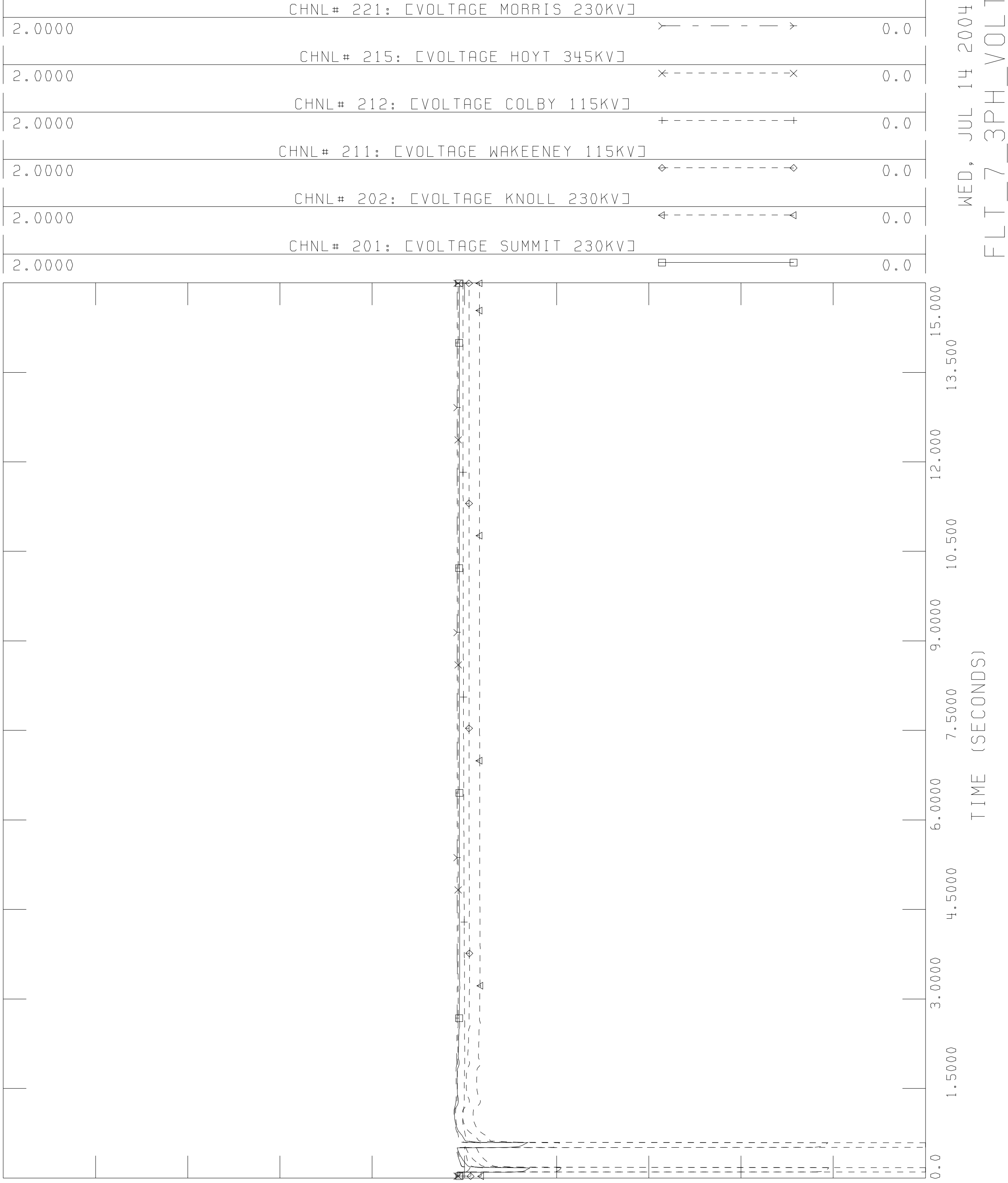


POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:58
FLT_7_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_7_3PH.OUT



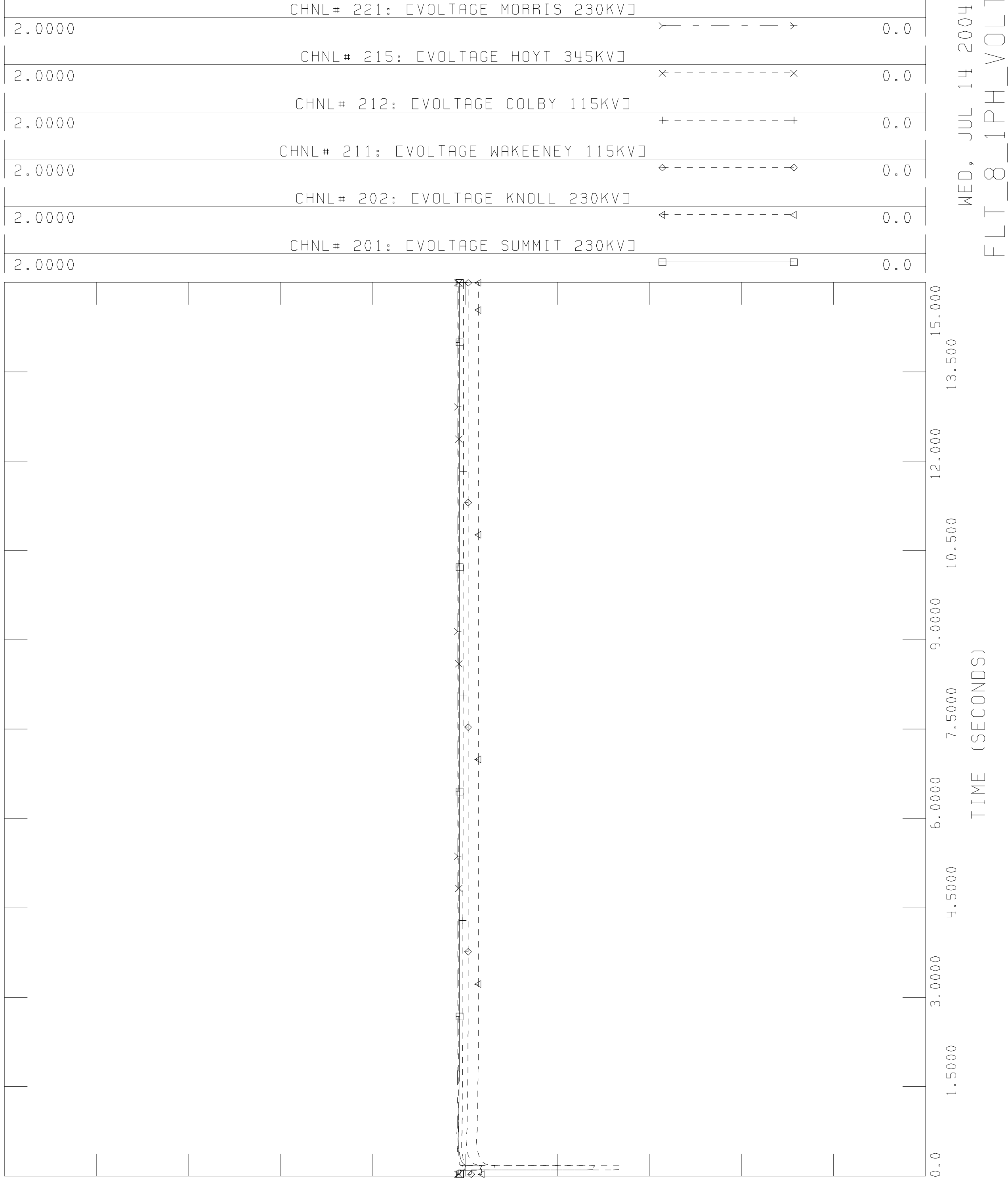
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:58

FLT_8_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_8_1PH.OUT



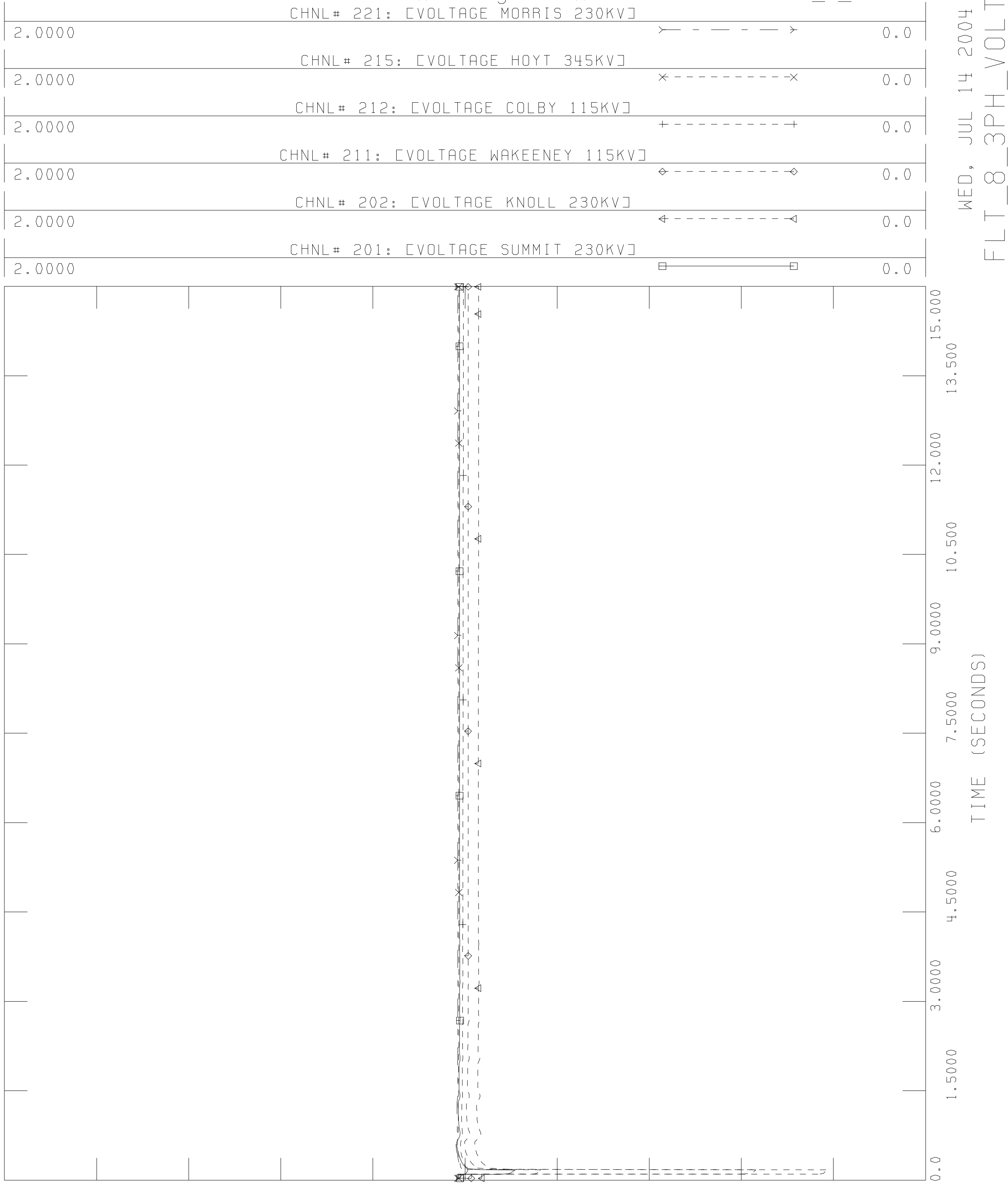
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:58

FLT_8_3PH_VOLTAGES

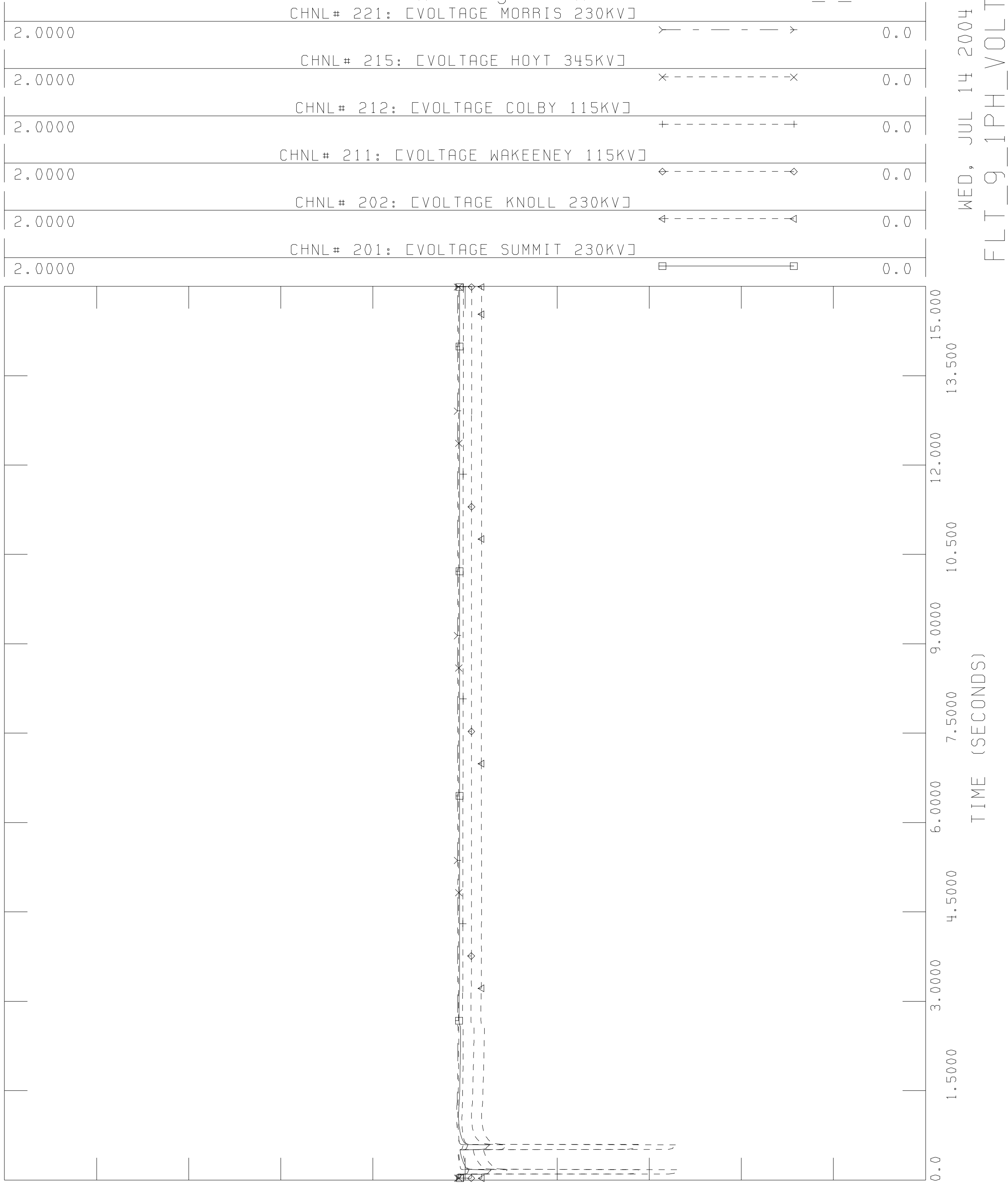
FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_8_3PH.OUT



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:58
FLT_9_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_9_1PH.OUT

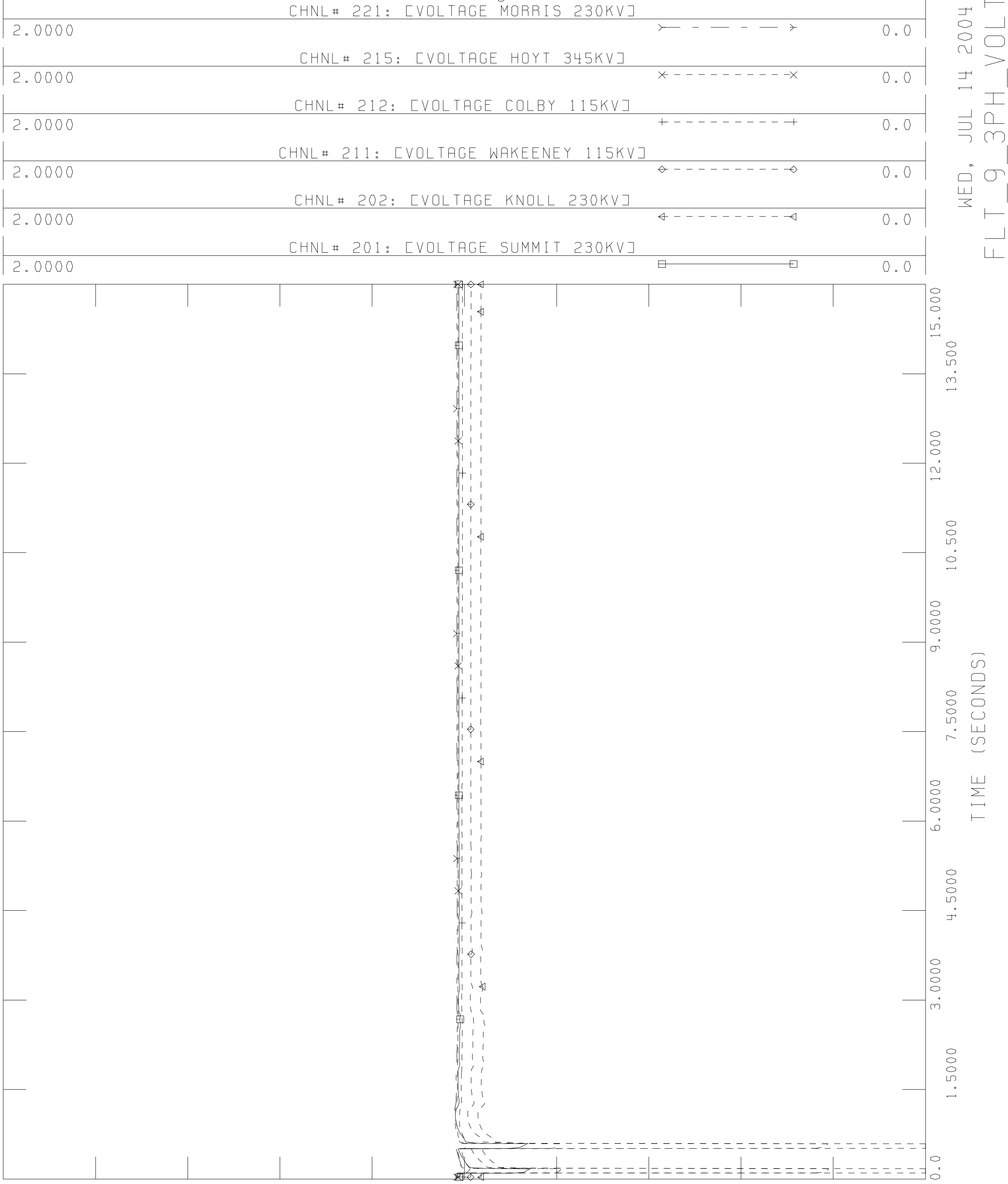


POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_9_3PH.OUT

WED, JUL 14 2004 10:58
FLT_9_3PH_VOLTAGES

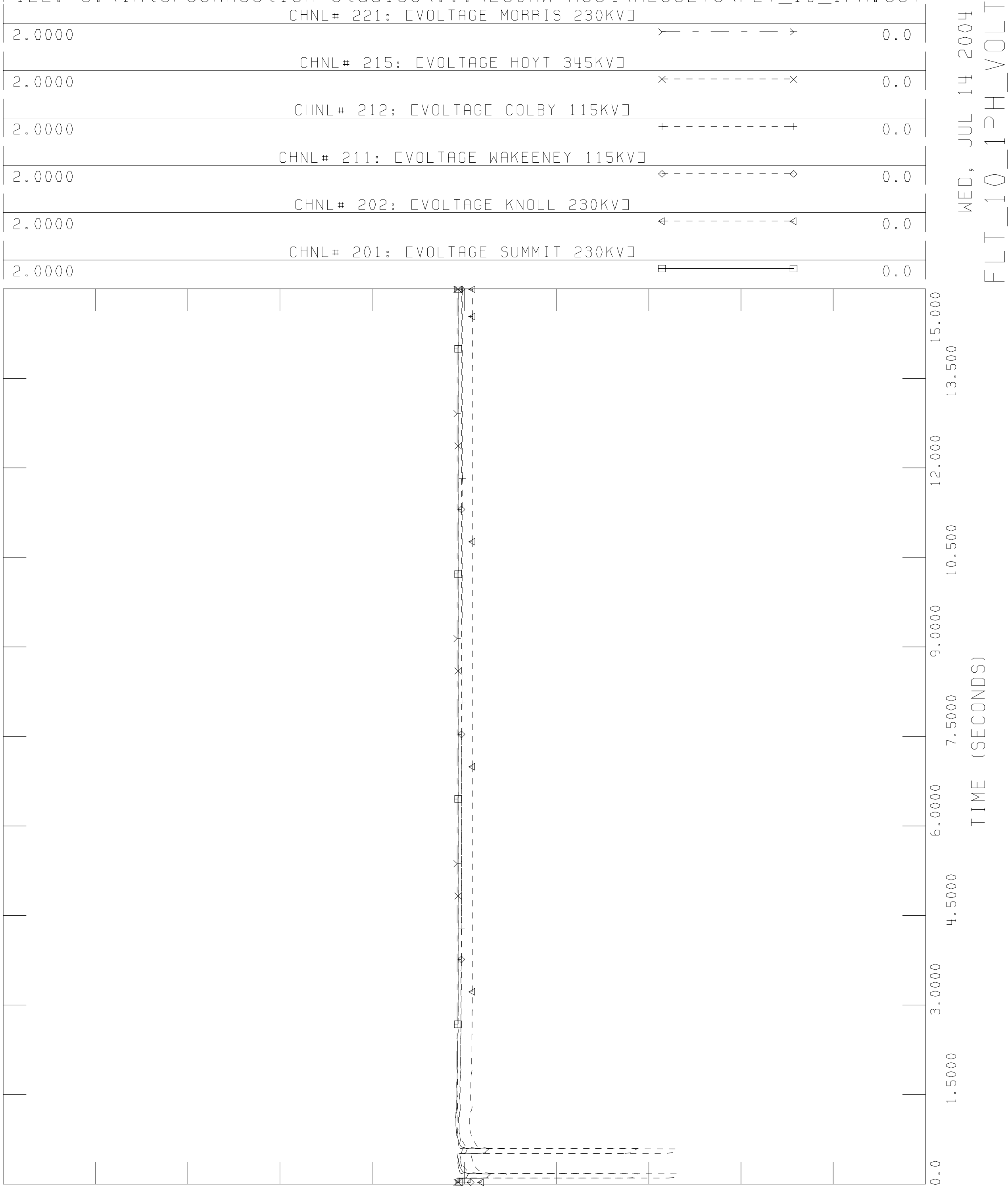


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\...\250MW-AG04\RESULTS\FLT_10_1PH.OUT

WED, JUL 14 2004 10:58

FLT_10_1PH_VOLTAGES

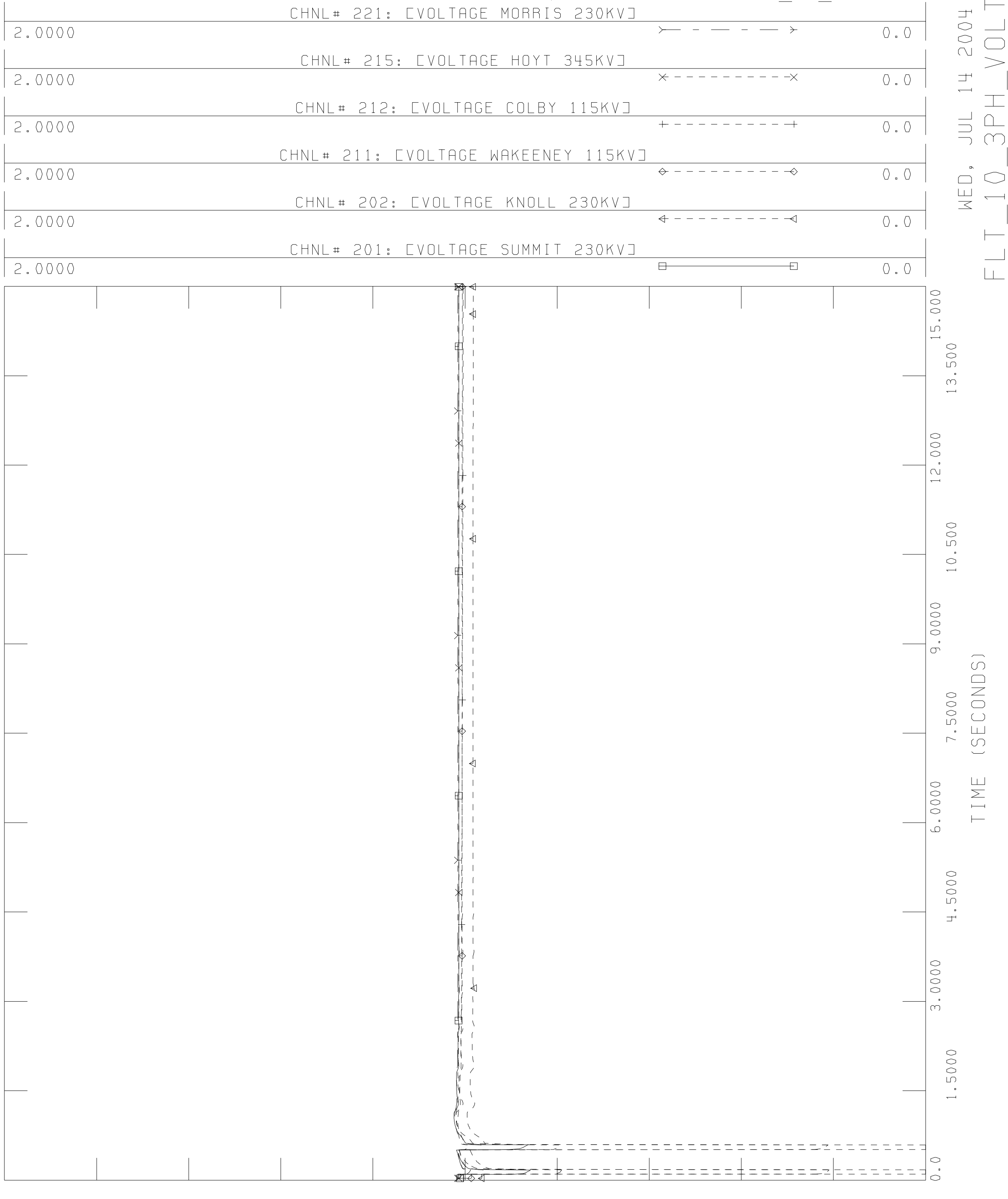


POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:58
FLT_10_3PH_VOLTAGES

FILE: C:\Interconnection Studies\...\250MW-AG04\RESULTS\FLT_10_3PH.OUT



Appendix B-2

Plots of Fault Simulations

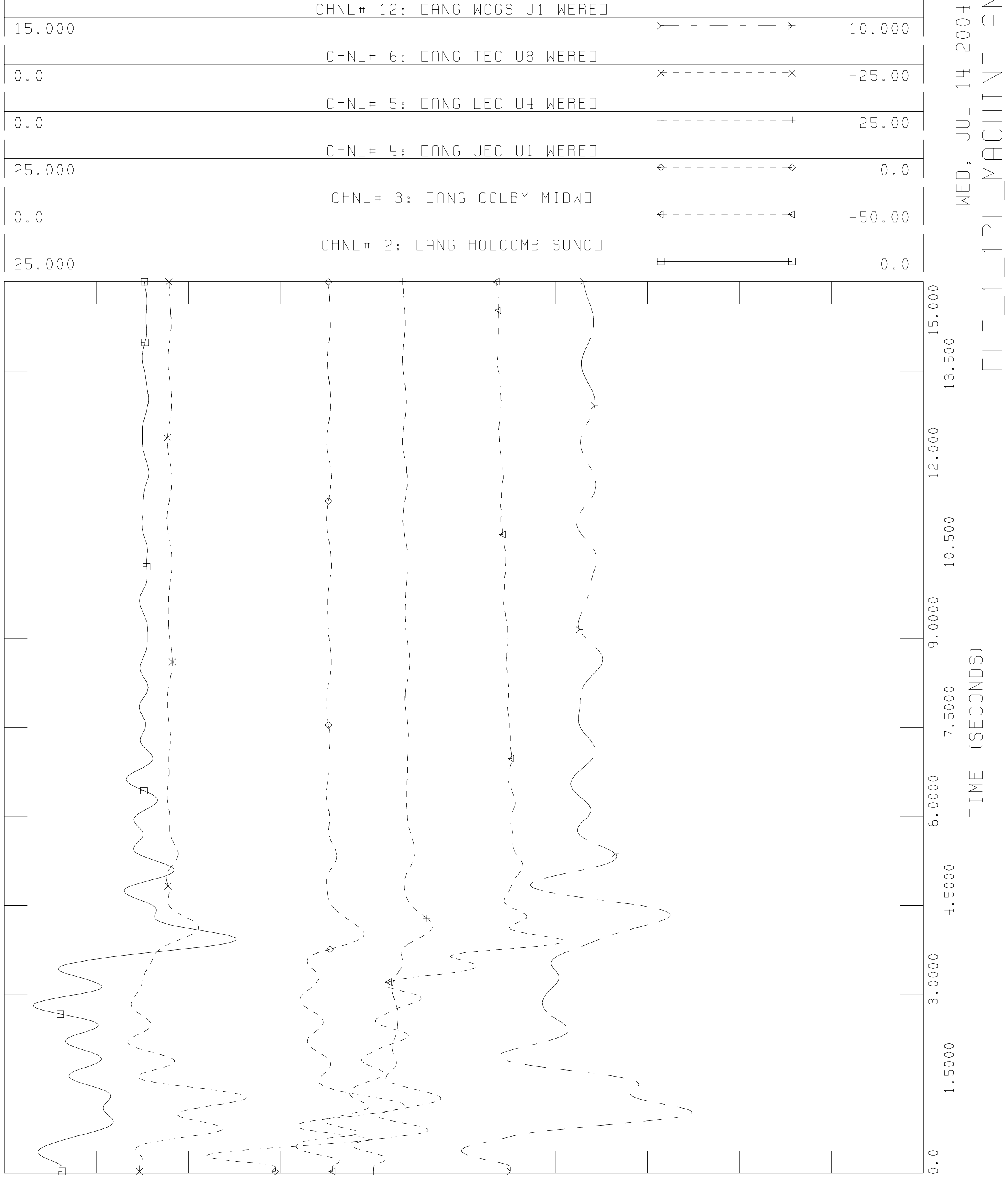
Plots of selected machine phase angles during faults

Scenario:
2005 Summer Peak
Wind Farm at 250MW (100% rated power)
AGO4 Protection Settings

POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_1_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_1_3PH.OUT

WED, JUL 14 2004 11:03

FLT_1_3PH_MACHINE ANGLES

CHNL# 12: [ANG WCGS U1 WERE]
15.000 ⟩— - — - — ⟩ 10.000

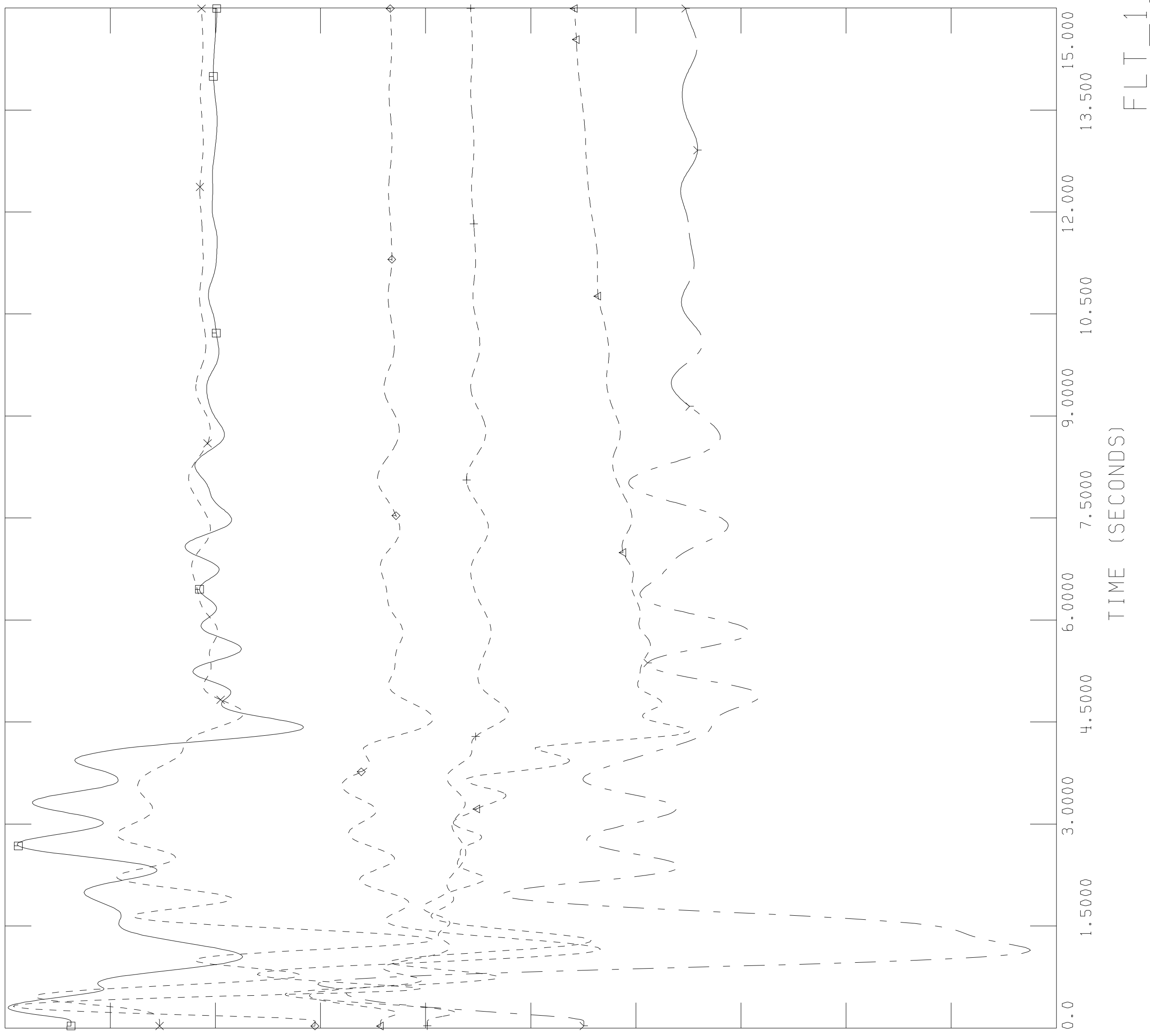
CHNL# 6: [ANG TEC U8 WERE]
0.0 ×- - - - - - - - - -× -25.00

CHNL# 5: [ANG LEC U4 WERE]
0.0 +- - - - - - - - - -+ -25.00

CHNL# 4: [ANG JEC U1 WERE]
25.000 ◇- - - - - - - - - -◇ 0.0

CHNL# 3: [ANG COLBY MIDW]
0.0 ◁- - - - - - - - - -◁ -50.00

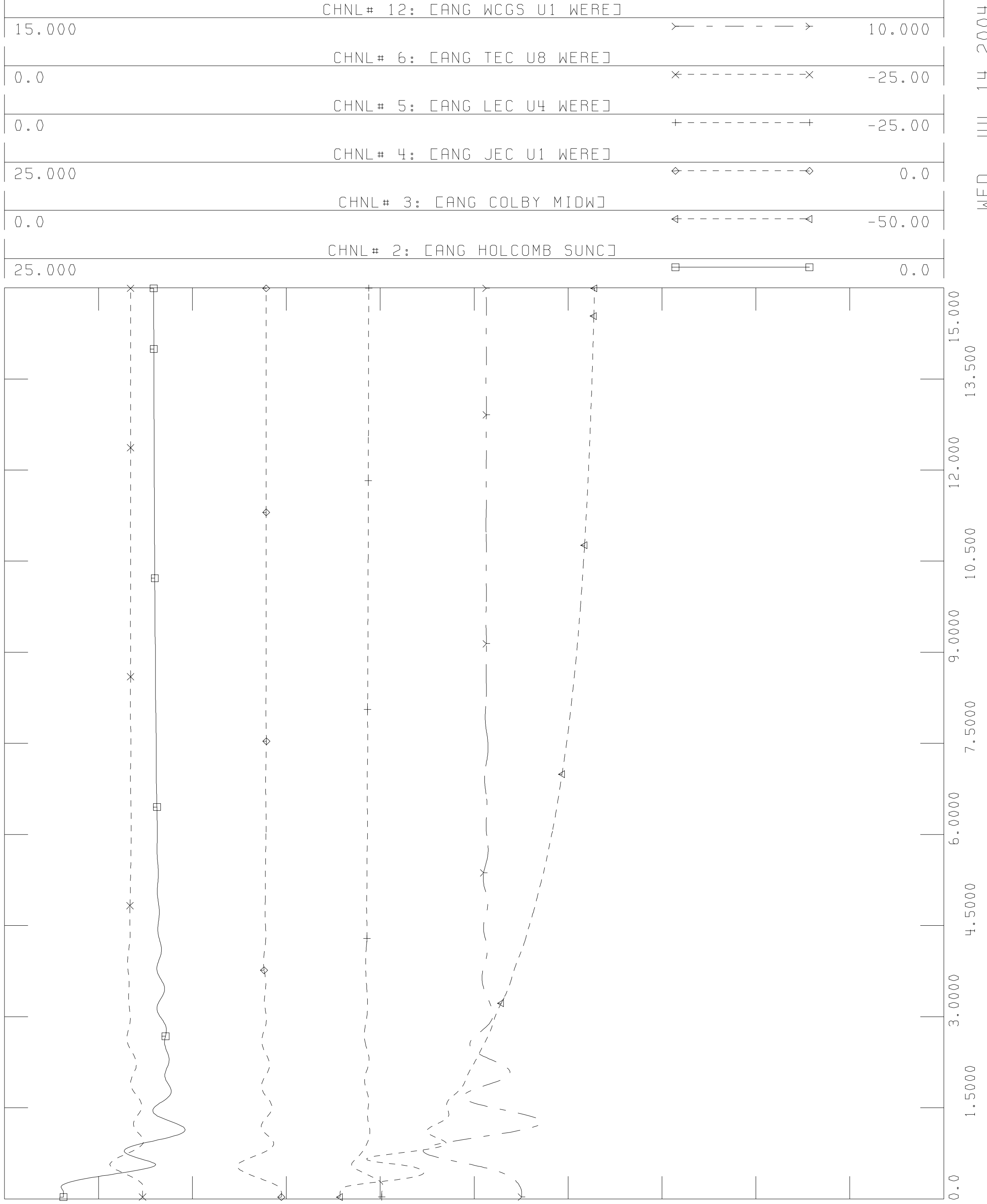
CHNL# 2: [ANG HOLCOMB SUNC]
25.000 □——————□ 0.0



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_2_1PH.OUT



WED, JUL 14 2004 11:03

FLT_2_1PH_MACHINE ANGLES

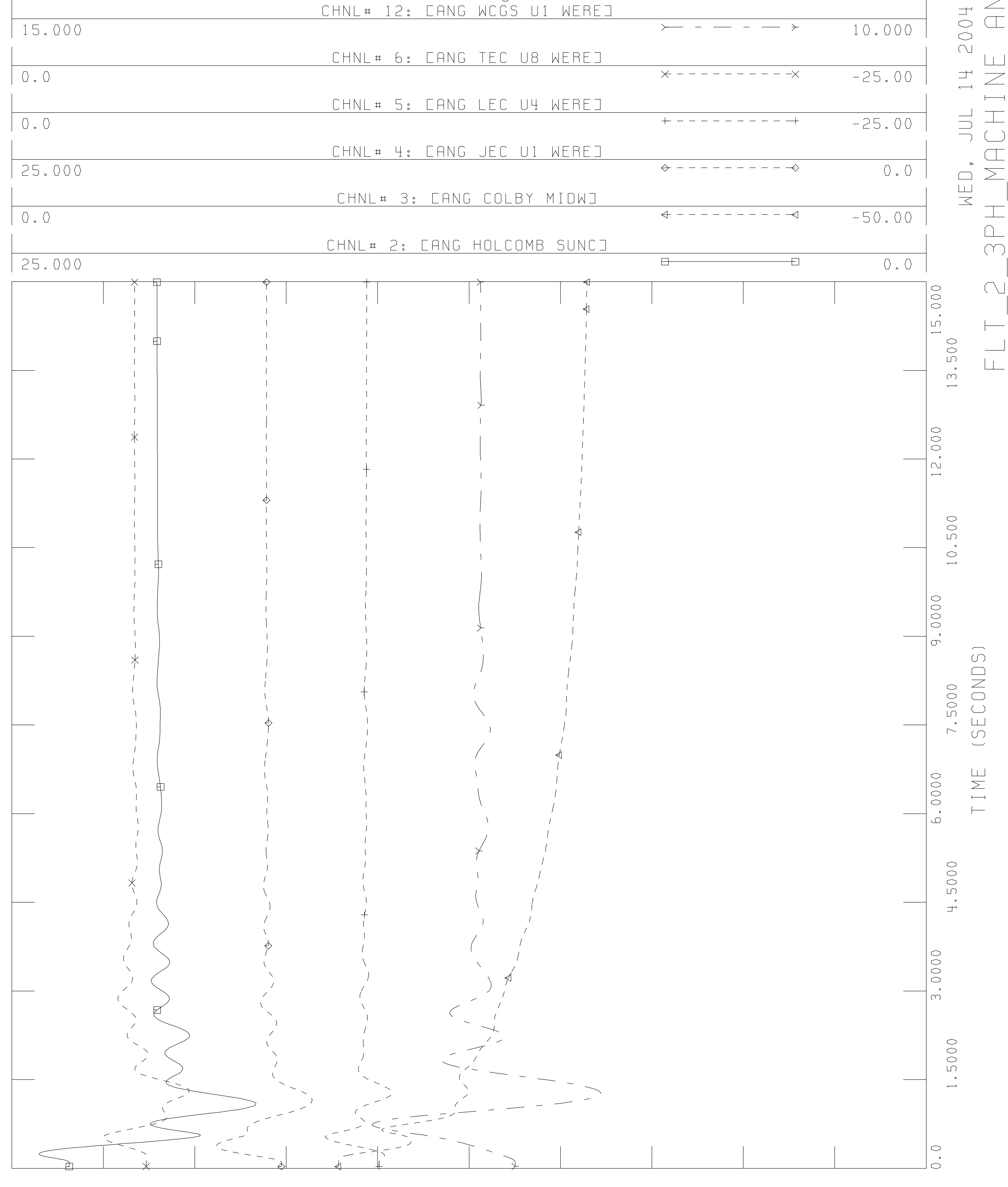
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_2_3PH.OUT

WED, JUL 14 2004 11:03

FLT_2_3PH_MACHINE ANGLES

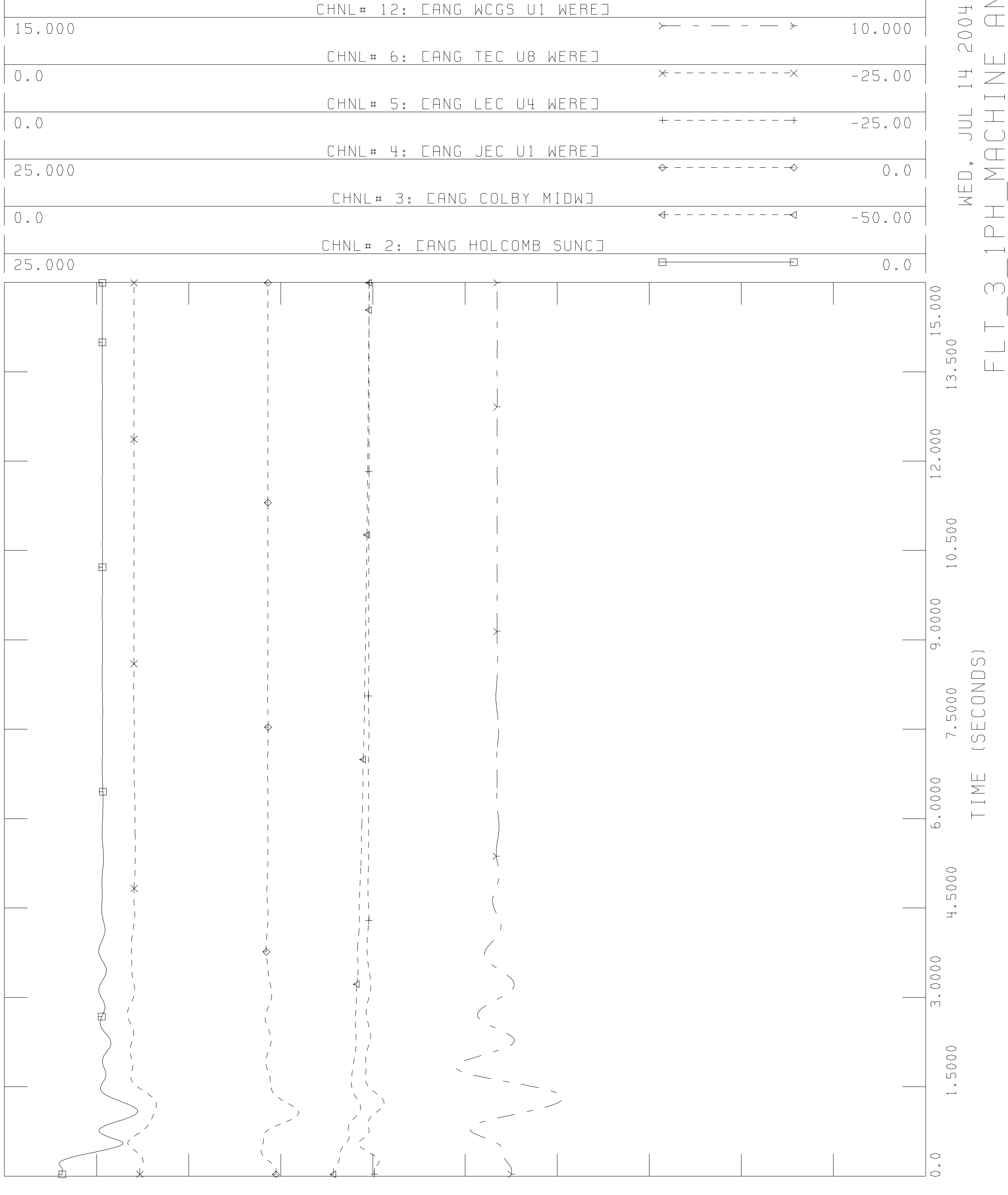


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_3_1PH.OUT

WED, JUL 14 2004 11:03

FLT_3_1PH_MACHINE ANGLES

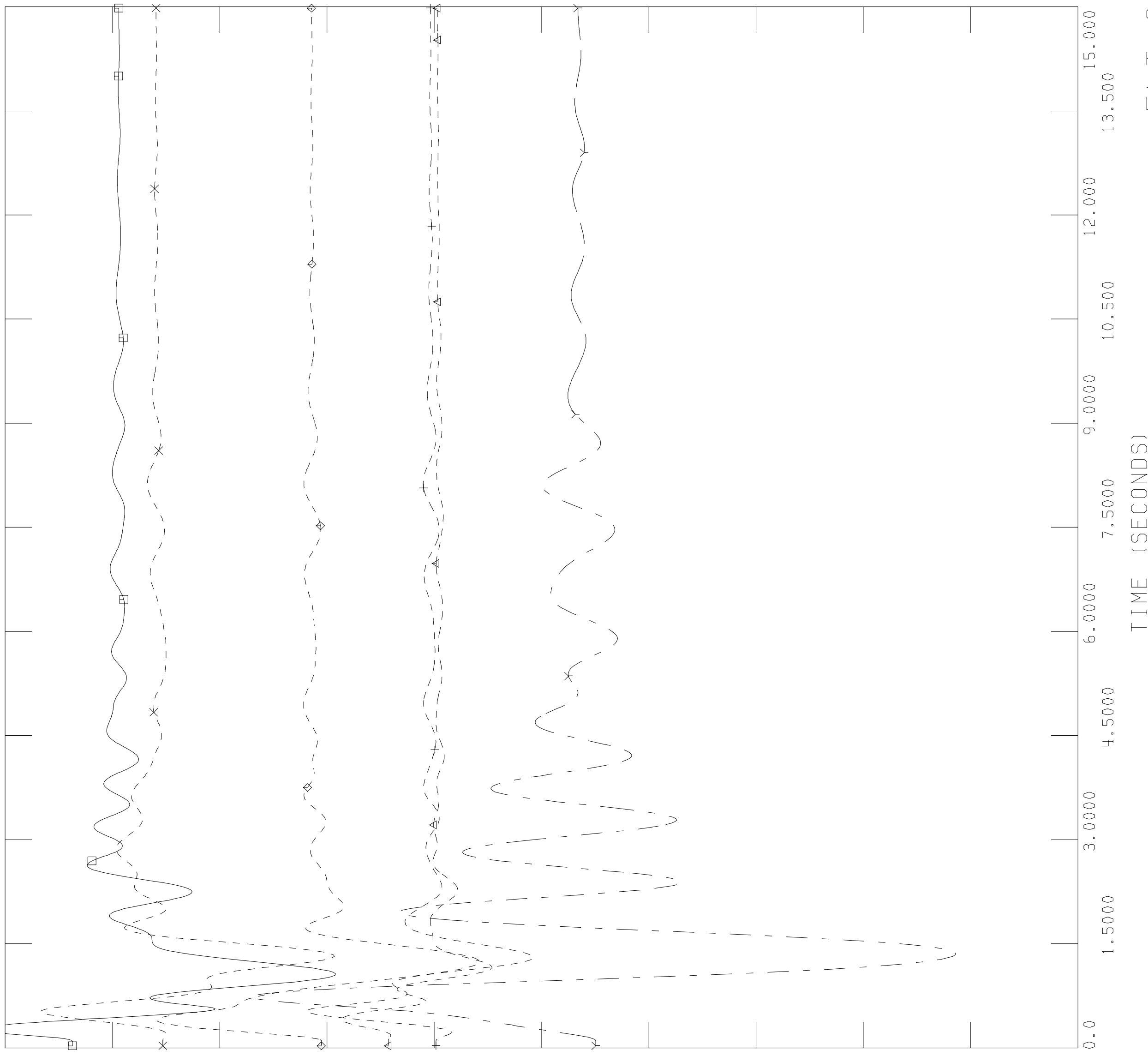


POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_3_3PH.OUT

CHNL# 12: [ANG WCGS U1 WERE]		
15.000	⋎- - — - - — ⋎	10.000
CHNL# 6: [ANG TEC U8 WERE]		
0.0	×- - - - - - - - - - ×	-25.00
CHNL# 5: [ANG LEC U4 WERE]		
0.0	+- - - - - - - - - - +	-25.00
CHNL# 4: [ANG JEC U1 WERE]		
25.000	◇- - - - - - - - - - ◇	0.0
CHNL# 3: [ANG COLBY MIDW]		
0.0	◁- - - - - - - - - - ◁	-50.00
CHNL# 2: [ANG HOLCOMB SUNC]		
25.000	□———————□	0.0



WED, JUL 14 2004 11:03

FLT_3_3PH_MACHINE ANGLES

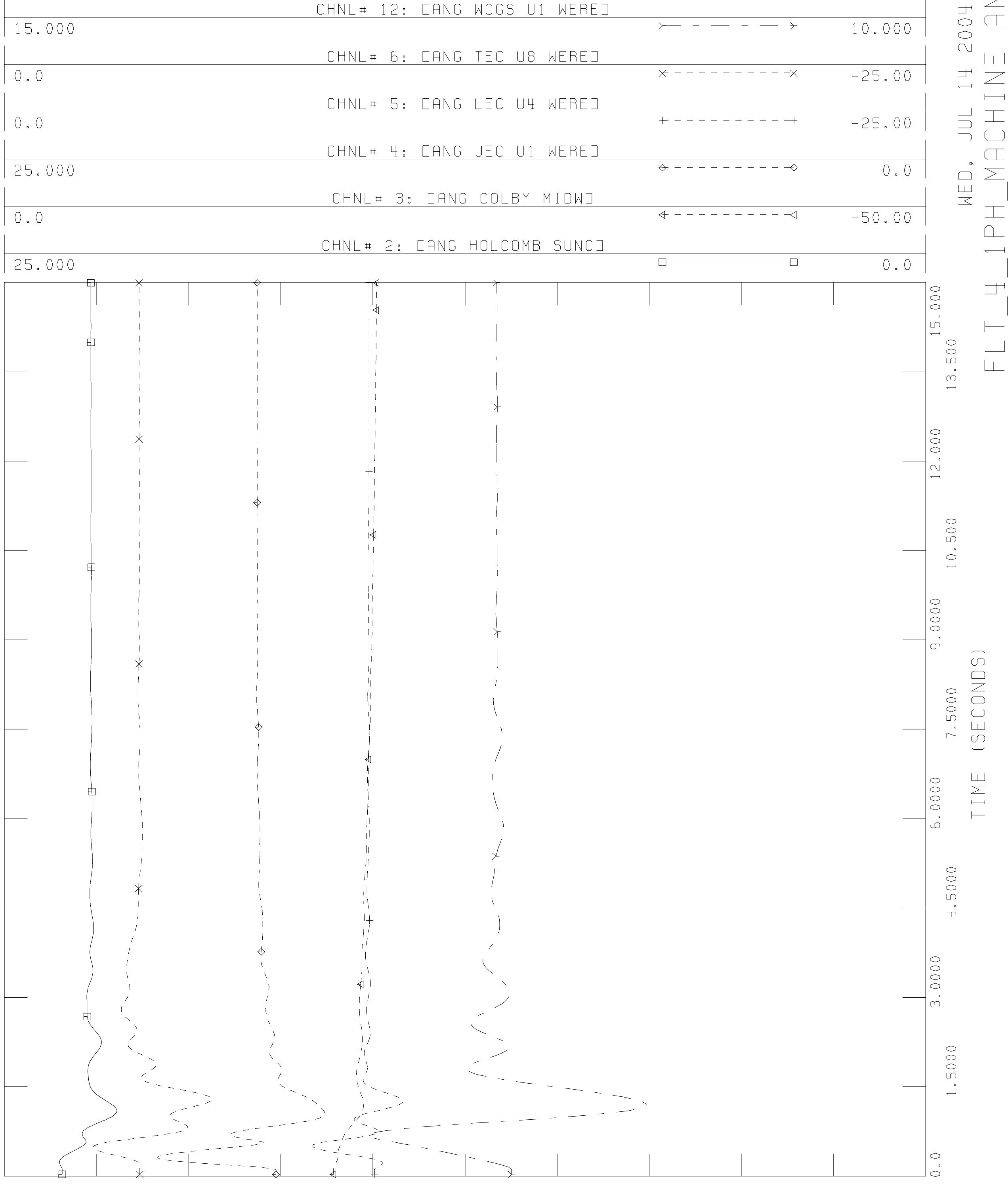
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 11:03

FLT_4_1PH_MACHINE ANGLES

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_4_1PH.OUT



POWER
TECHNOLOGIES
INC.®

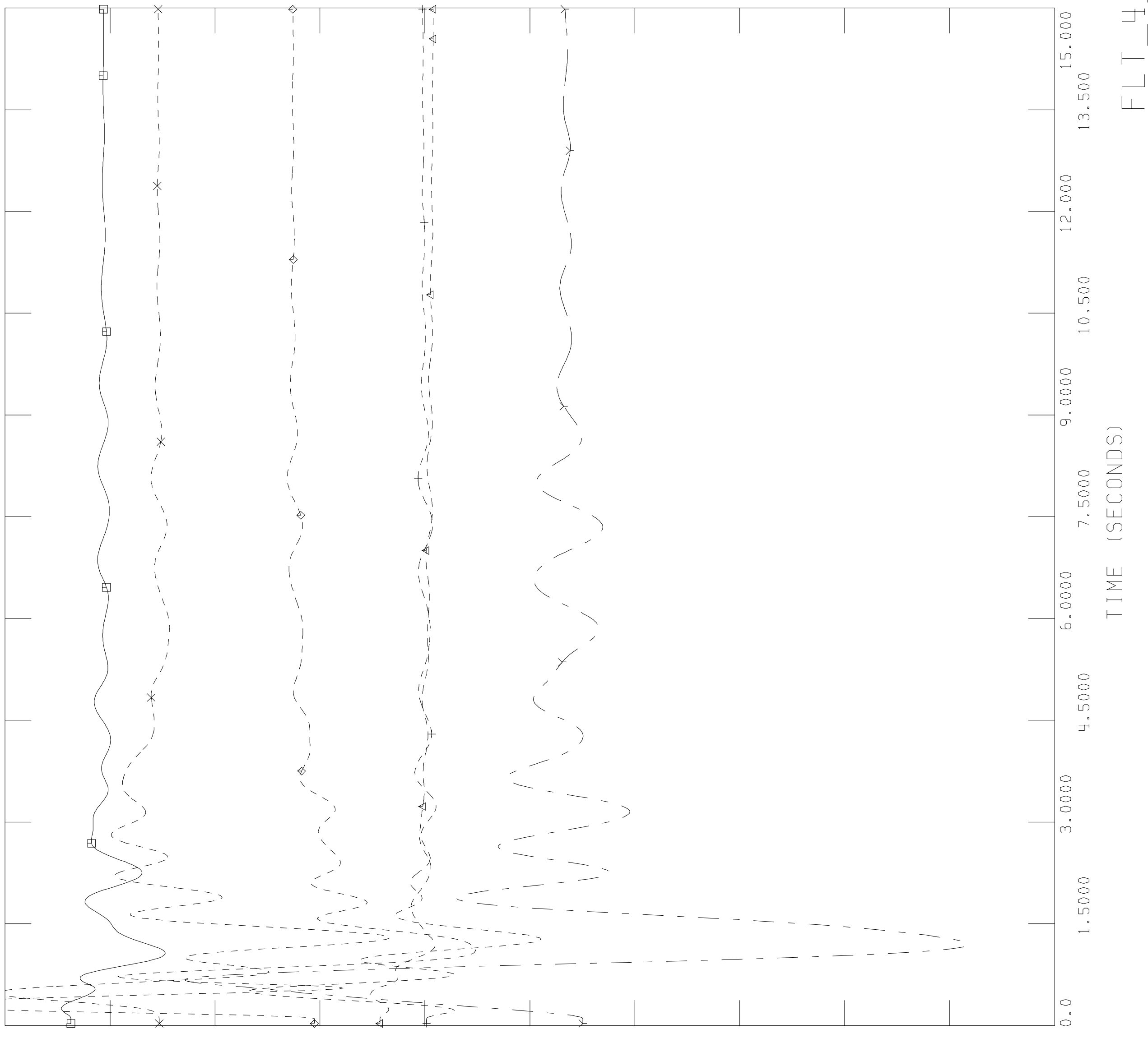
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 11:03

FLT_4_3PH_MACHINE ANGLES

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_4_3PH.OUT

CHNL# 12: [ANG WCGS U1 WERE]		
15.000	≻ - — - — ≻	10.000
CHNL# 6: [ANG TEC U8 WERE]		
0.0	×- - - - - - - - - -×	-25.00
CHNL# 5: [ANG LEC U4 WERE]		
0.0	+- - - - - - - - - -+	-25.00
CHNL# 4: [ANG JEC U1 WERE]		
25.000	◇- - - - - - - - - -◇	0.0
CHNL# 3: [ANG COLBY MIDW]		
0.0	◁- - - - - - - - - -◁	-50.00
CHNL# 2: [ANG HOLCOMB SUNC]		
25.000	□——————□	0.0



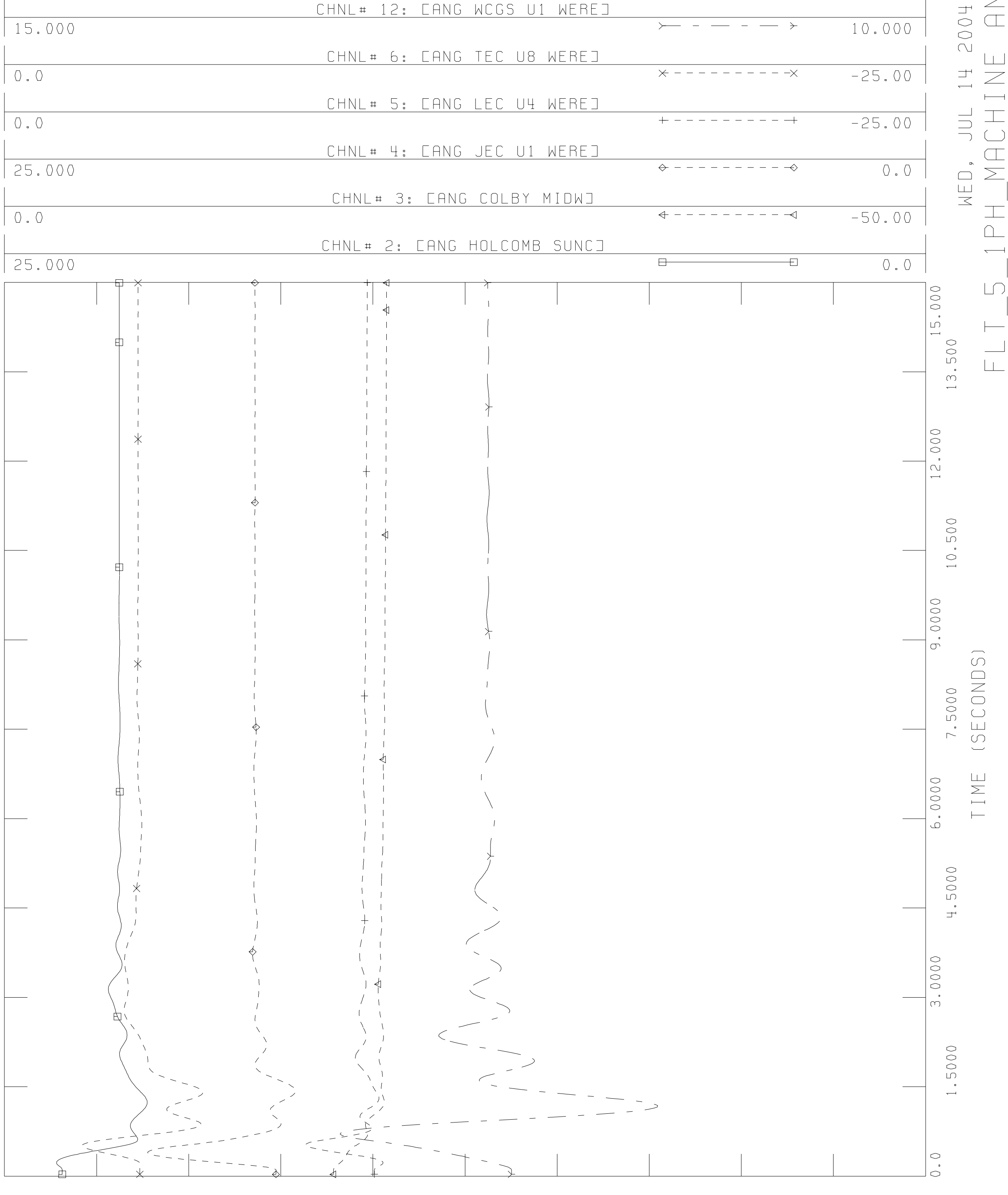
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER
TECHNOLOGIES
INC.®

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_5_1PH.OUT

WED, JUL 14 2004 11:03

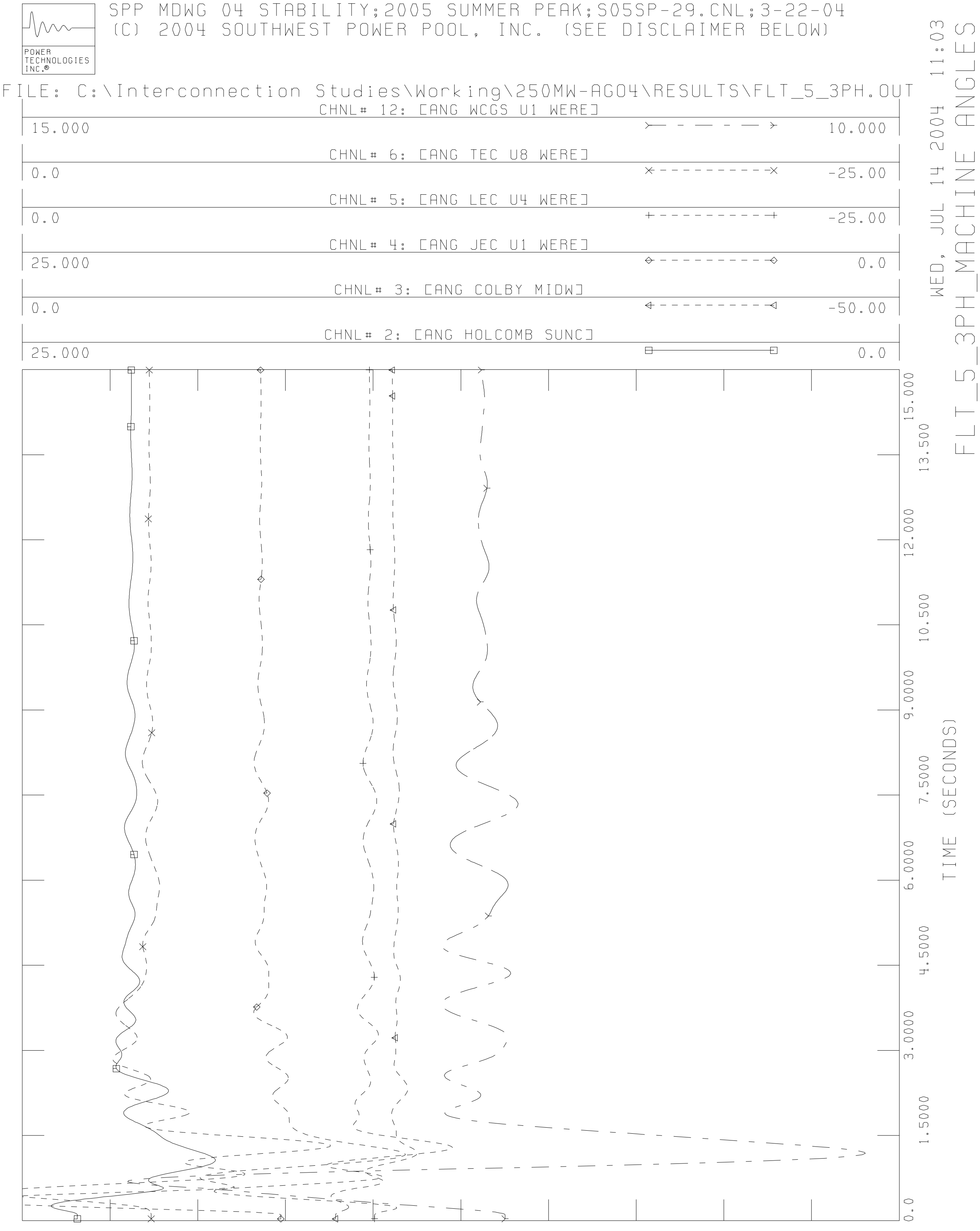
FLT_5_1PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_5_3PH.OUT



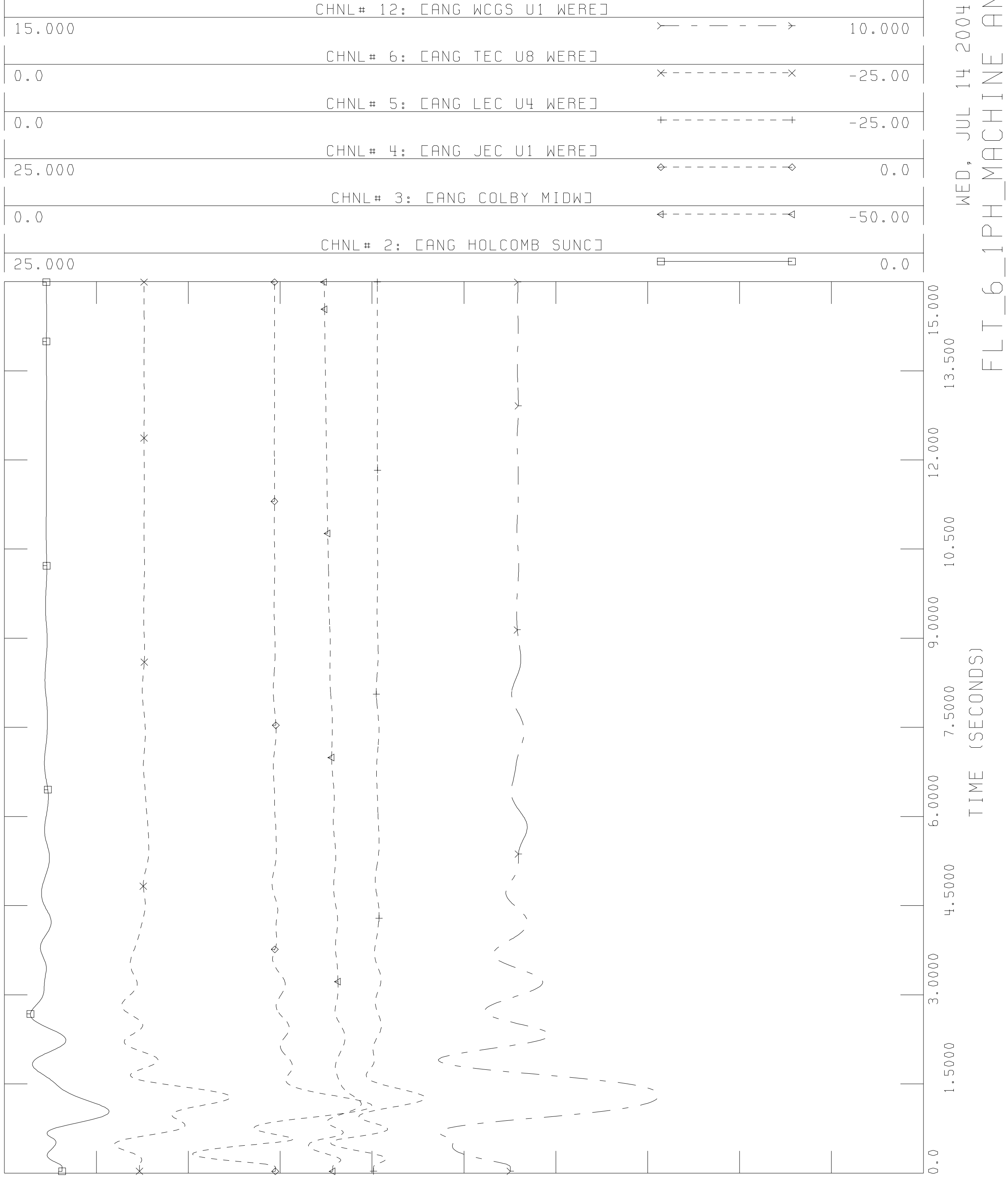
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 11:03

FLT_6_1PH_MACHINE ANGLES

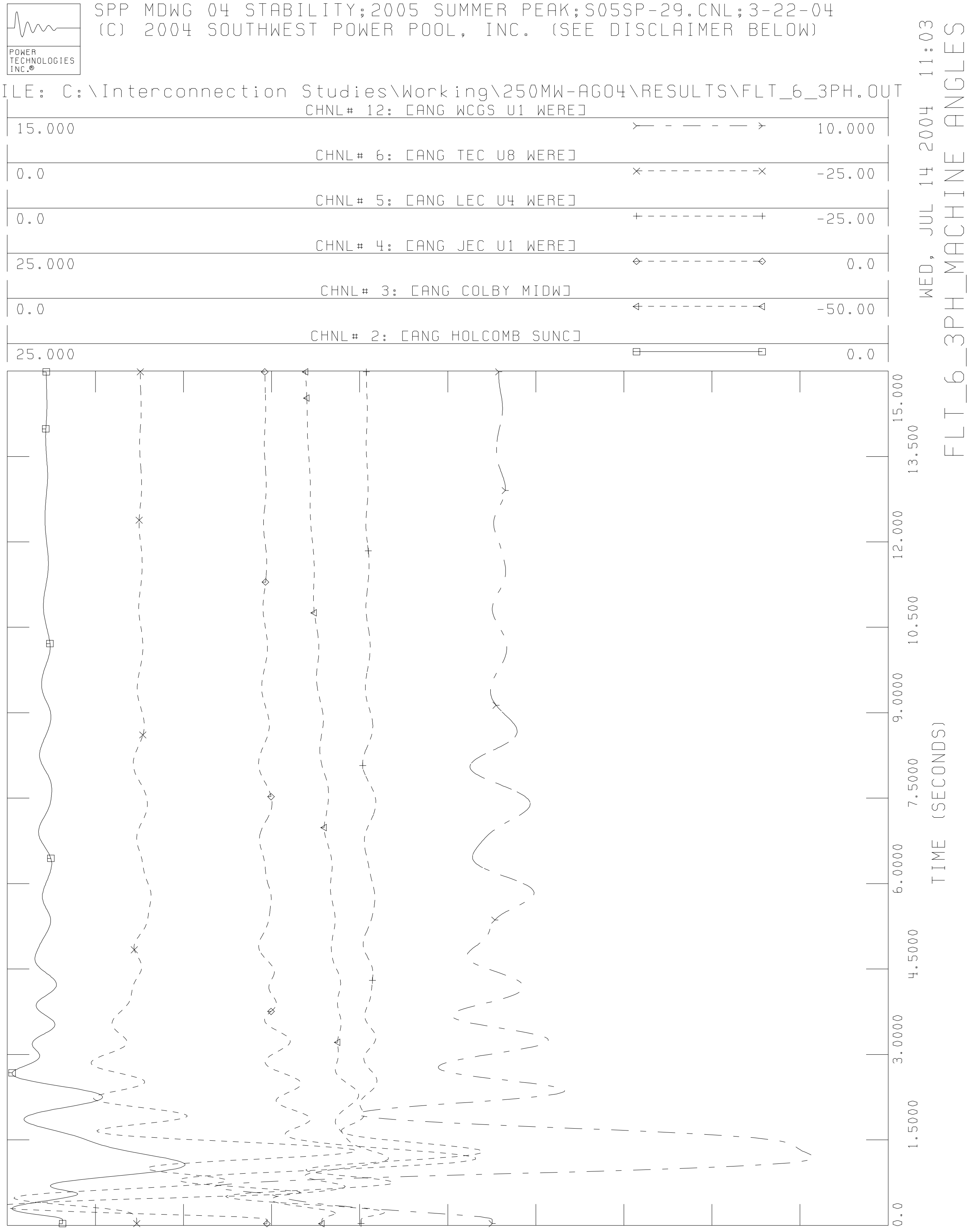
FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_6_1PH.OUT



POWER
TECHNOLOGIES
INC.®

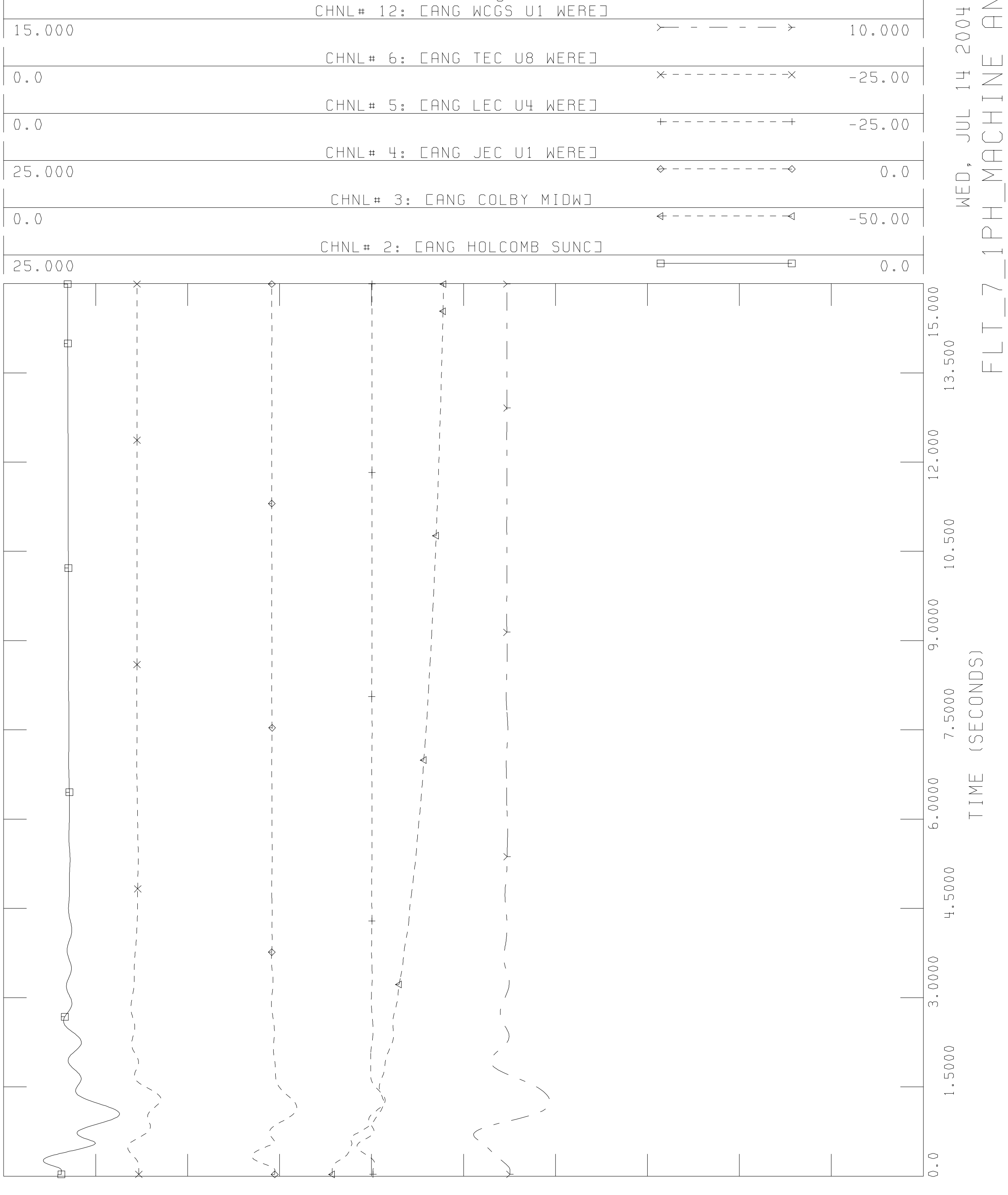
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_6_3PH.OUT



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

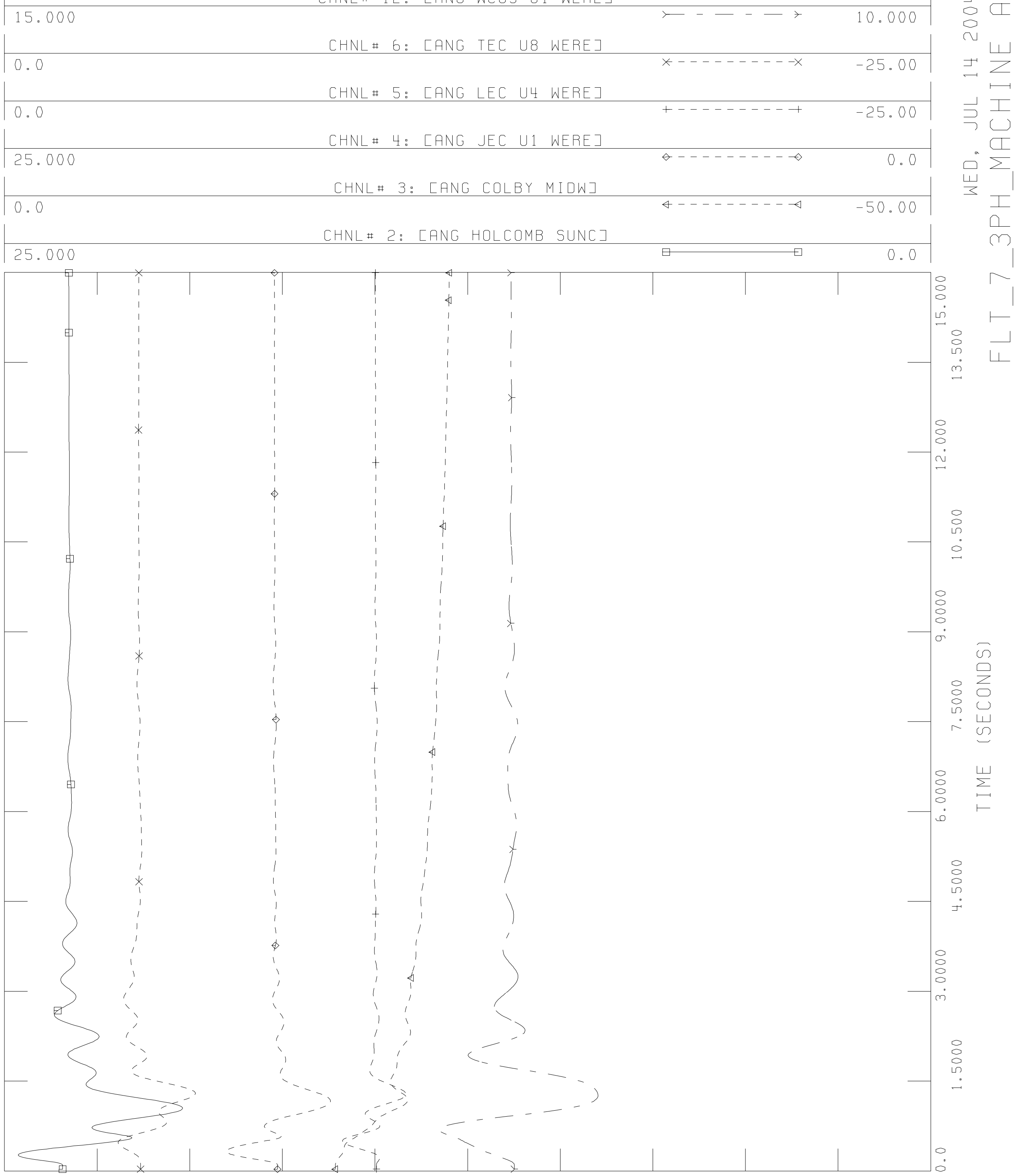
FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_7_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_7_3PH.OUT



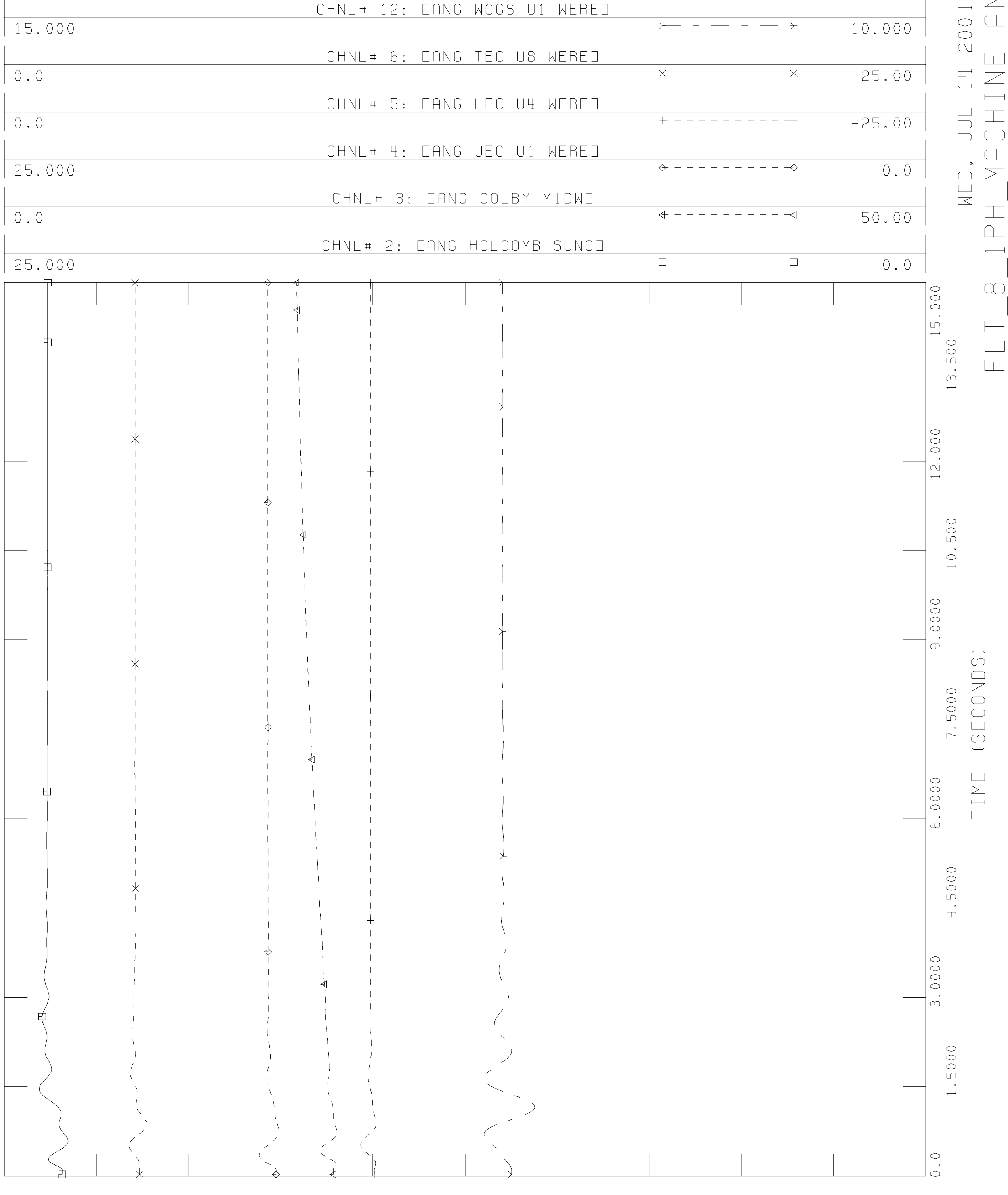
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_8_1PH.OUT

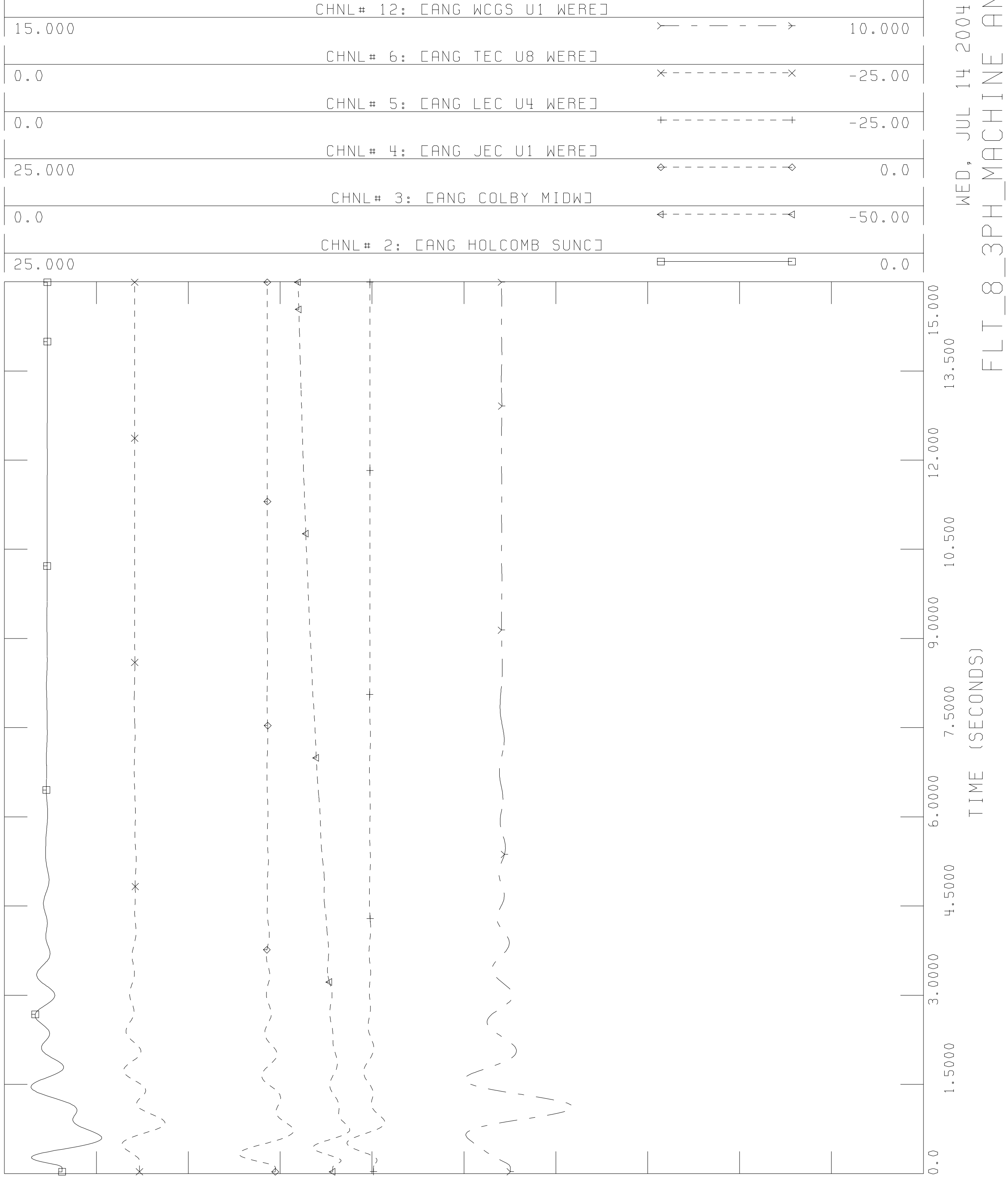
WED, JUL 14 2004 11:03

FLT_8_1PH_MACHINE ANGLES



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_8_3PH.OUT



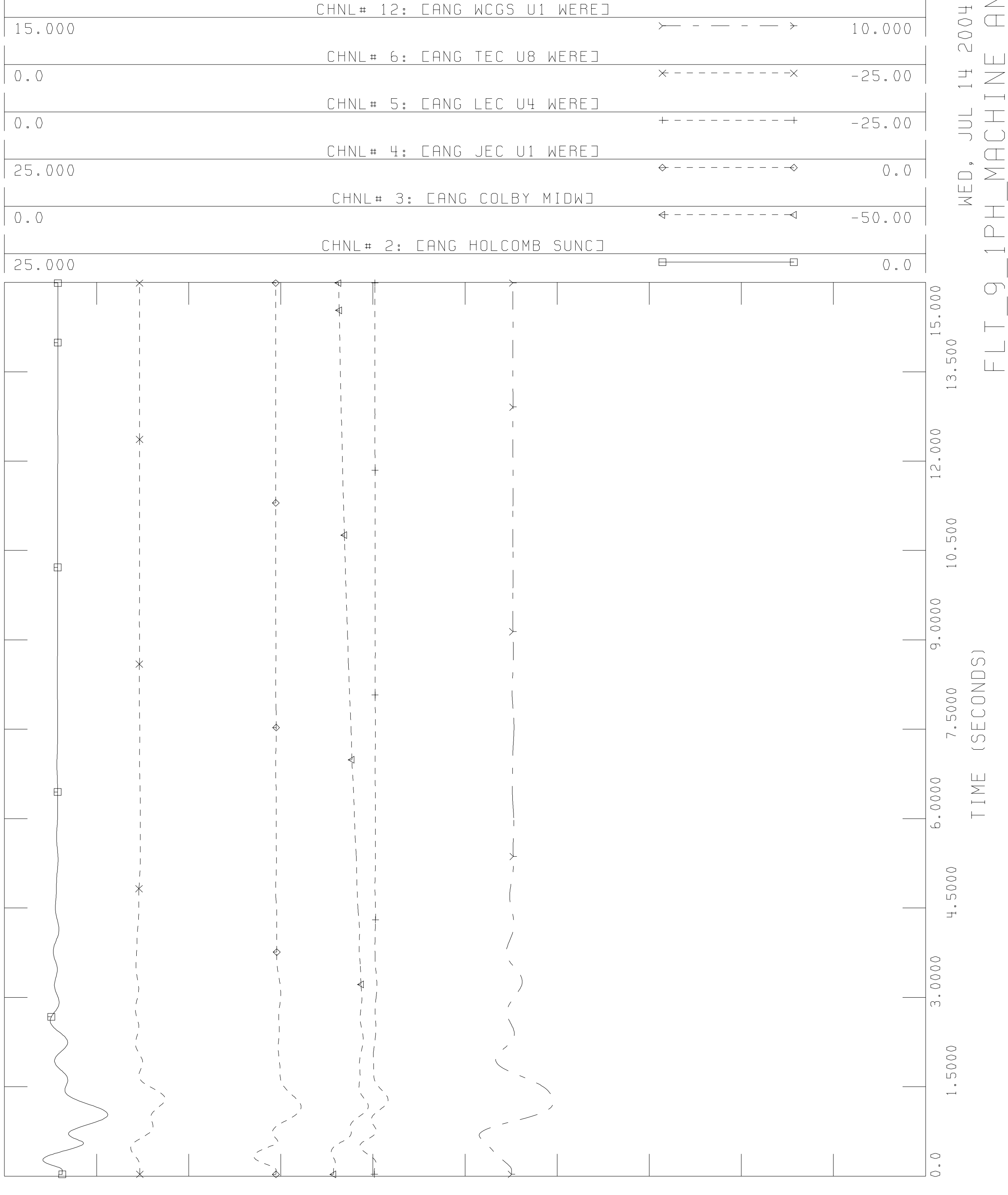
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER TECHNOLOGIES INC.®

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_9_1PH.OUT

WED, JUL 14 2004 11:03

FLT_9_1PH_MACHINE ANGLES



POWER TECHNOLOGIES INC.®

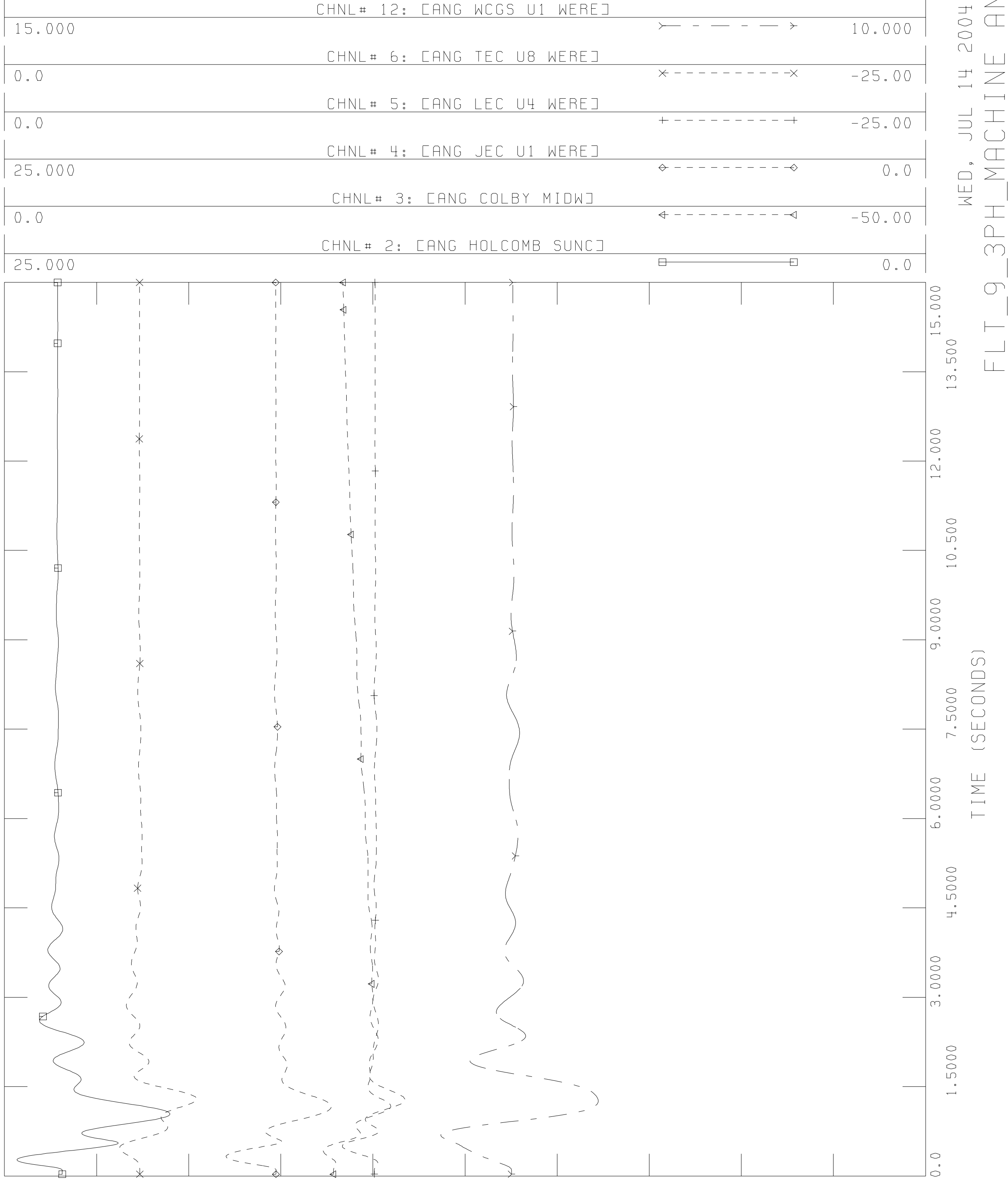
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 11:03

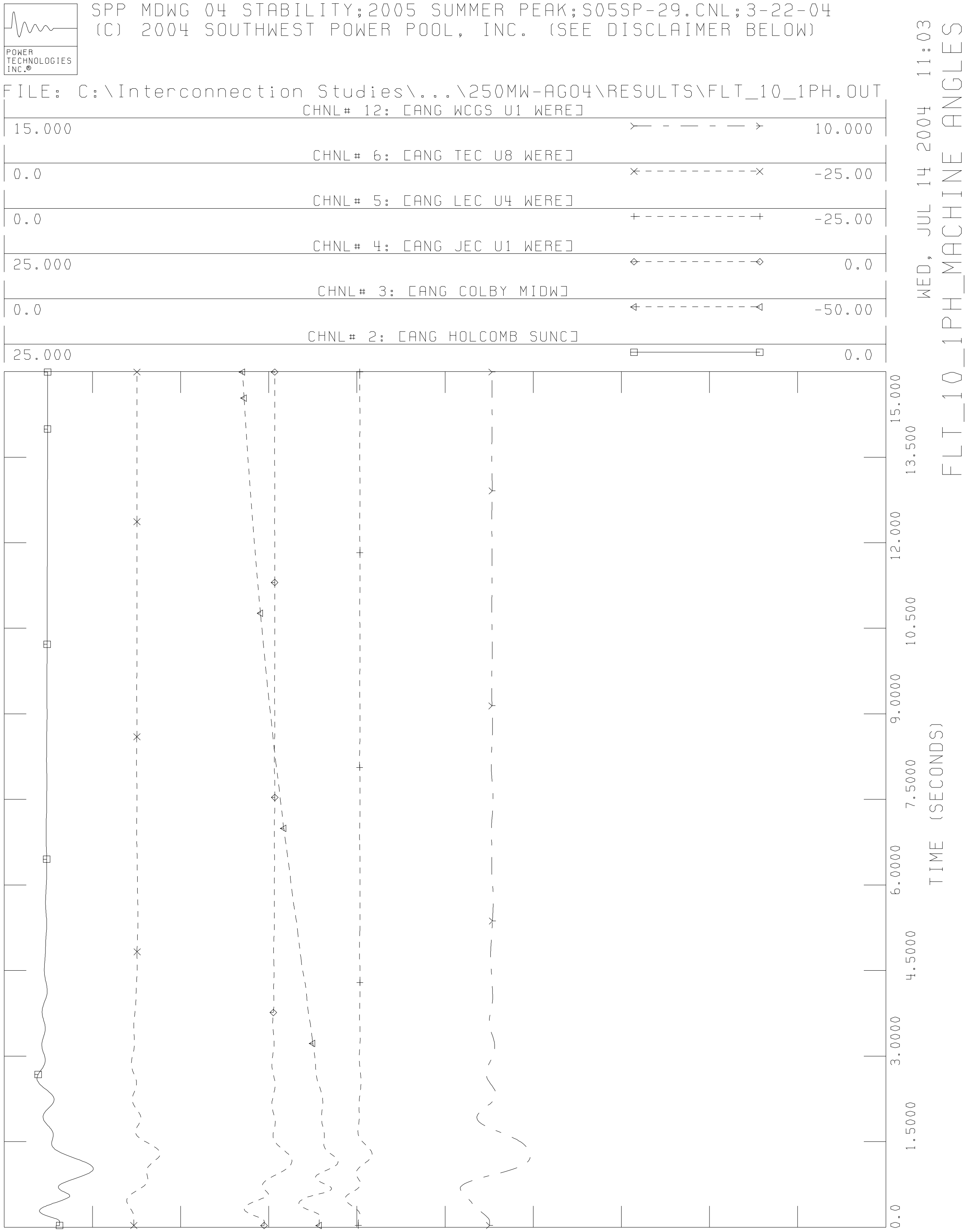
FLT_9_3PH_MACHINE ANGLES

FILE: C:\Interconnection Studies\Working\250MW-AG04\RESULTS\FLT_9_3PH.OUT



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\...\250MW-AG04\RESULTS\FLT_10_1PH.OUT



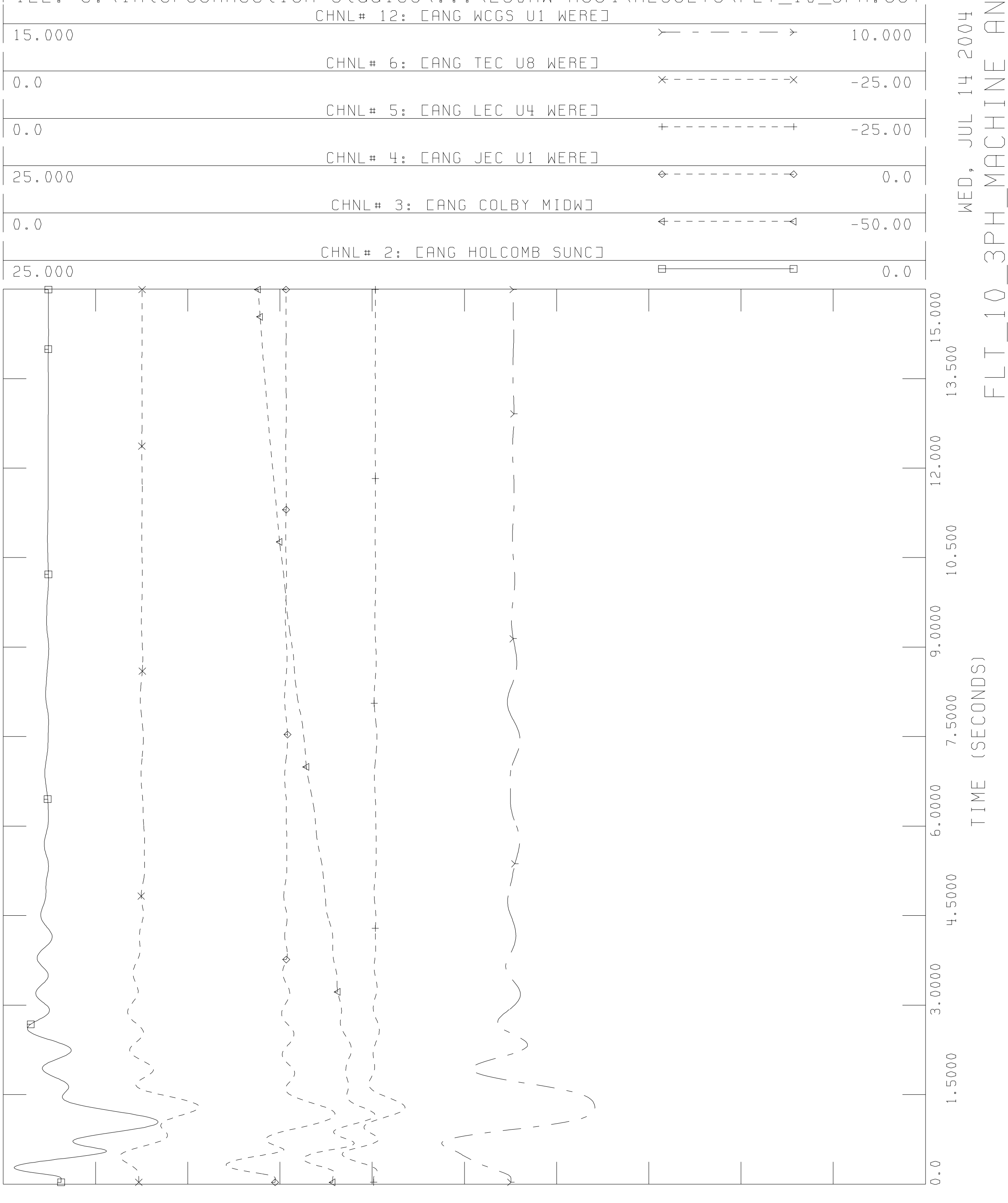
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\...\250MW-AG04\RESULTS\FLT_10_3PH.OUT

WED, JUL 14 2004 11:03

FLT_10_3PH_MACHINE ANGLES



Appendix C-1

Plots of Fault Simulations

Plots of selected bus voltage response during faults

Scenario:
2005 Summer Peak
Wind Farm at 150MW (100% rated power)
Standard Protection Settings

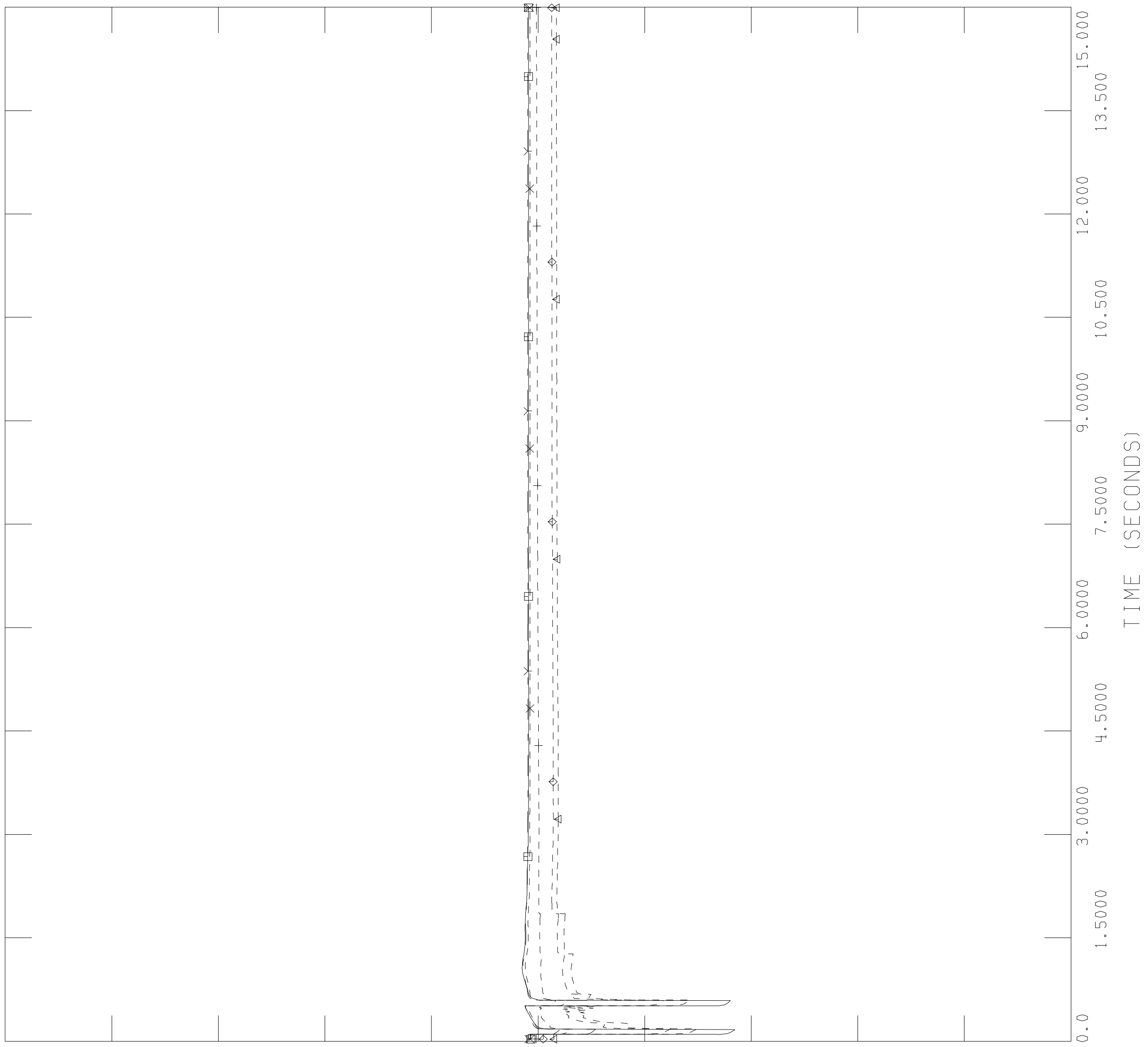
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_1_1PH.OUT

WED, JUL 14 2004 10:40
FLT_1_1PH_VOLTAGES

CHNL# 165: [VOLTAGE MORRIS 230KV]	2.0000	≻— - — - —≻	0.0
CHNL# 159: [VOLTAGE HOYT 345KV]	2.0000	×----------×	0.0
CHNL# 156: [VOLTAGE COLBY 115KV]	2.0000	+----------+	0.0
CHNL# 155: [VOLTAGE WAKEENEY 115KV]	2.0000	◇----------◇	0.0
CHNL# 146: [VOLTAGE KNOLL 230KV]	2.0000	◁----------◁	0.0
CHNL# 145: [VOLTAGE SUMMIT 230KV]	2.0000	□——————□	0.0

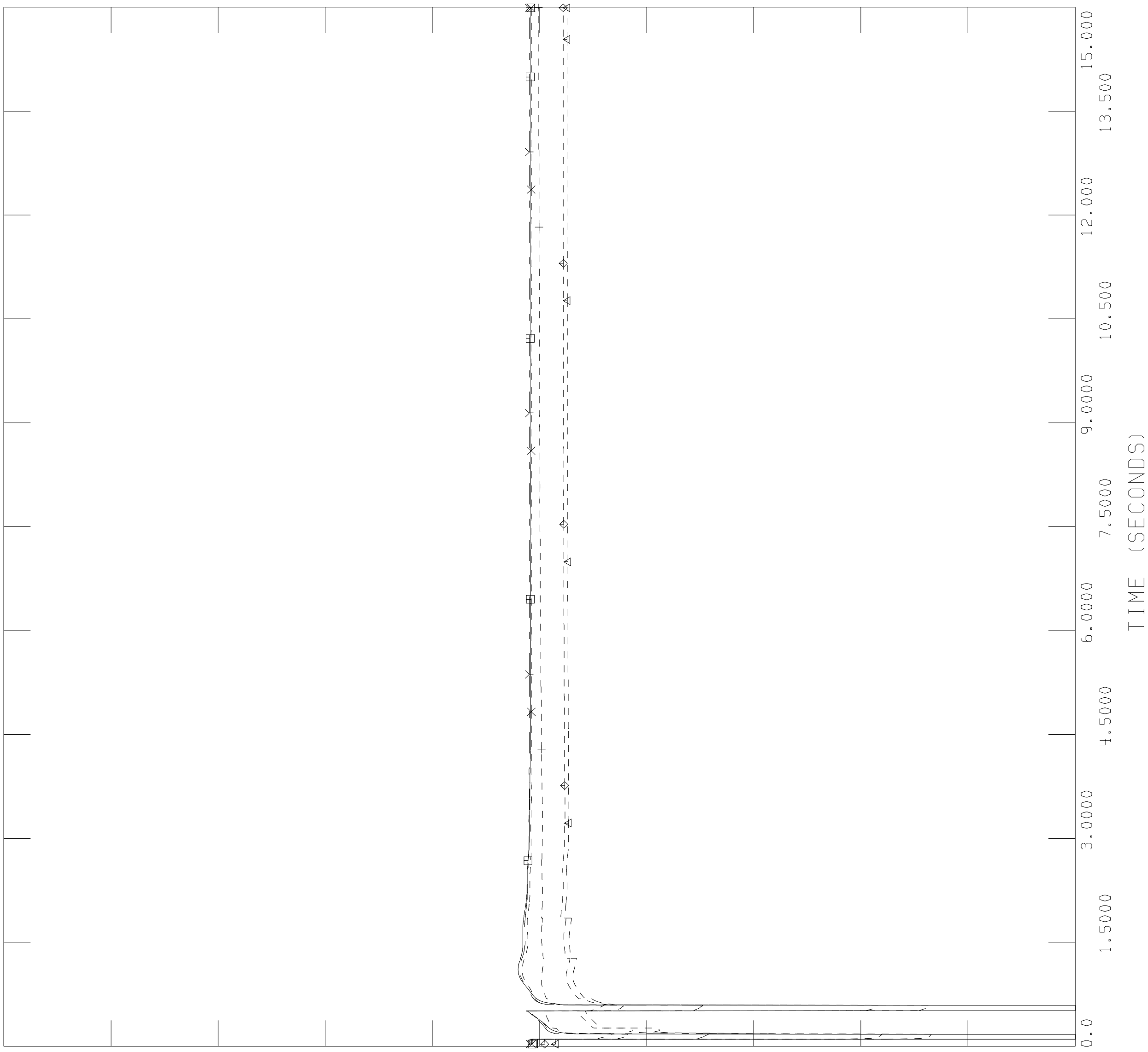


POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_1_3PH.OUT

	CHNL# 165: [VOLTAGE MORRIS 230KV]	
2.0000	≻— - — - —≻	0.0
	CHNL# 159: [VOLTAGE HOYT 345KV]	
2.0000	×- - - - - - - - - -×	0.0
	CHNL# 156: [VOLTAGE COLBY 115KV]	
2.0000	+- - - - - - - - - -+	0.0
	CHNL# 155: [VOLTAGE WAKEENEY 115KV]	
2.0000	◇- - - - - - - - - -◇	0.0
	CHNL# 146: [VOLTAGE KNOLL 230KV]	
2.0000	◁- - - - - - - - - -◁	0.0
	CHNL# 145: [VOLTAGE SUMMIT 230KV]	
2.0000	⊡———————⊡	0.0



WED, JUL 14 2004 10:40
FLT_1_3PH_VOLTAGES

POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:40
FLT_2_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_2_1PH.OUT

CHNL# 165: [VOLTAGE MORRIS 230KV]
2.0000 0.0

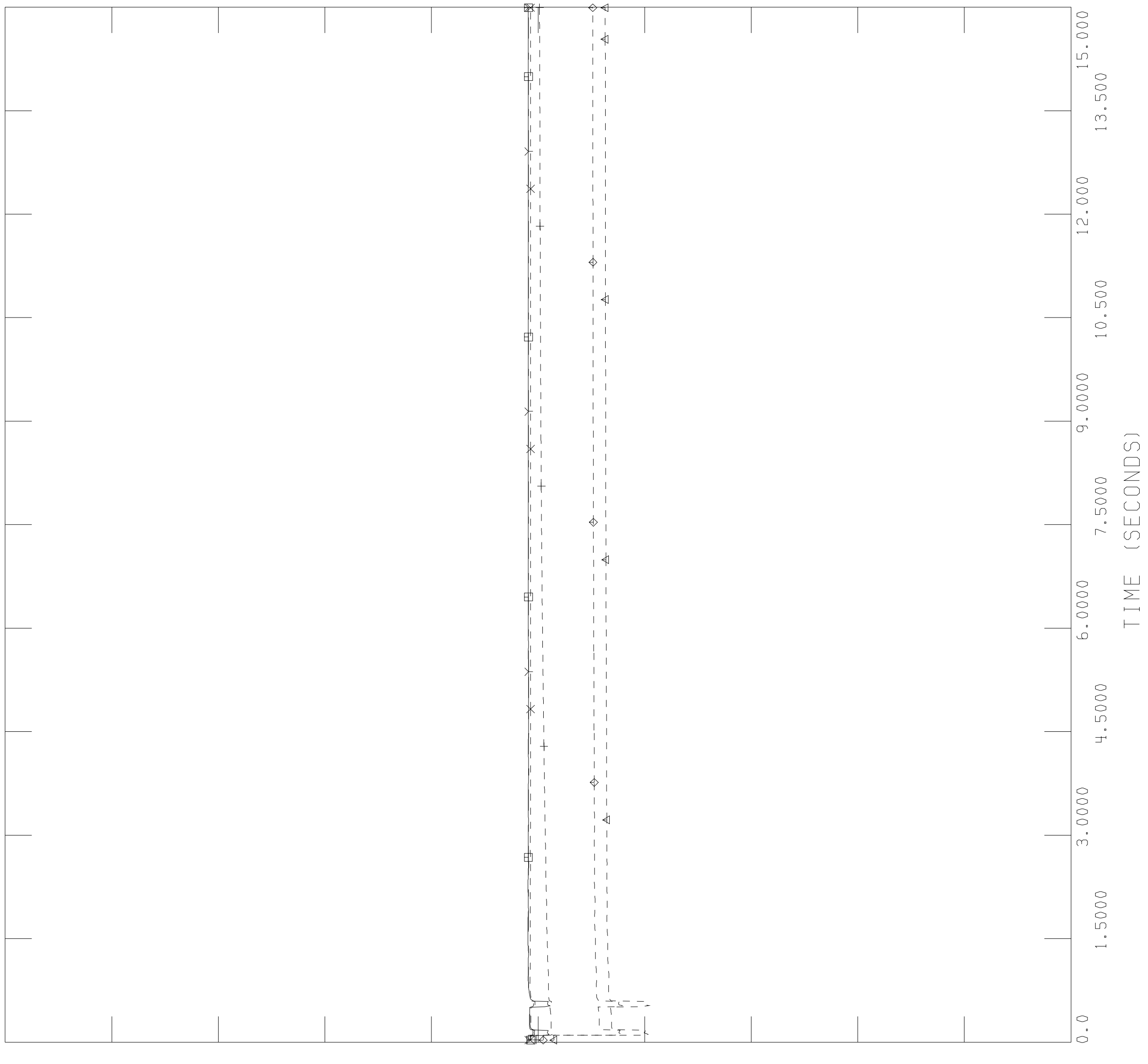
CHNL# 159: [VOLTAGE HOYT 345KV]
2.0000 0.0

CHNL# 156: [VOLTAGE COLBY 115KV]
2.0000 0.0

CHNL# 155: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 146: [VOLTAGE KNOLL 230KV]
2.0000 0.0

CHNL# 145: [VOLTAGE SUMMIT 230KV]
2.0000 0.0



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:40

FLT_2_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_2_3PH.OUT

CHNL# 165: [VOLTAGE MORRIS 230KV]
2.0000 ≻— - — - —≻ 0.0

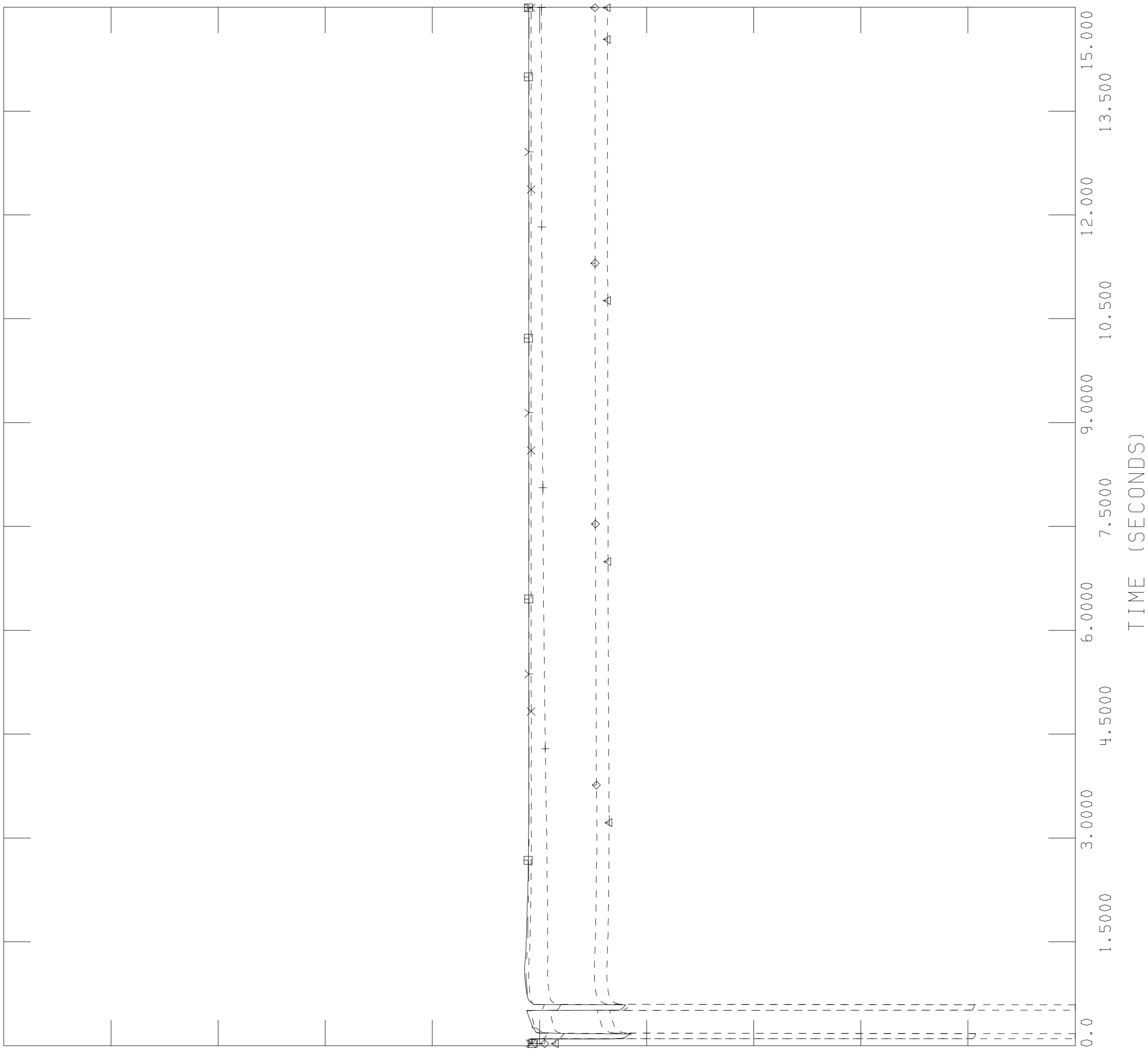
CHNL# 159: [VOLTAGE HOYT 345KV]
2.0000 ×- - - - - - - - - -× 0.0

CHNL# 156: [VOLTAGE COLBY 115KV]
2.0000 +- - - - - - - - - -+ 0.0

CHNL# 155: [VOLTAGE WAKEENEY 115KV]
2.0000 ◇- - - - - - - - - -◇ 0.0

CHNL# 146: [VOLTAGE KNOLL 230KV]
2.0000 ◁- - - - - - - - - -◁ 0.0

CHNL# 145: [VOLTAGE SUMMIT 230KV]
2.0000 ⊡——————⊡ 0.0

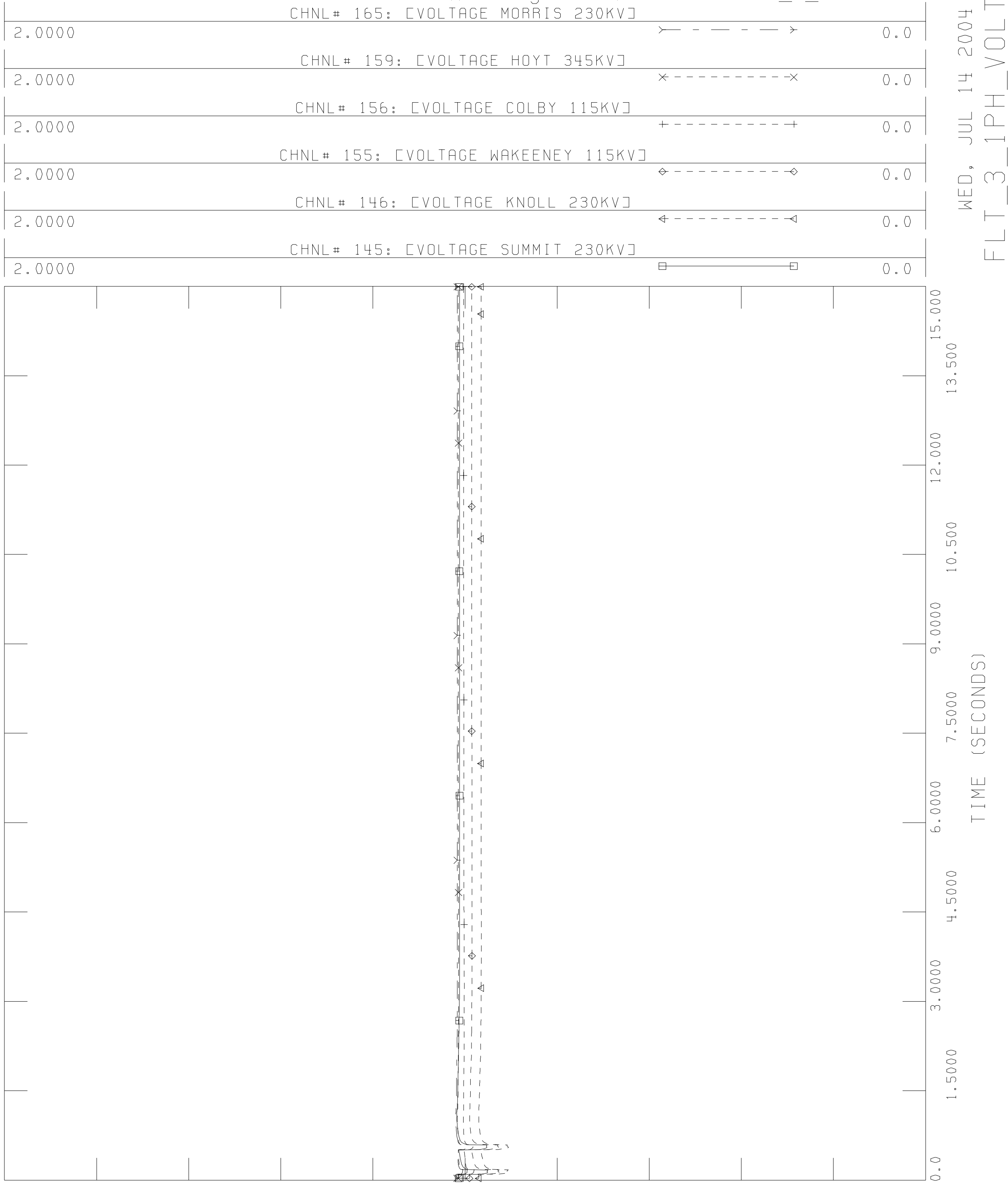


POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:40
FLT_3_1PH_VOLTAGES

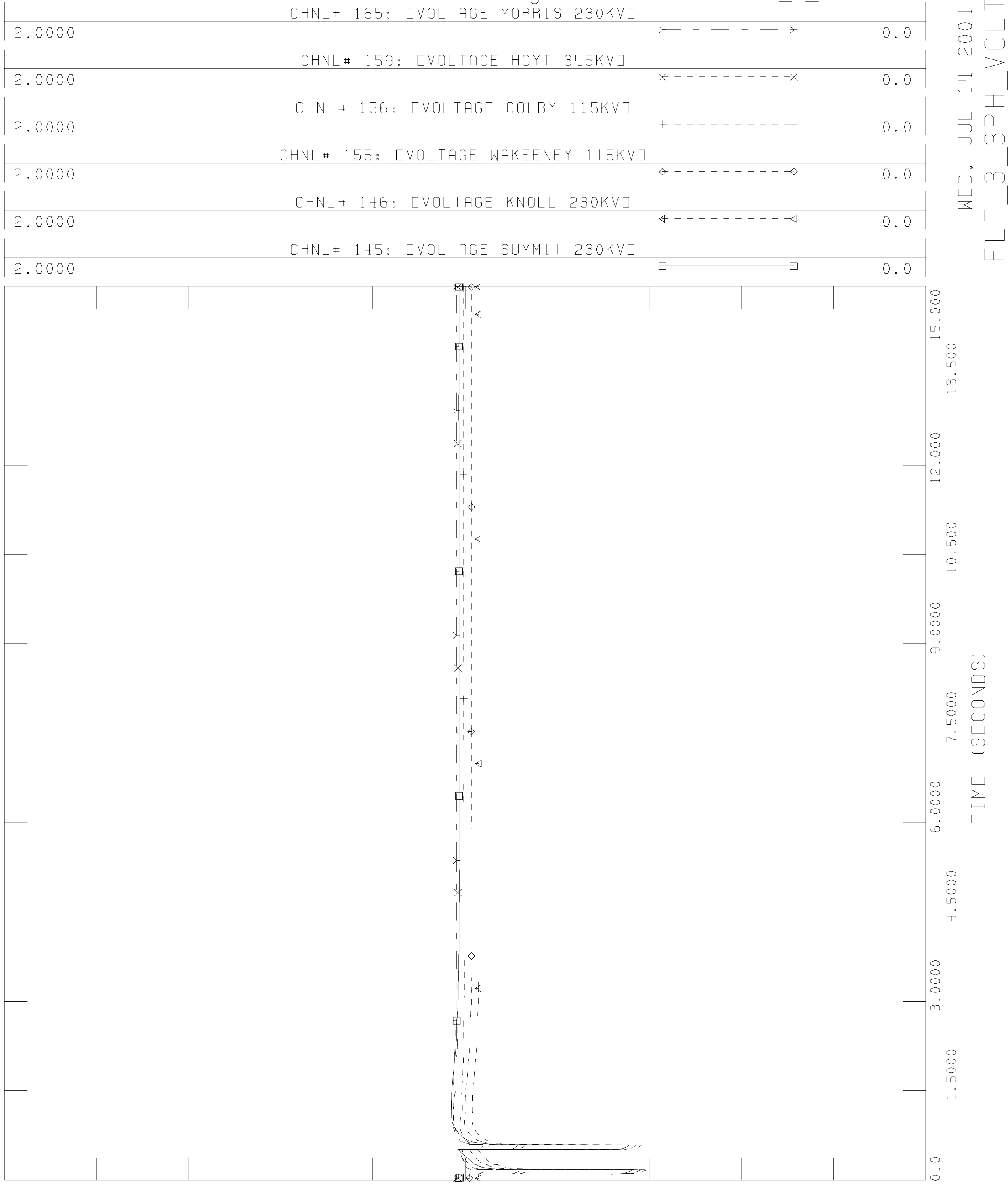
FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_3_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_3_3PH.OUT



WED, JUL 14 2004 10:40
FLT_3_3PH_VOLTAGES

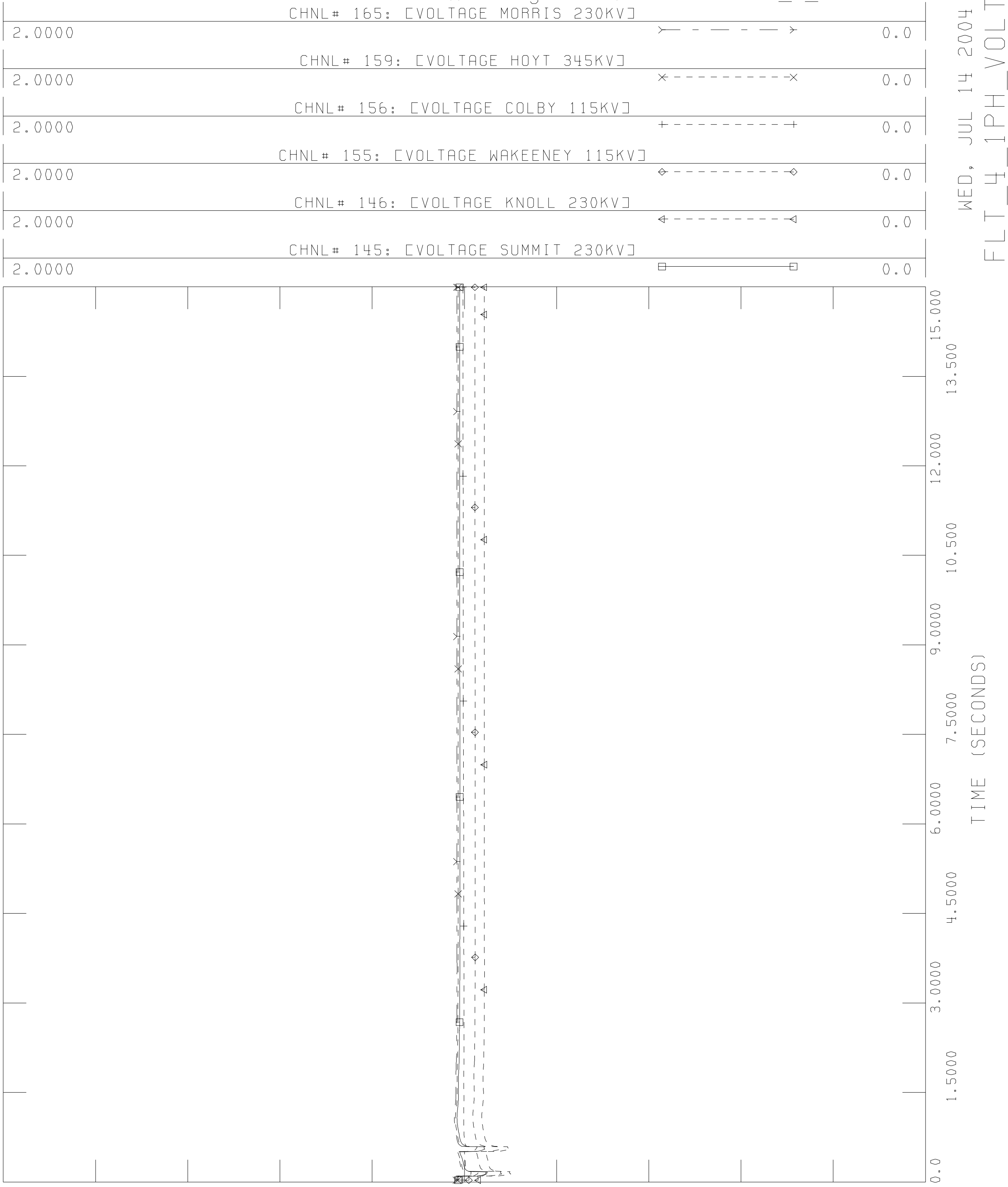
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:40

FLT_4_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_4_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_4_3PH.OUT

CHNL# 165: [VOLTAGE MORRIS 230KV]
2.0000 0.0

CHNL# 159: [VOLTAGE HOYT 345KV]
2.0000 0.0

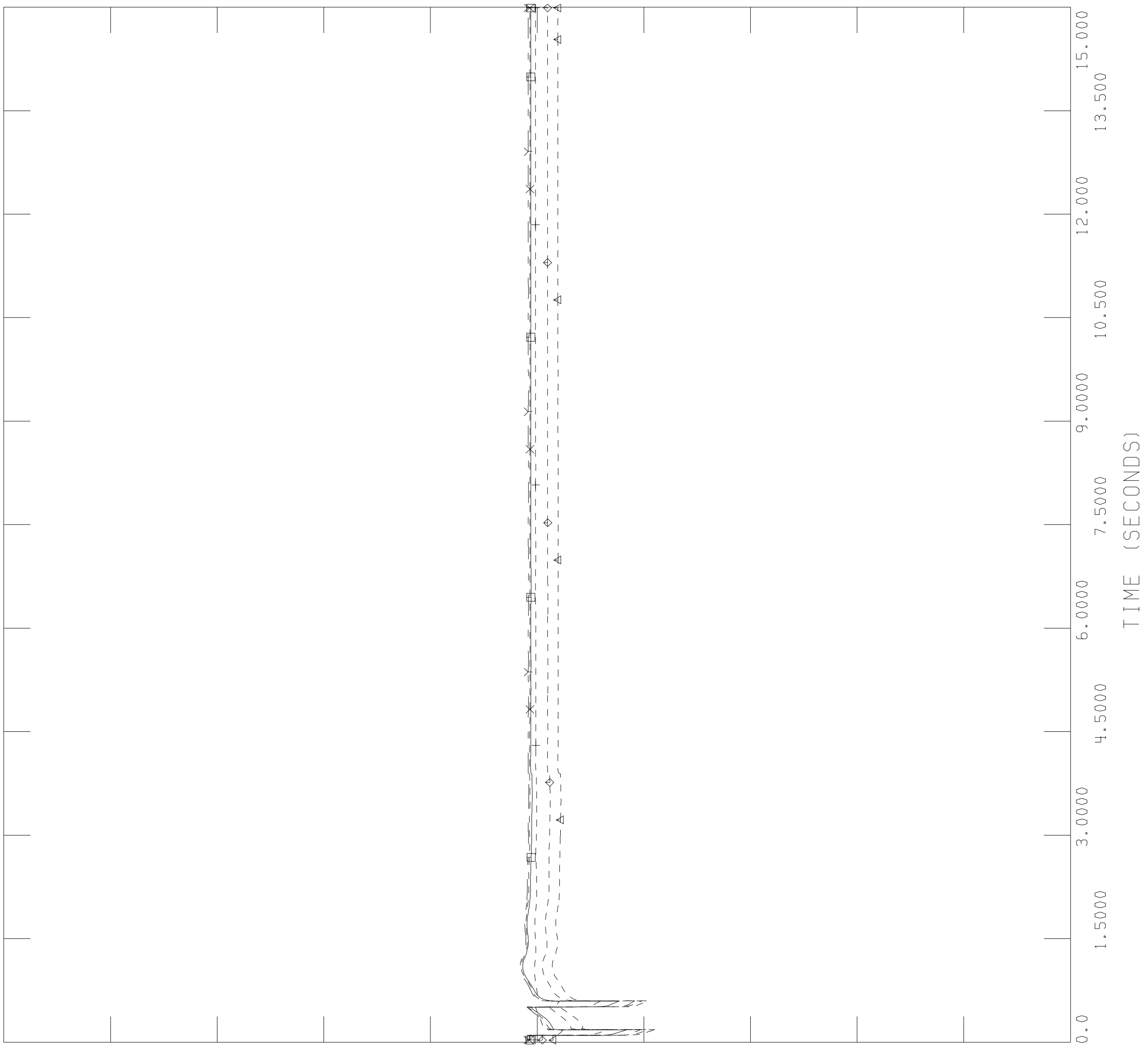
CHNL# 156: [VOLTAGE COLBY 115KV]
2.0000 0.0

CHNL# 155: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 146: [VOLTAGE KNOLL 230KV]
2.0000 0.0

CHNL# 145: [VOLTAGE SUMMIT 230KV]
2.0000 0.0

WED, JUL 14 2004 10:40
FLT_4_3PH_VOLTAGES

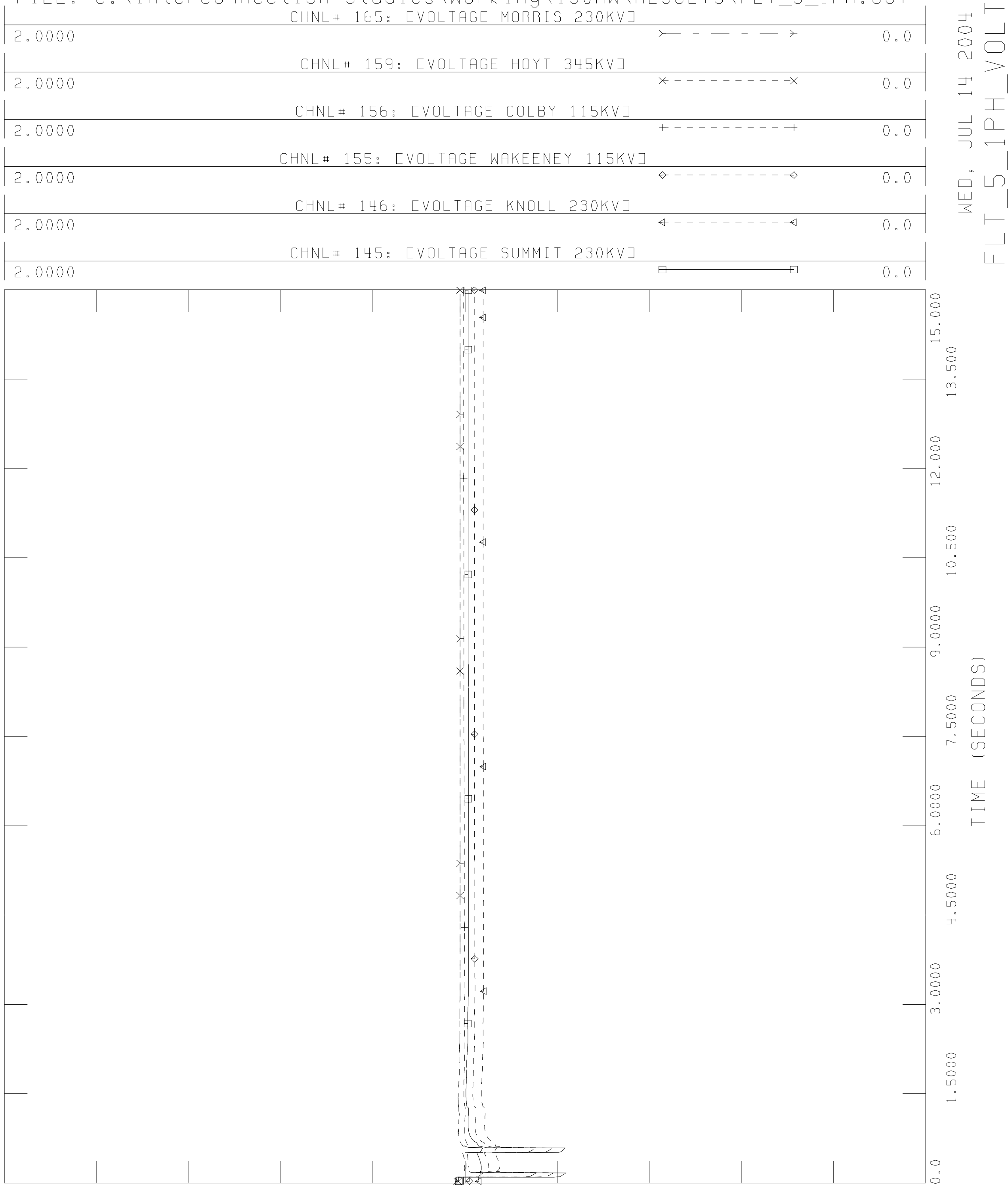


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:40

FLT_5_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_5_1PH.OUT

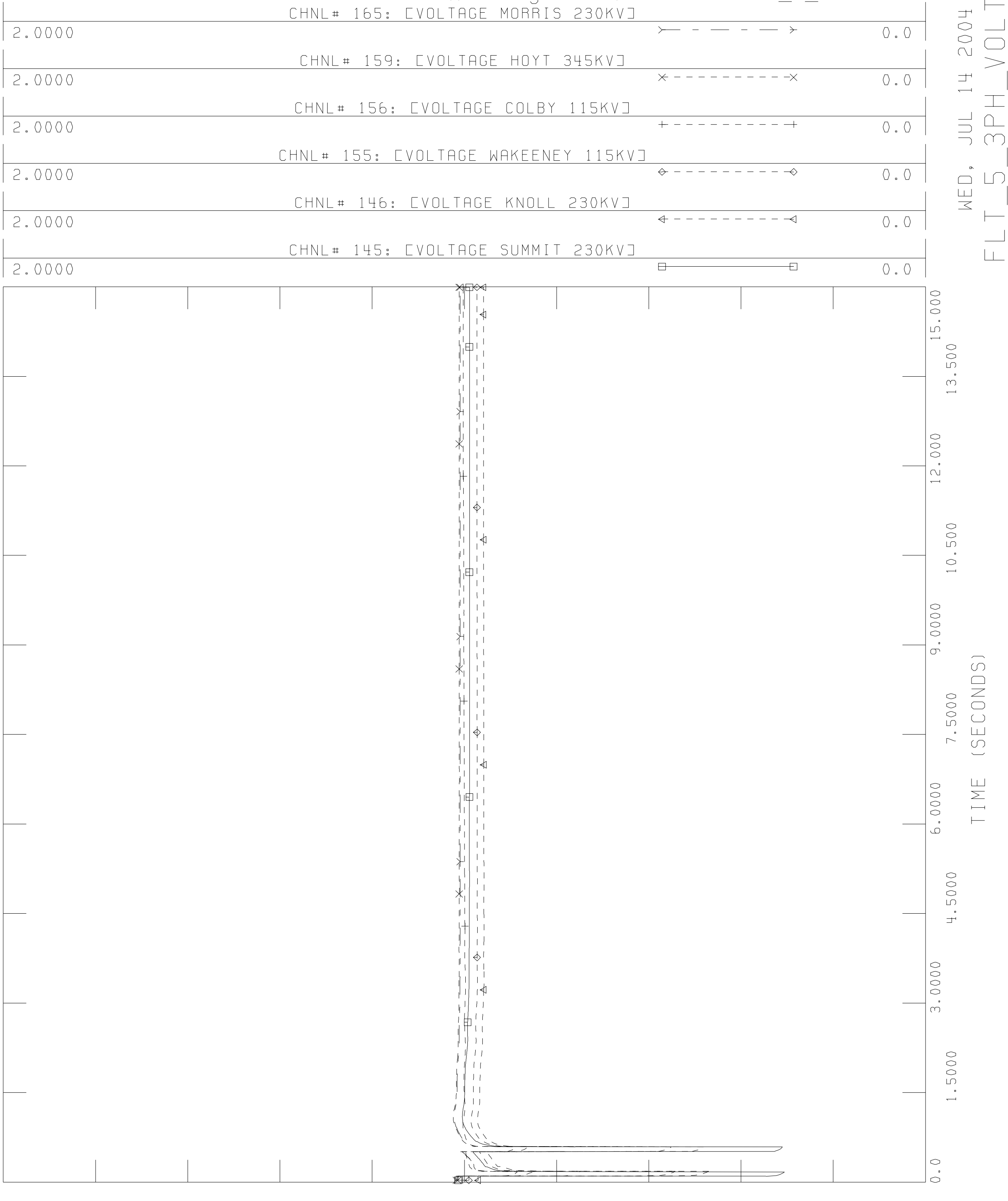


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER TECHNOLOGIES INC.®

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_5_3PH.OUT

WED, JUL 14 2004 10:40
FLT_5_3PH_VOLTAGES

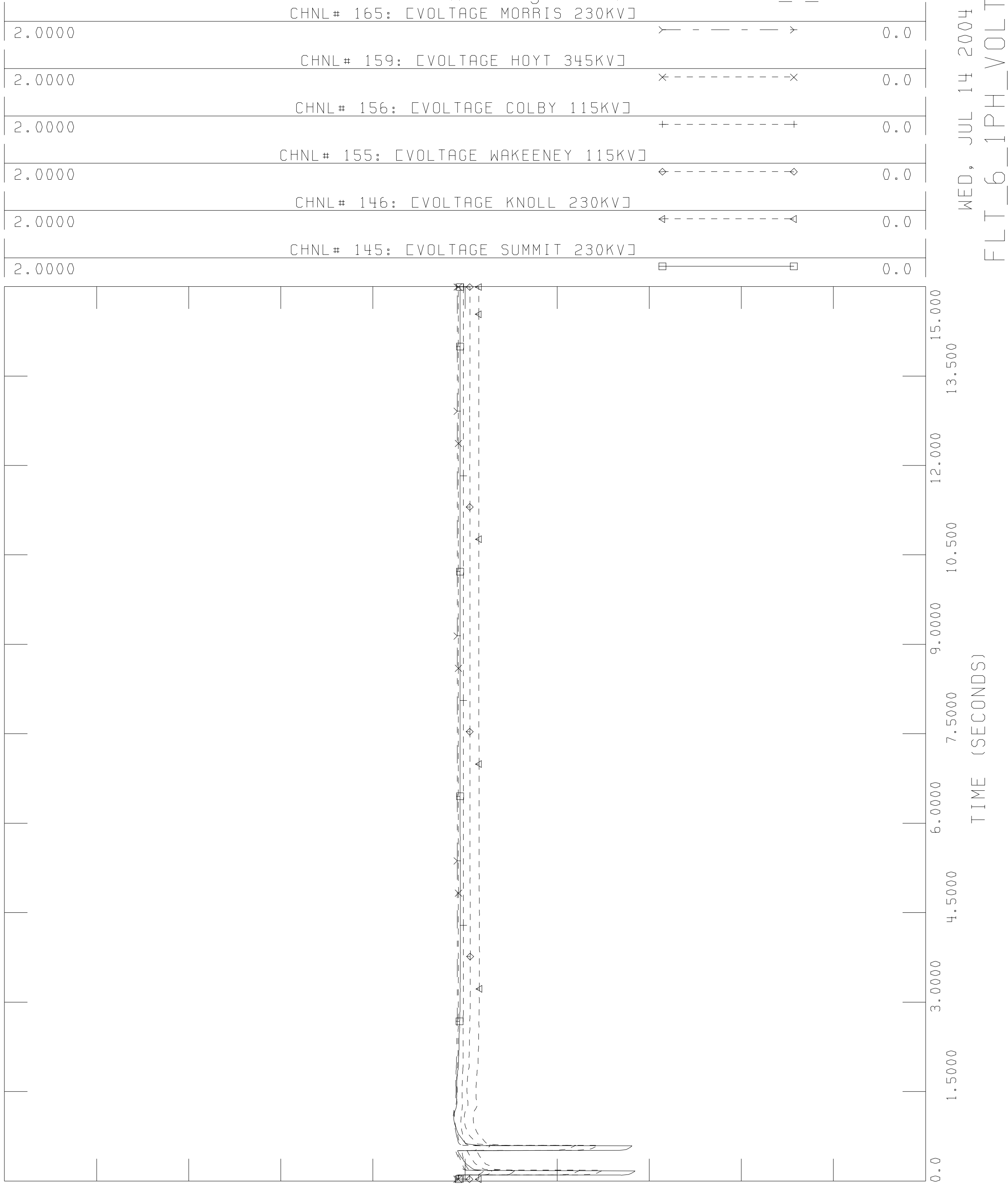


POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_6_1PH.OUT

WED, JUL 14 2004 10:40
FLT_6_1PH_VOLTAGES

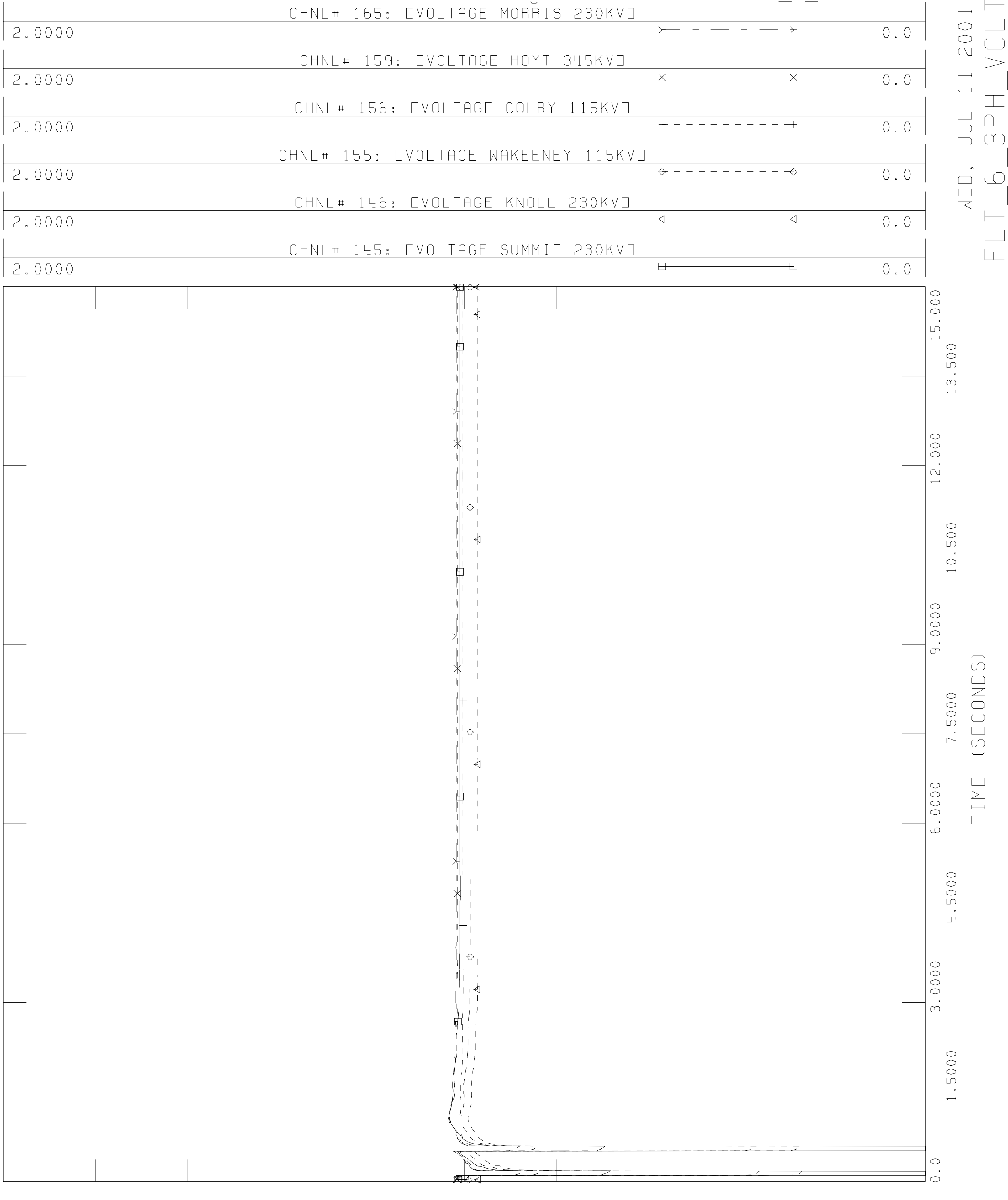


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER TECHNOLOGIES INC.®

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_6_3PH.OUT

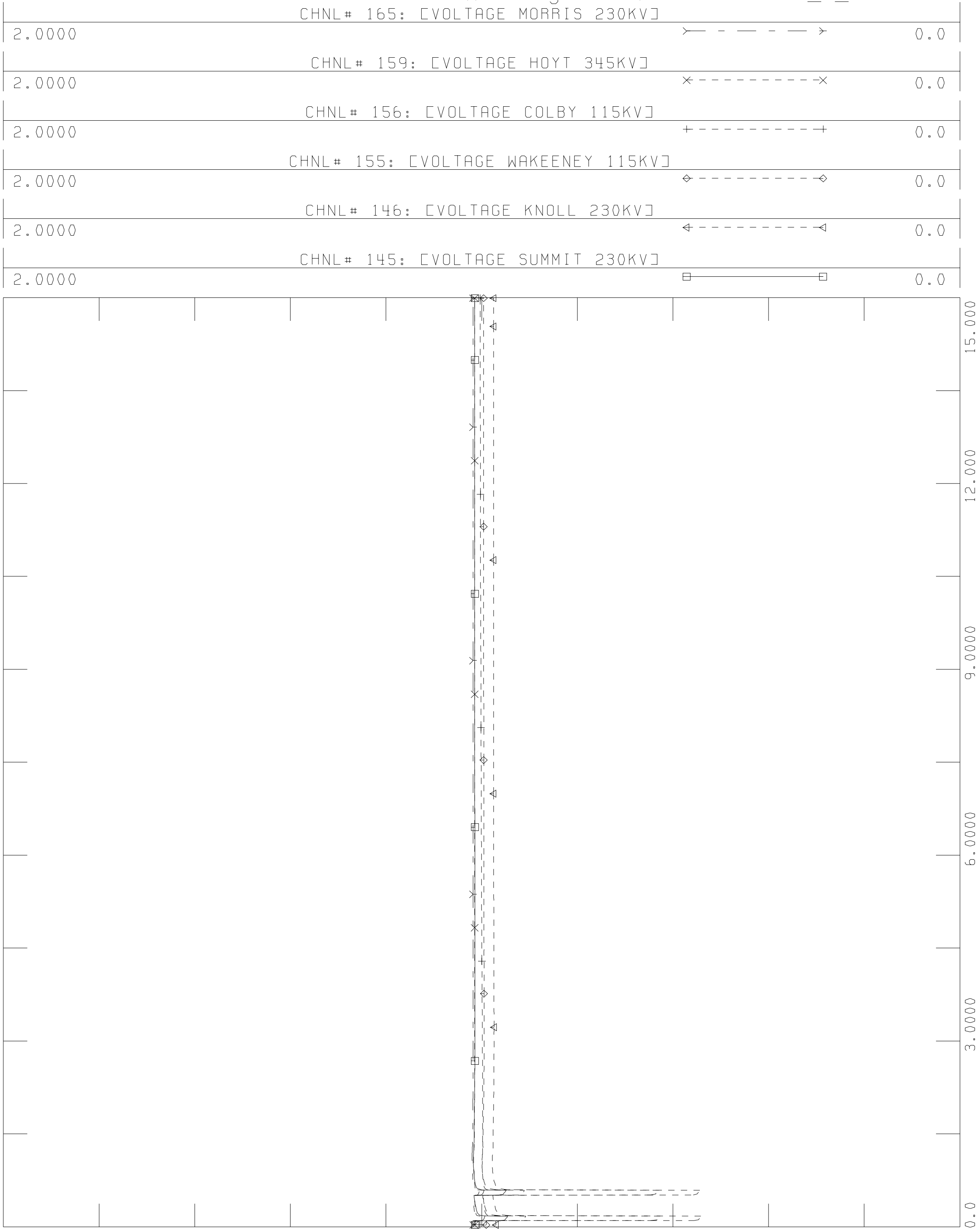
WED, JUL 14 2004 10:40
FLT_6_3PH_VOLTAGES



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER TECHNOLOGIES INC.®

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_7_1PH.OUT



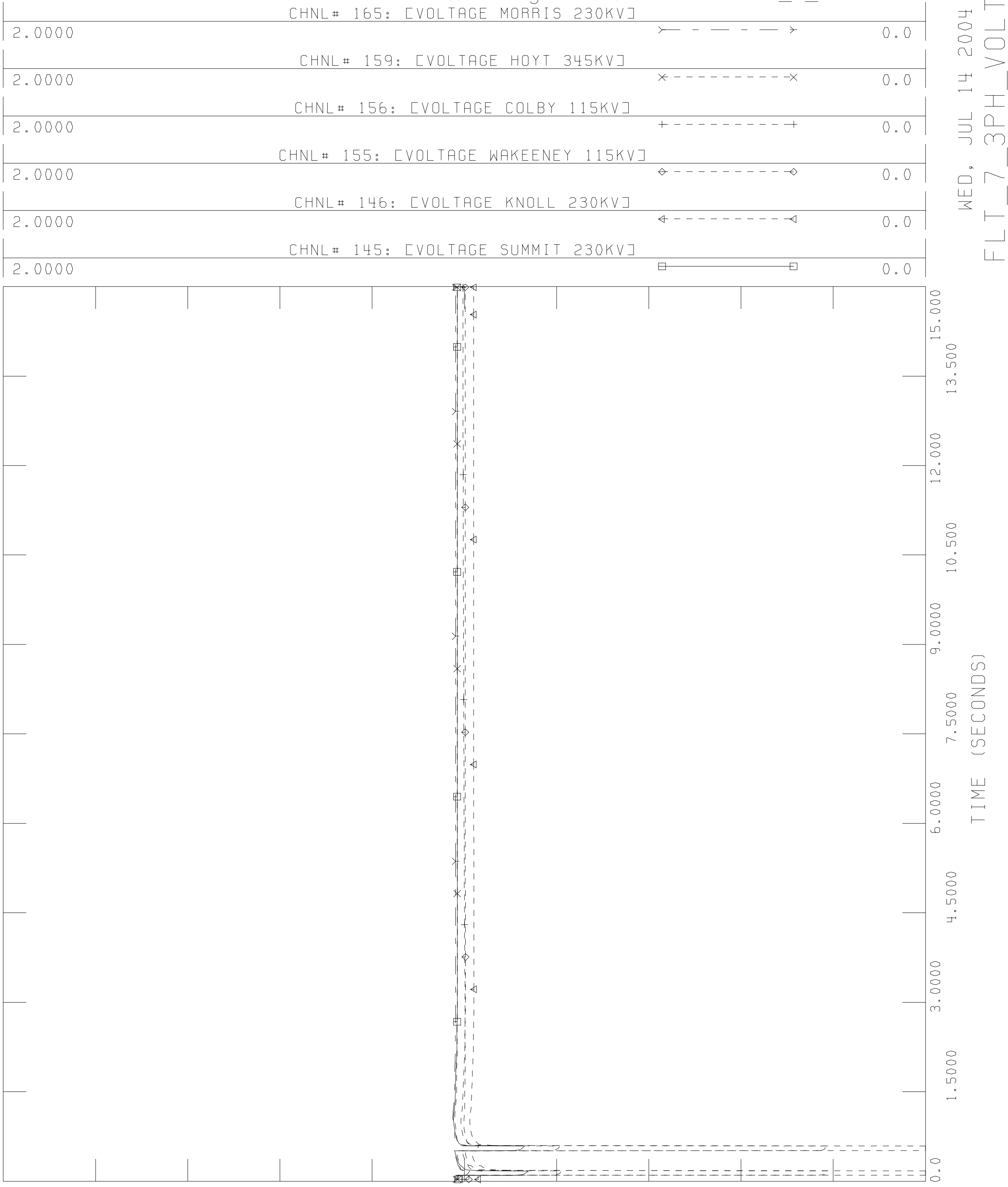
WED, JUL 14 2004 10:40
FLT_7_1PH_VOLTAGES

POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:40
FLT_7_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_7_3PH.OUT



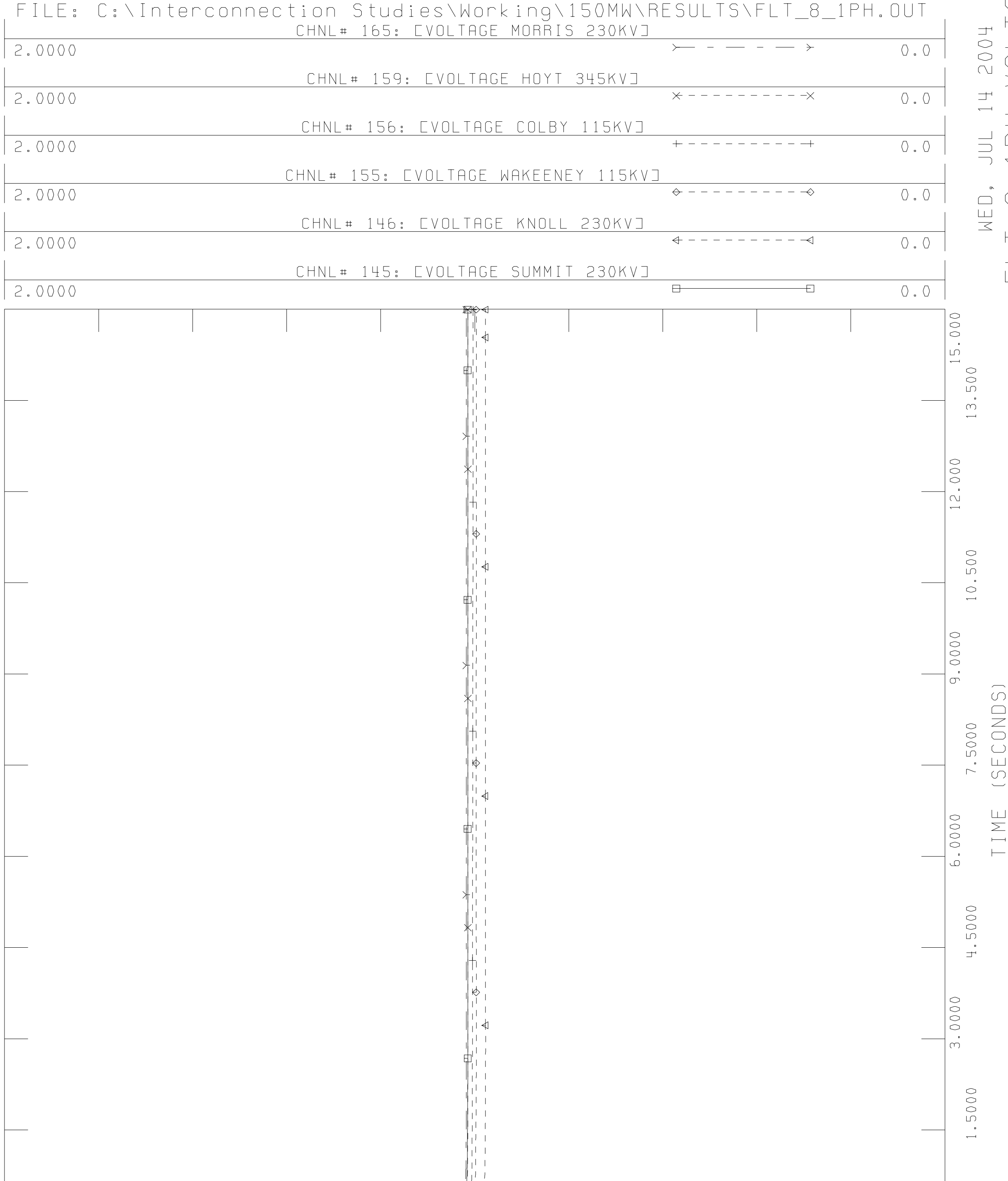
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:40

FLT_8_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_8_1PH.OUT



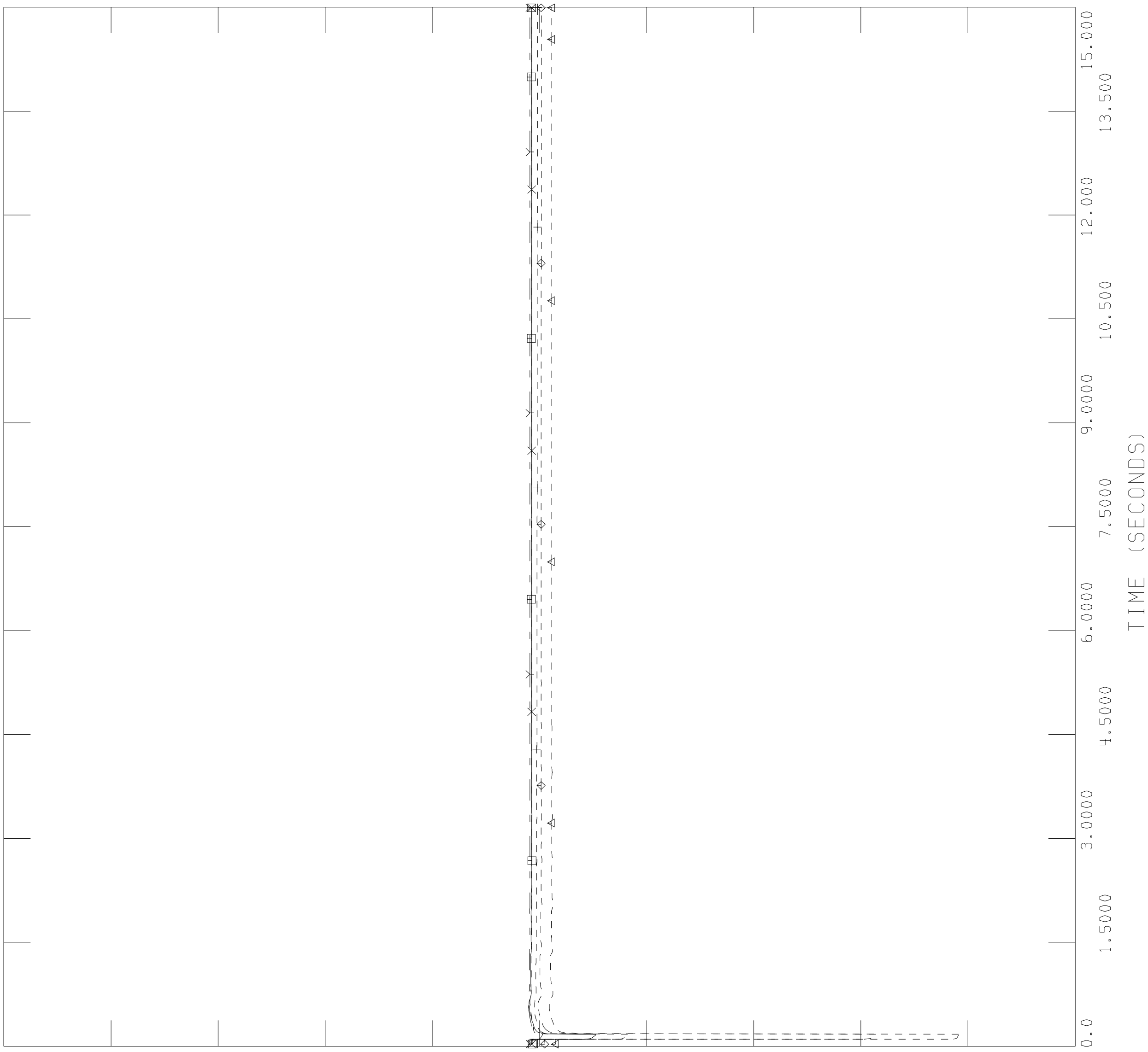
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:40
FLT_8_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_8_3PH.OUT

CHNL# 165: [VOLTAGE MORRIS 230KV]		
2.0000	⋎— - — - —⋎	0.0
CHNL# 159: [VOLTAGE HOYT 345KV]		
2.0000	×----------×	0.0
CHNL# 156: [VOLTAGE COLBY 115KV]		
2.0000	+----------+	0.0
CHNL# 155: [VOLTAGE WAKEENEY 115KV]		
2.0000	◇----------◇	0.0
CHNL# 146: [VOLTAGE KNOLL 230KV]		
2.0000	◁----------◁	0.0
CHNL# 145: [VOLTAGE SUMMIT 230KV]		
2.0000	□——————□	0.0



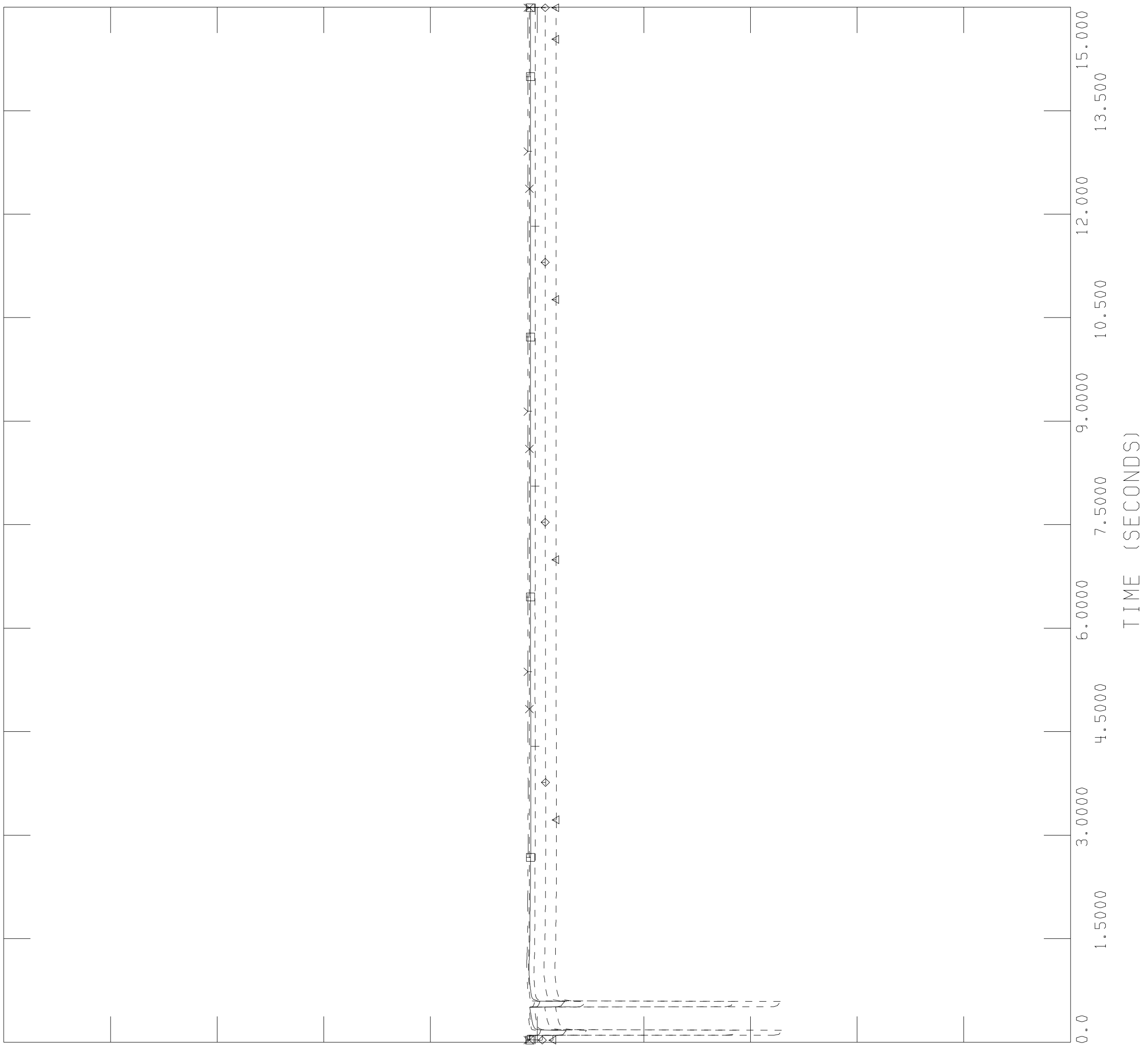
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:40
FLT_9_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_9_1PH.OUT

CHNL# 165: [VOLTAGE MORRIS 230KV]		
2.0000	≻— - — - —≻	0.0
CHNL# 159: [VOLTAGE HOYT 345KV]		
2.0000	×----------×	0.0
CHNL# 156: [VOLTAGE COLBY 115KV]		
2.0000	+----------+	0.0
CHNL# 155: [VOLTAGE WAKEENEY 115KV]		
2.0000	◇----------◇	0.0
CHNL# 146: [VOLTAGE KNOLL 230KV]		
2.0000	◁----------◁	0.0
CHNL# 145: [VOLTAGE SUMMIT 230KV]		
2.0000	□——————□	0.0



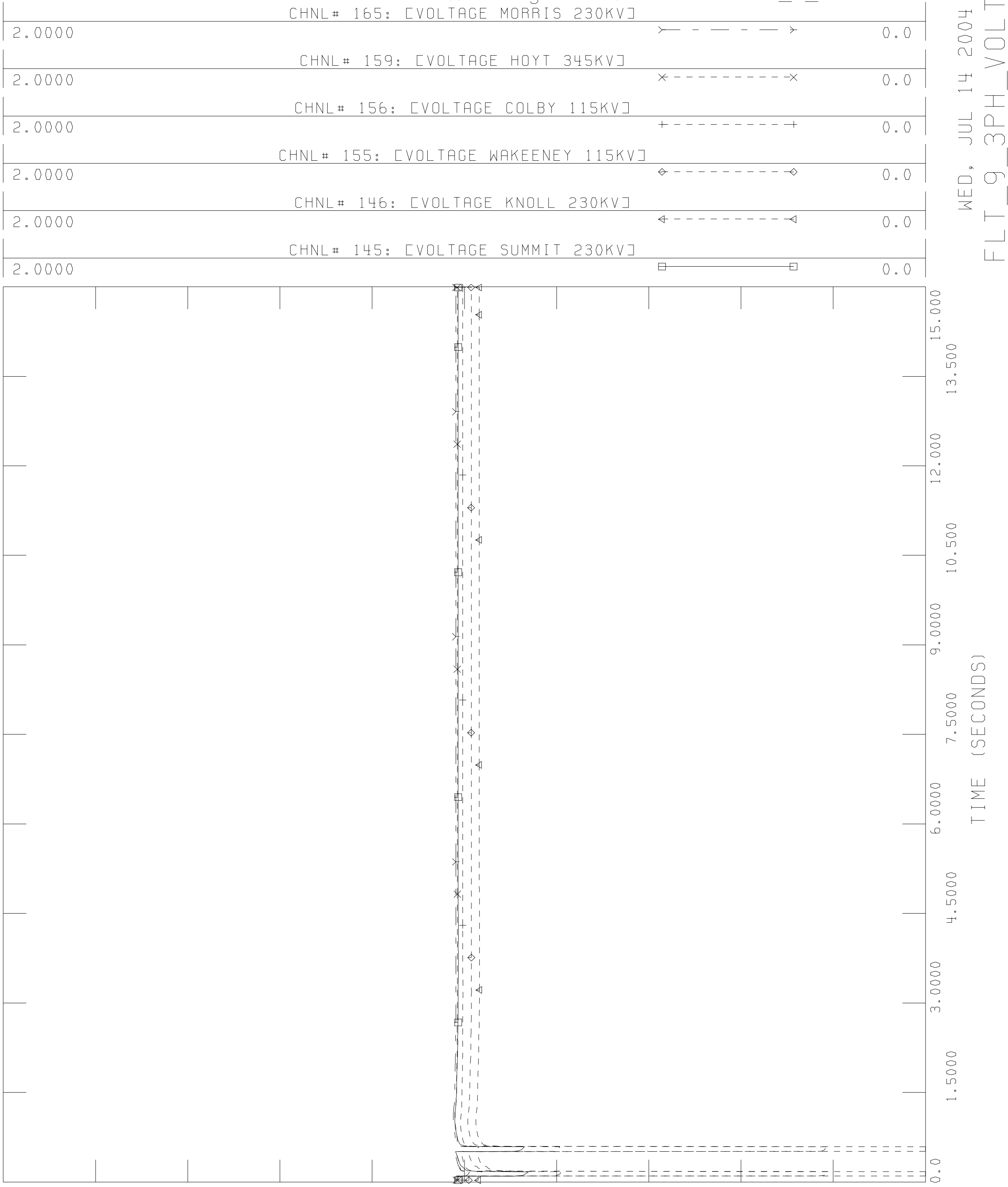
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_9_3PH.OUT

WED, JUL 14 2004 10:40

FLT_9_3PH_VOLTAGES



POWER
TECHNOLOGIES
INC.®

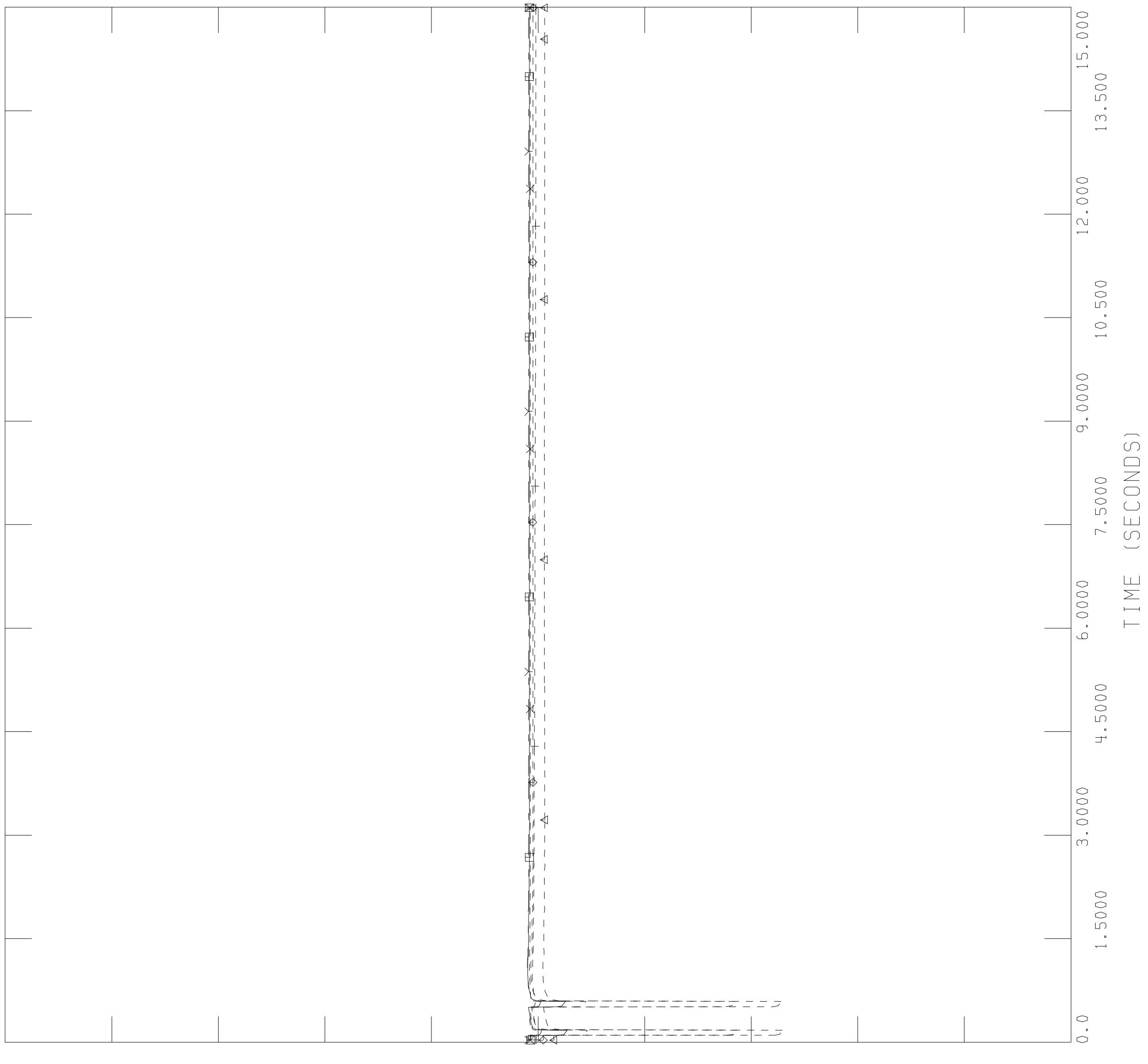
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:40

FLT_10_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_10_1PH.OUT

2.0000	CHNL# 165: [VOLTAGE MORRIS 230KV]	0.0
2.0000	CHNL# 159: [VOLTAGE HOYT 345KV]	0.0
2.0000	CHNL# 156: [VOLTAGE COLBY 115KV]	0.0
2.0000	CHNL# 155: [VOLTAGE WAKEENEY 115KV]	0.0
2.0000	CHNL# 146: [VOLTAGE KNOLL 230KV]	0.0
2.0000	CHNL# 145: [VOLTAGE SUMMIT 230KV]	0.0



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER TECHNOLOGIES INC.®

WED, JUL 14 2004 10:40

FLT_10_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_10_3PH.OUT

CHNL# 165: [VOLTAGE MORRIS 230KV]
2.0000 0.0

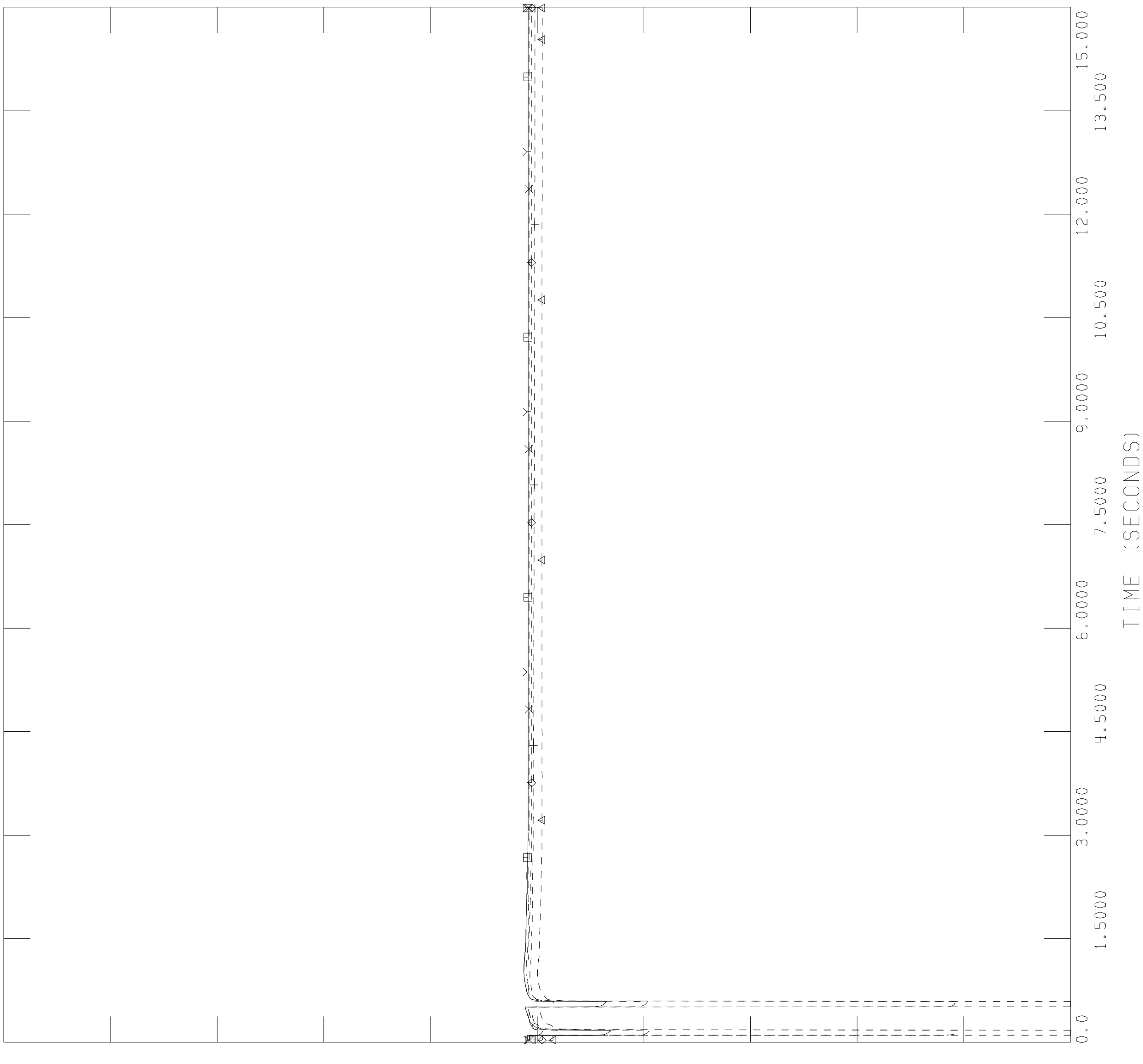
CHNL# 159: [VOLTAGE HOYT 345KV]
2.0000 0.0

CHNL# 156: [VOLTAGE COLBY 115KV]
2.0000 0.0

CHNL# 155: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 146: [VOLTAGE KNOLL 230KV]
2.0000 0.0

CHNL# 145: [VOLTAGE SUMMIT 230KV]
2.0000 0.0



Appendix C-2

Plots of Fault Simulations

Plots of selected machine phase angles during faults

Scenario:
2005 Summer Peak
Wind Farm at 150MW (100% rated power)
Standard Protection Settings

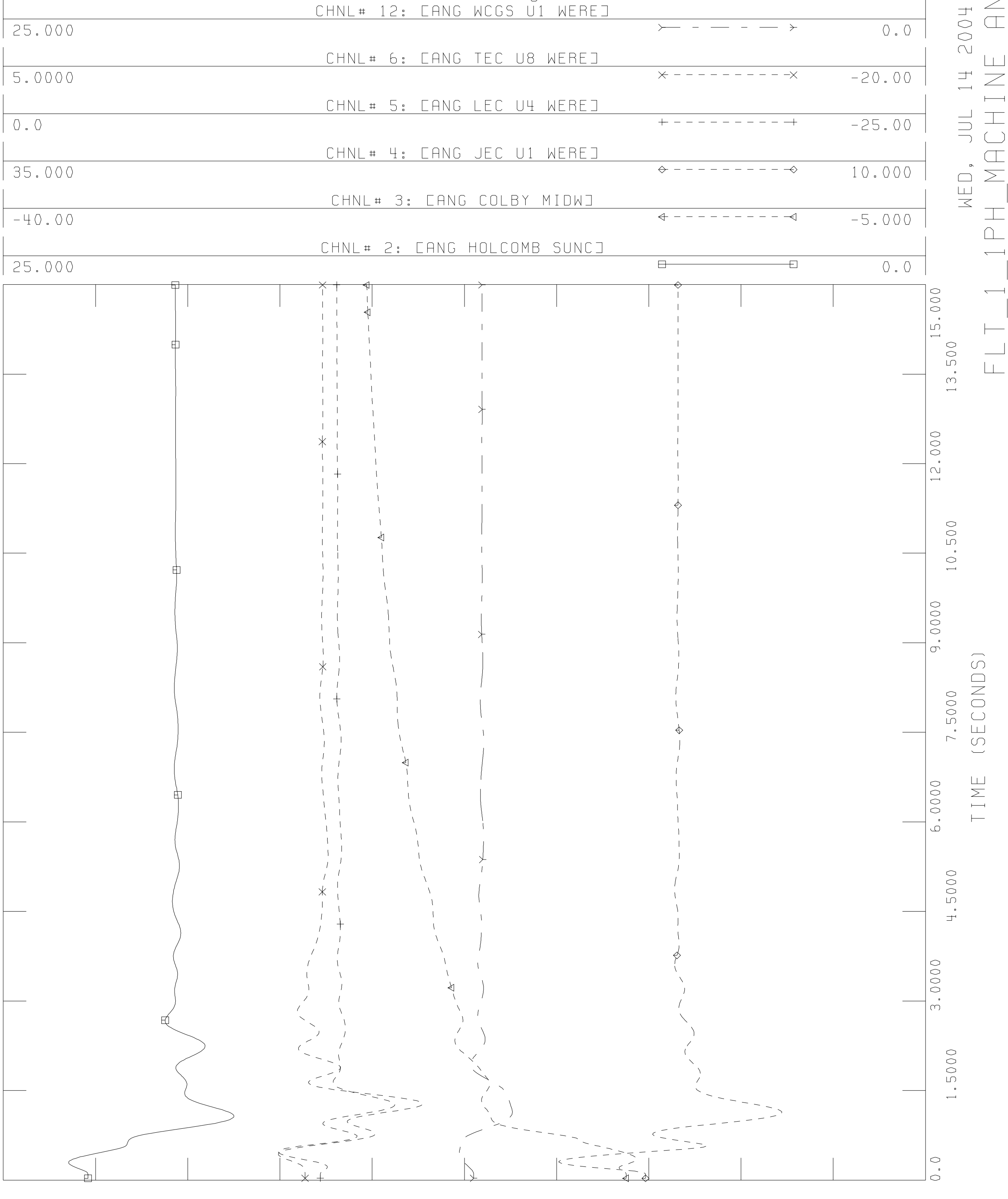
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_1_1PH.OUT

WED, JUL 14 2004 10:36

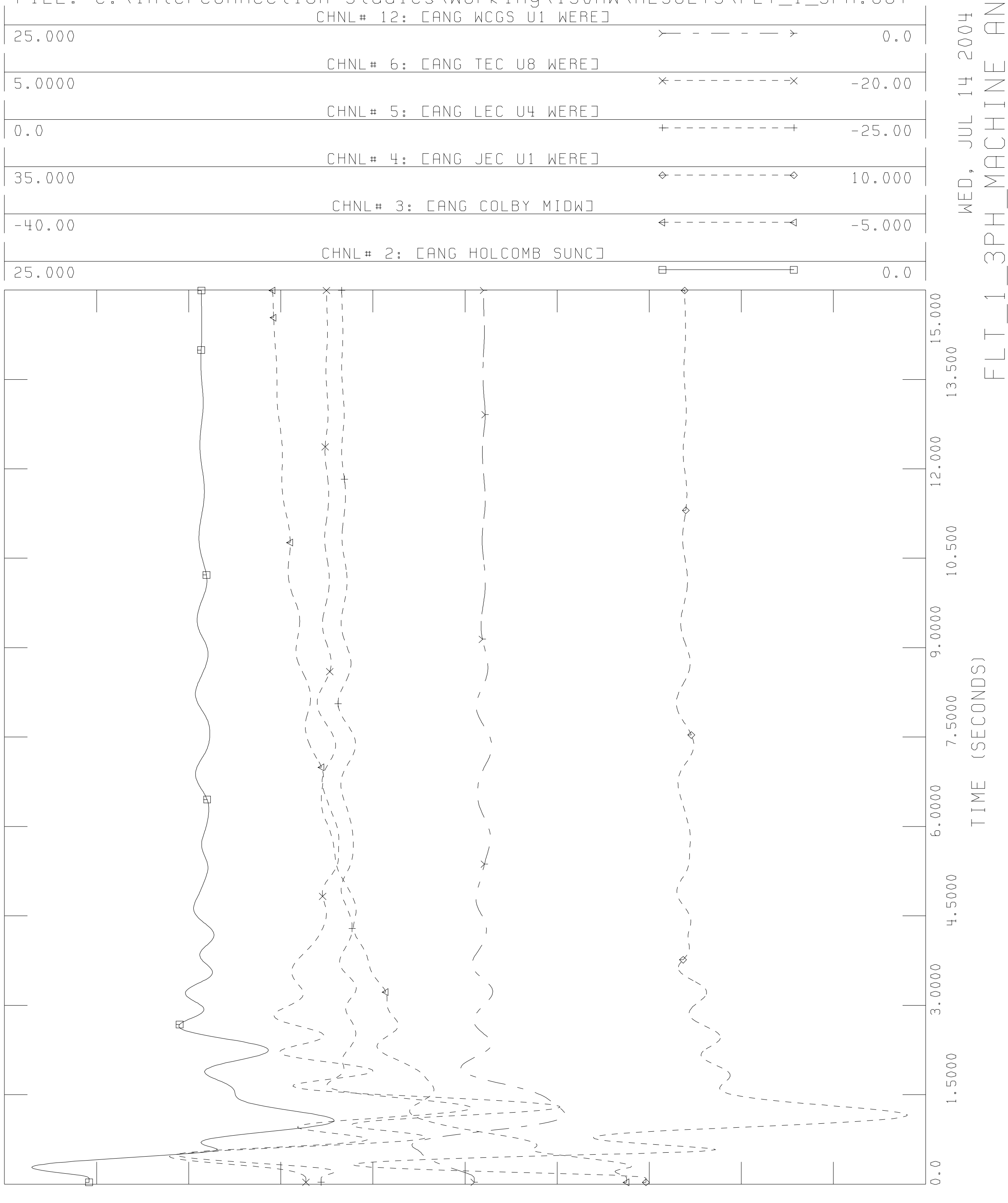
FLT_1_1PH_MACHINE ANGLES



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_1_3PH.OUT



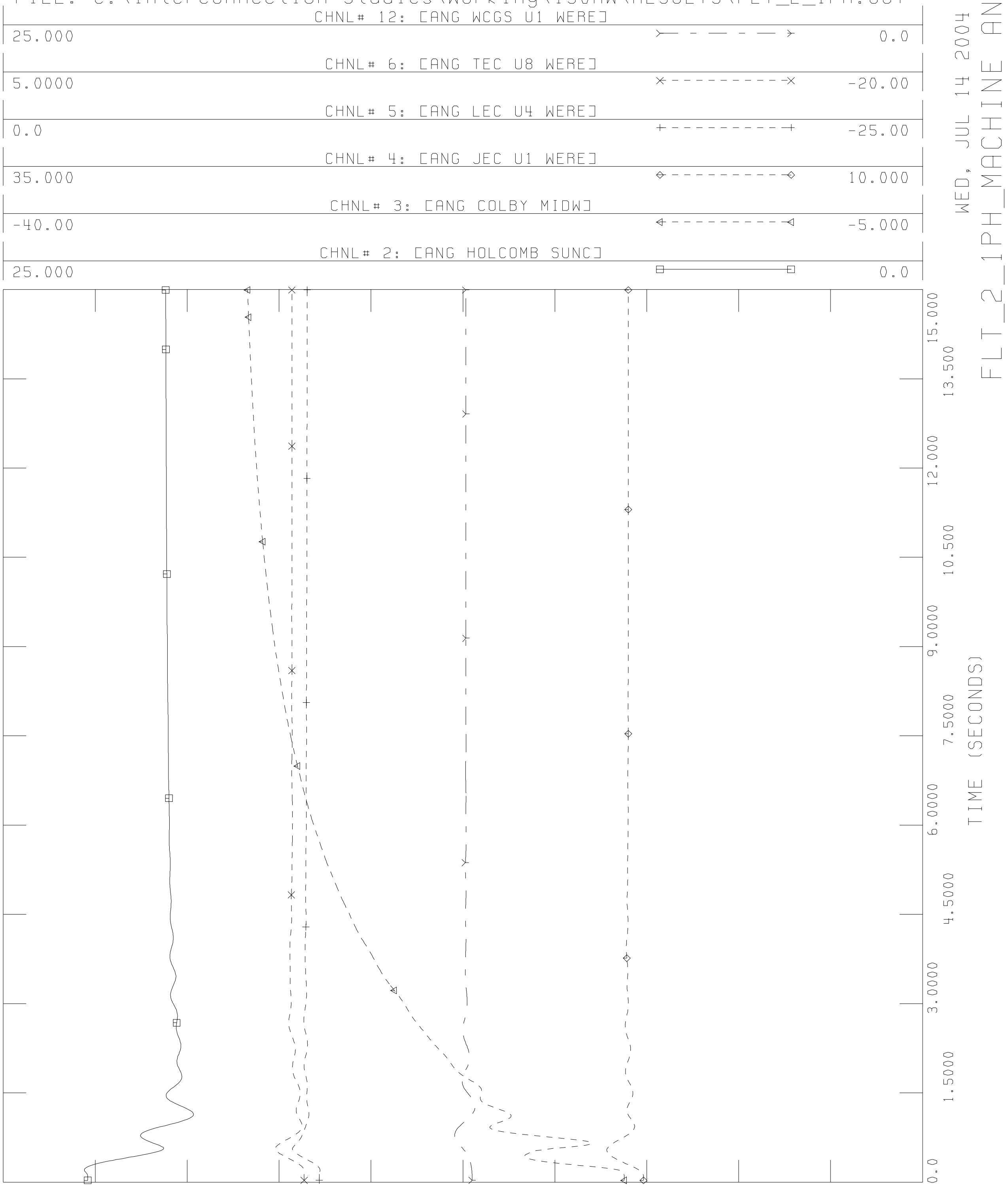
WED, JUL 14 2004 10:36

FLT_1_3PH_MACHINE ANGLES

POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_2_1PH.OUT



WED, JUL 14 2004 10:36
FLT_2_1PH_MACHINE ANGLES

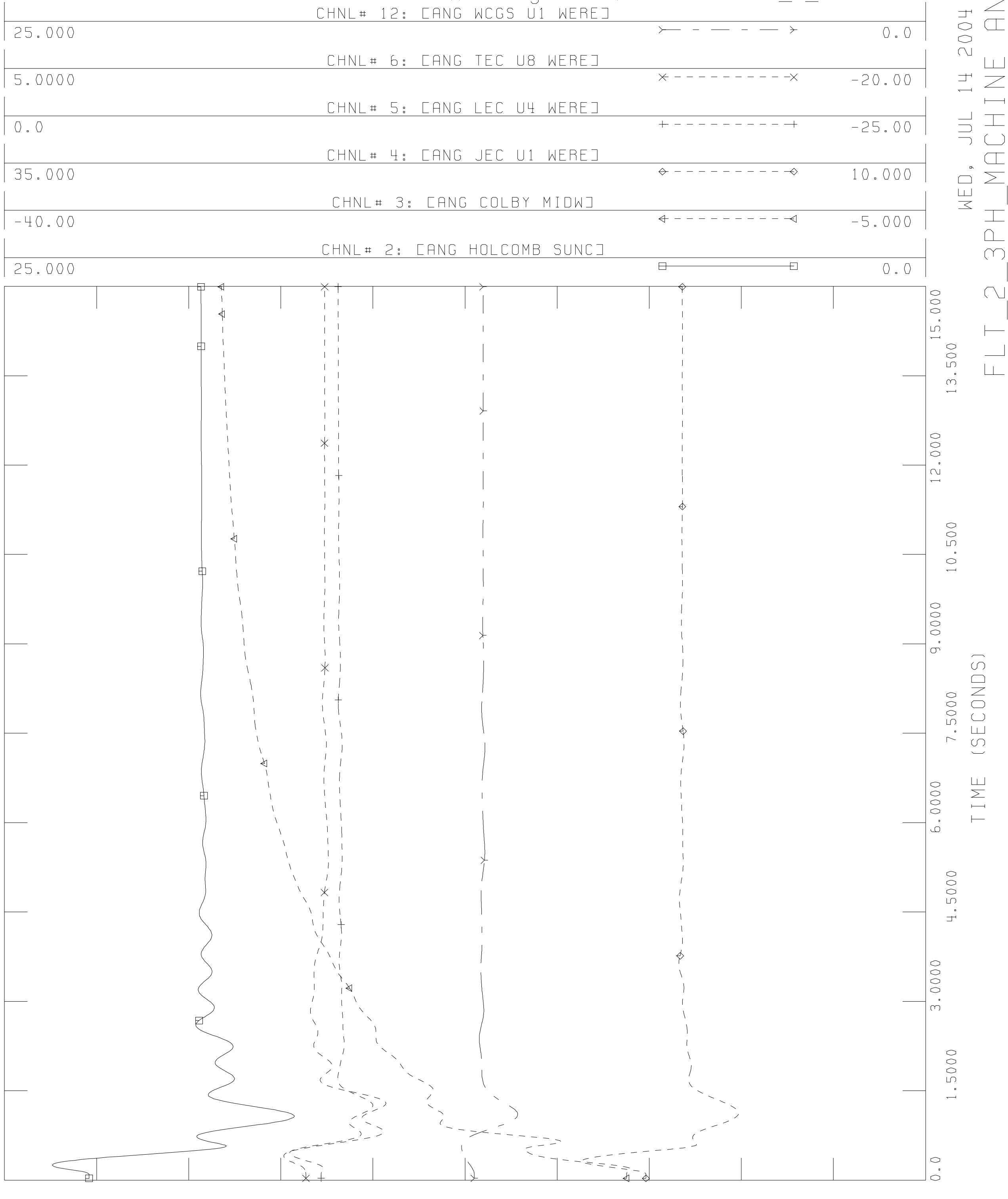
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER TECHNOLOGIES INC.®

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_2_3PH.OUT

WED, JUL 14 2004 10:36

FLT_2_3PH_MACHINE ANGLES



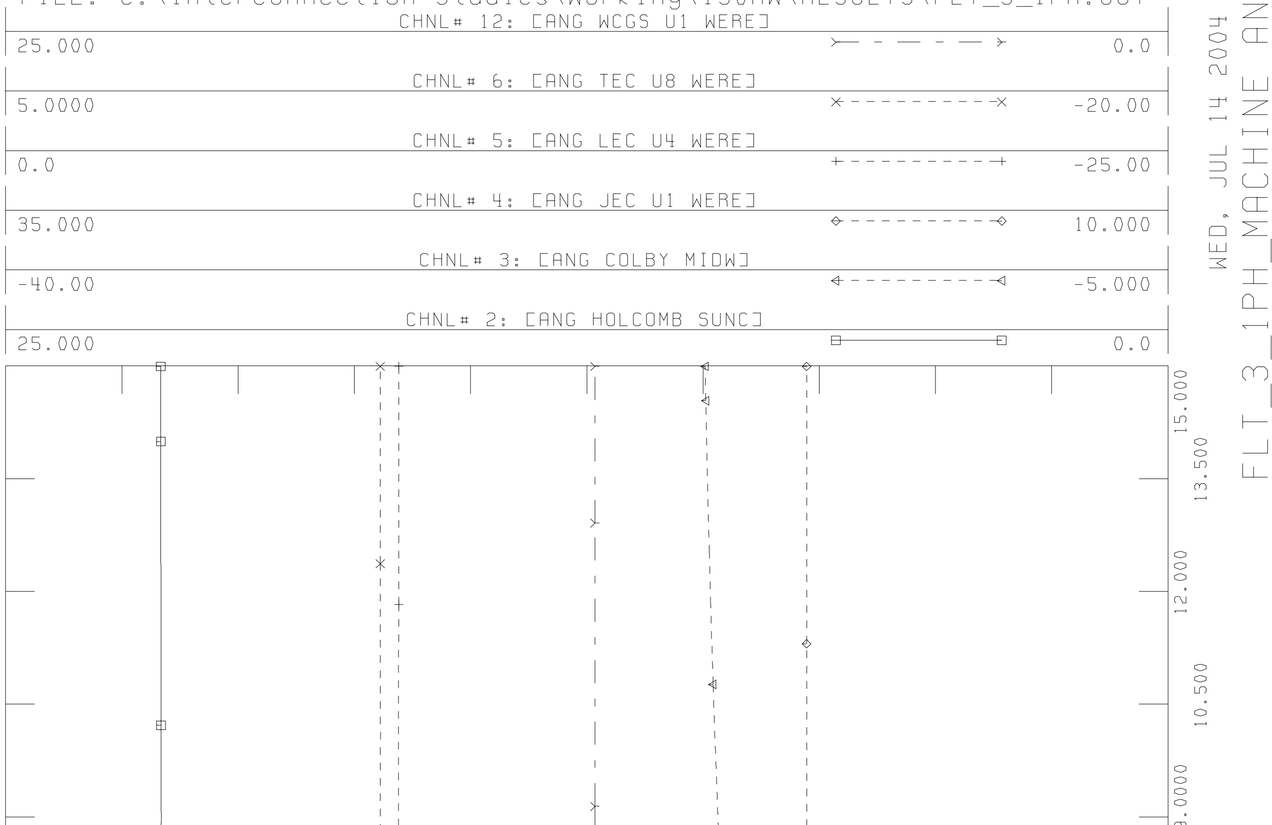
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_3_1PH.OUT

WED, JUL 14 2004 10:36

FLT_3_1PH_MACHINE ANGLES



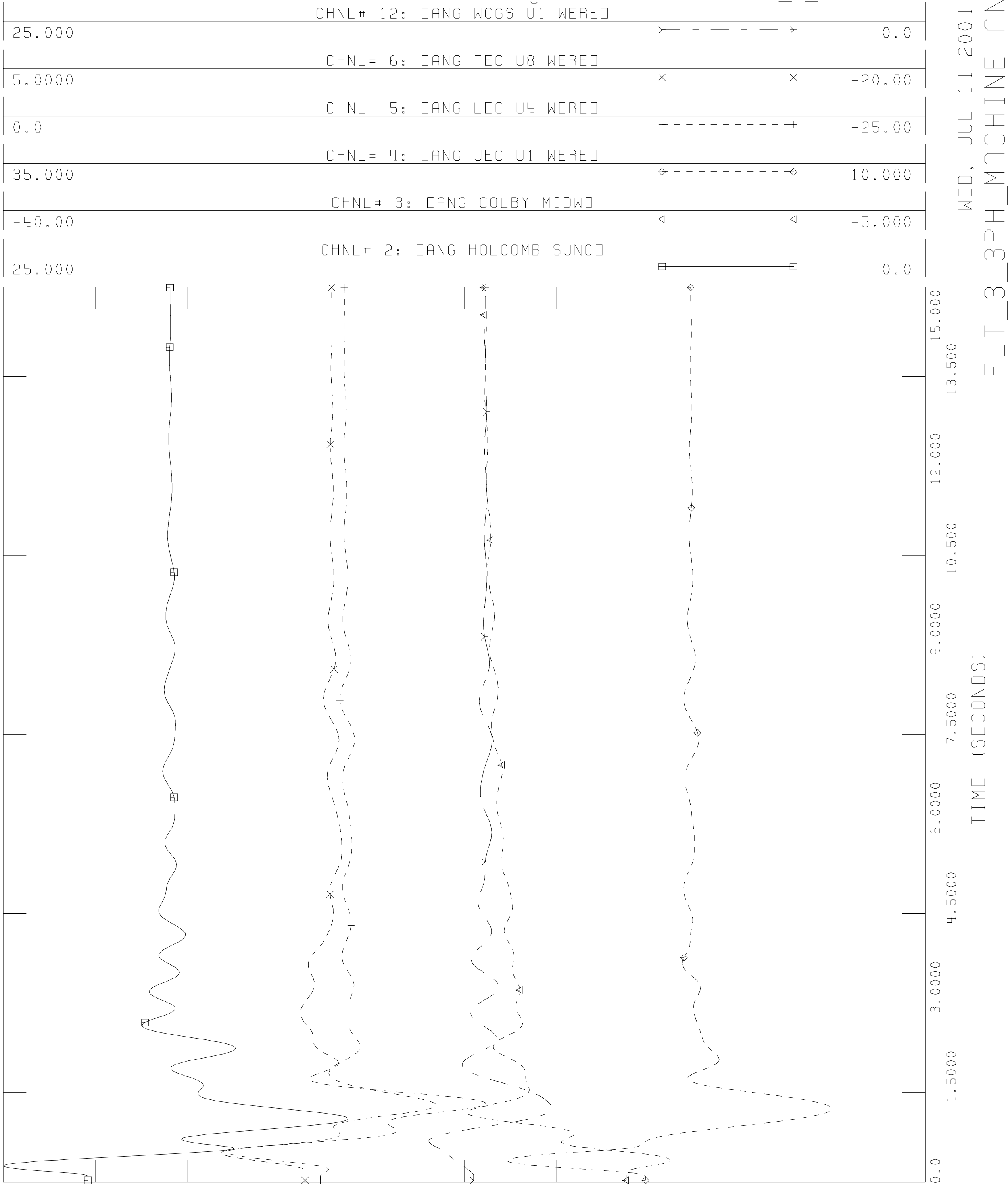
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER TECHNOLOGIES INC.®

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_3_3PH.OUT

WED, JUL 14 2004 10:36

FLT_3_3PH_MACHINE ANGLES

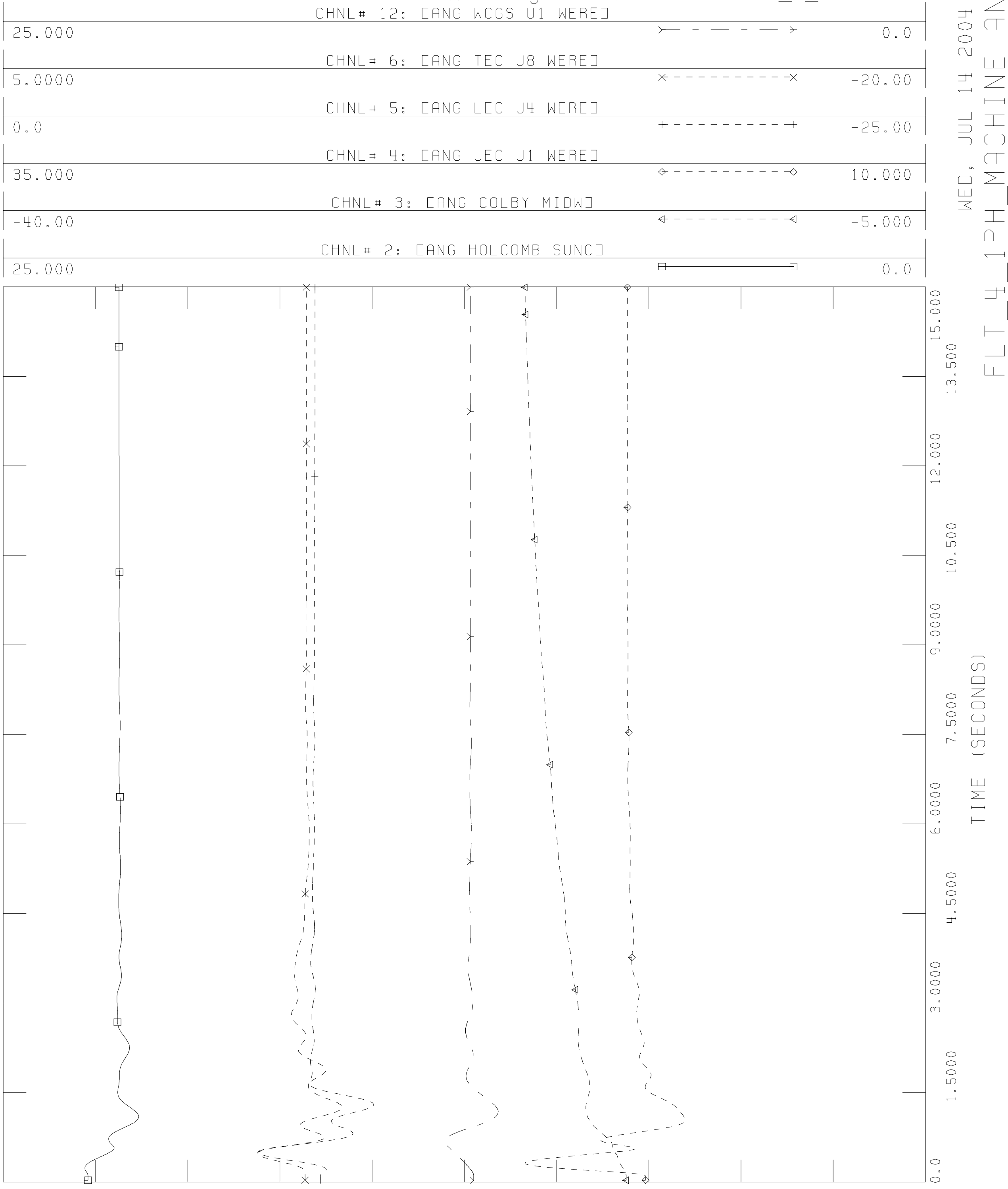


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER
TECHNOLOGIES
INC.®

WED, JUL 14 2004 10:36
FLT_4_1PH_MACHINE ANGLES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_4_1PH.OUT



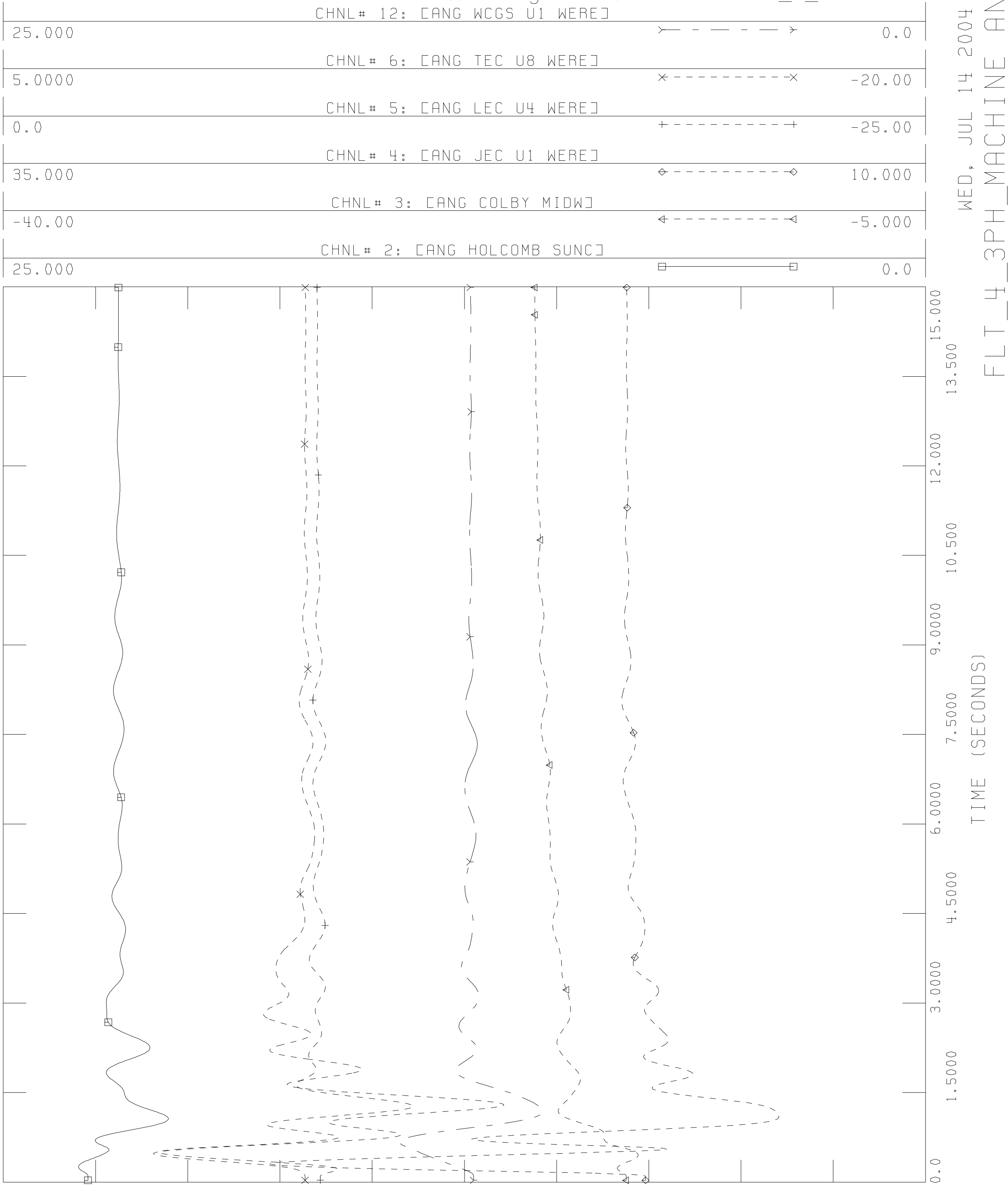
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_4_3PH.OUT

WED, JUL 14 2004 10:36

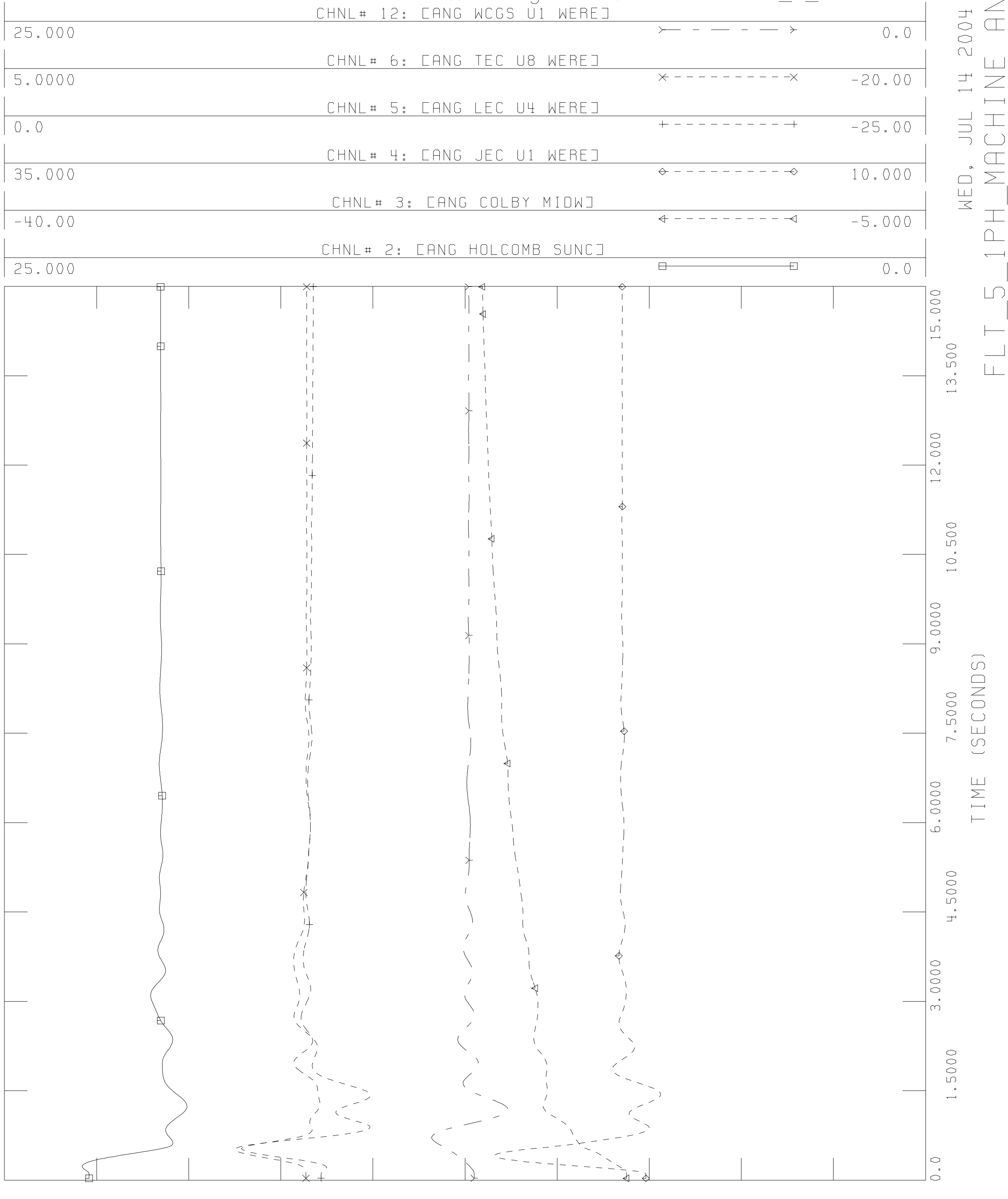
FLT_4_3PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_5_1PH.OUT



FLT_5_1PH_MACHINE ANGLES

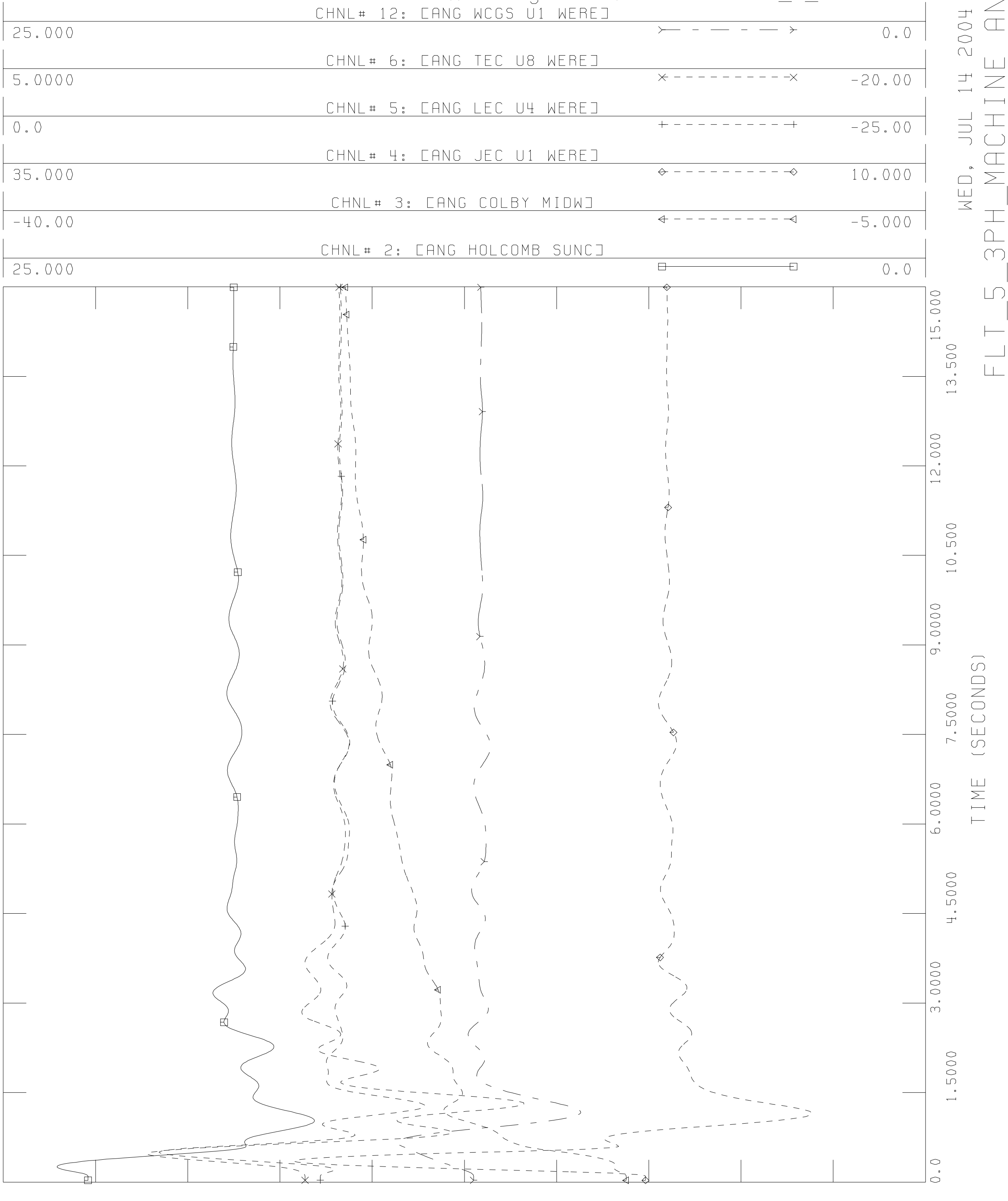
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER TECHNOLOGIES INC.®

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_5_3PH.OUT

WED, JUL 14 2004 10:36

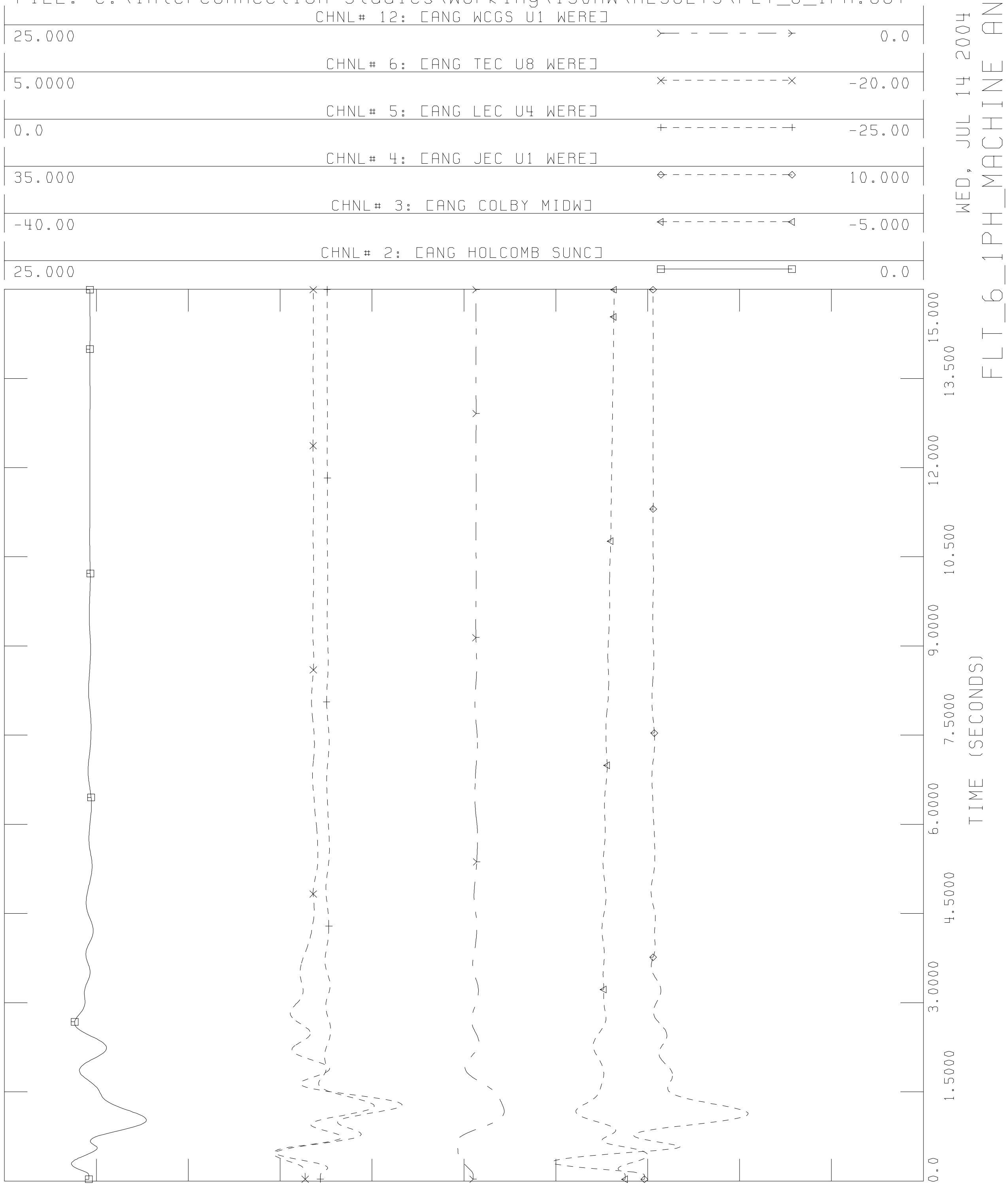
FLT_5_3PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_6_1PH.OUT



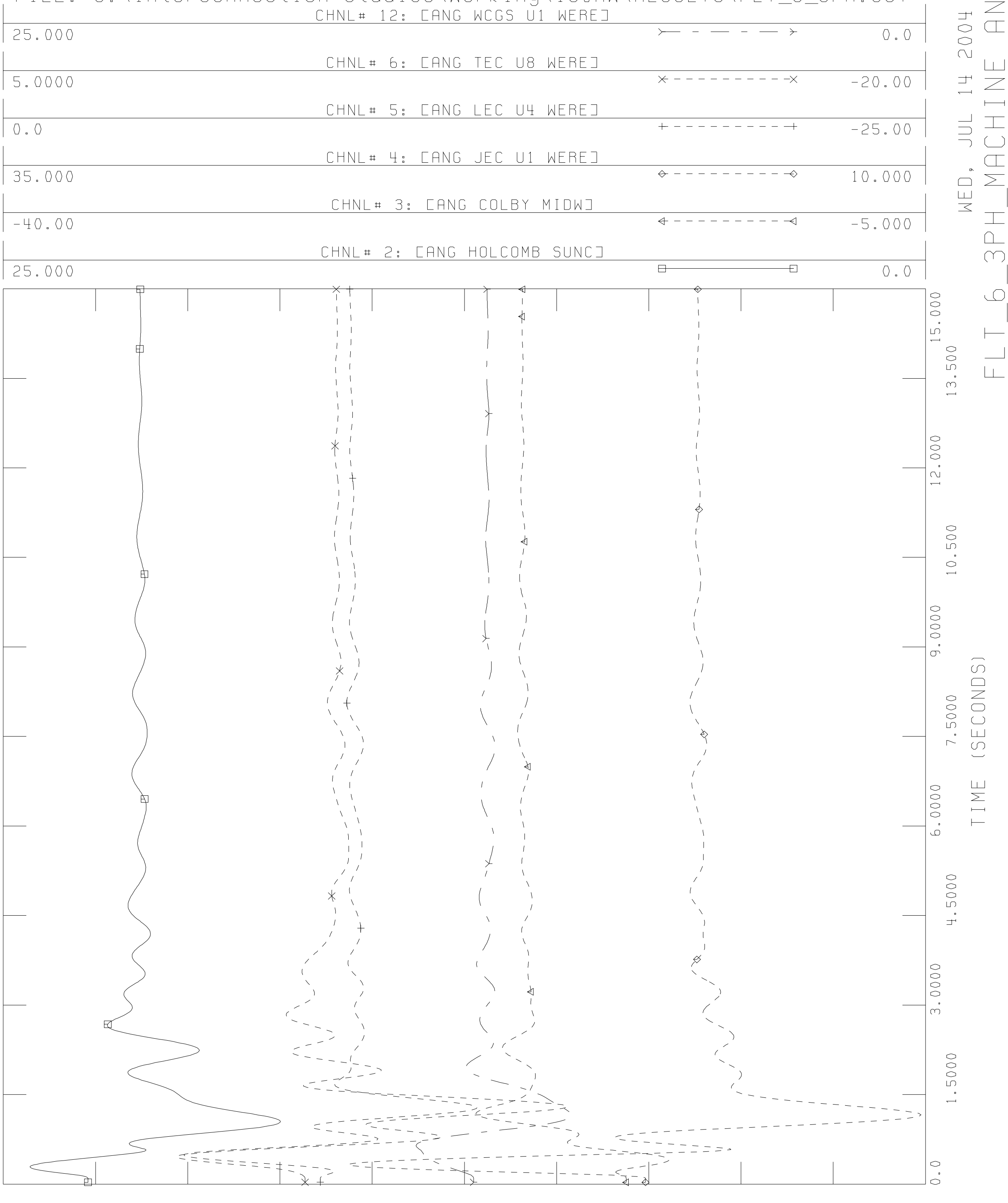
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:36

FLT_6_3PH_MACHINE ANGLES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_6_3PH.OUT

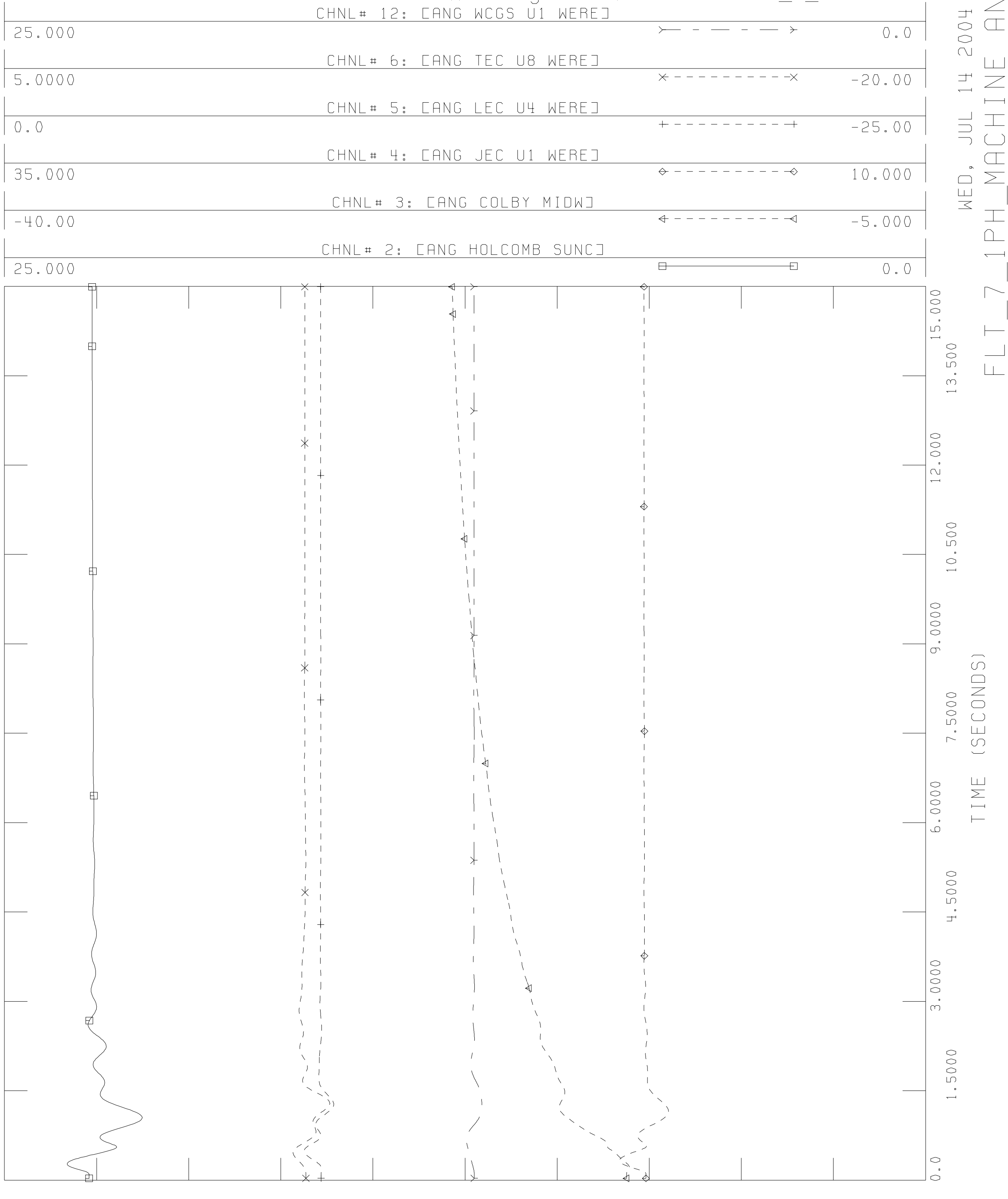


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_7_1PH.OUT

WED, JUL 14 2004 10:36

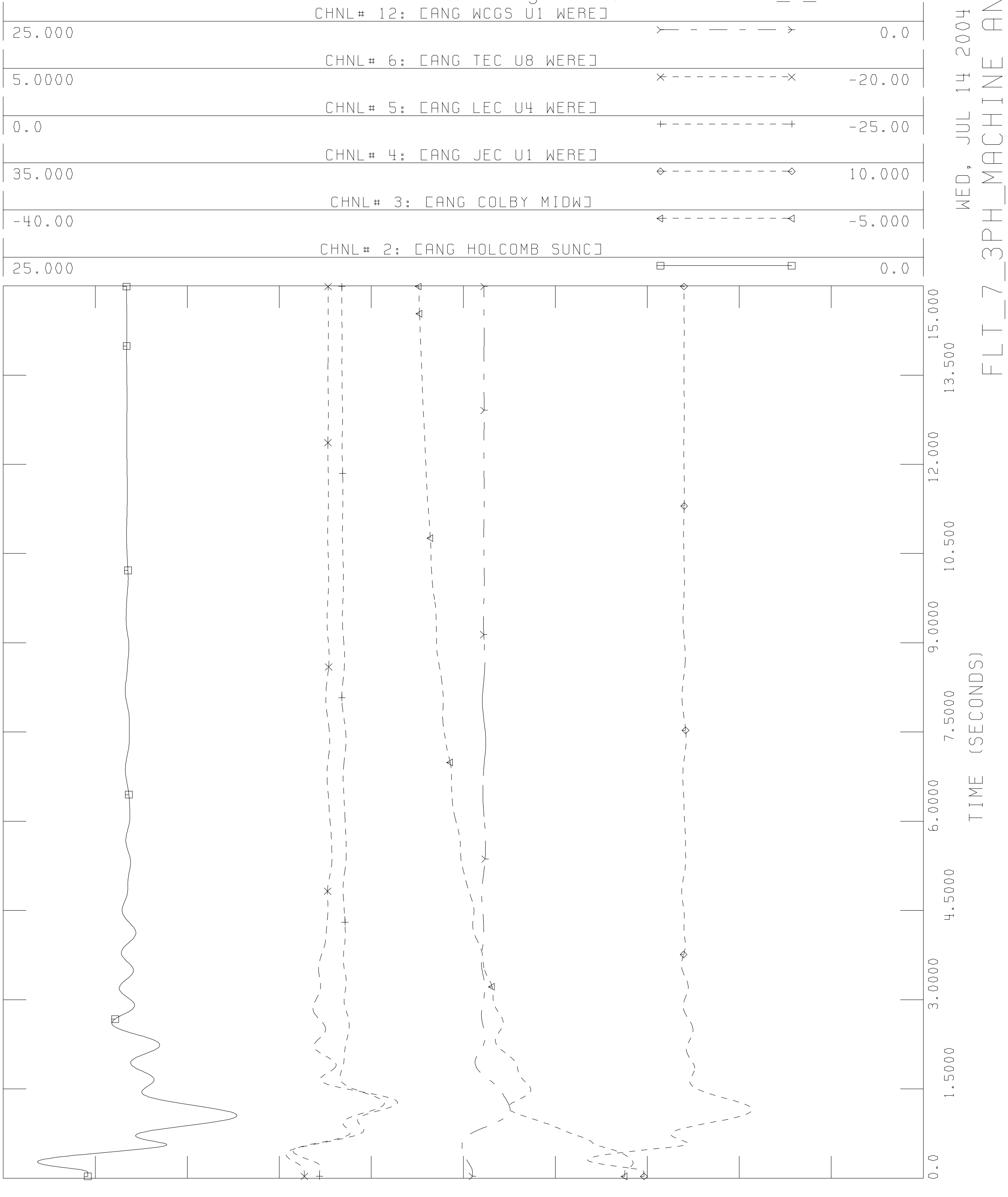
FLT_7_1PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

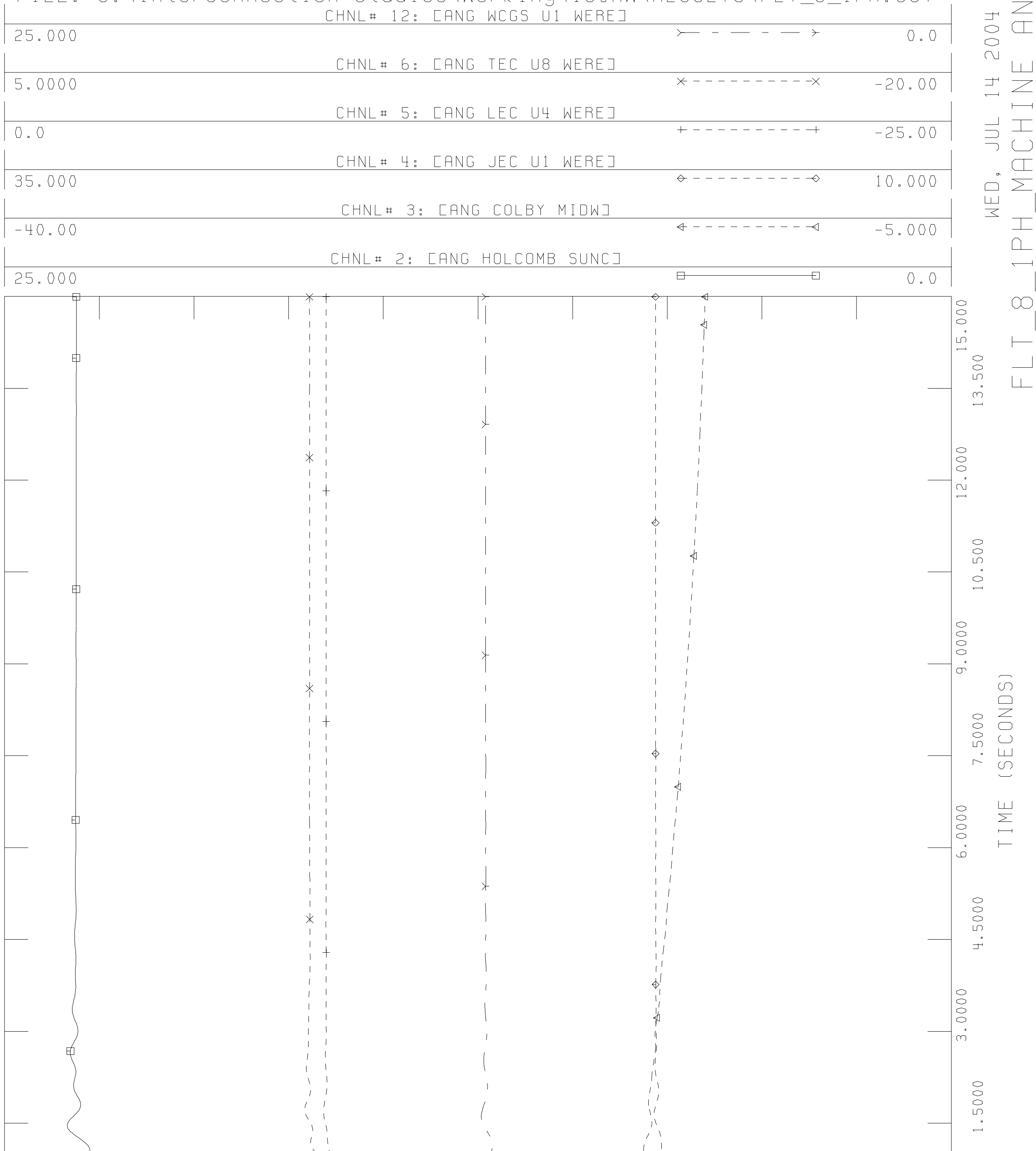
FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_7_3PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_8_1PH.OUT



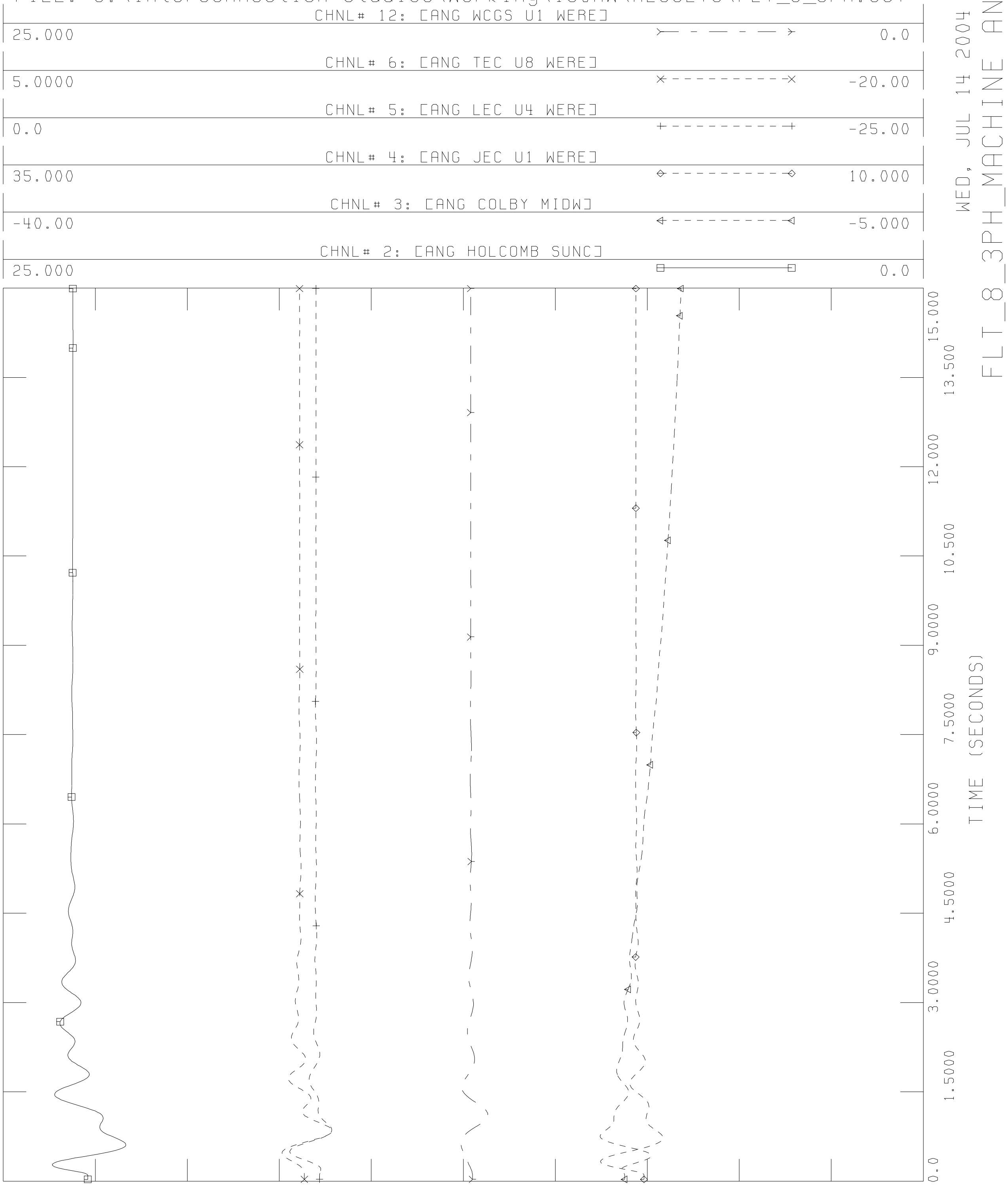
WED, JUL 14 2004 10:36

FLT_8_1PH_MACHINE ANGLES

POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

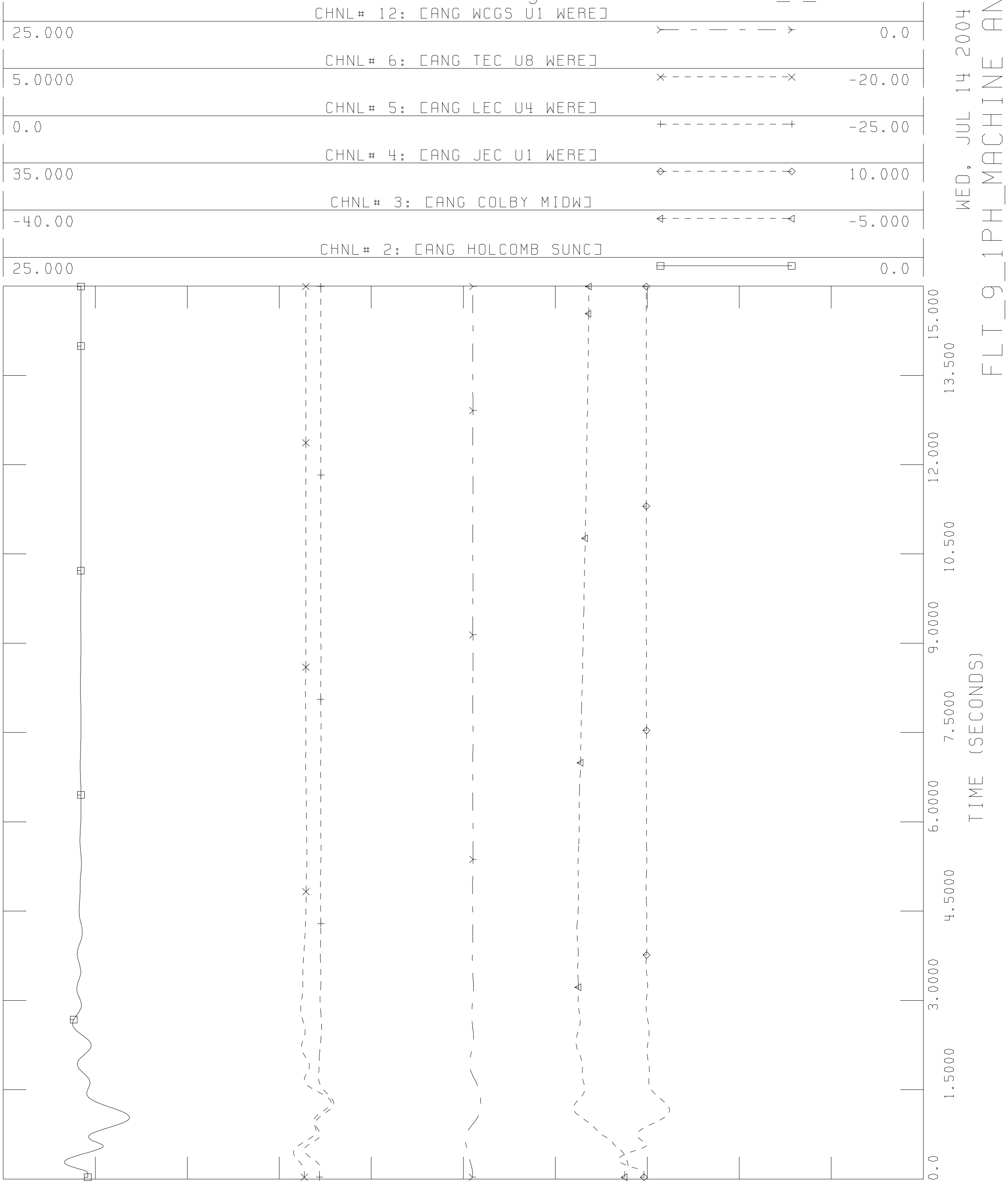
FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_8_3PH.OUT



POWER
TECHNOLOGIES
INC.®

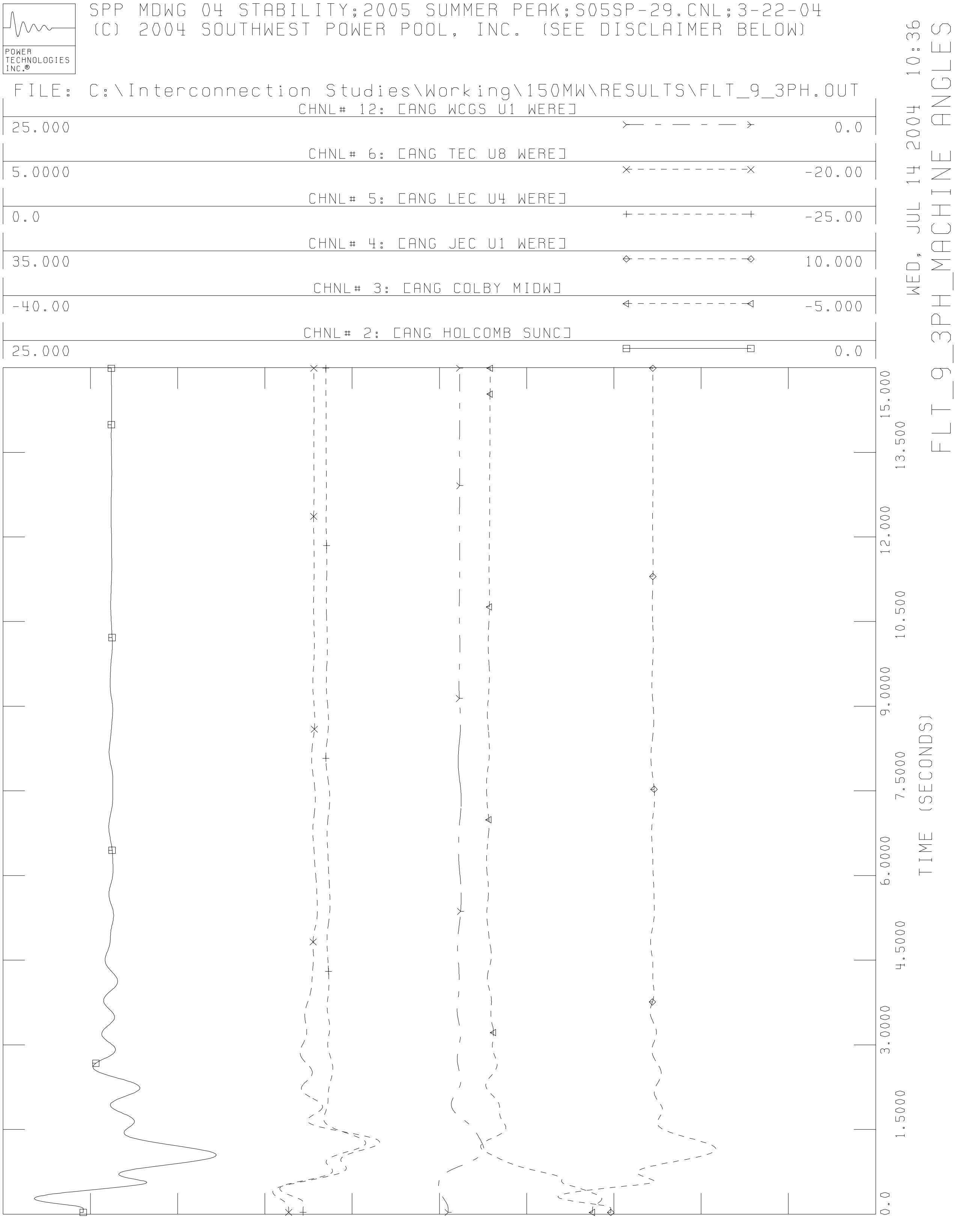
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_9_1PH.OUT



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_9_3PH.OUT



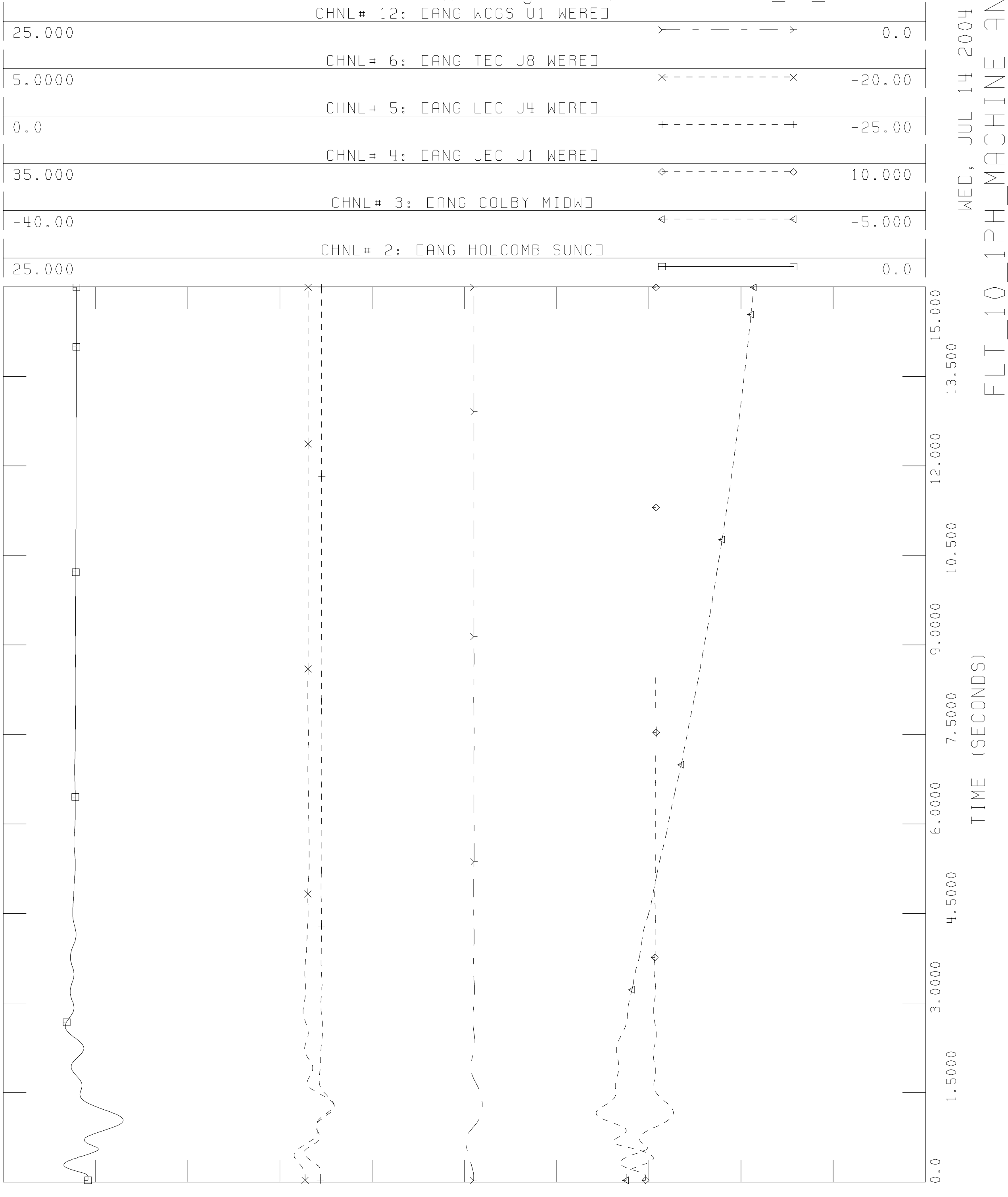
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_10_1PH.OUT

WED, JUL 14 2004 10:36

FLT_10_1PH_MACHINE ANGLES



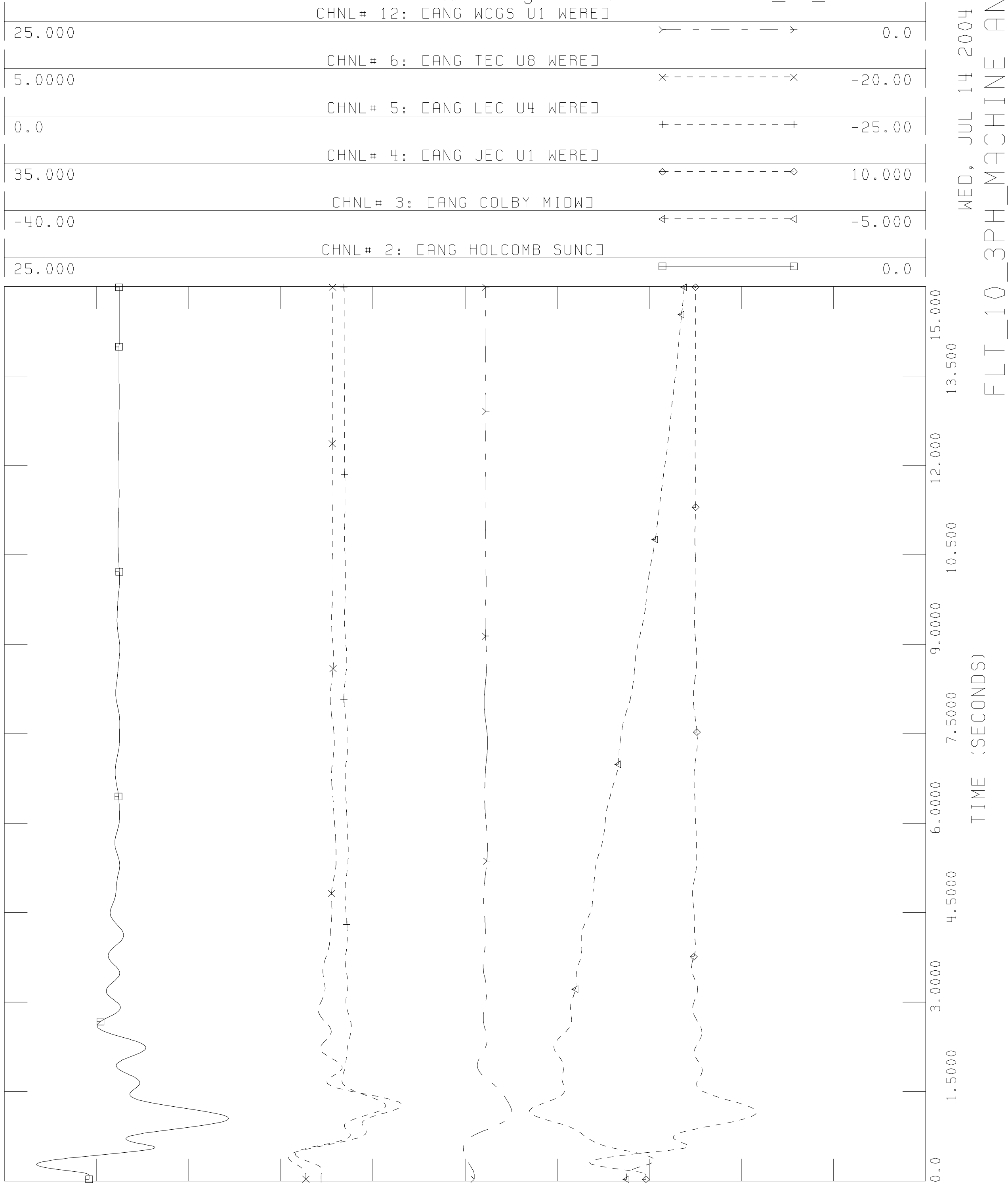
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 10:36

FLT_10_3PH_MACHINE ANGLES

FILE: C:\Interconnection Studies\Working\150MW\RESULTS\FLT_10_3PH.OUT



Appendix D-1

Plots of Fault Simulations

Plots of selected bus voltage response during faults

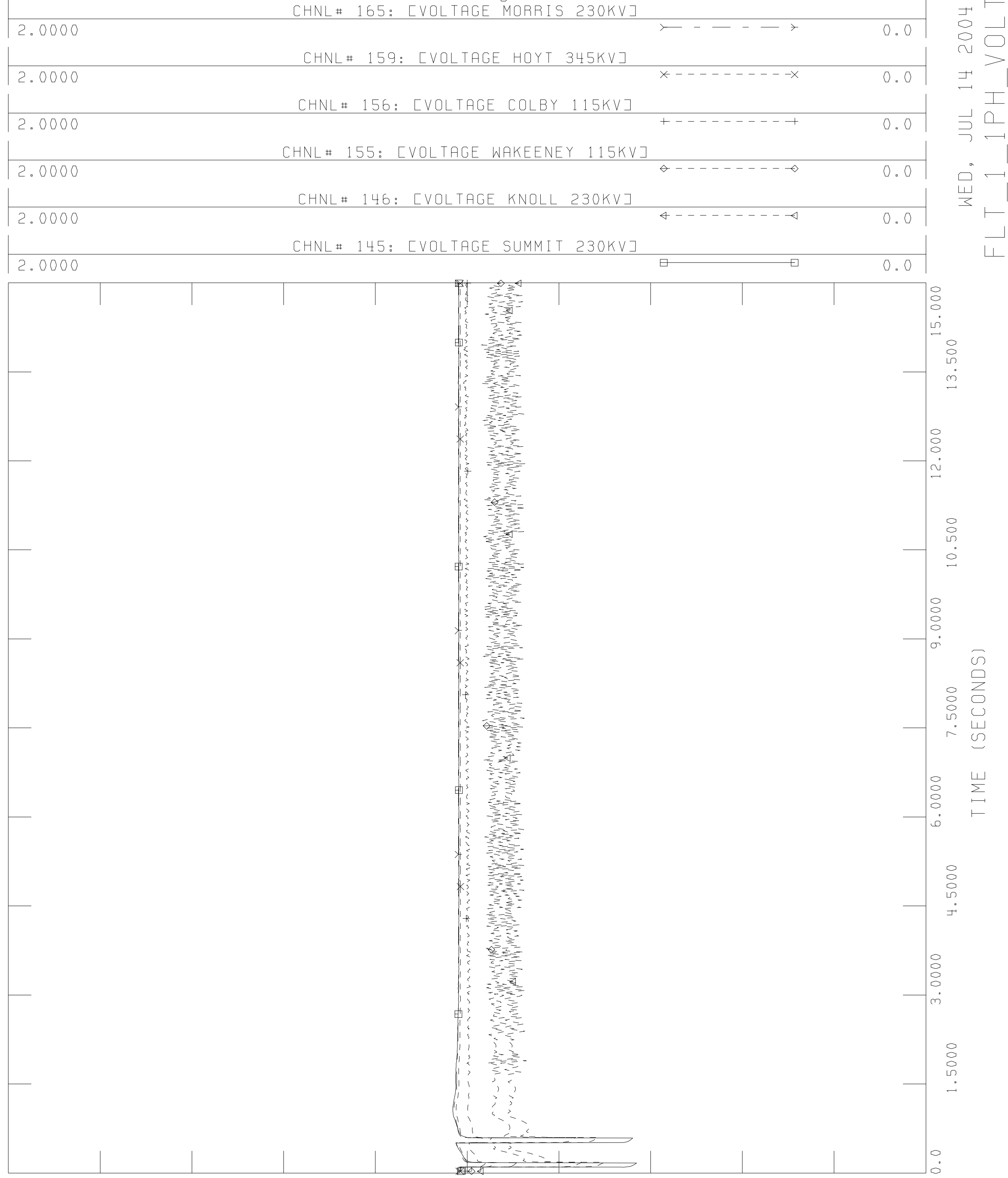
Scenario:
2005 Summer Peak
Wind Farm at 150MW (100% rated power)
AGO4 Protection Settings

POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_1_1PH.OUT

WED, JUL 14 2004 13:39
FLT_1_1PH_VOLTAGES

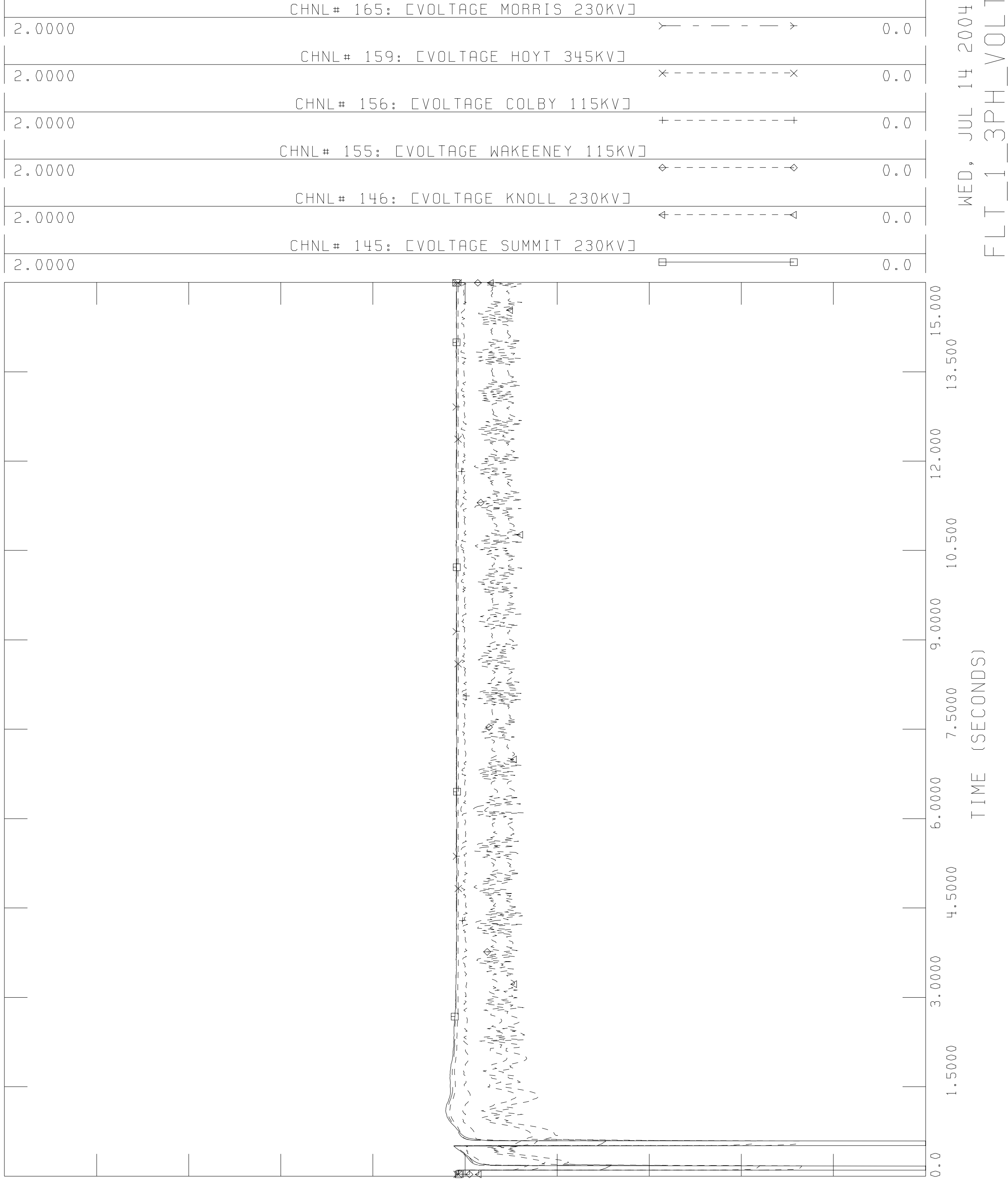


POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_1_3PH.OUT

WED, JUL 14 2004 13:39
FLT_1_3PH_VOLTAGES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 13:39
FLT_2_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_2_1PH.OUT

CHNL# 165: [VOLTAGE MORRIS 230KV]
2.0000 ≻- — - — -≻ 0.0

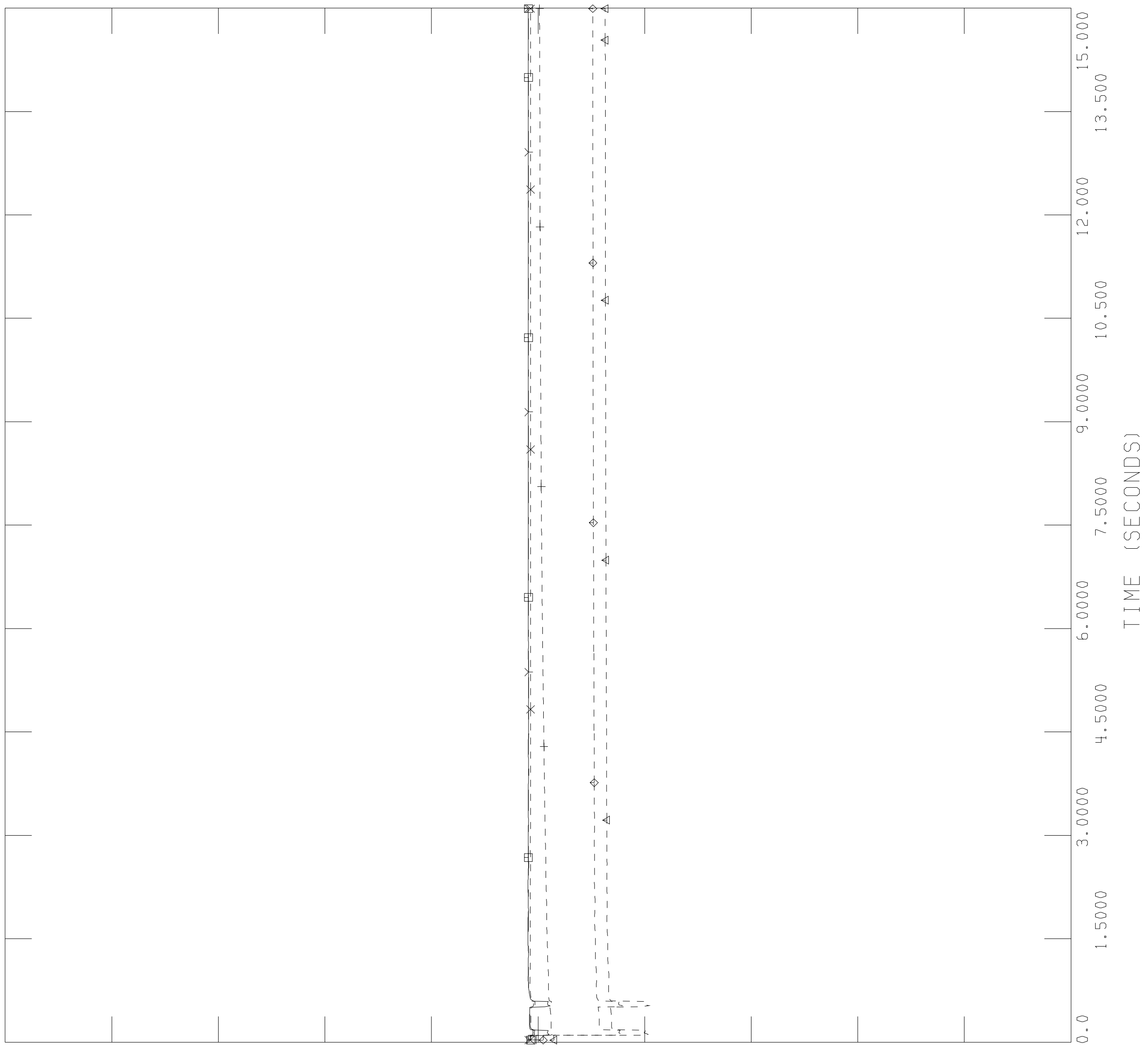
CHNL# 159: [VOLTAGE HOYT 345KV]
2.0000 ×----------× 0.0

CHNL# 156: [VOLTAGE COLBY 115KV]
2.0000 +----------+ 0.0

CHNL# 155: [VOLTAGE WAKEENEY 115KV]
2.0000 ◇----------◇ 0.0

CHNL# 146: [VOLTAGE KNOLL 230KV]
2.0000 ◁----------◁ 0.0

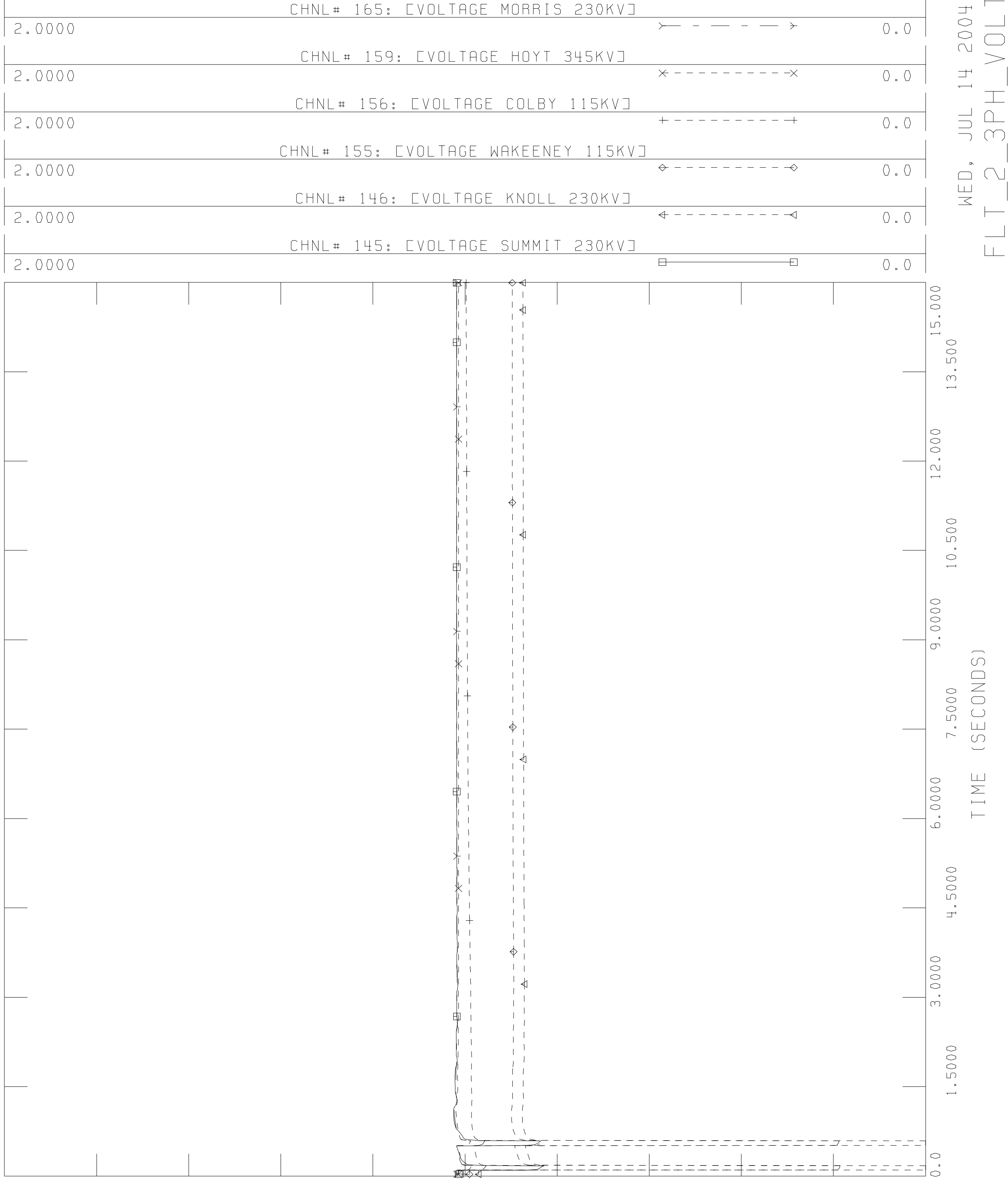
CHNL# 145: [VOLTAGE SUMMIT 230KV]
2.0000 □——————□ 0.0



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_2_3PH.OUT



WED, JUL 14 2004 13:39
FLT_2_3PH_VOLTAGES

POWER
TECHNOLOGIES
INC.®

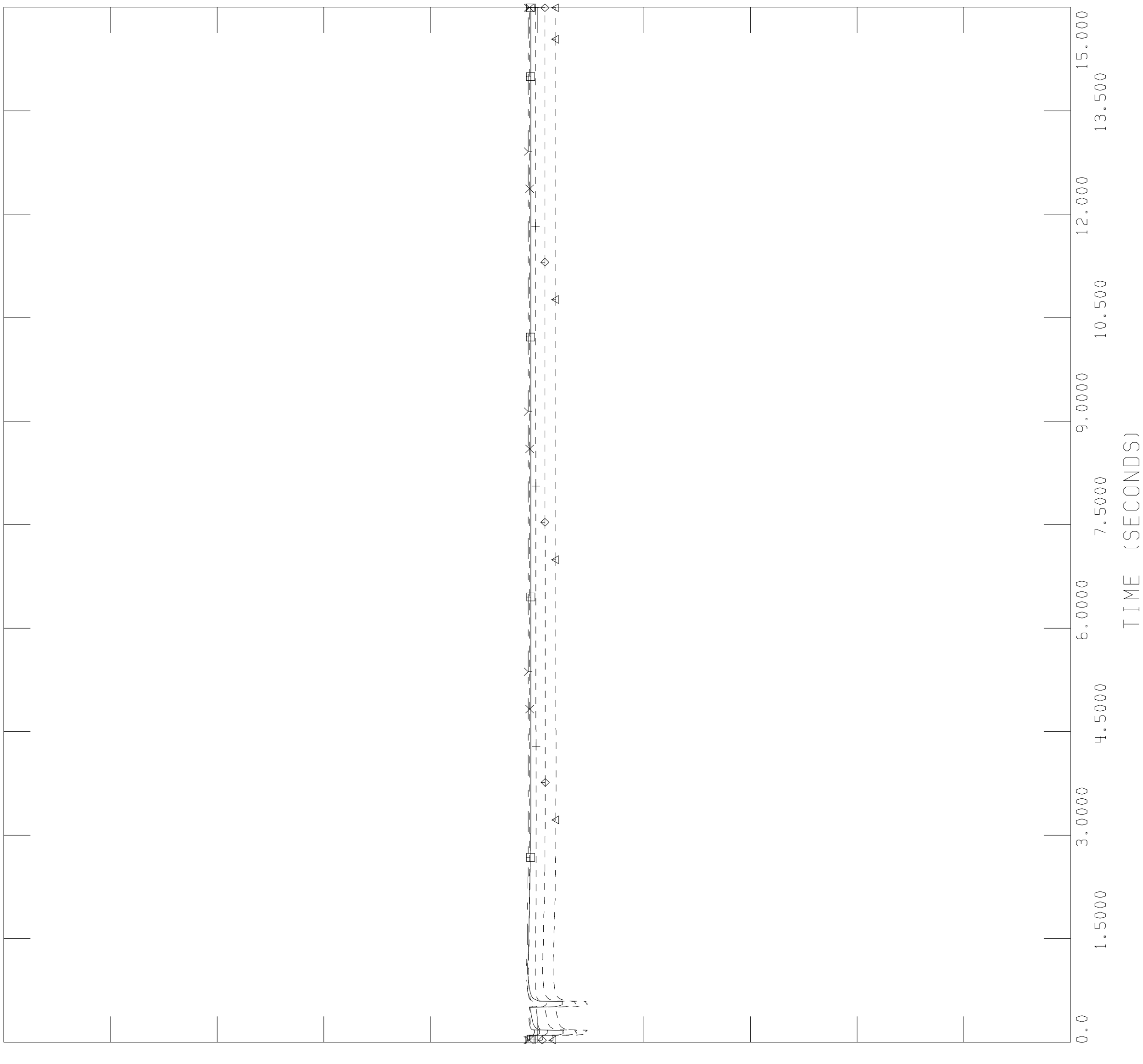
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 13:39

FLT_3_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_3_1PH.OUT

CHNL# 165: [VOLTAGE MORRIS 230KV]		
2.0000	≻ - — - — ≻	0.0
CHNL# 159: [VOLTAGE HOYT 345KV]		
2.0000	× - - - - - - - - - - ×	0.0
CHNL# 156: [VOLTAGE COLBY 115KV]		
2.0000	+ - - - - - - - - - - +	0.0
CHNL# 155: [VOLTAGE WAKEENEY 115KV]		
2.0000	◇ - - - - - - - - - - ◇	0.0
CHNL# 146: [VOLTAGE KNOLL 230KV]		
2.0000	◁ - - - - - - - - - - ◁	0.0
CHNL# 145: [VOLTAGE SUMMIT 230KV]		
2.0000	□——————□	0.0

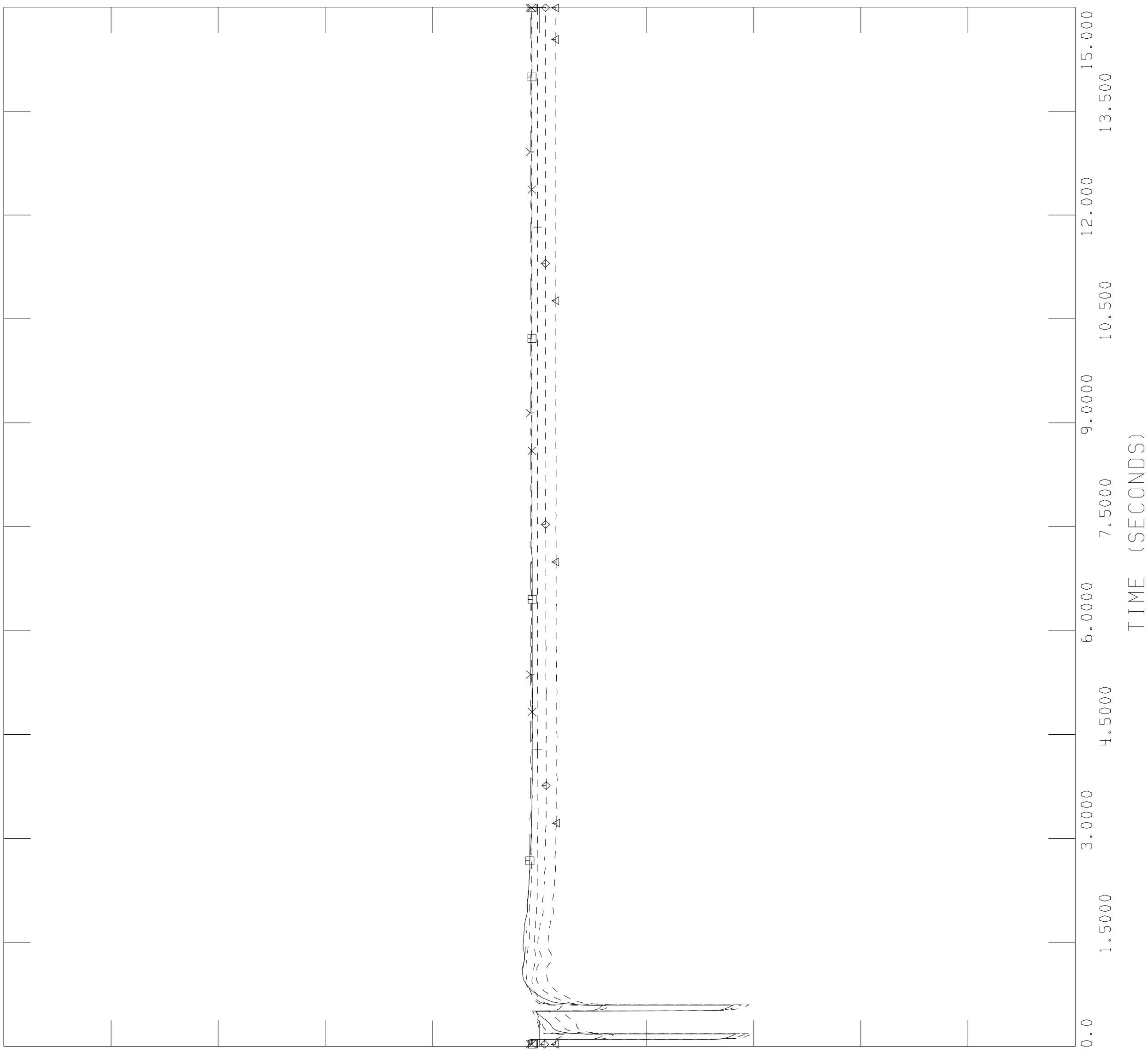


POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_3_3PH.OUT

CHNL# 165: [VOLTAGE MORRIS 230KV]		
2.0000	Y- - — - — Y	0.0
CHNL# 159: [VOLTAGE HOYT 345KV]		
2.0000	×- - - - - - - - - -×	0.0
CHNL# 156: [VOLTAGE COLBY 115KV]		
2.0000	+- - - - - - - - - -+	0.0
CHNL# 155: [VOLTAGE WAKEENEY 115KV]		
2.0000	◇- - - - - - - - - -◇	0.0
CHNL# 146: [VOLTAGE KNOLL 230KV]		
2.0000	◁- - - - - - - - - -◁	0.0
CHNL# 145: [VOLTAGE SUMMIT 230KV]		
2.0000	□———————□	0.0



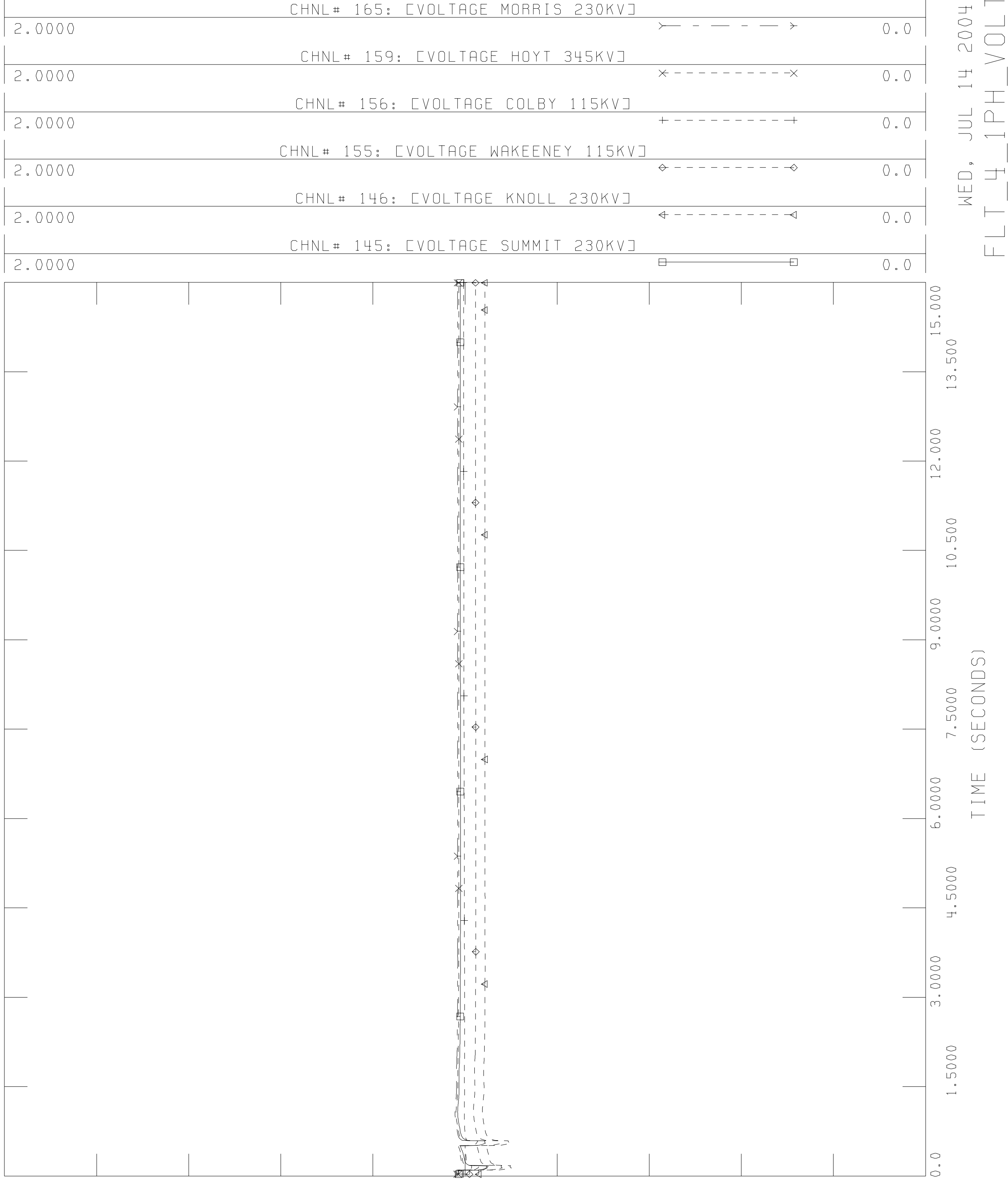
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 13:39

FLT_4_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_4_1PH.OUT



POWER
TECHNOLOGIES
INC.®

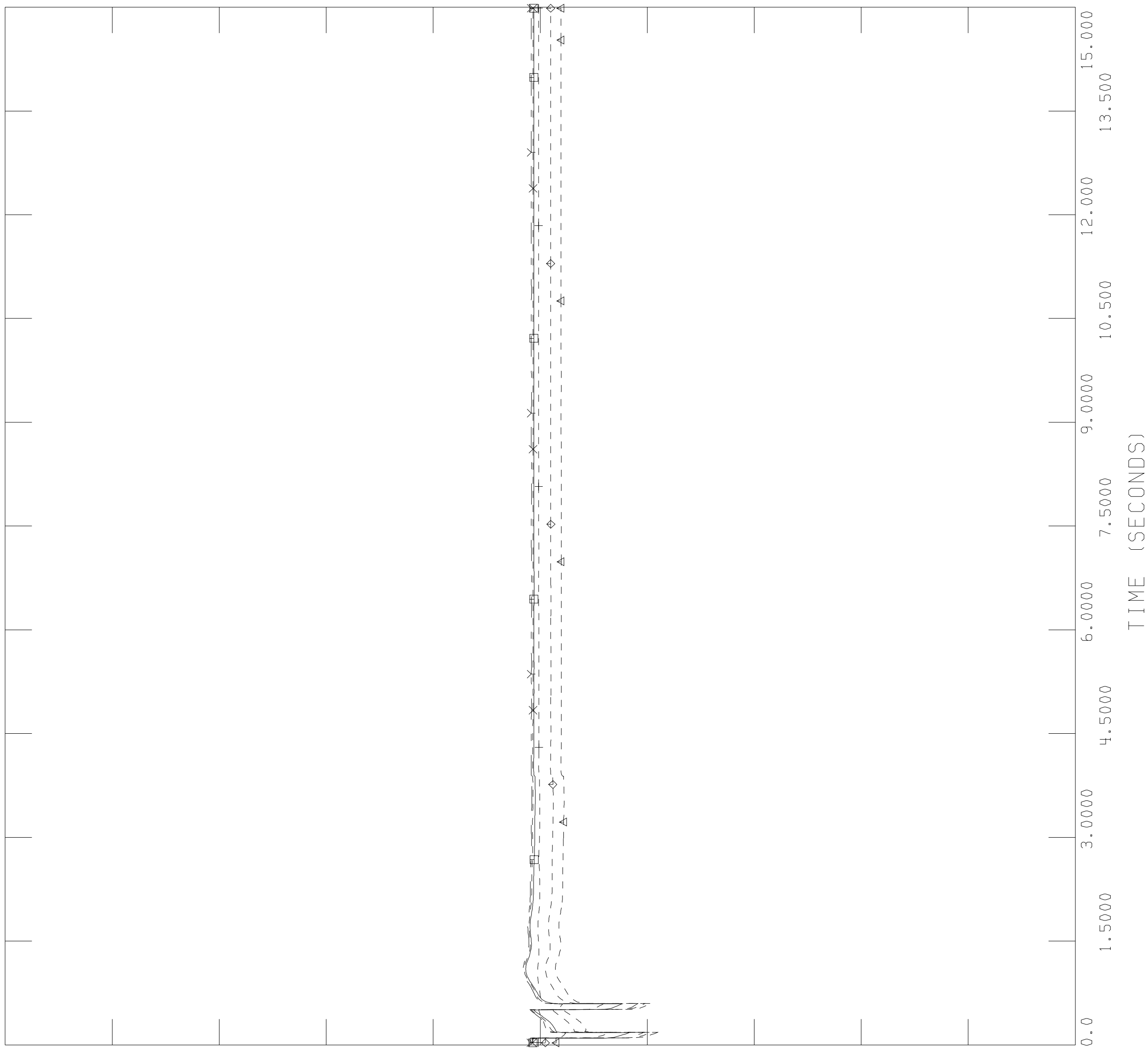
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 13:39

FLT_4_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_4_3PH.OUT

CHNL# 165: [VOLTAGE MORRIS 230KV]		
2.0000	≻— - — - —≻	0.0
CHNL# 159: [VOLTAGE HOYT 345KV]		
2.0000	×----------×	0.0
CHNL# 156: [VOLTAGE COLBY 115KV]		
2.0000	+----------+	0.0
CHNL# 155: [VOLTAGE WAKEENEY 115KV]		
2.0000	◇----------◇	0.0
CHNL# 146: [VOLTAGE KNOLL 230KV]		
2.0000	◁----------◁	0.0
CHNL# 145: [VOLTAGE SUMMIT 230KV]		
2.0000	□——————□	0.0

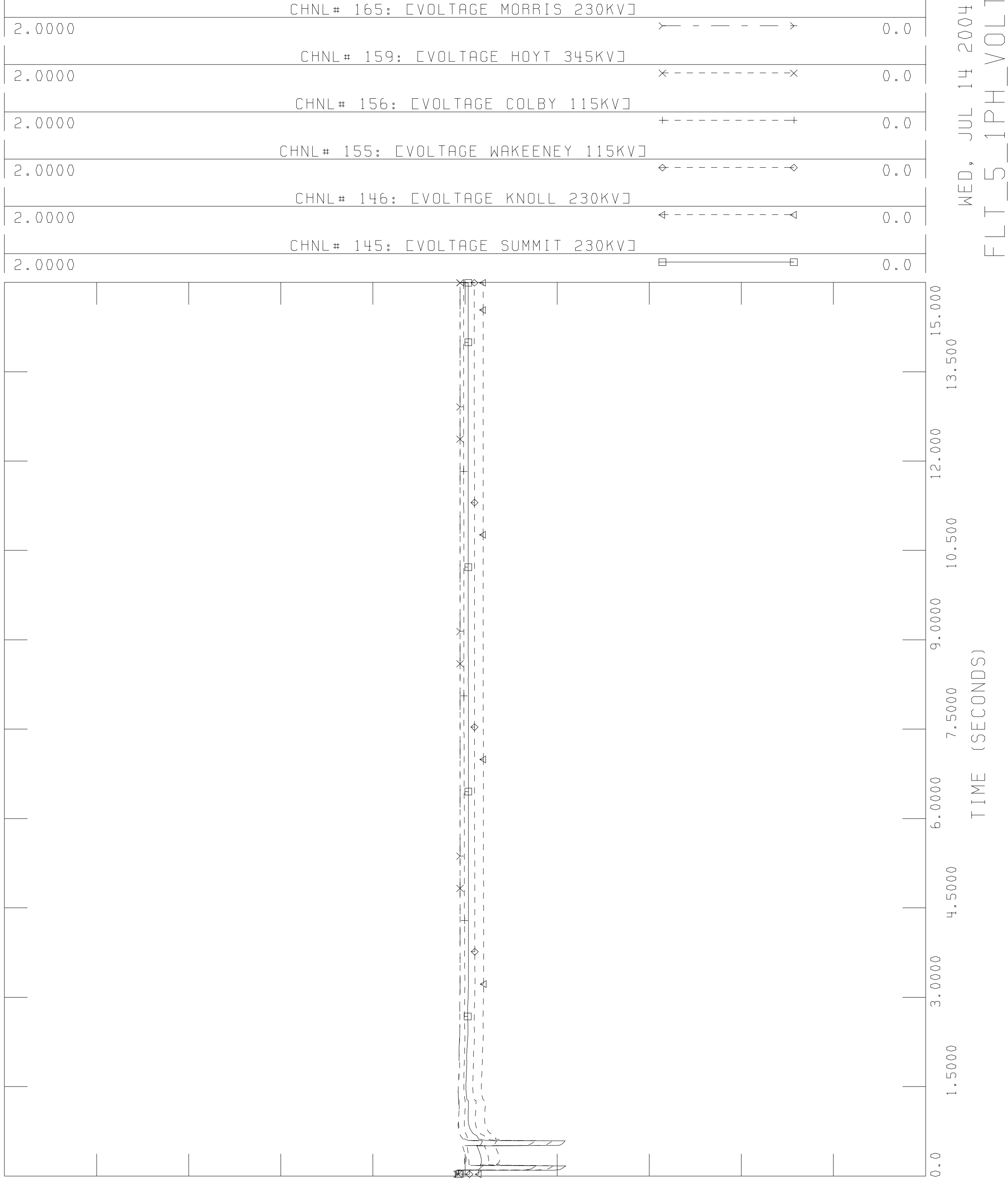


POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_5_1PH.OUT

WED, JUL 14 2004 13:39
FLT_5_1PH_VOLTAGES



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER
TECHNOLOGIES
INC.®

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_5_3PH.OUT

WED, JUL 14 2004 13:39

FLT_5_3PH_VOLTAGES

CHNL# 165: [VOLTAGE MORRIS 230KV] 2.0000 0.0

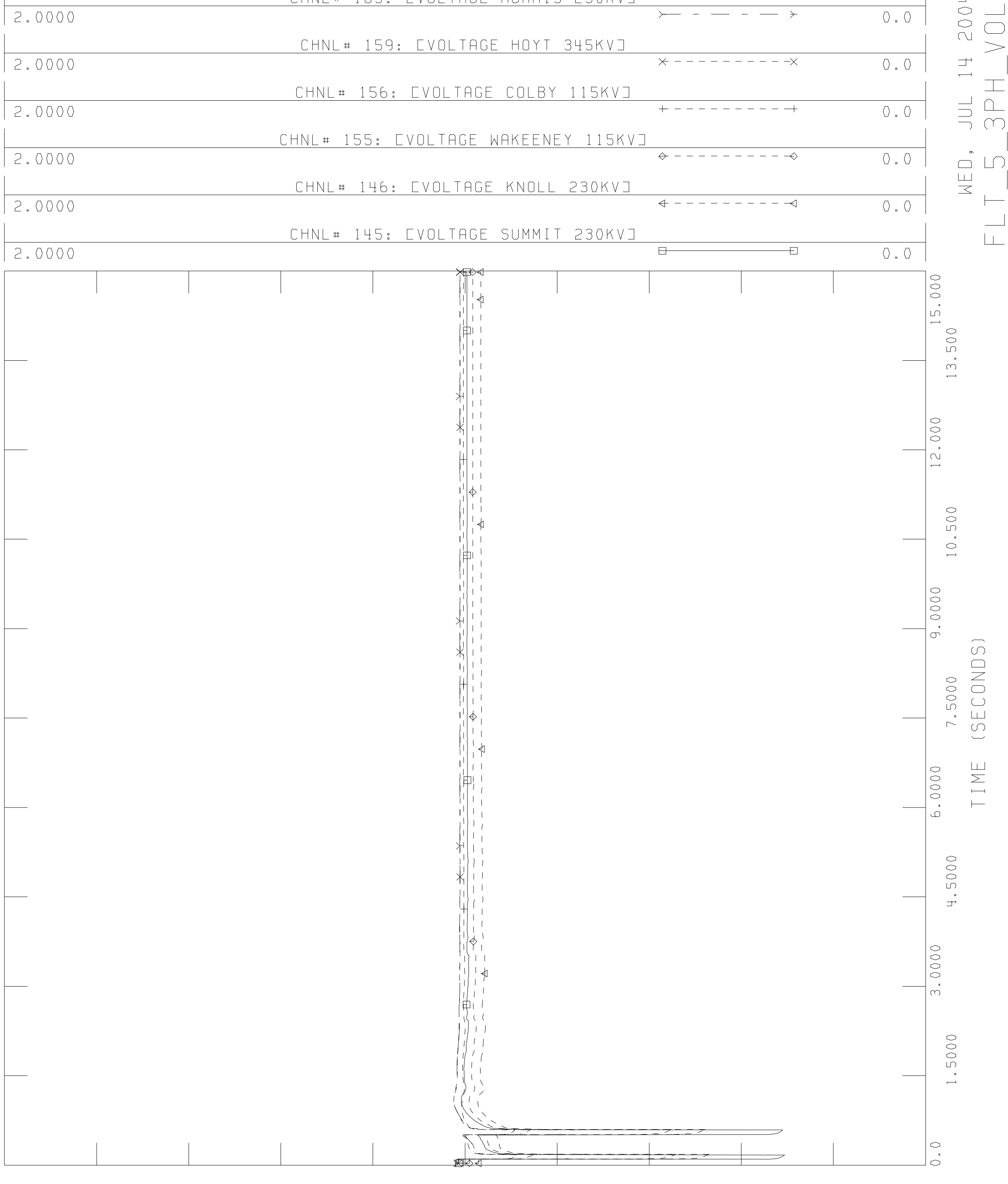
CHNL# 159: [VOLTAGE HOYT 345KV] 2.0000 0.0

CHNL# 156: [VOLTAGE COLBY 115KV] 2.0000 0.0

CHNL# 155: [VOLTAGE WAKEENEY 115KV] 2.0000 0.0

CHNL# 146: [VOLTAGE KNOLL 230KV] 2.0000 0.0

CHNL# 145: [VOLTAGE SUMMIT 230KV] 2.0000 0.0

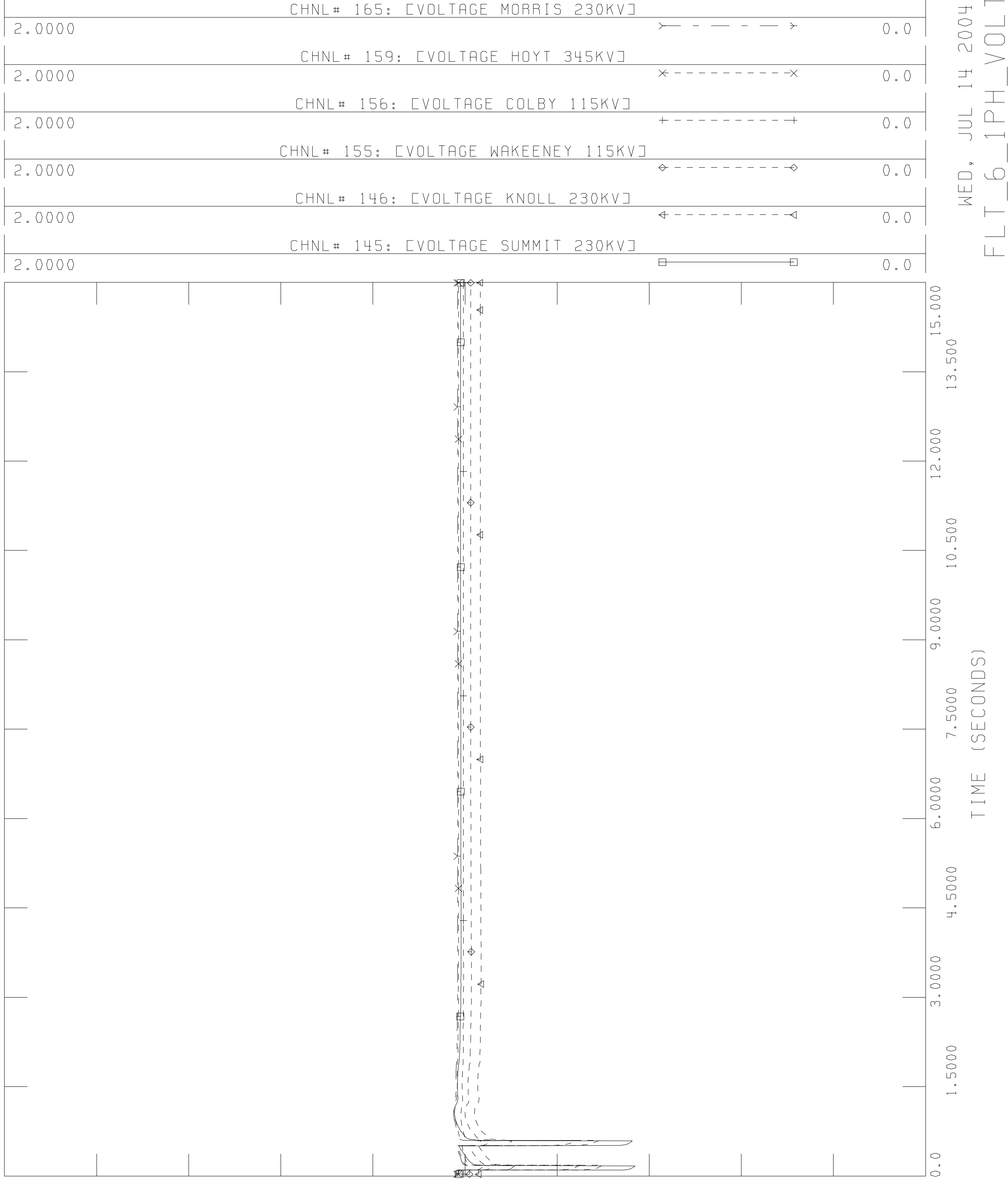


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER TECHNOLOGIES INC.®

WED, JUL 14 2004 13:39
FLT_6_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_6_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 13:39
FLT_6_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_6_3PH.OUT

CHNL# 165: [VOLTAGE MORRIS 230KV]
2.0000 ≻ - — - — ≻ 0.0

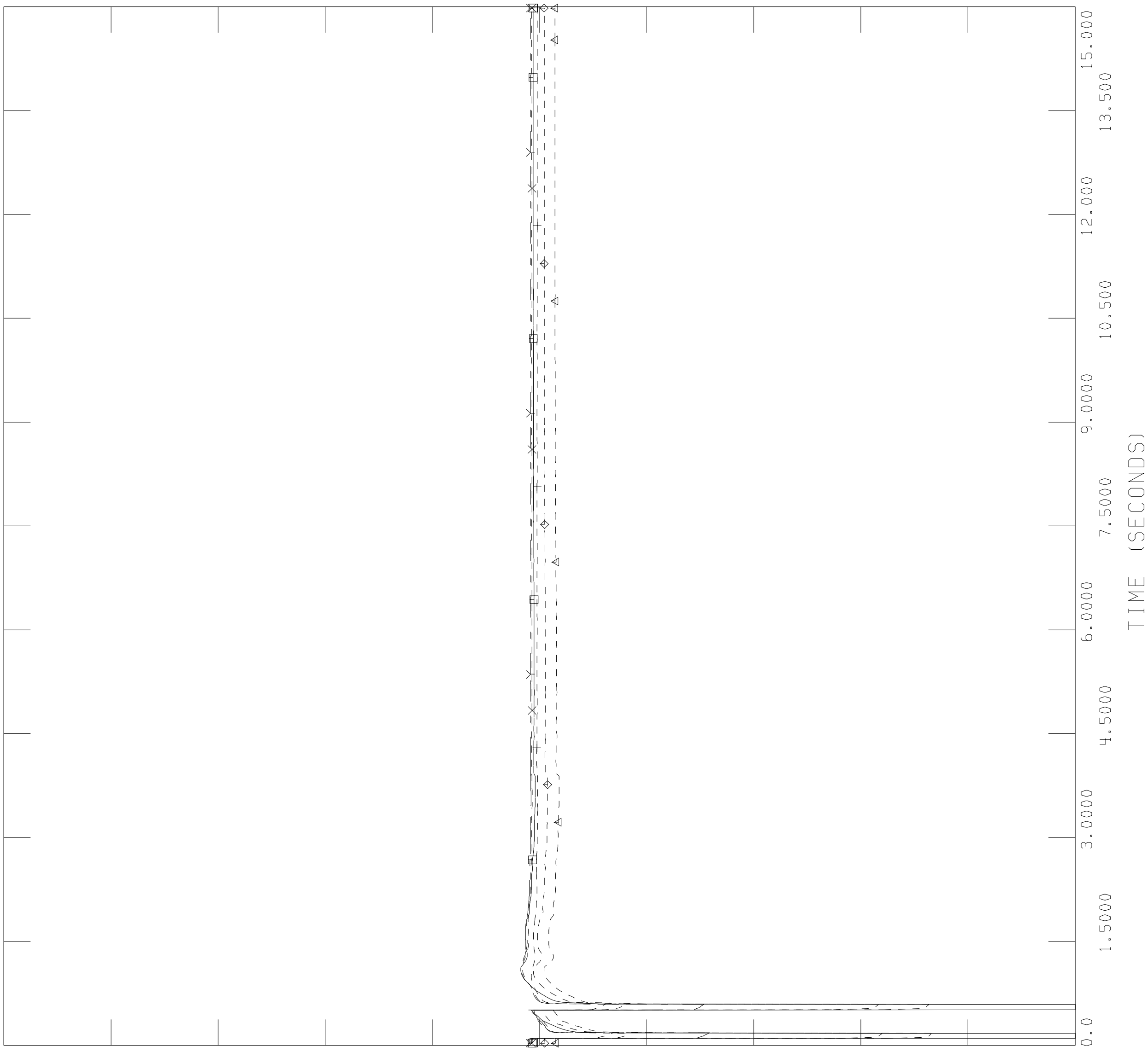
CHNL# 159: [VOLTAGE HOYT 345KV]
2.0000 × - - - - - - - - - × 0.0

CHNL# 156: [VOLTAGE COLBY 115KV]
2.0000 + - - - - - - - - - + 0.0

CHNL# 155: [VOLTAGE WAKEENEY 115KV]
2.0000 ◇ - - - - - - - - - ◇ 0.0

CHNL# 146: [VOLTAGE KNOLL 230KV]
2.0000 ◁ - - - - - - - - - ◁ 0.0

CHNL# 145: [VOLTAGE SUMMIT 230KV]
2.0000 □ ——————— □ 0.0

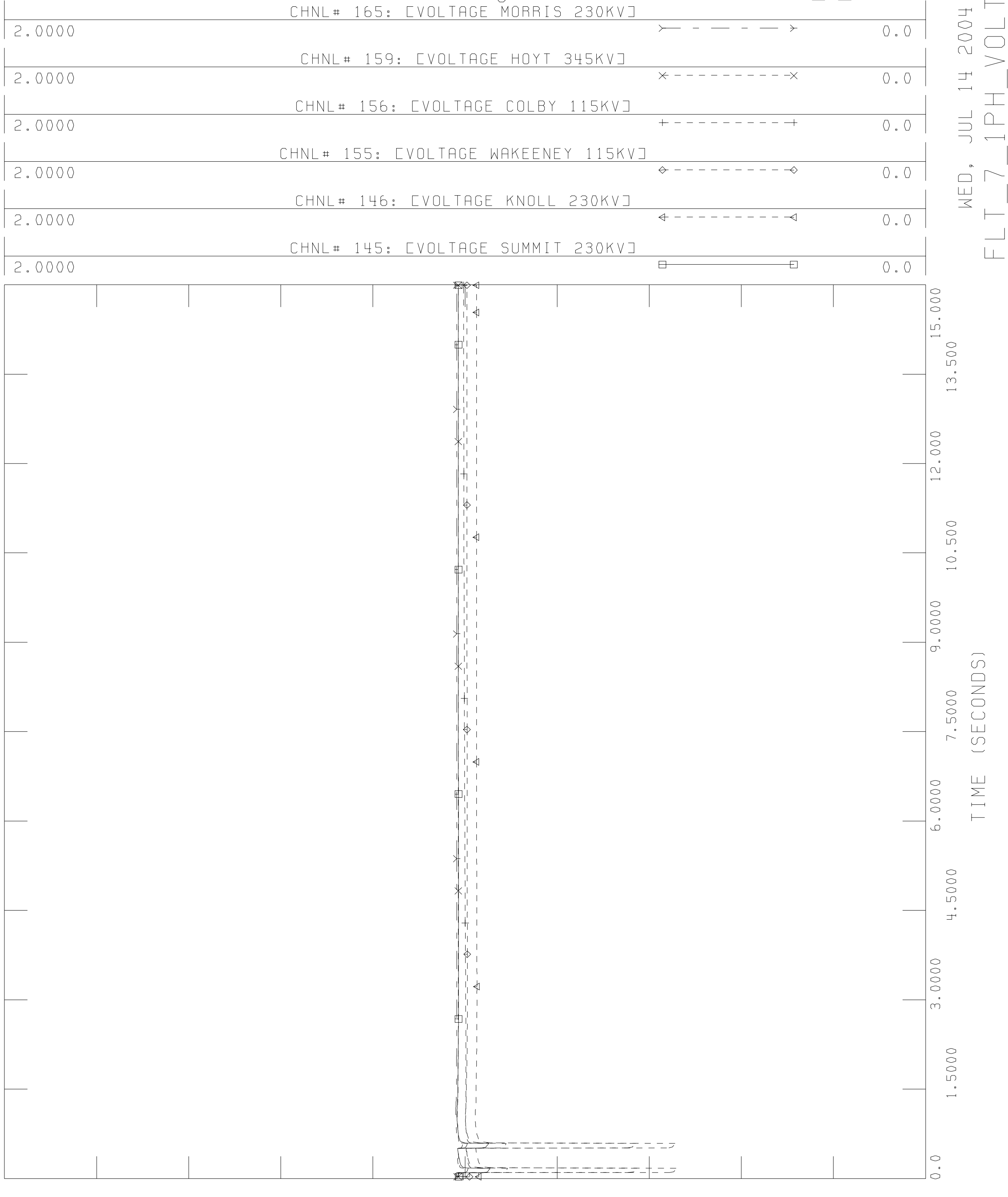


POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 13:39
FLT_7_1PH_VOLTAGES

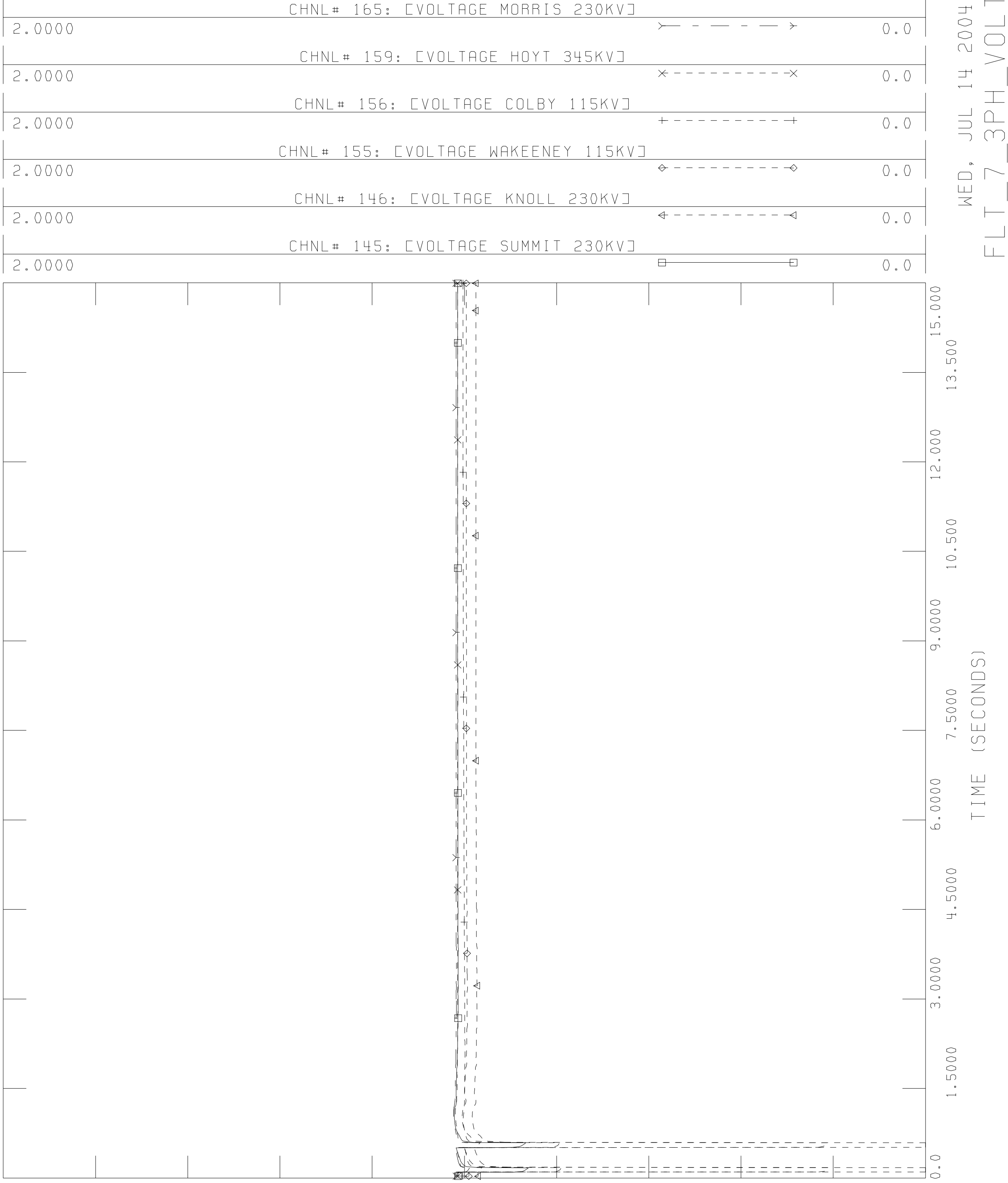
FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_7_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_7_3PH.OUT



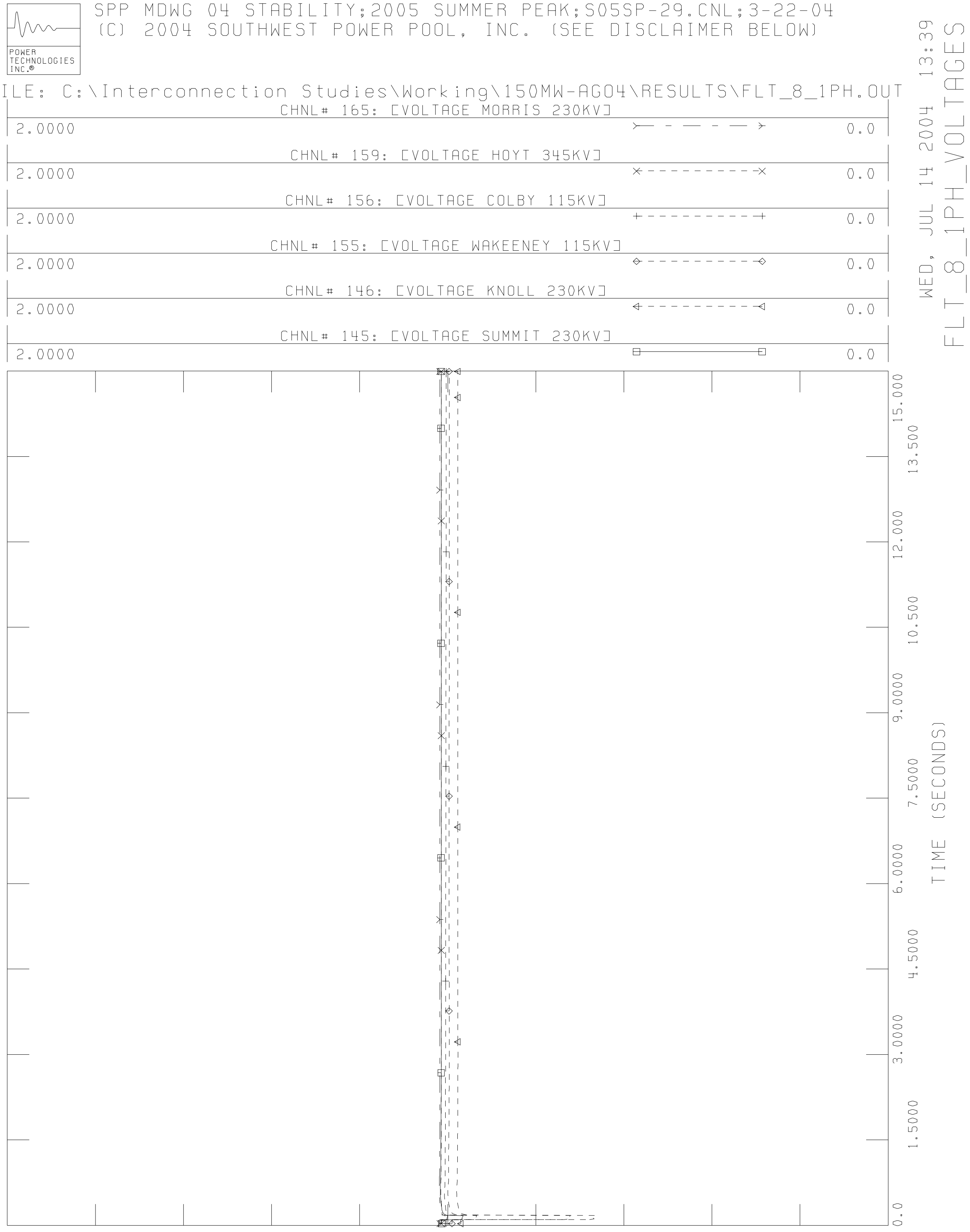
WED, JUL 14 2004 13:39

FLT_7_3PH_VOLTAGES

POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

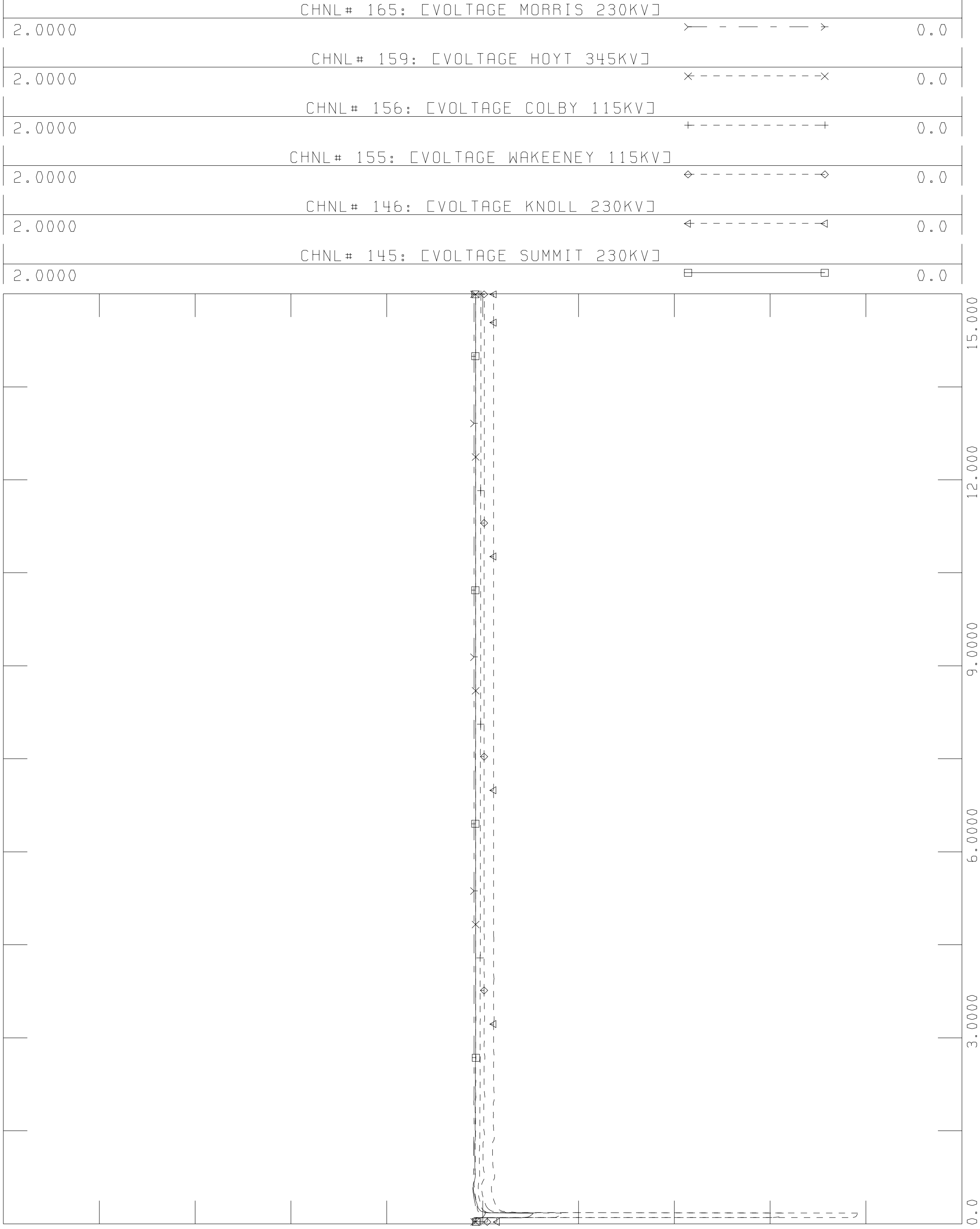
FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_8_1PH.OUT



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_8_3PH.OUT



WED, JUL 14 2004 13:39

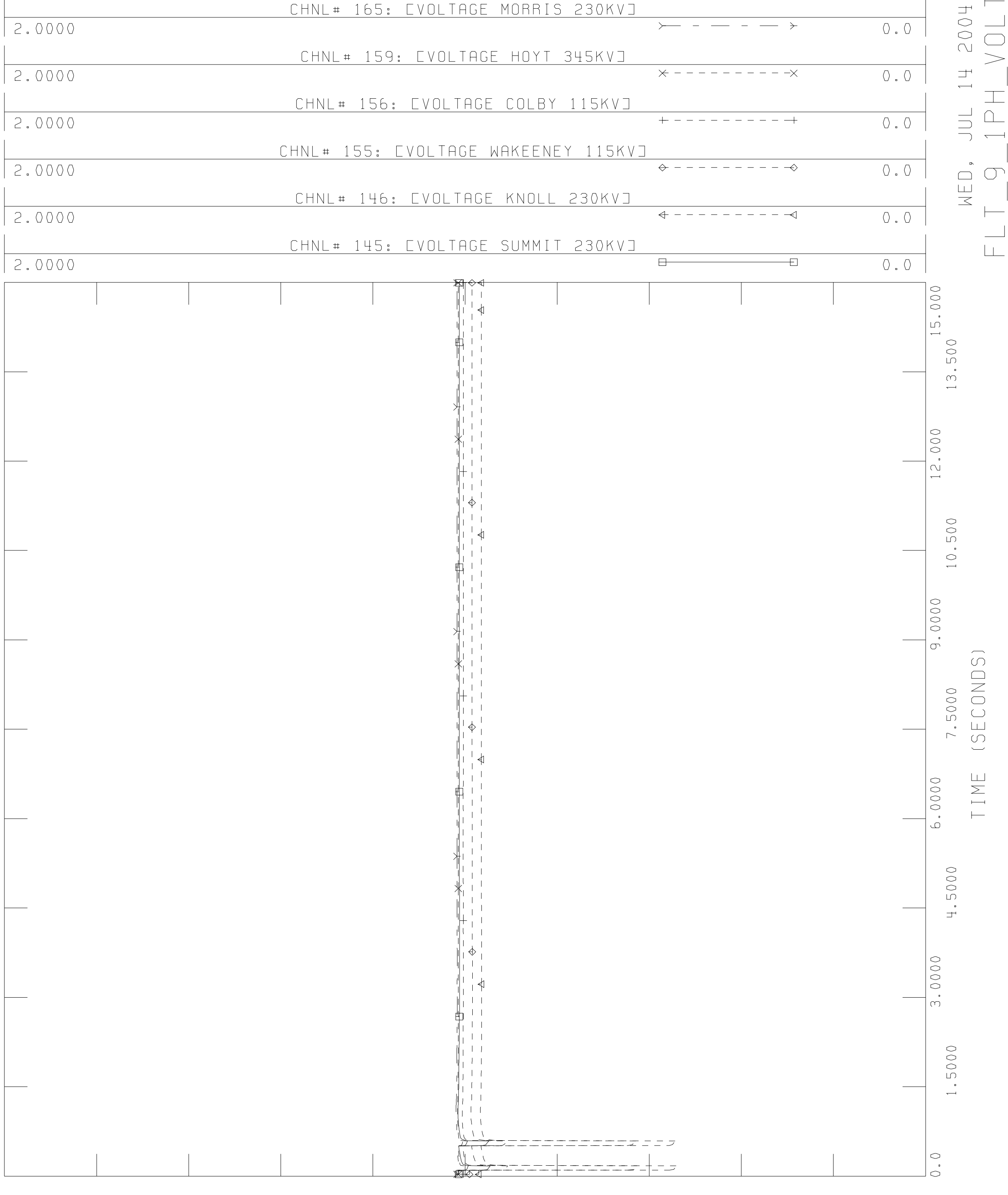
FLT_8_3PH_VOLTAGES

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_9_1PH.OUT

WED, JUL 14 2004 13:39

FLT_9_1PH_VOLTAGES

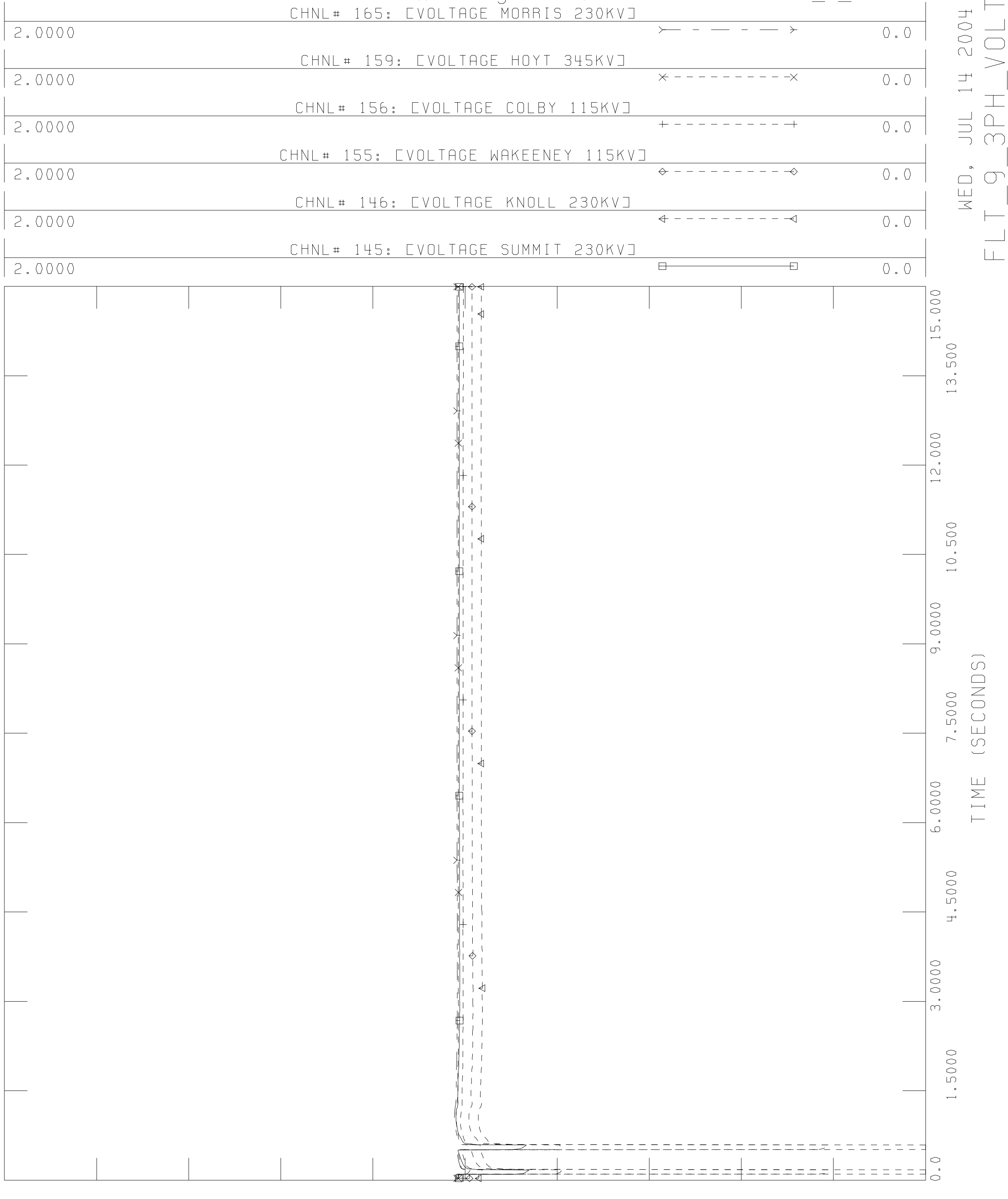


POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 13:39
FLT_9_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_9_3PH.OUT

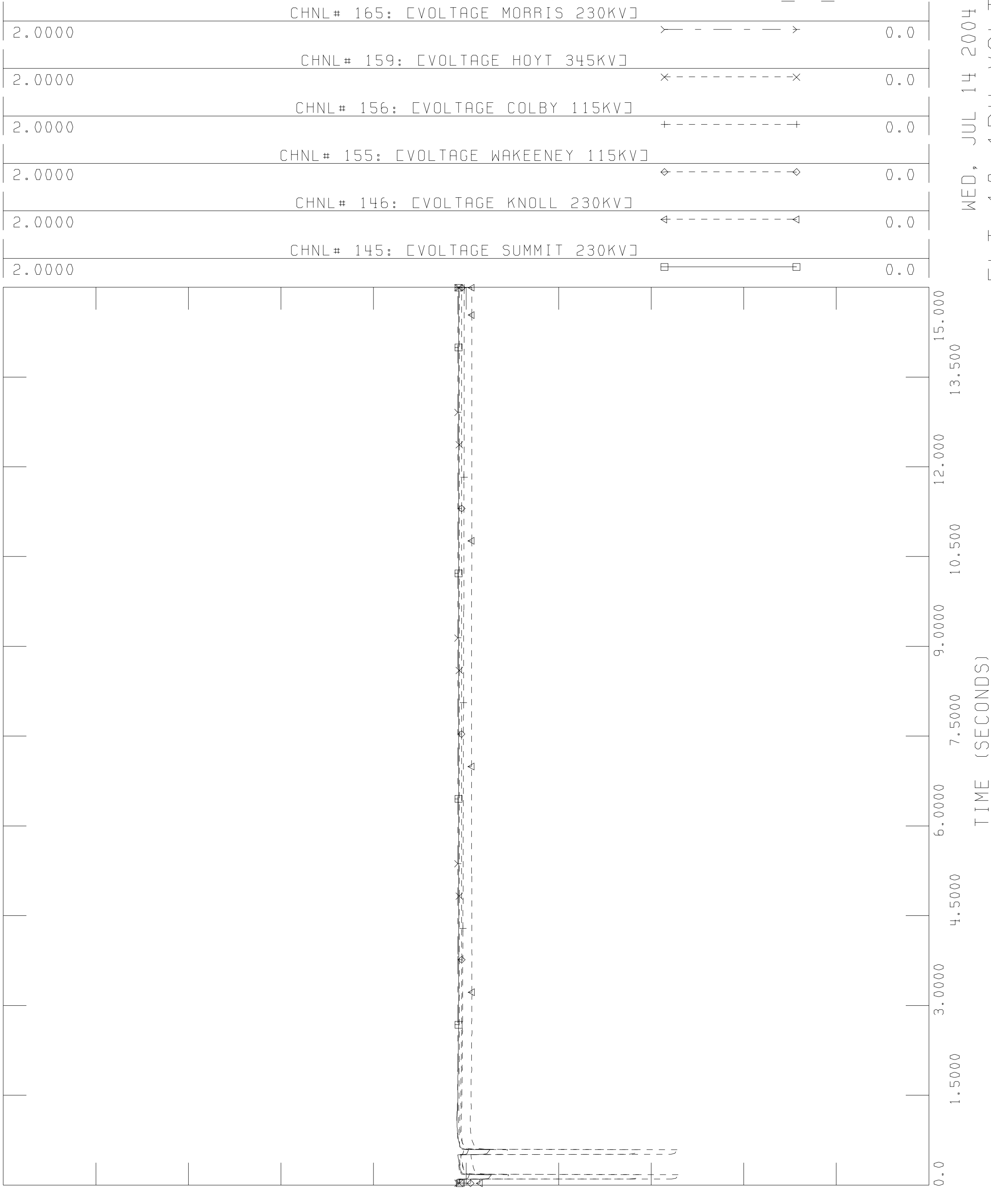


POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 13:39
FLT_10_1PH_VOLTAGES

FILE: C:\Interconnection Studies\...\150MW-AG04\RESULTS\FLT_10_1PH.OUT



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 13:39
FLT_10_3PH_VOLTAGES

FILE: C:\Interconnection Studies\...\150MW-AG04\RESULTS\FLT_10_3PH.OUT

CHNL# 165: [VOLTAGE MORRIS 230KV]
2.0000 0.0

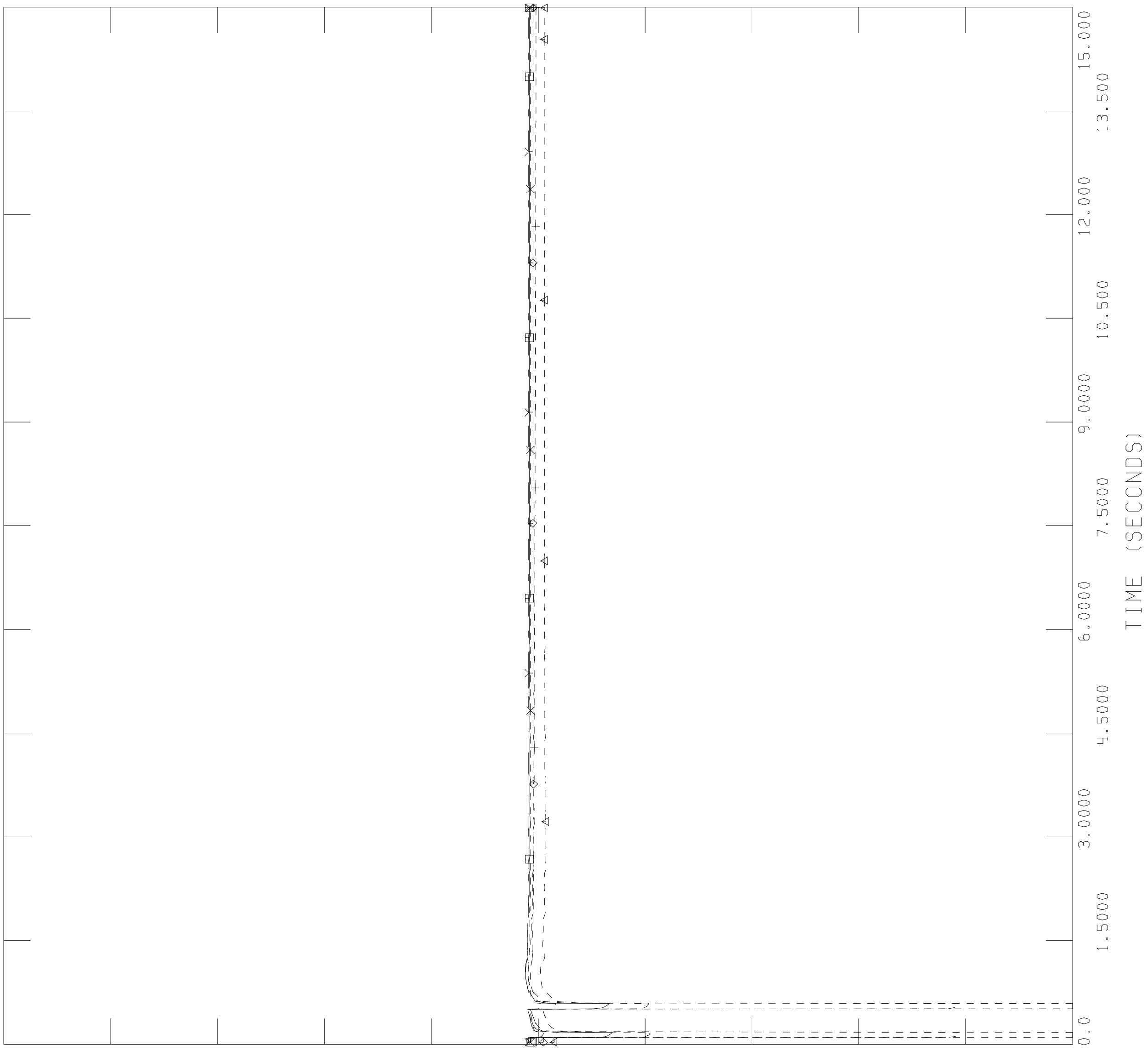
CHNL# 159: [VOLTAGE HOYT 345KV]
2.0000 0.0

CHNL# 156: [VOLTAGE COLBY 115KV]
2.0000 0.0

CHNL# 155: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 146: [VOLTAGE KNOLL 230KV]
2.0000 0.0

CHNL# 145: [VOLTAGE SUMMIT 230KV]
2.0000 0.0



Appendix D-2

Plots of Fault Simulations

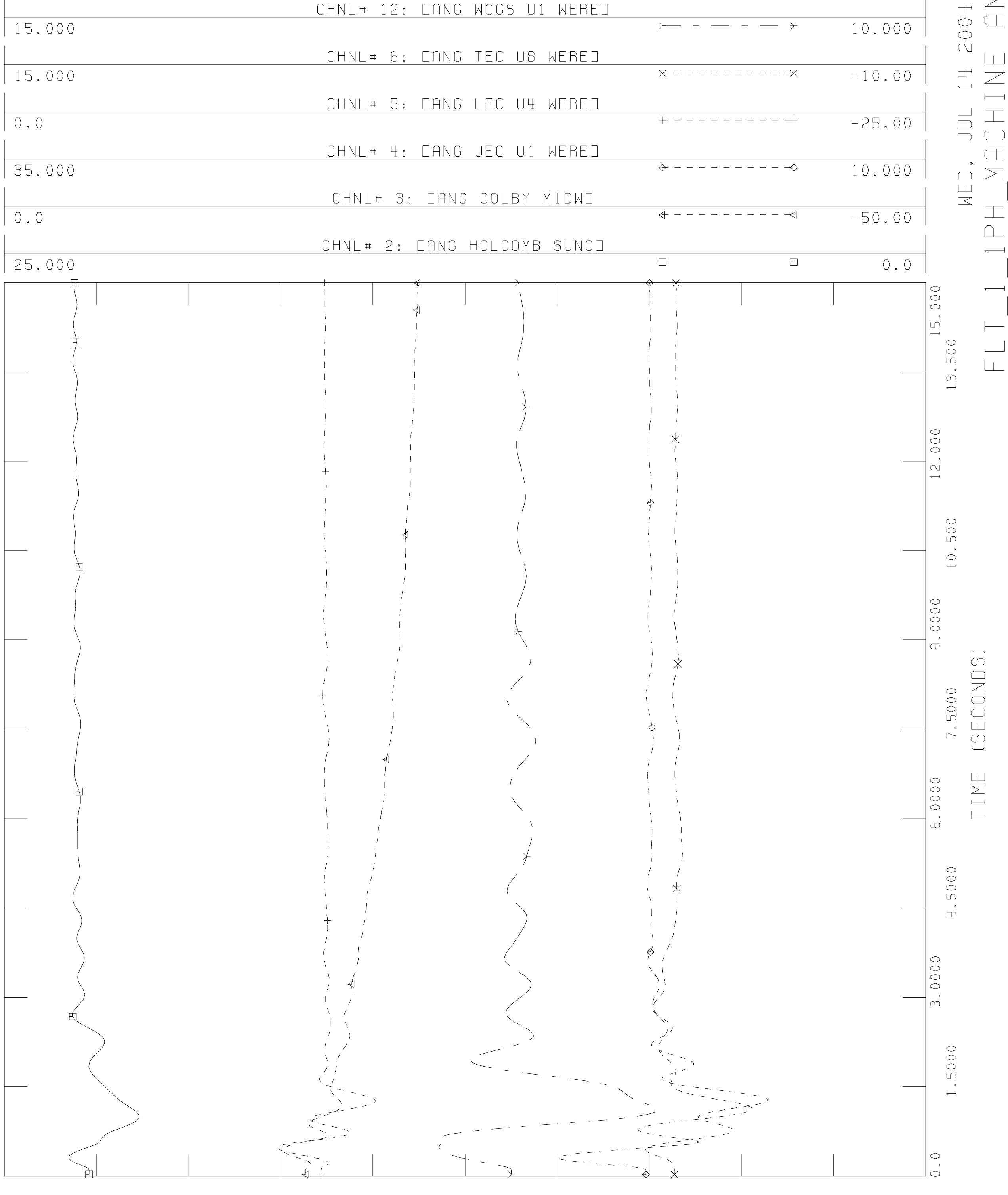
Plots of selected machine phase angles during faults

Scenario:
2005 Summer Peak
Wind Farm at 150MW (100% rated power)
AGO4 Protection Settings

POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_1_1PH.OUT



WED, JUL 14 2004 13:47

FLT_1_1PH_MACHINE ANGLES

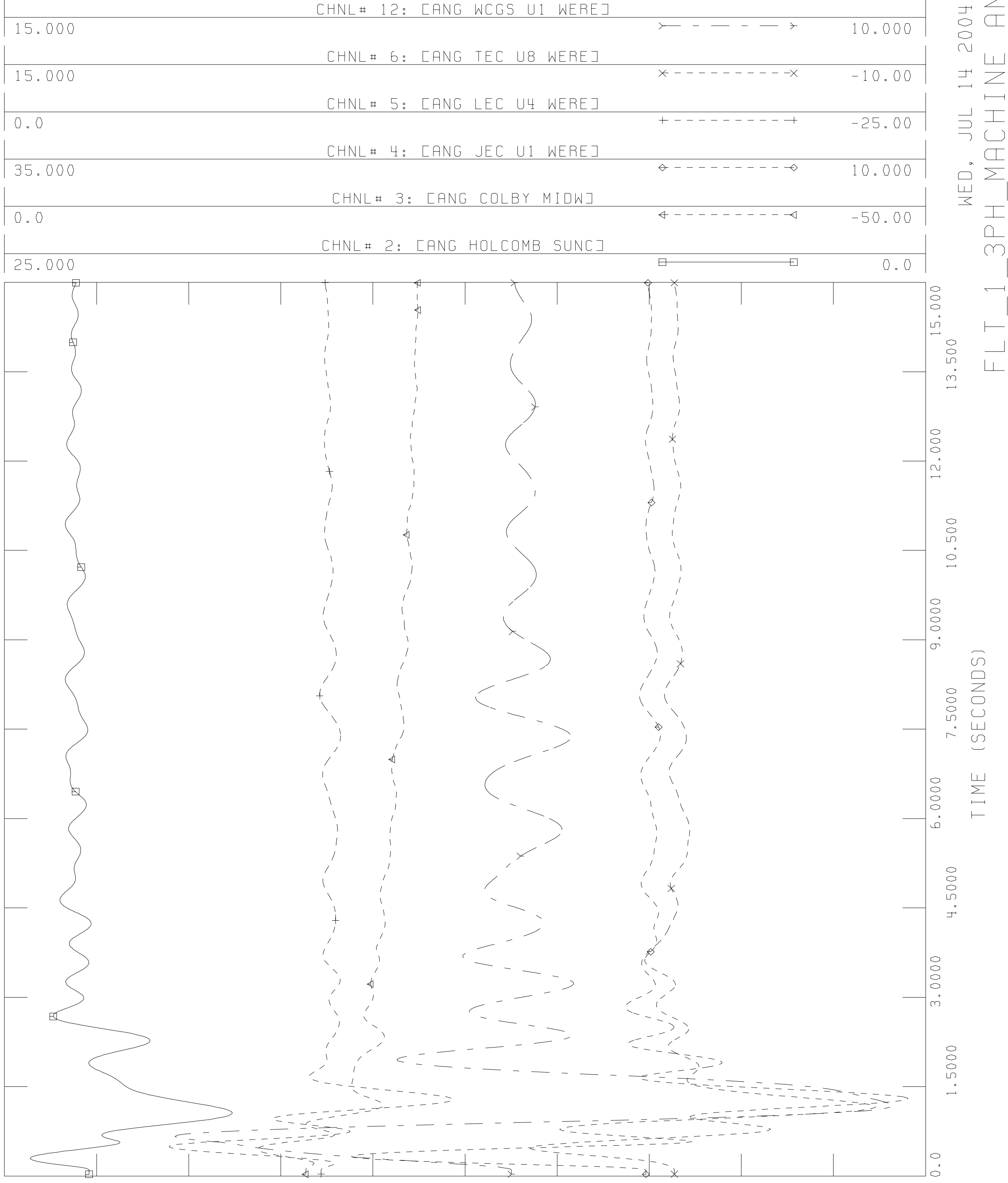
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_1_3PH.OUT

WED, JUL 14 2004 13:47

FLT_1_3PH_MACHINE ANGLES

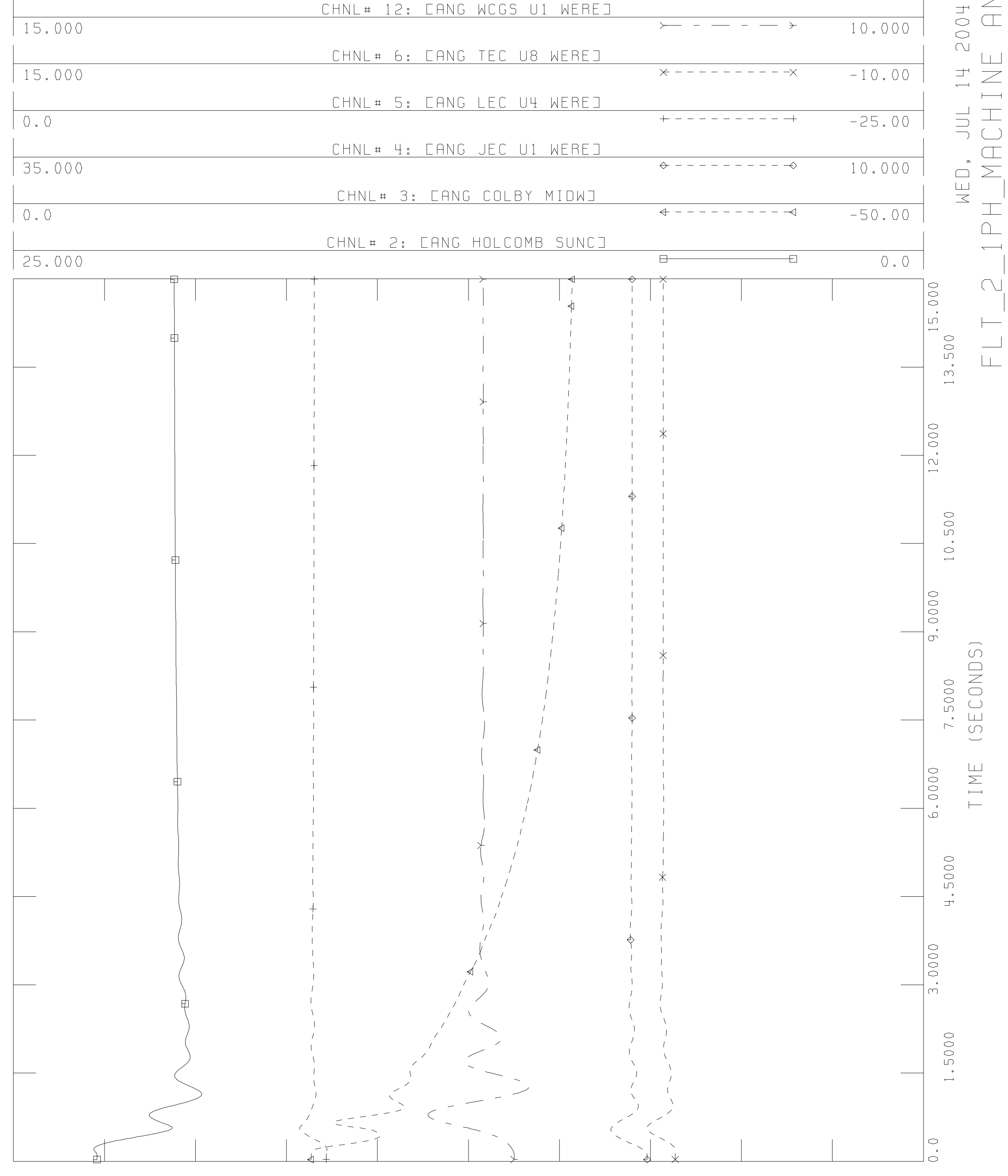


POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_2_1PH.OUT



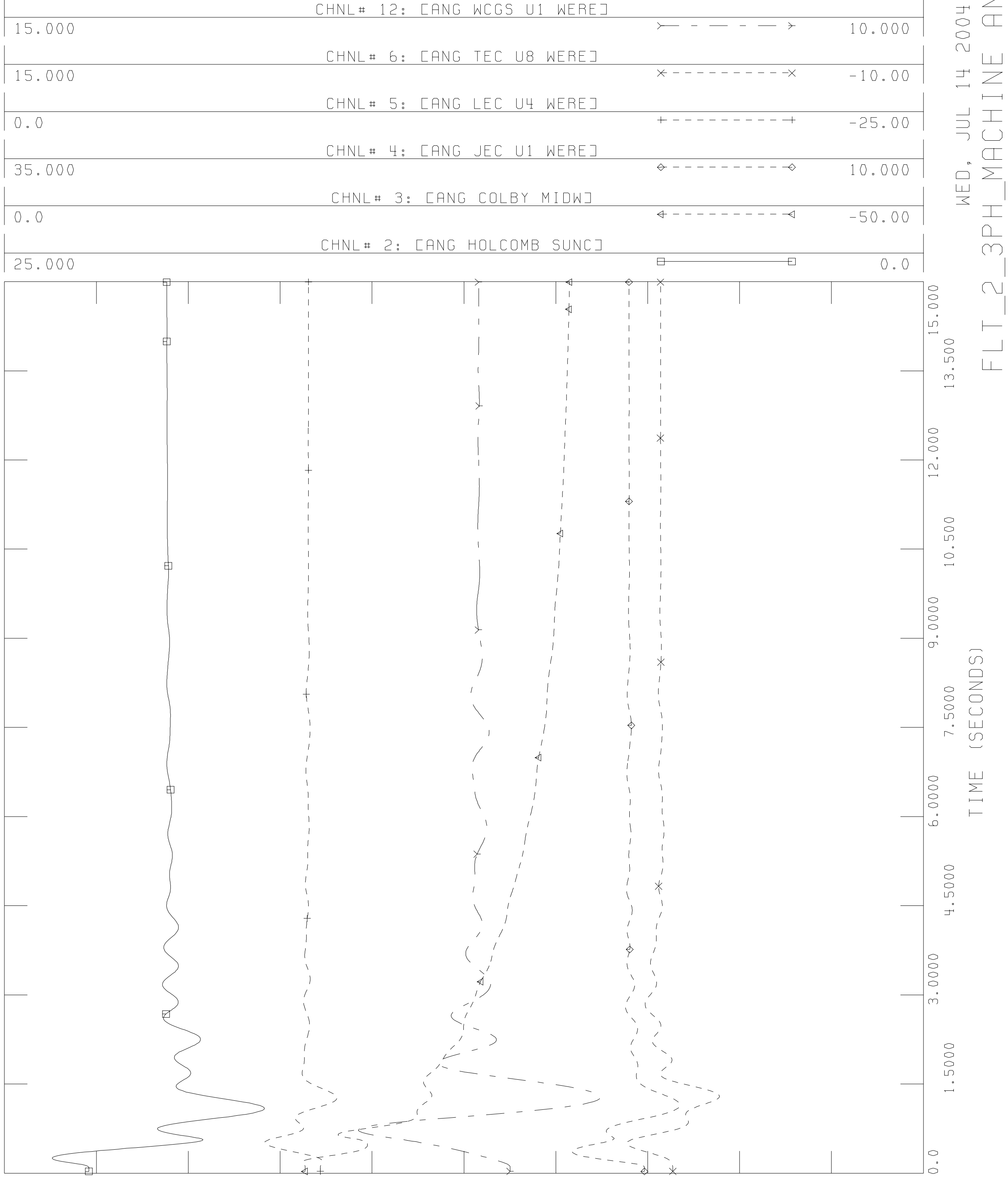
WED, JUL 14 2004 13:47

FLT_2_1PH_MACHINE ANGLES

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

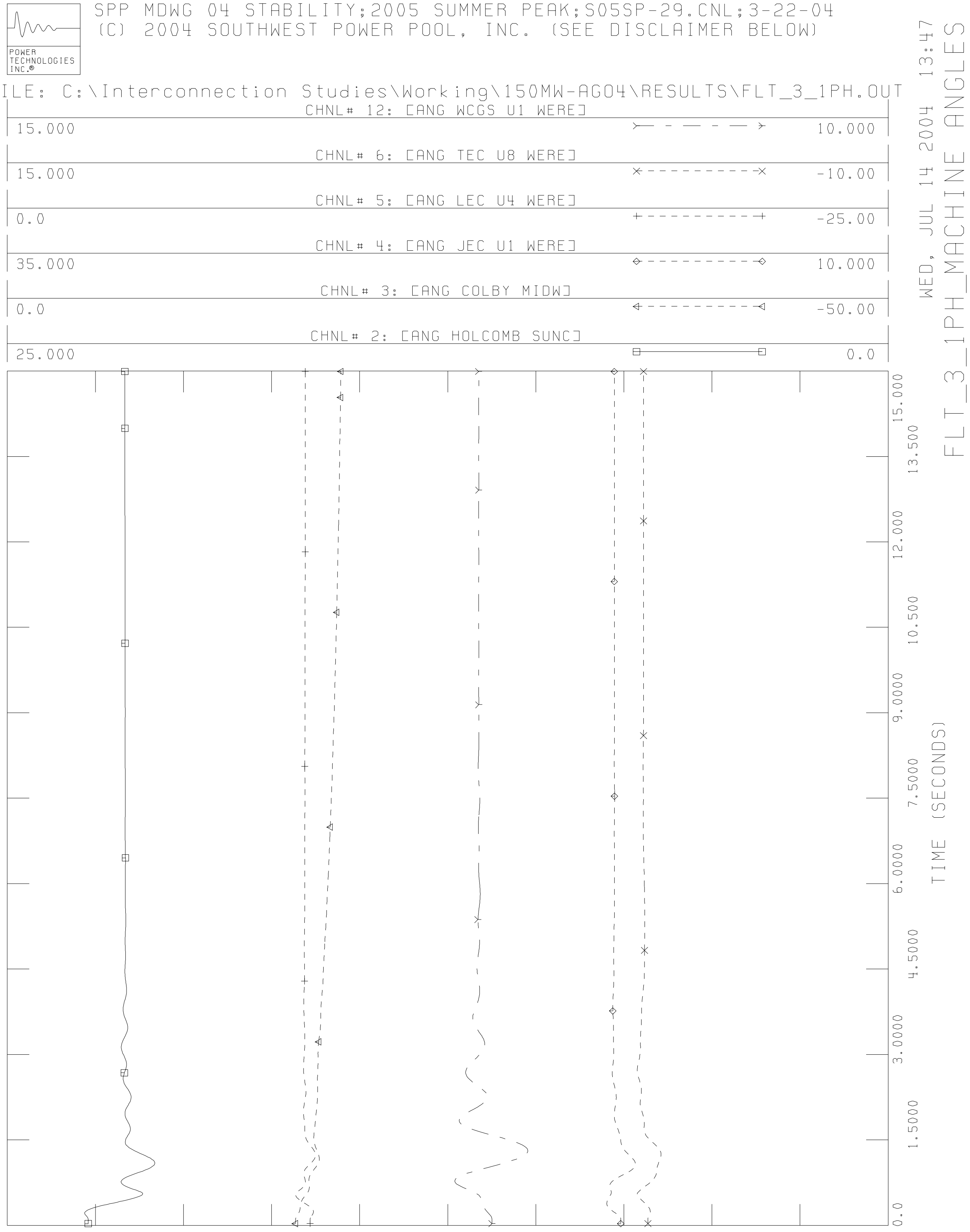
FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_2_3PH.OUT



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

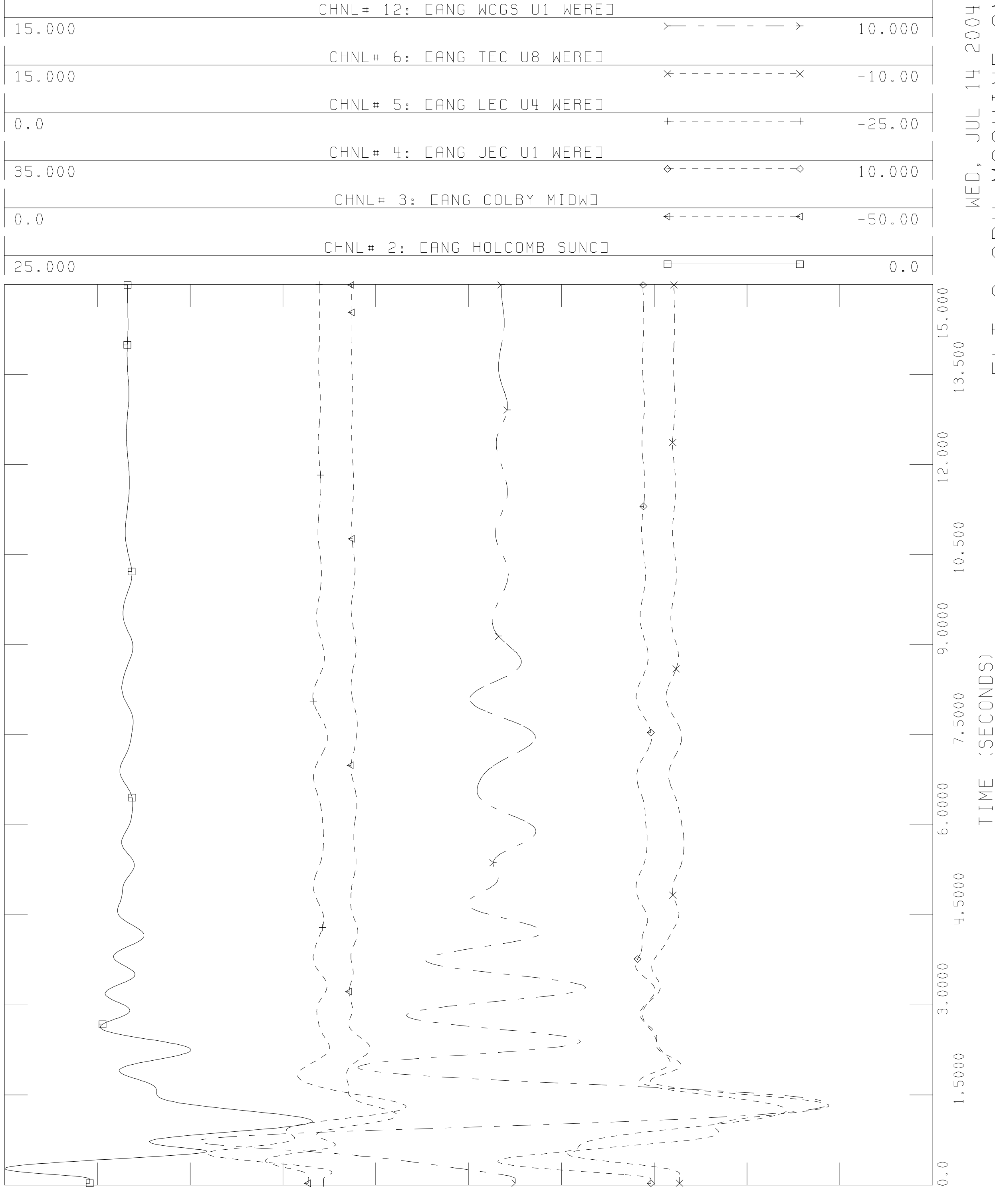
FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_3_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_3_3PH.OUT



WED, JUL 14 2004 13:47

FLT_3_3PH_MACHINE ANGLES

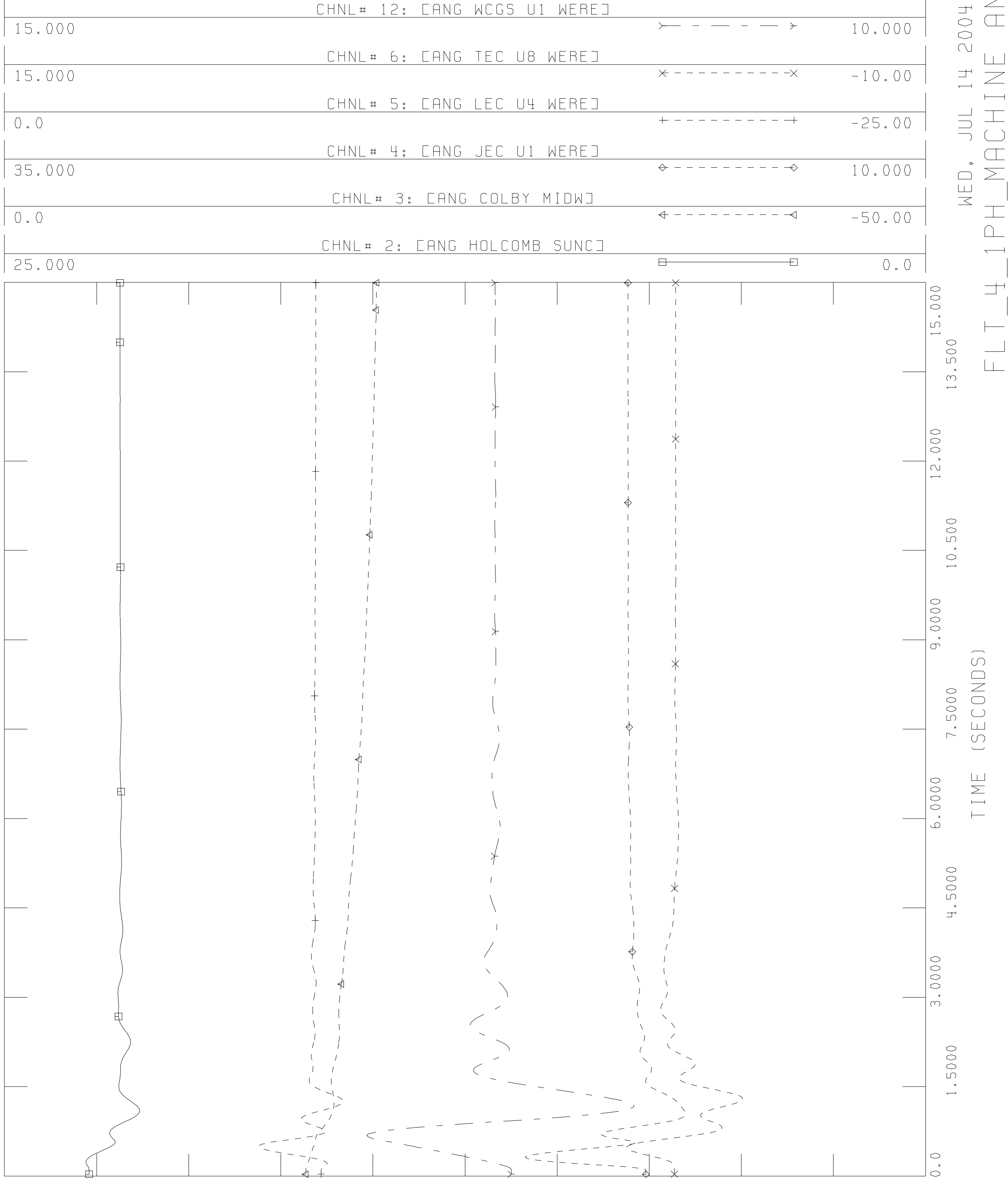
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_4_1PH.OUT

WED, JUL 14 2004 13:47

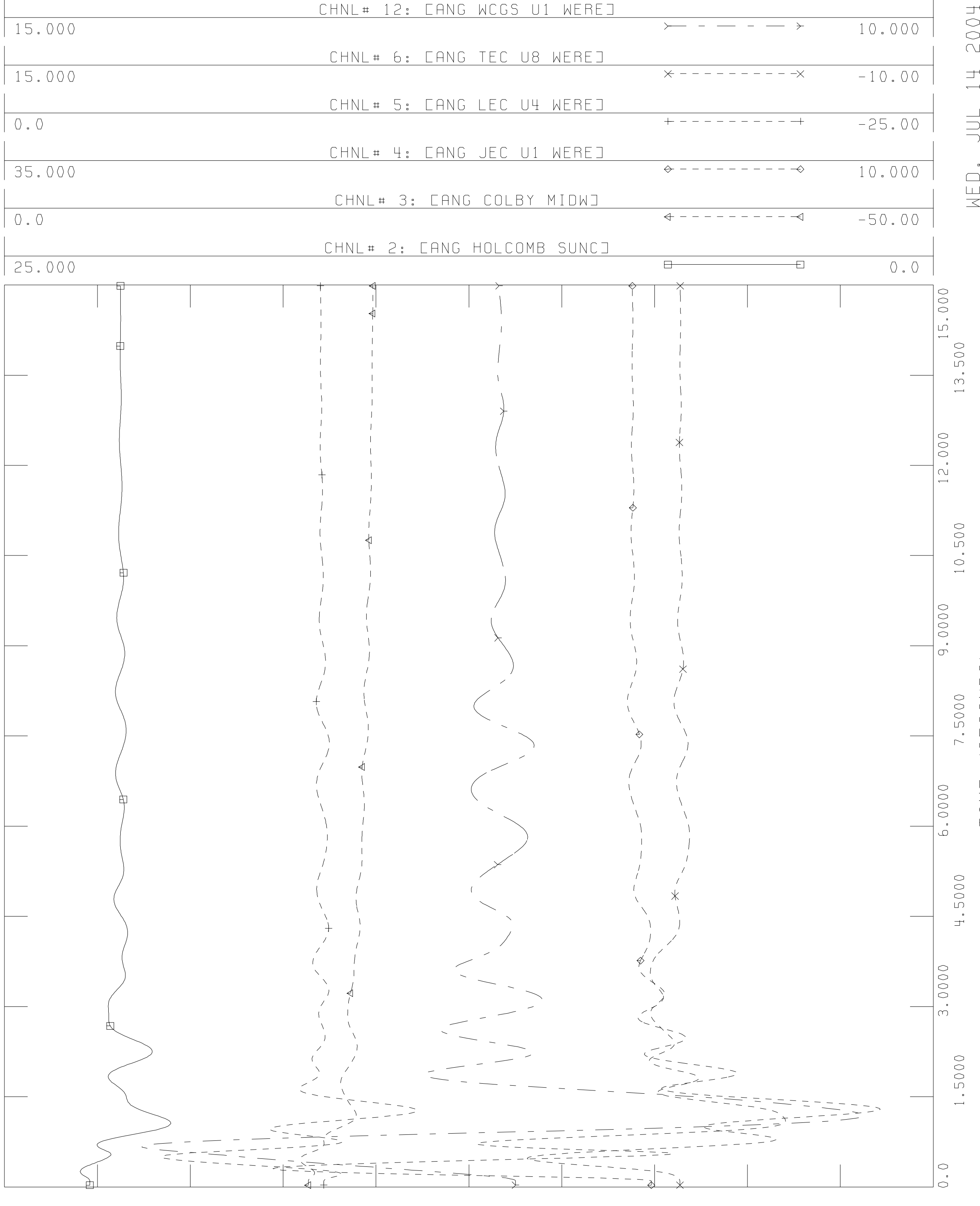
FLT_4_1PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_4_3PH.OUT



WED, JUL 14 2004 13:47

FLT_4_3PH_MACHINE ANGLES

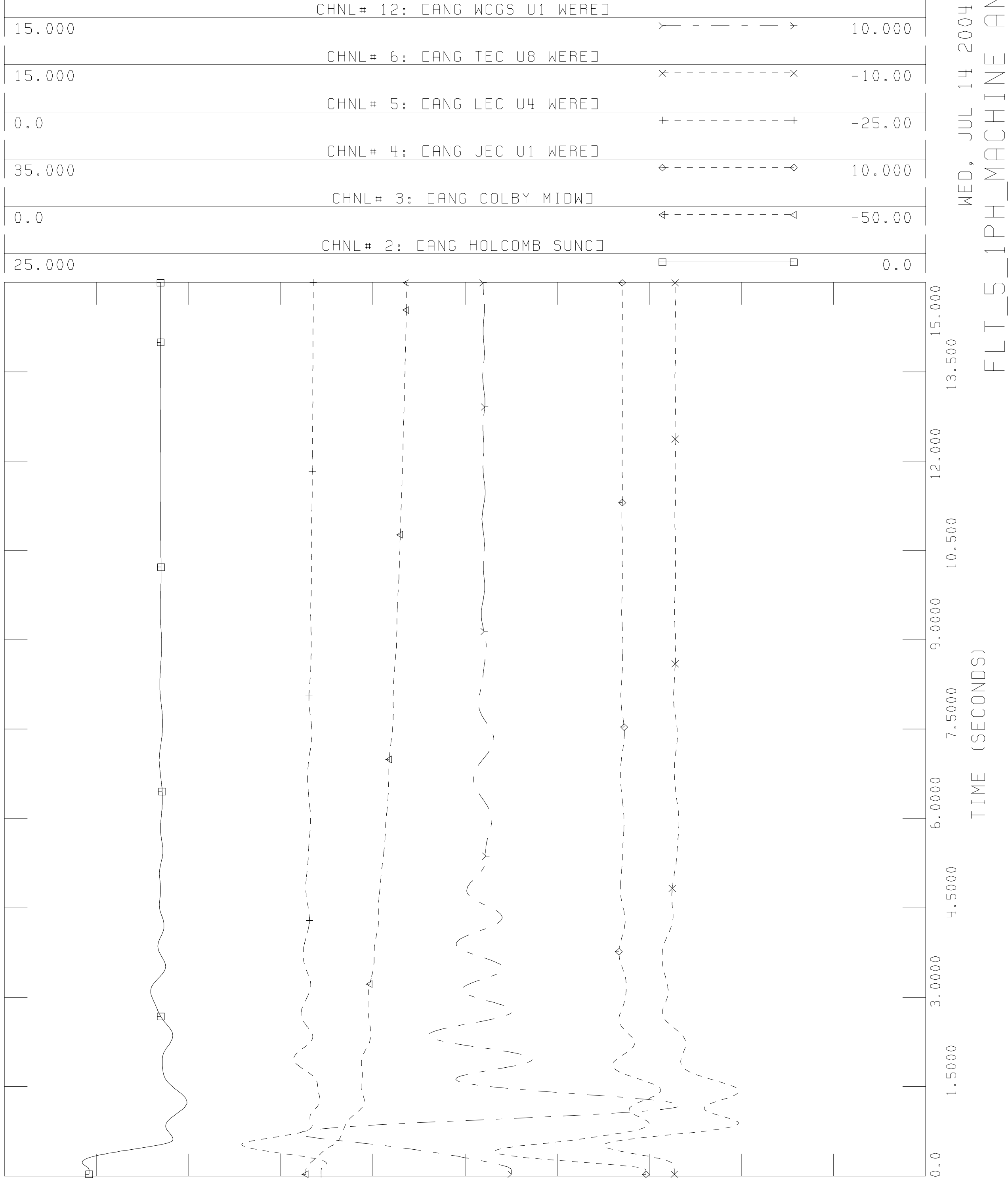
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 13:47

FLT_5_1PH_MACHINE ANGLES

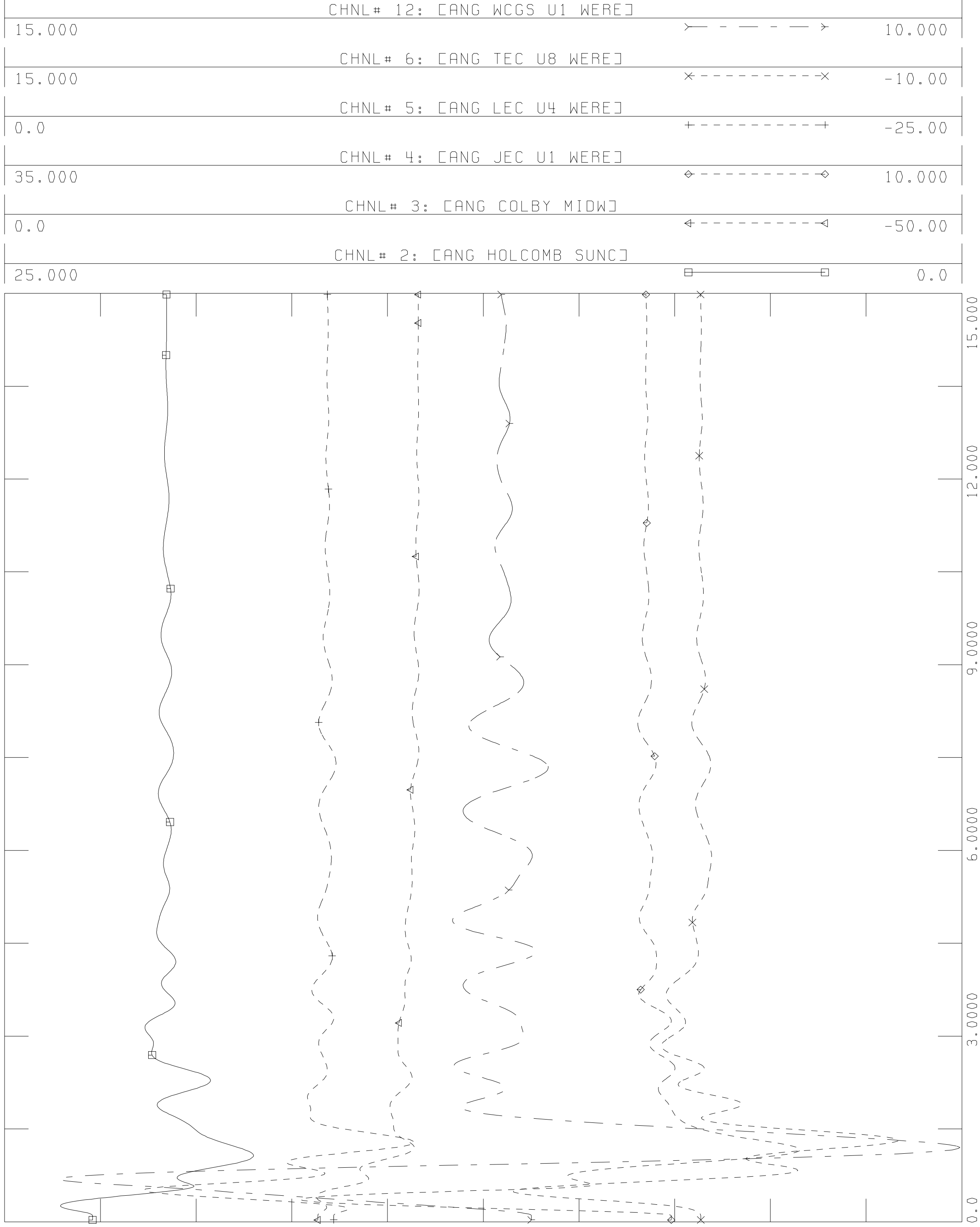
FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_5_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_5_3PH.OUT



WED, JUL 14 2004 13:47

FLT_5_3PH_MACHINE ANGLES

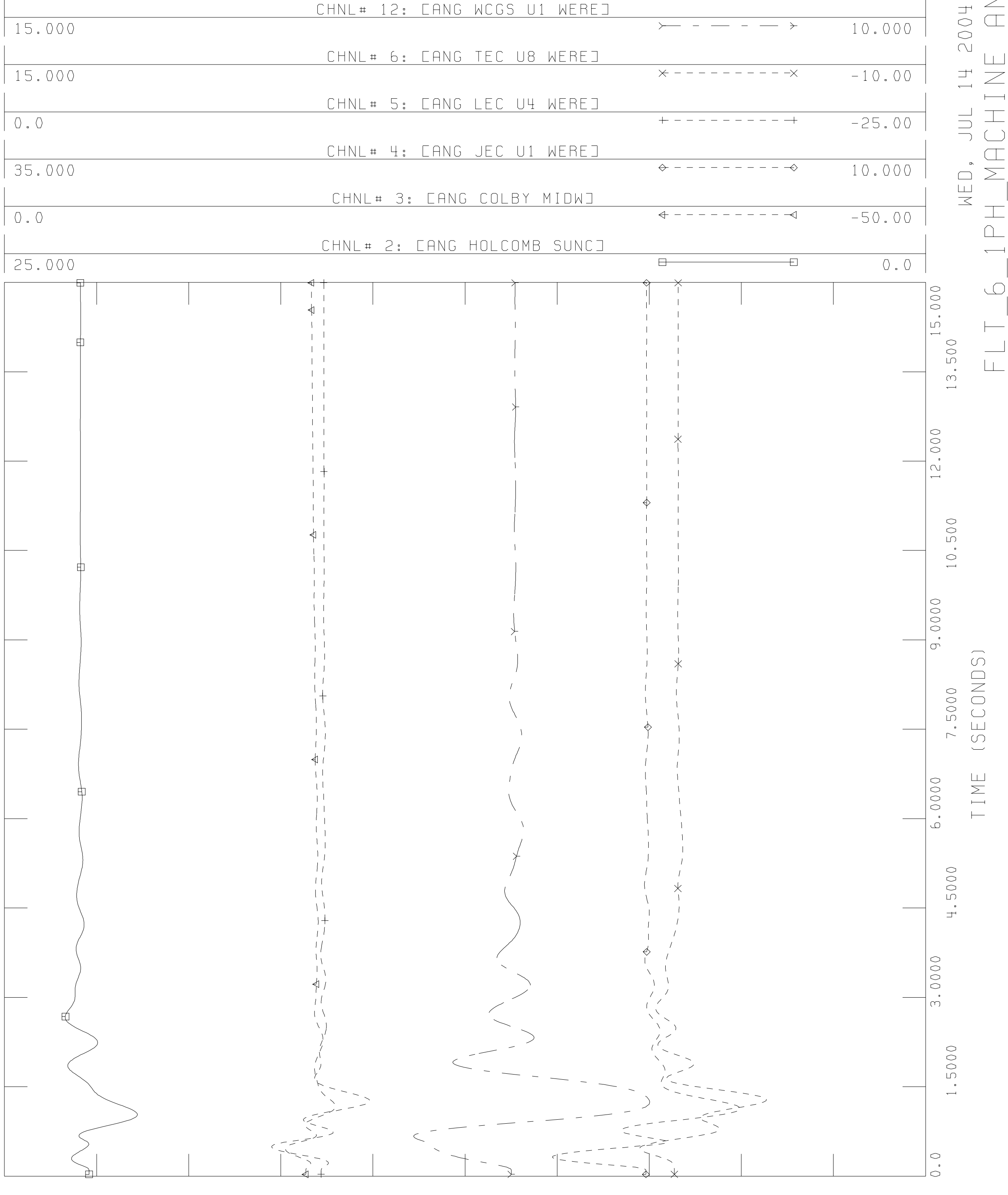
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_6_1PH.OUT

WED, JUL 14 2004 13:47

FLT_6_1PH_MACHINE ANGLES



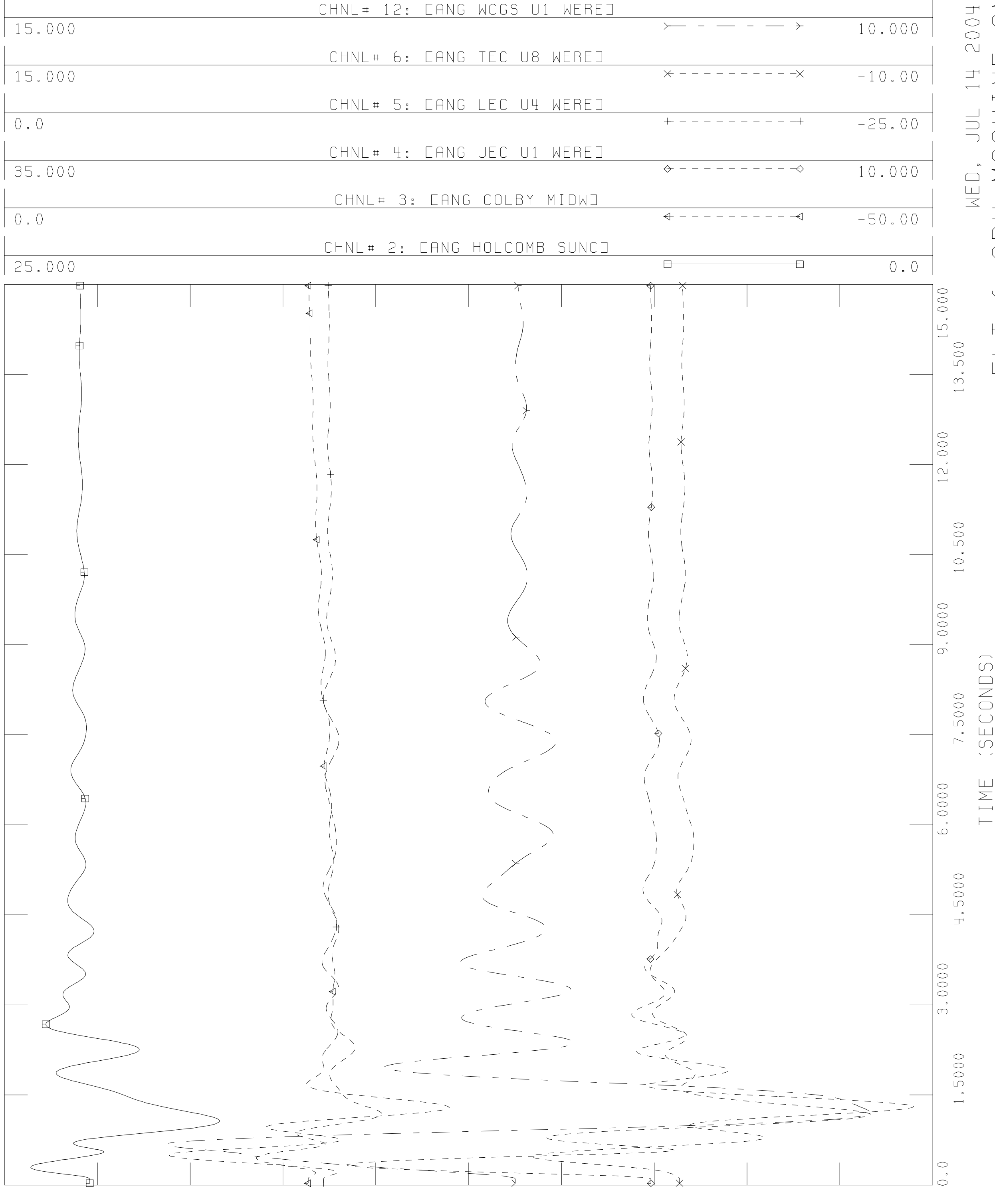
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_6_3PH.OUT

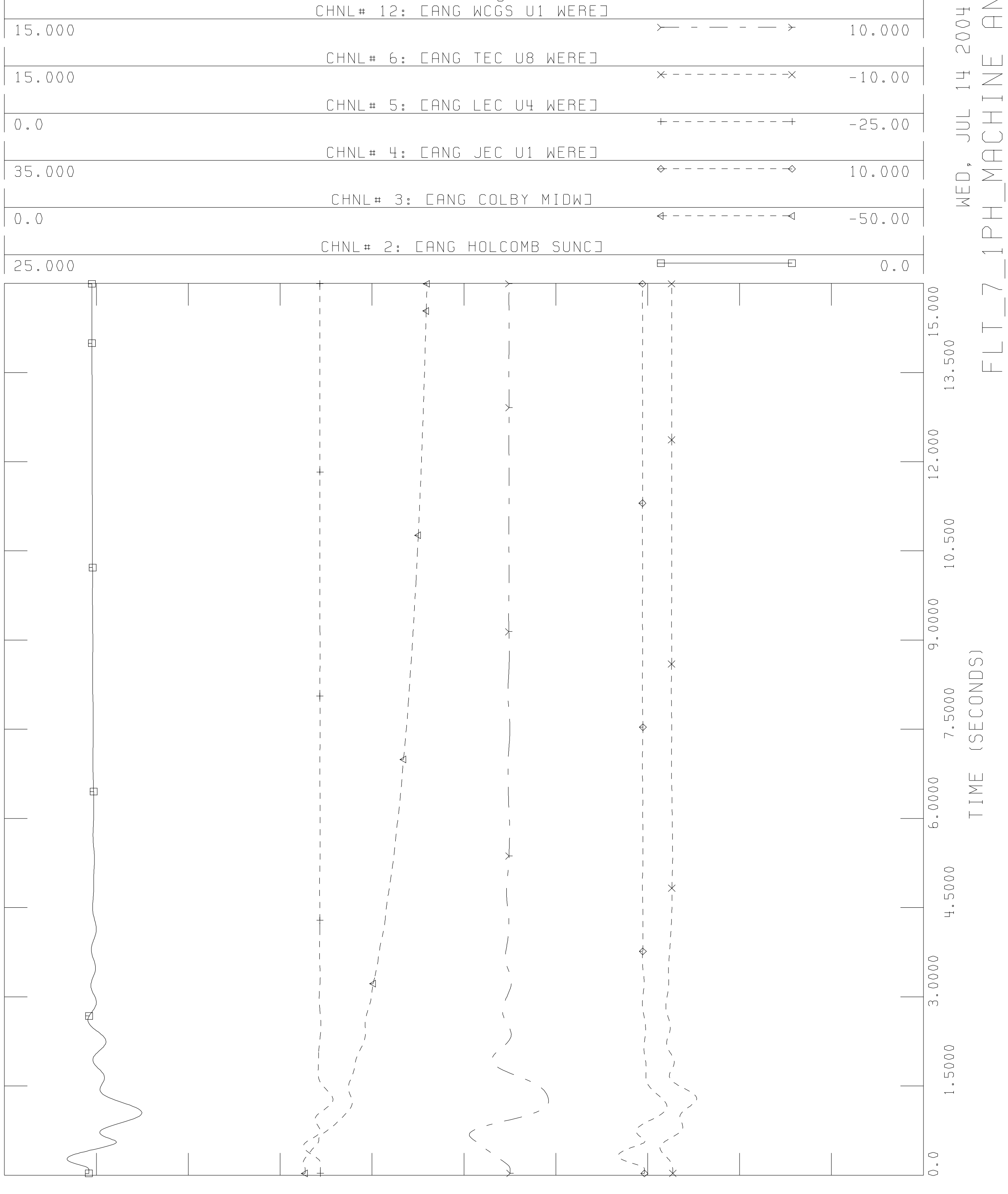
WED, JUL 14 2004 13:47

FLT_6_3PH_MACHINE ANGLES



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_7_1PH.OUT



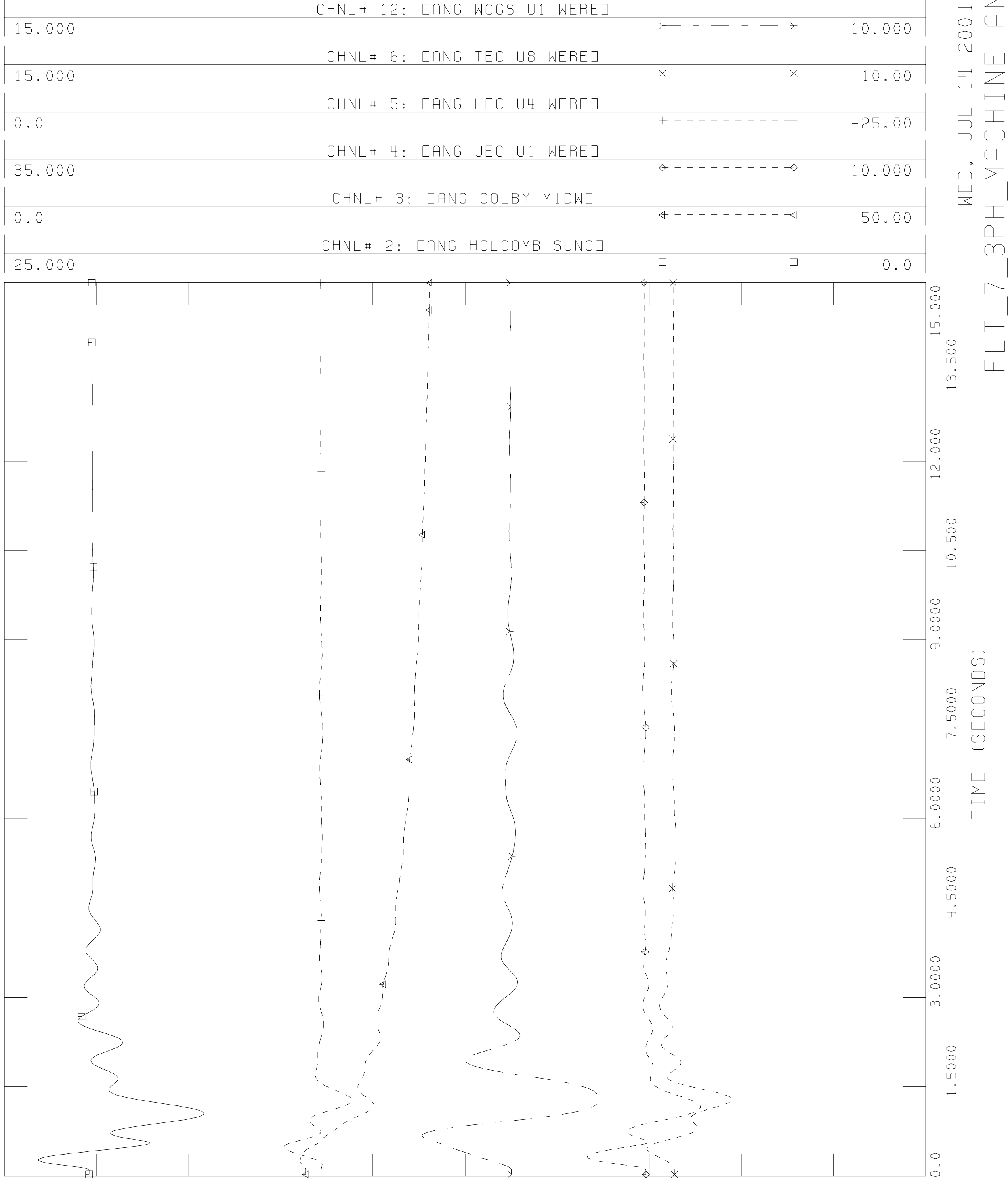
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_7_3PH.OUT

WED, JUL 14 2004 13:47

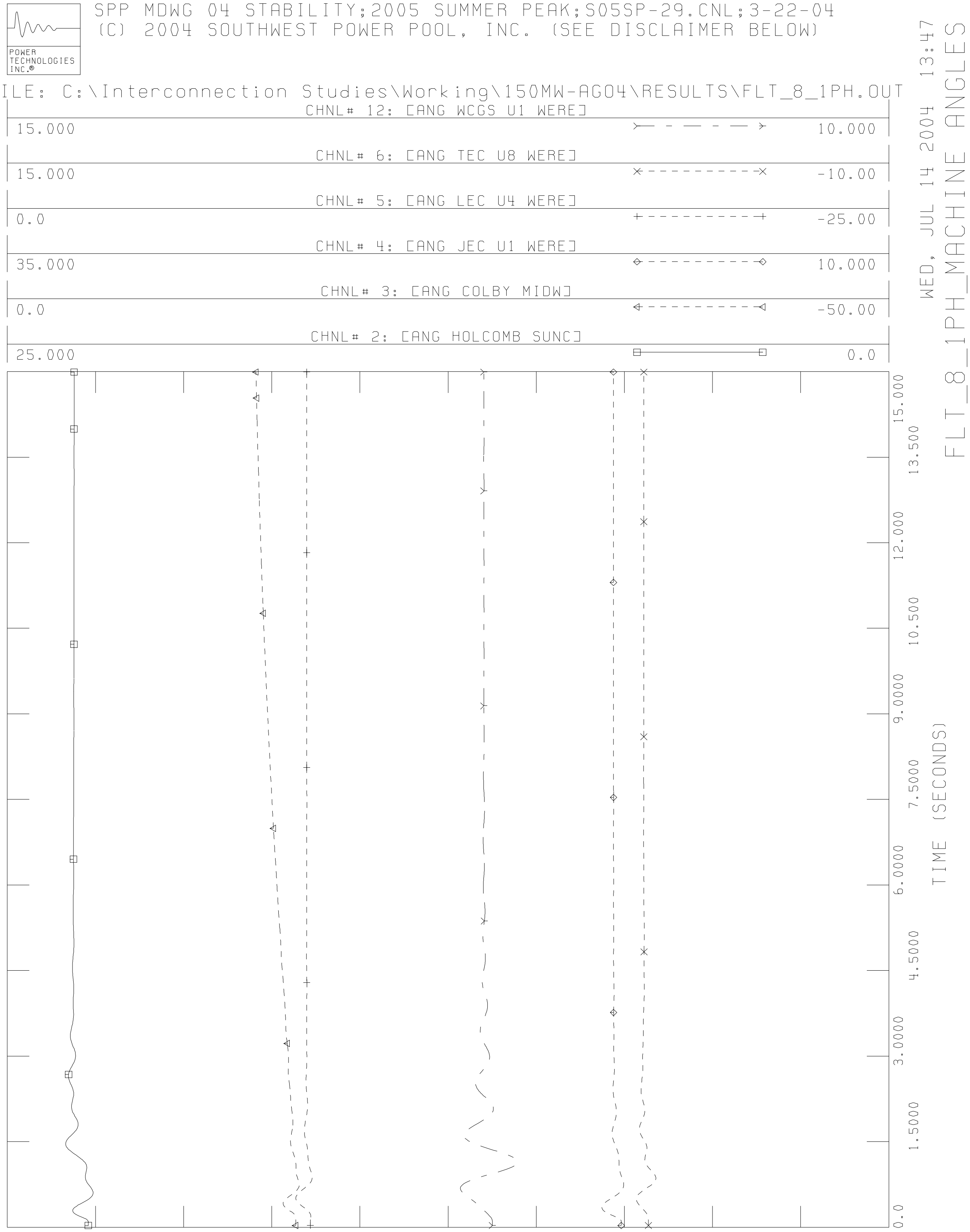
FLT_7_3PH_MACHINE ANGLES



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER
TECHNOLOGIES
INC.®

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_8_1PH.OUT



POWER
TECHNOLOGIES
INC.®

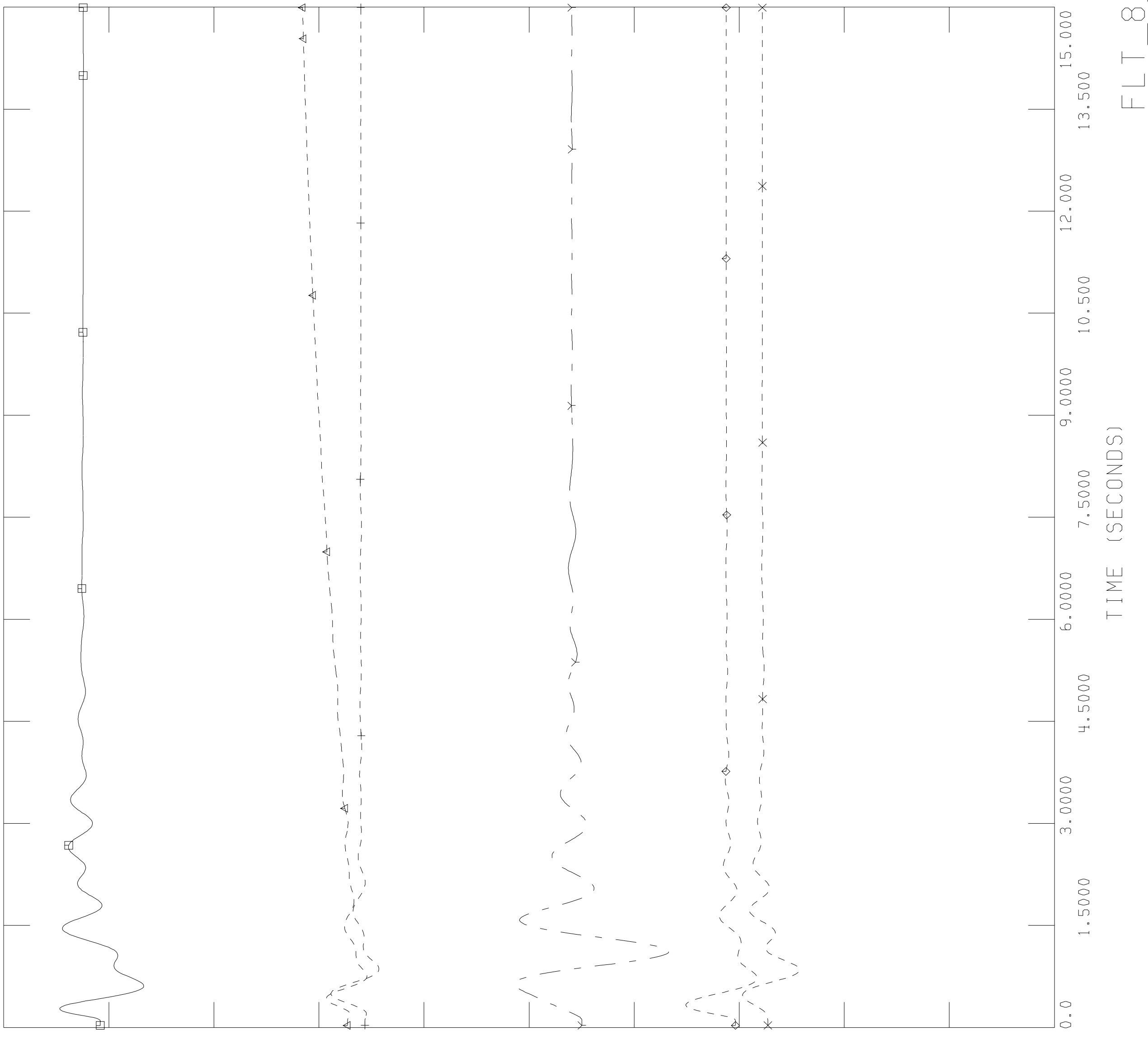
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 13:47

FLT_8_3PH_MACHINE ANGLES

FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_8_3PH.OUT

CHNL# 12: [ANG WCGS U1 WERE]	15.000	10.000
CHNL# 6: [ANG TEC U8 WERE]	15.000	-10.00
CHNL# 5: [ANG LEC U4 WERE]	0.0	-25.00
CHNL# 4: [ANG JEC U1 WERE]	35.000	10.000
CHNL# 3: [ANG COLBY MIDW]	0.0	-50.00
CHNL# 2: [ANG HOLCOMB SUNC]	25.000	0.0



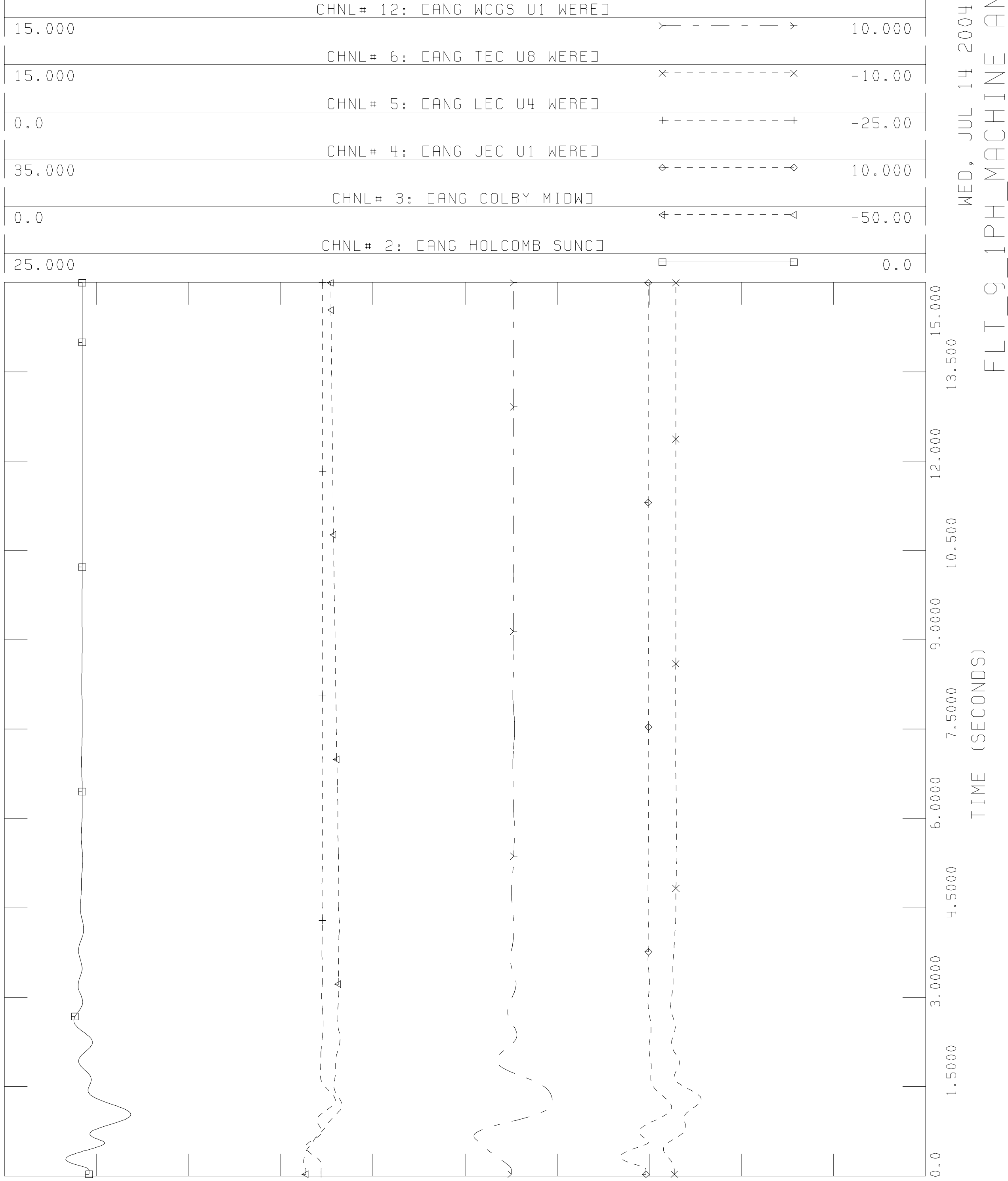
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

WED, JUL 14 2004 13:47

FLT_9_1PH_MACHINE ANGLES

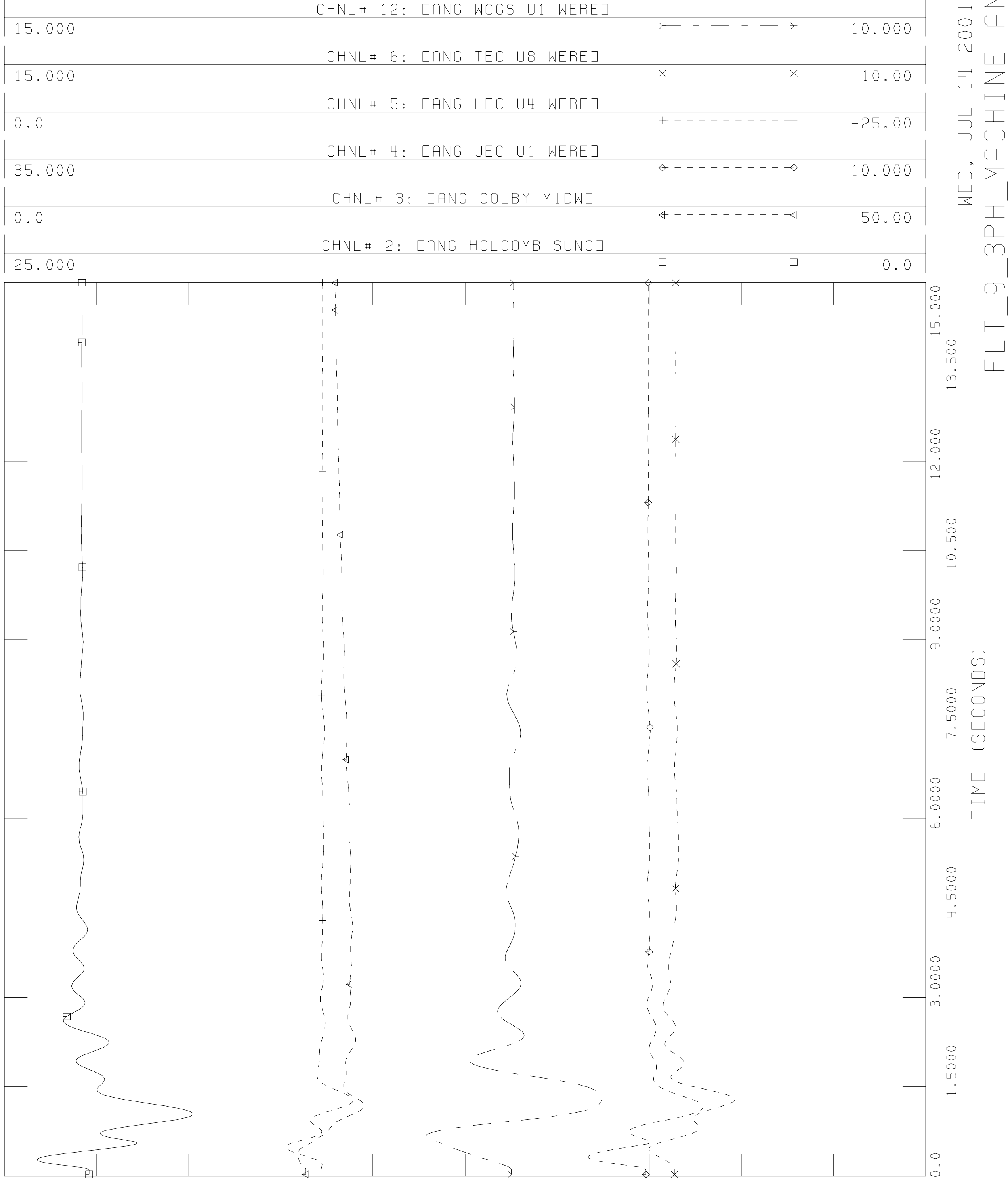
FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_9_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

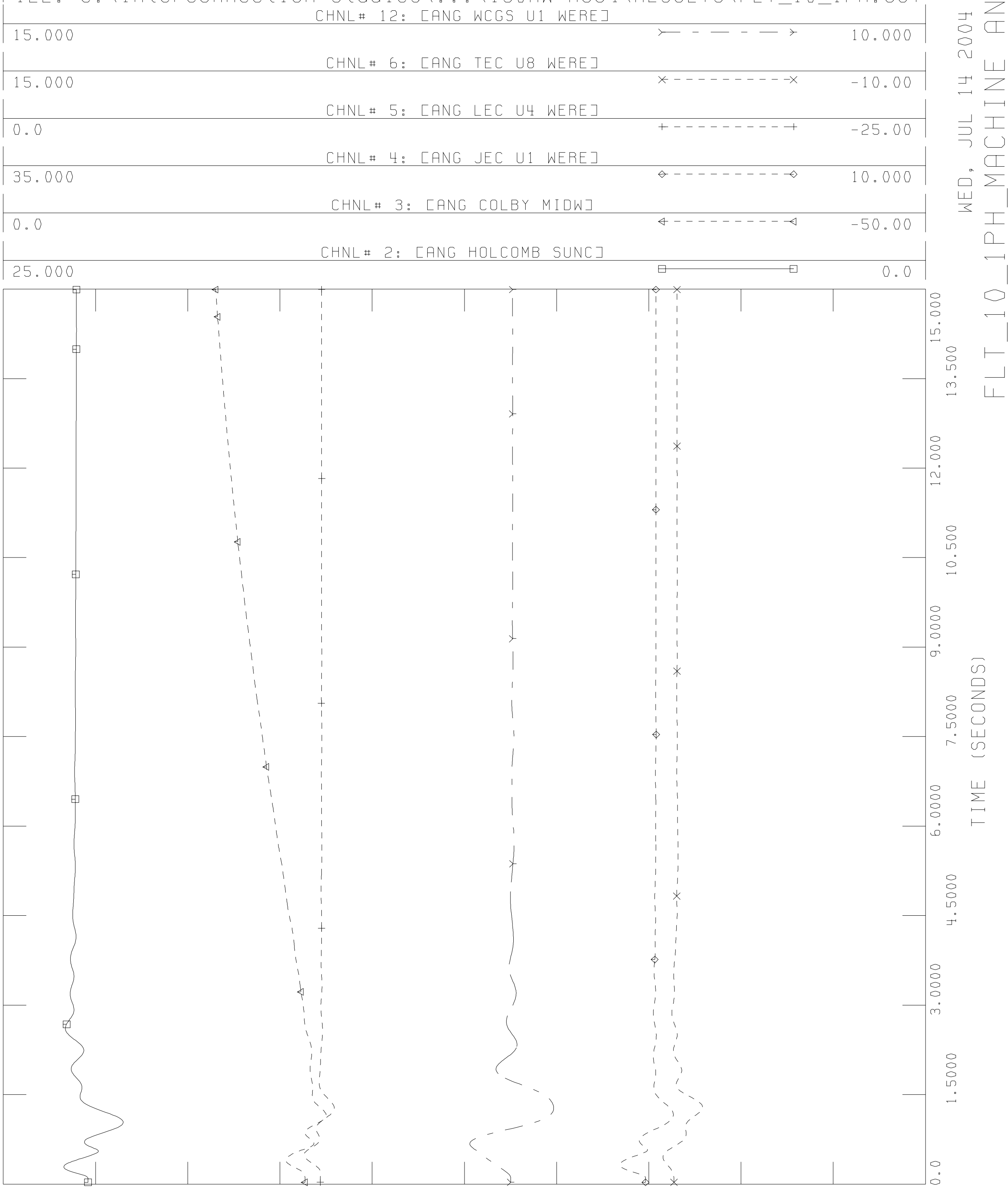
FILE: C:\Interconnection Studies\Working\150MW-AG04\RESULTS\FLT_9_3PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

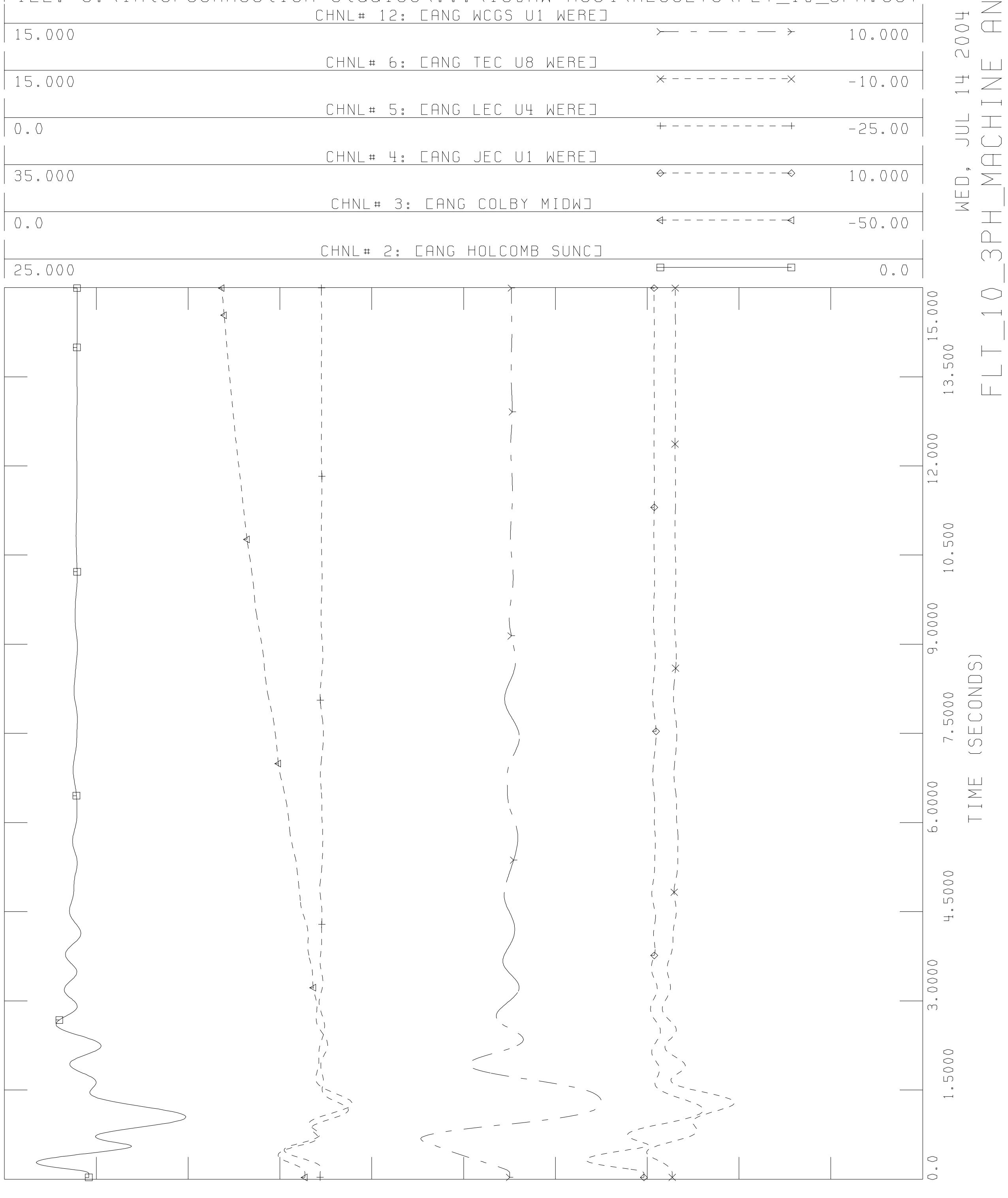
FILE: C:\Interconnection Studies\...\150MW-AG04\RESULTS\FLT_10_1PH.OUT



WED, JUL 14 2004 13:47
FLT_10_1PH_MACHINE ANGLES

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\...\150MW-AG04\RESULTS\FLT_10_3PH.OUT



Appendix E-1

Plots of Fault Simulations

Plots of selected bus voltage response during faults

Scenario:
2005 Summer Peak
Wind Farm at 125MW (50% rated power)
Standard Protection Settings

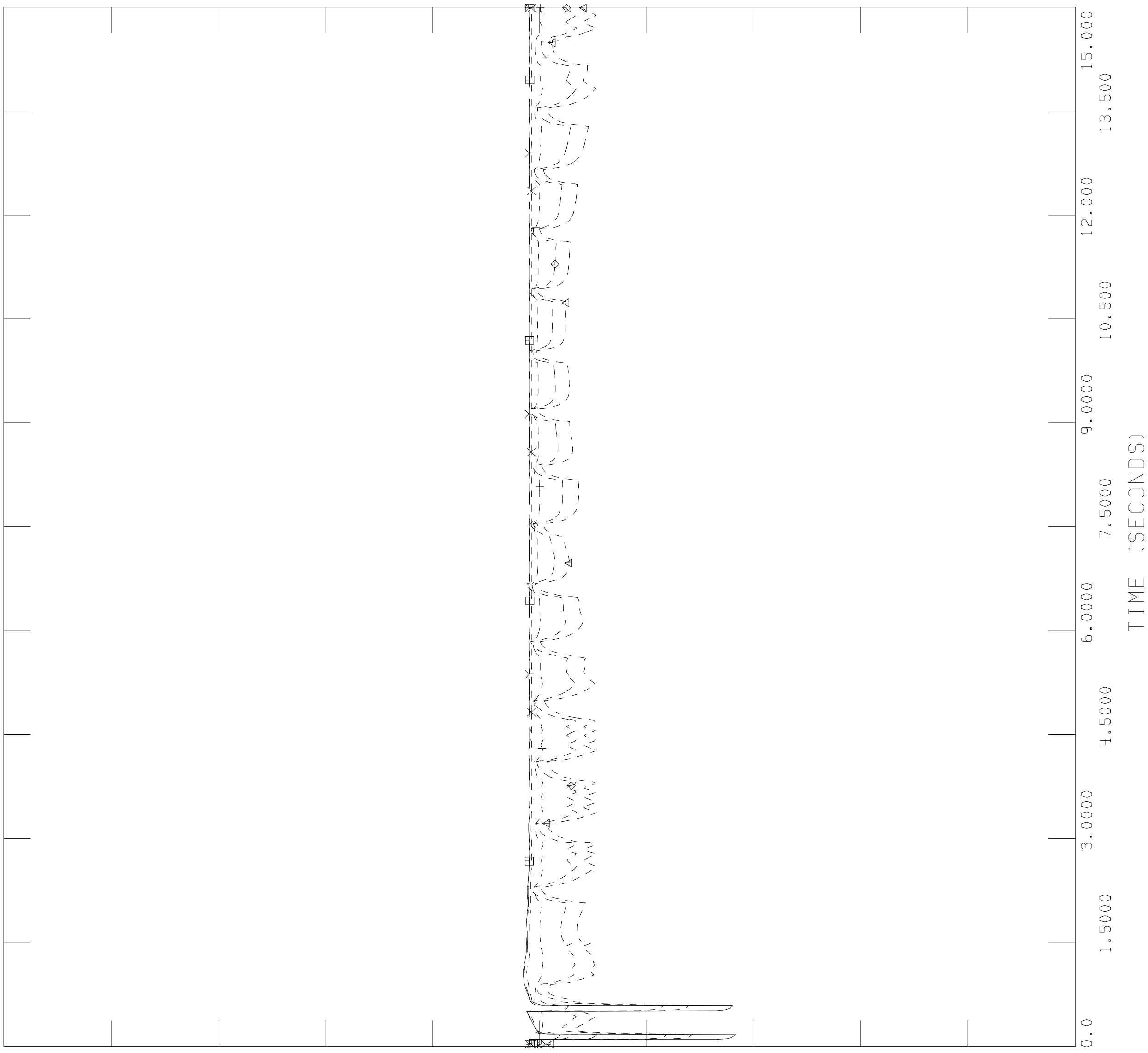
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FRI, JUL 16 2004 13:51
FLT_1_1PH_VOLTAGES

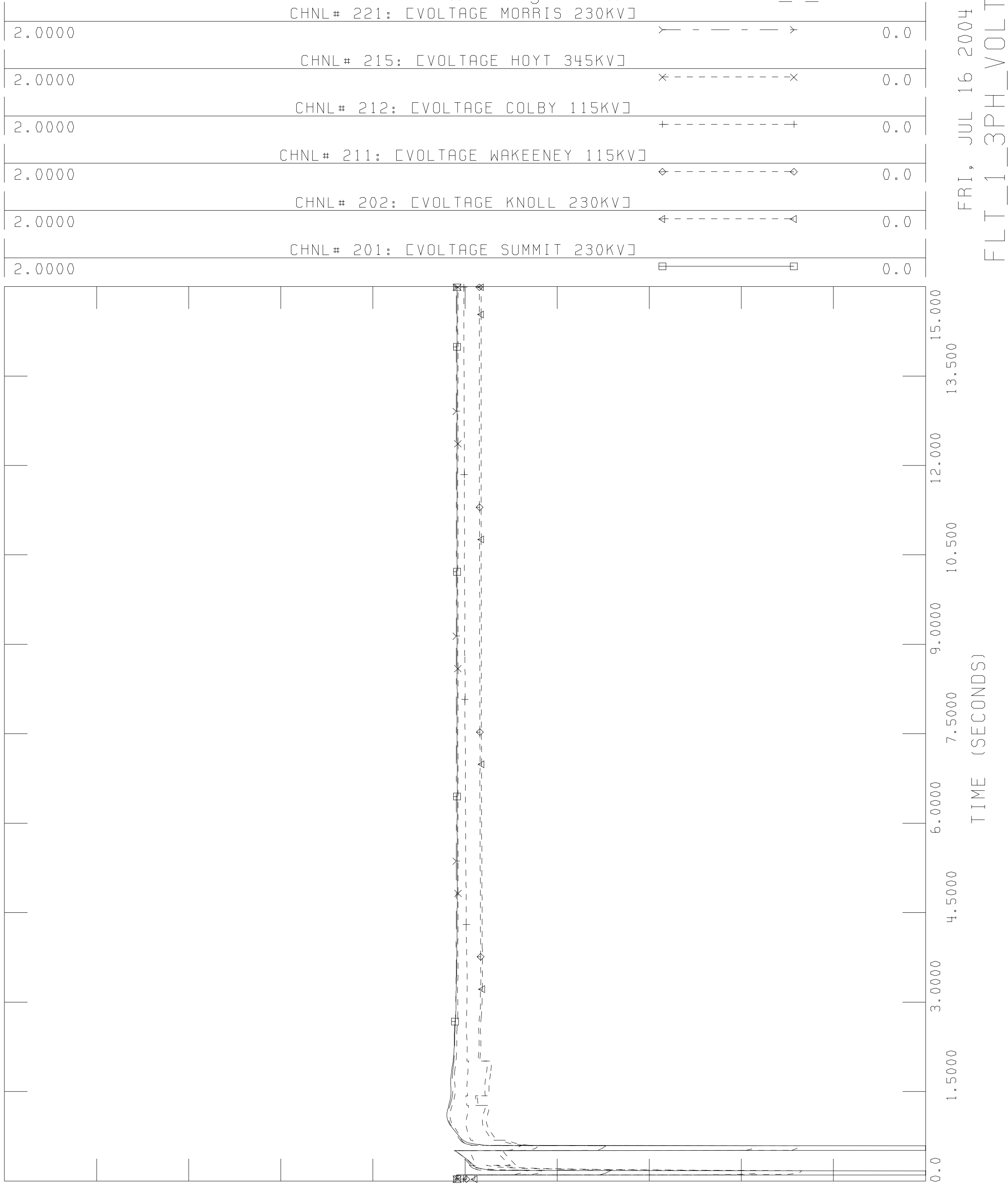
FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_1_1PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]		
2.0000	≻— - — - —≻	0.0
CHNL# 215: [VOLTAGE HOYT 345KV]		
2.0000	×- - - - - - - - - -×	0.0
CHNL# 212: [VOLTAGE COLBY 115KV]		
2.0000	+- - - - - - - - - -+	0.0
CHNL# 211: [VOLTAGE WAKEENEY 115KV]		
2.0000	◇- - - - - - - - - -◇	0.0
CHNL# 202: [VOLTAGE KNOLL 230KV]		
2.0000	◁- - - - - - - - - -◁	0.0
CHNL# 201: [VOLTAGE SUMMIT 230KV]		
2.0000	□————————□	0.0



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

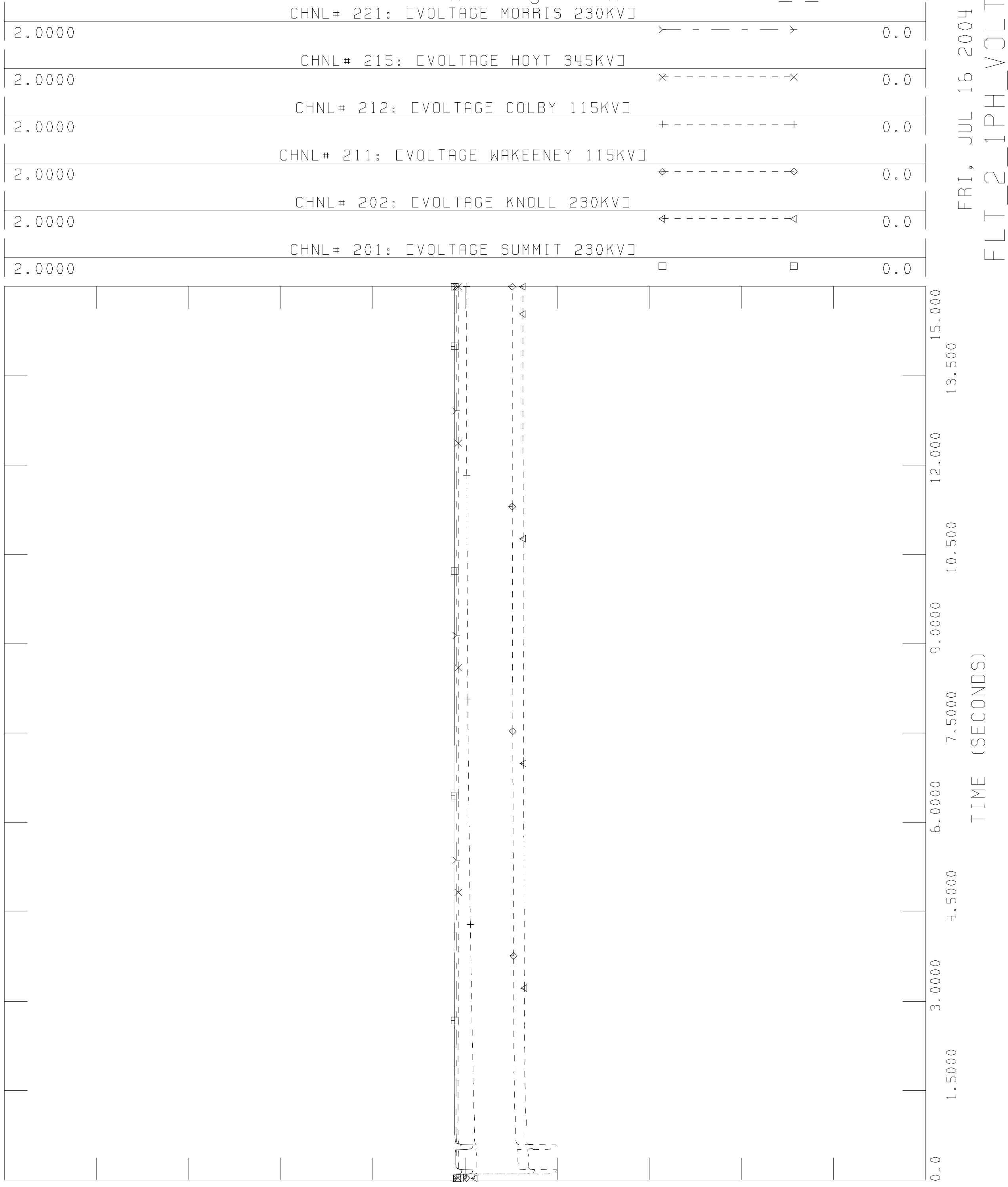
FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_1_3PH.OUT



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_2_1PH.OUT



FRI, JUL 16 2004 13:51

FLT_2_1PH_VOLTAGES

POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_2_3PH.OUT

FRI, JUL 16 2004 13:51
FLT_2_3PH_VOLTAGES

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 0.0

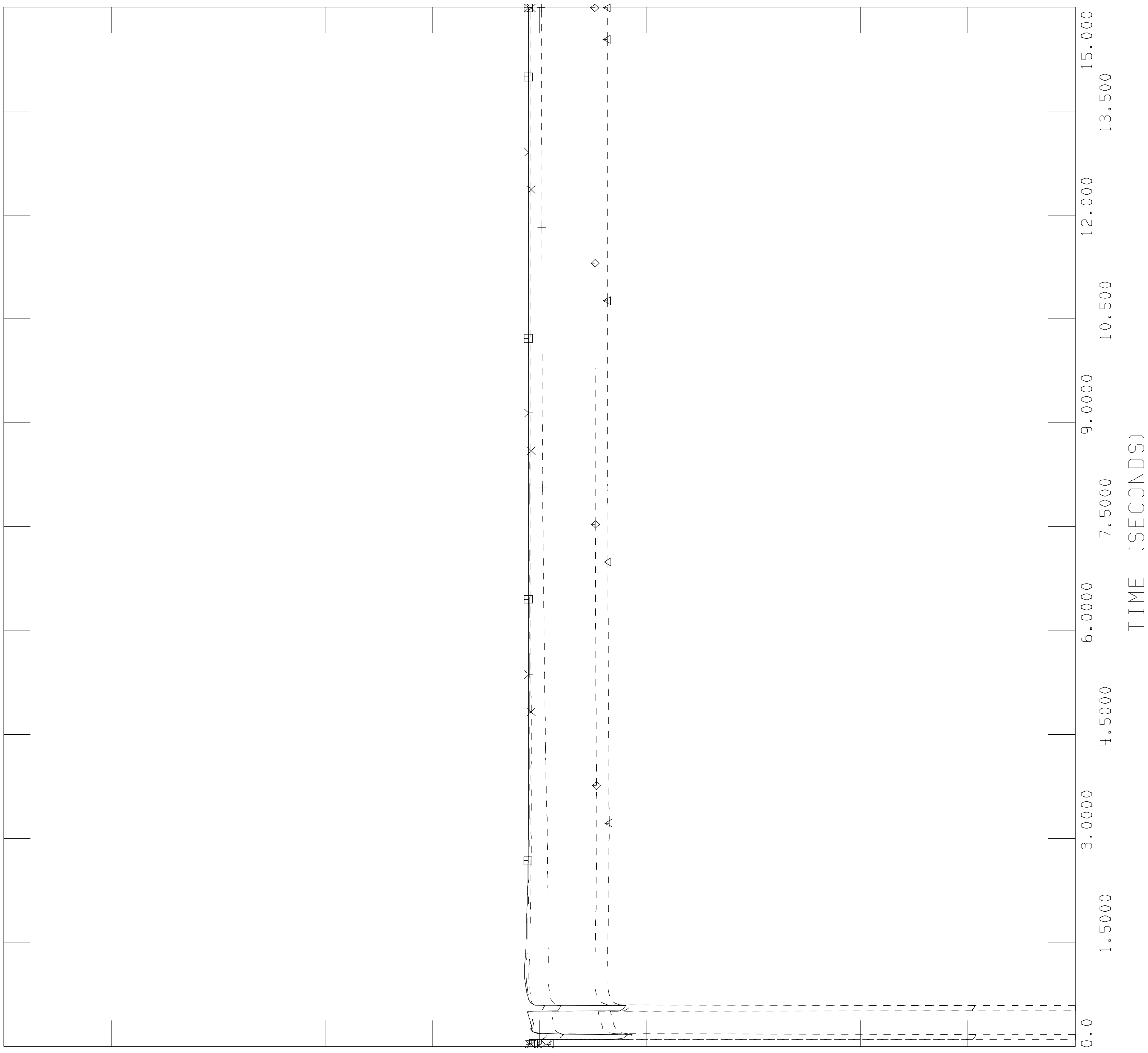
CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 0.0

CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 0.0

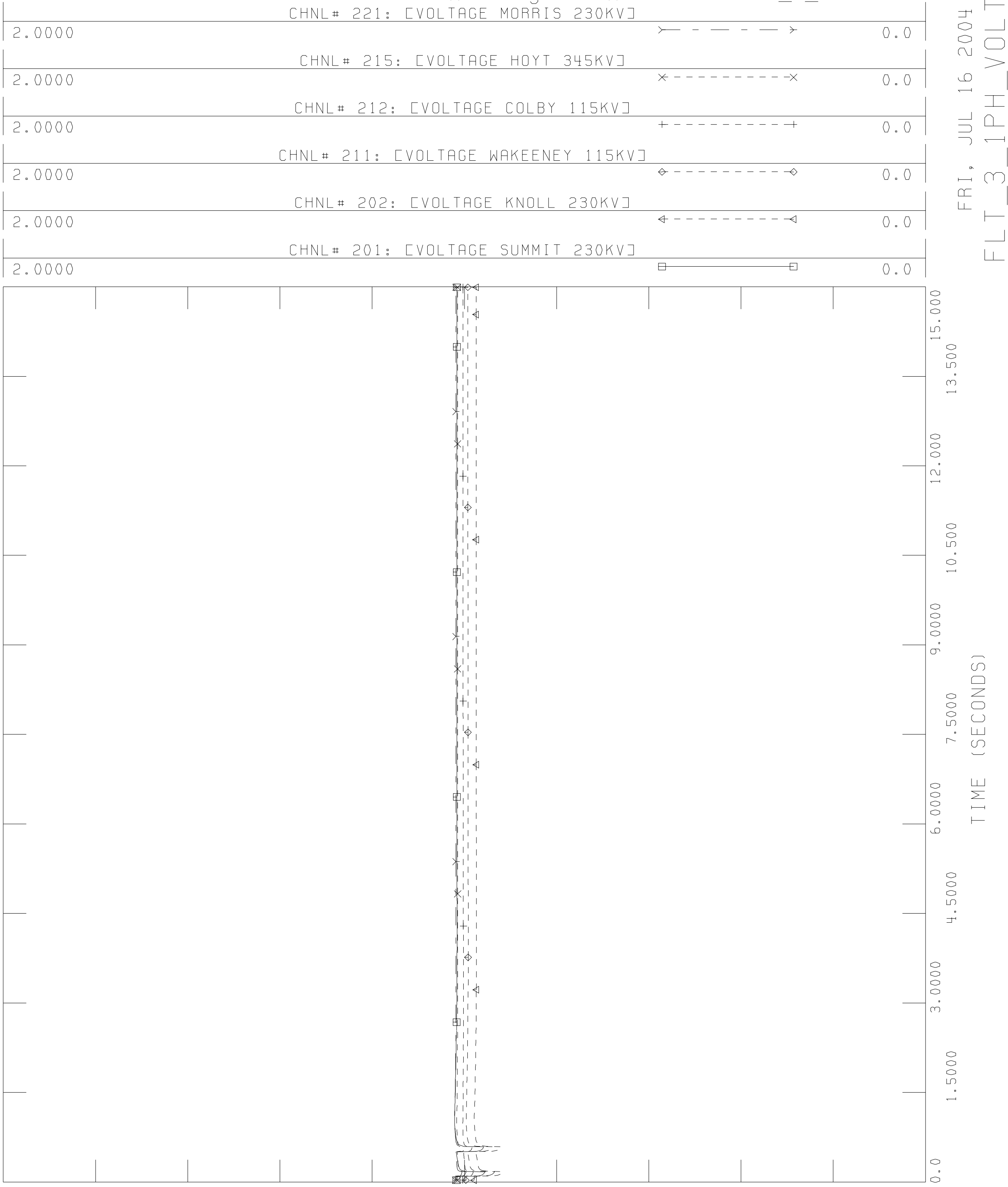
CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 0.0



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_3_1PH.OUT



FRI, JUL 16 2004 13:51
FLT_3_1PH_VOLTAGES

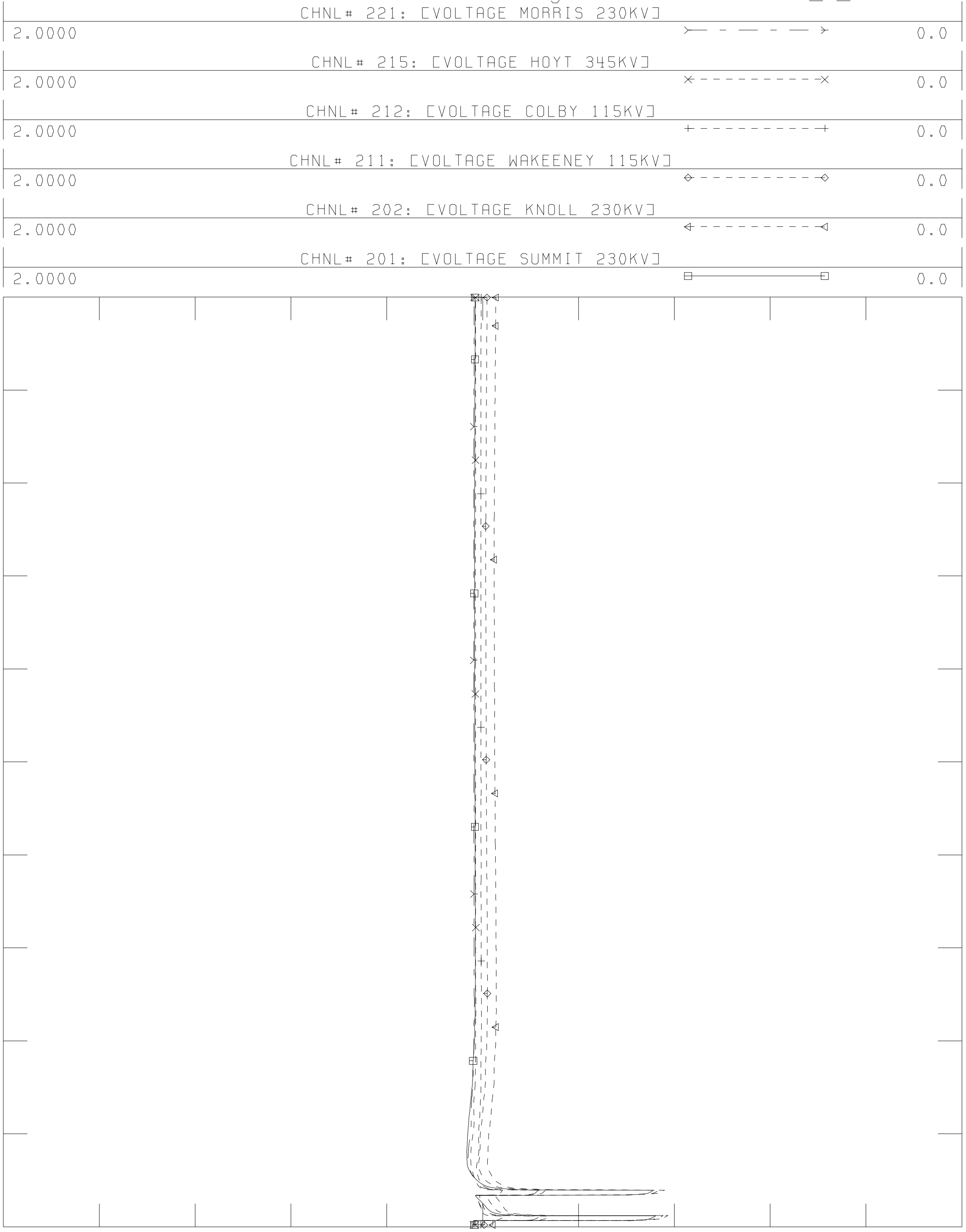
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_3_3PH.OUT

FRI, JUL 16 2004 13:51

FLT_3_3PH_VOLTAGES



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FRI, JUL 16 2004 13:51

FLT_4_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_4_1PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 ≻ - — - — ≻ 0.0

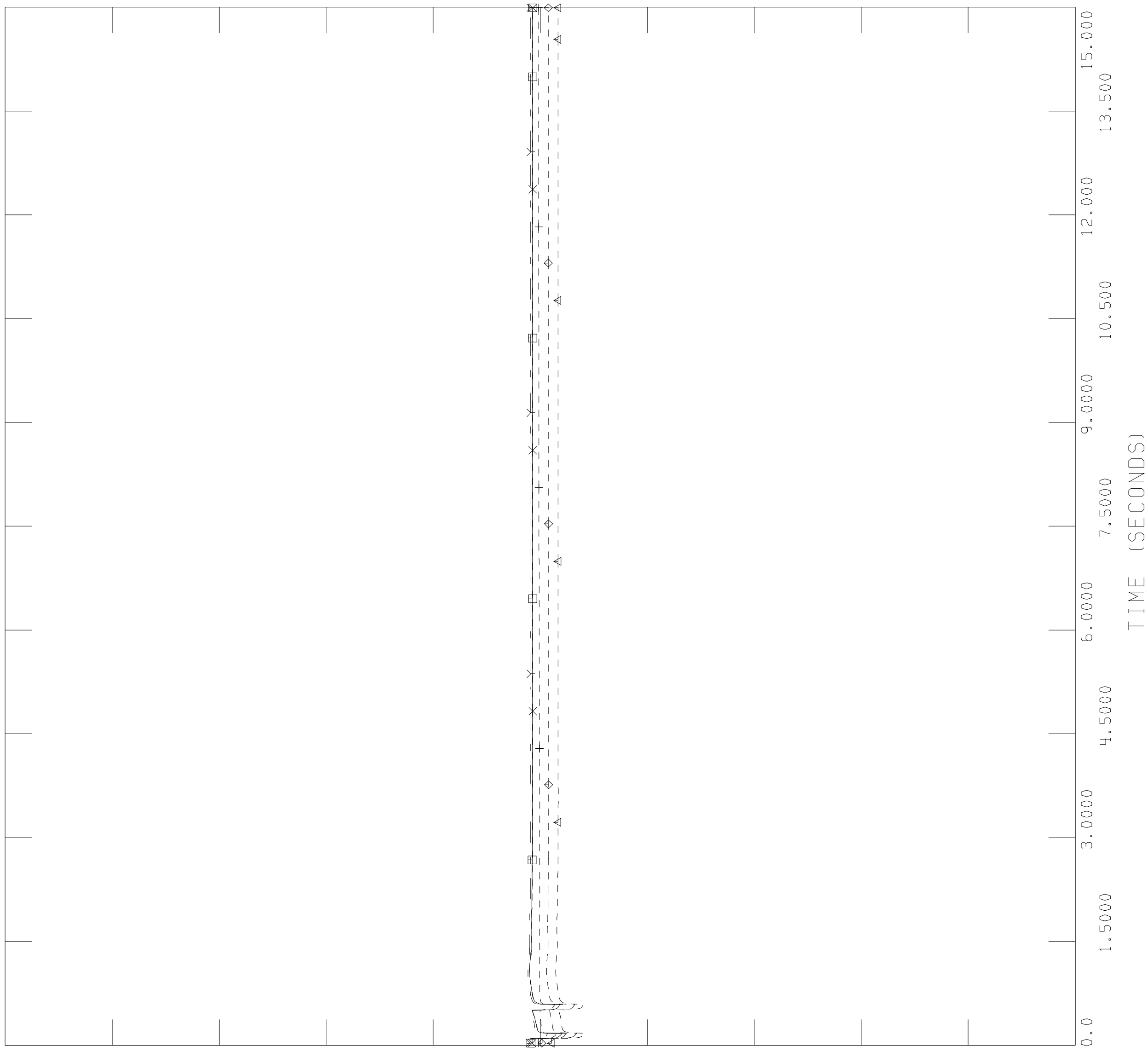
CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 ×----------× 0.0

CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 +----------+ 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 ◇----------◇ 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 ◁----------◁ 0.0

CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 ⊡——————⊡ 0.0



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_4_3PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 0.0

CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 0.0

CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 0.0

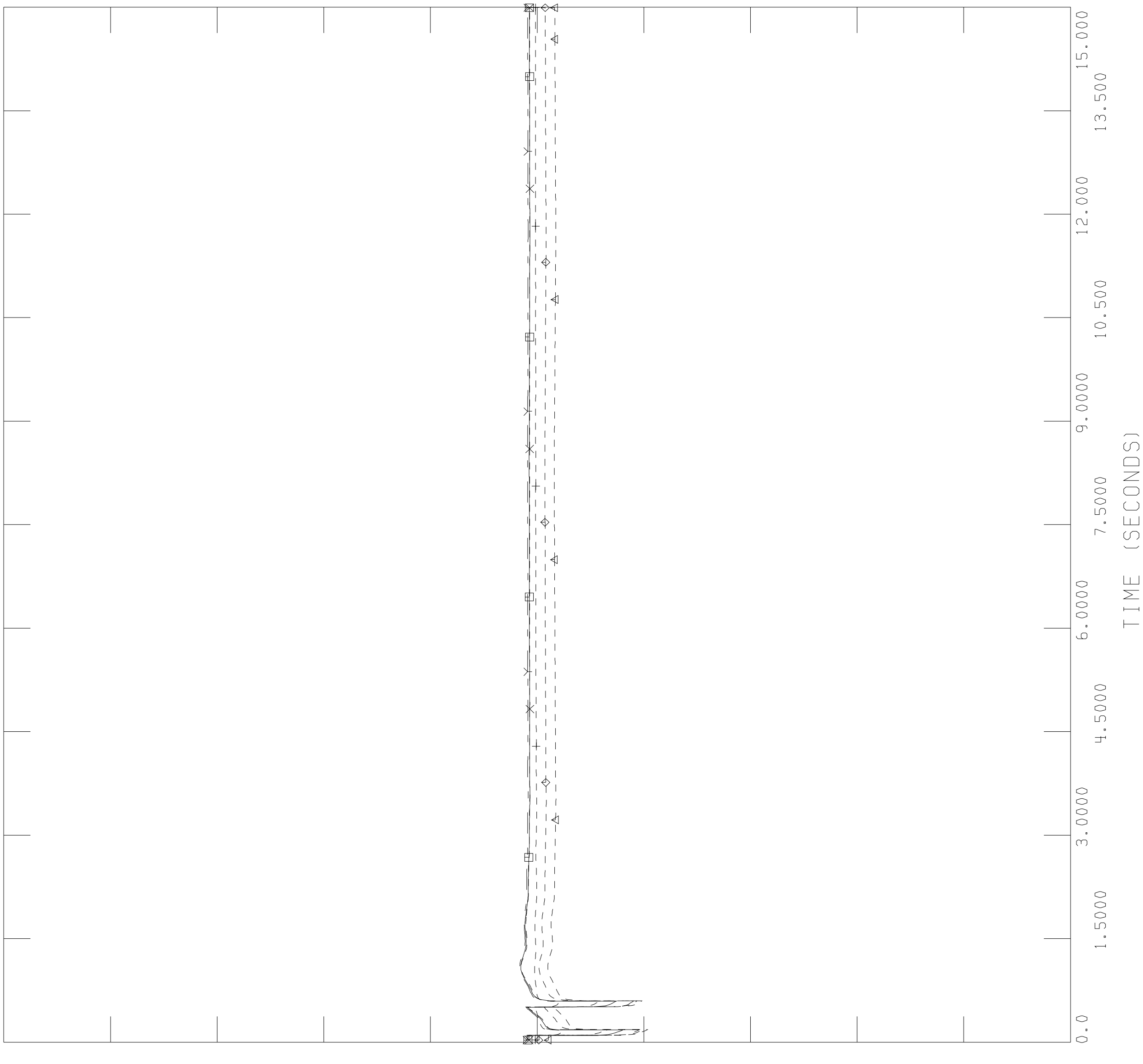
CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 0.0

CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 0.0

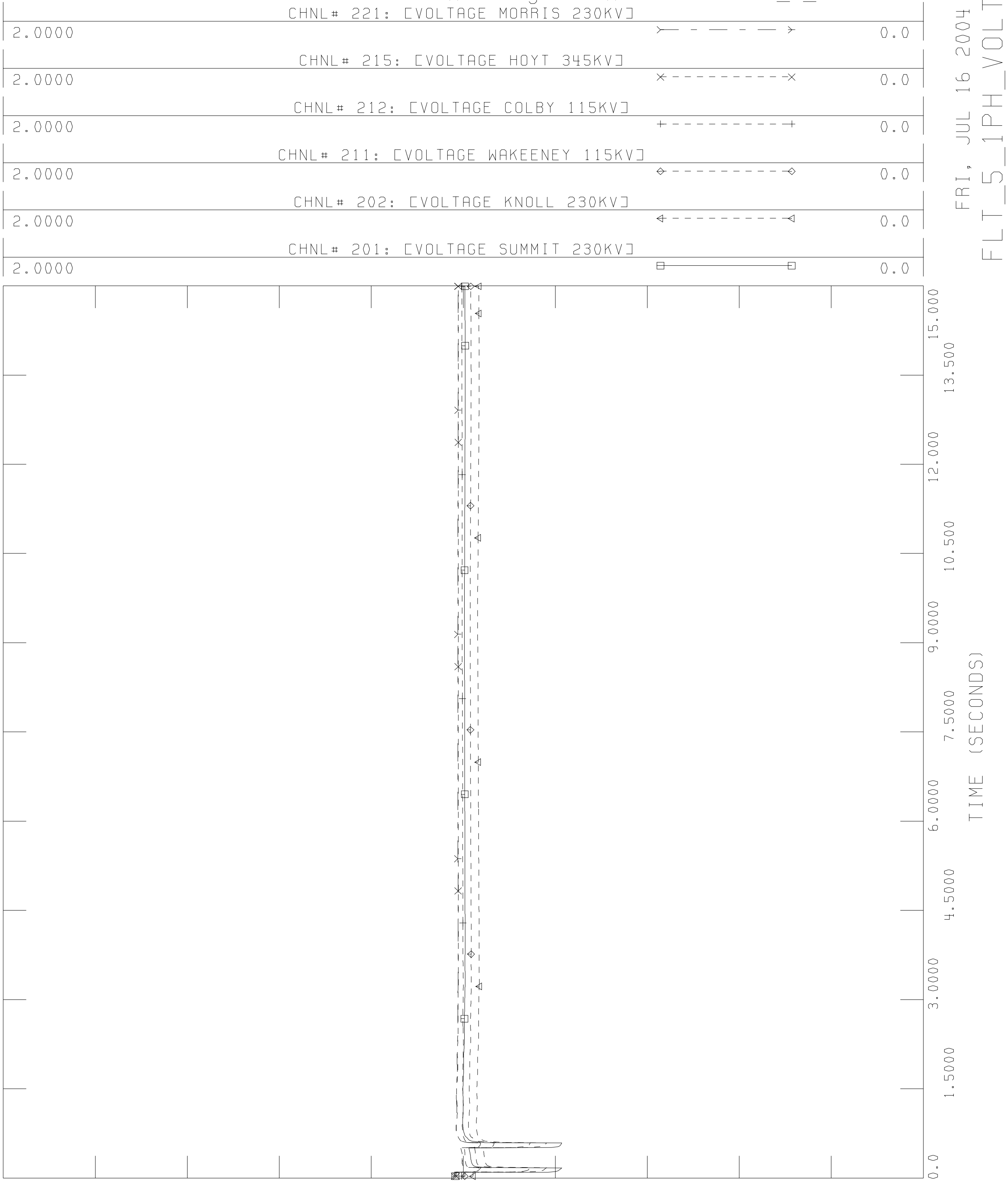
FRI, JUL 16 2004 13:51

FLT_4_3PH_VOLTAGES



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_5_1PH.OUT

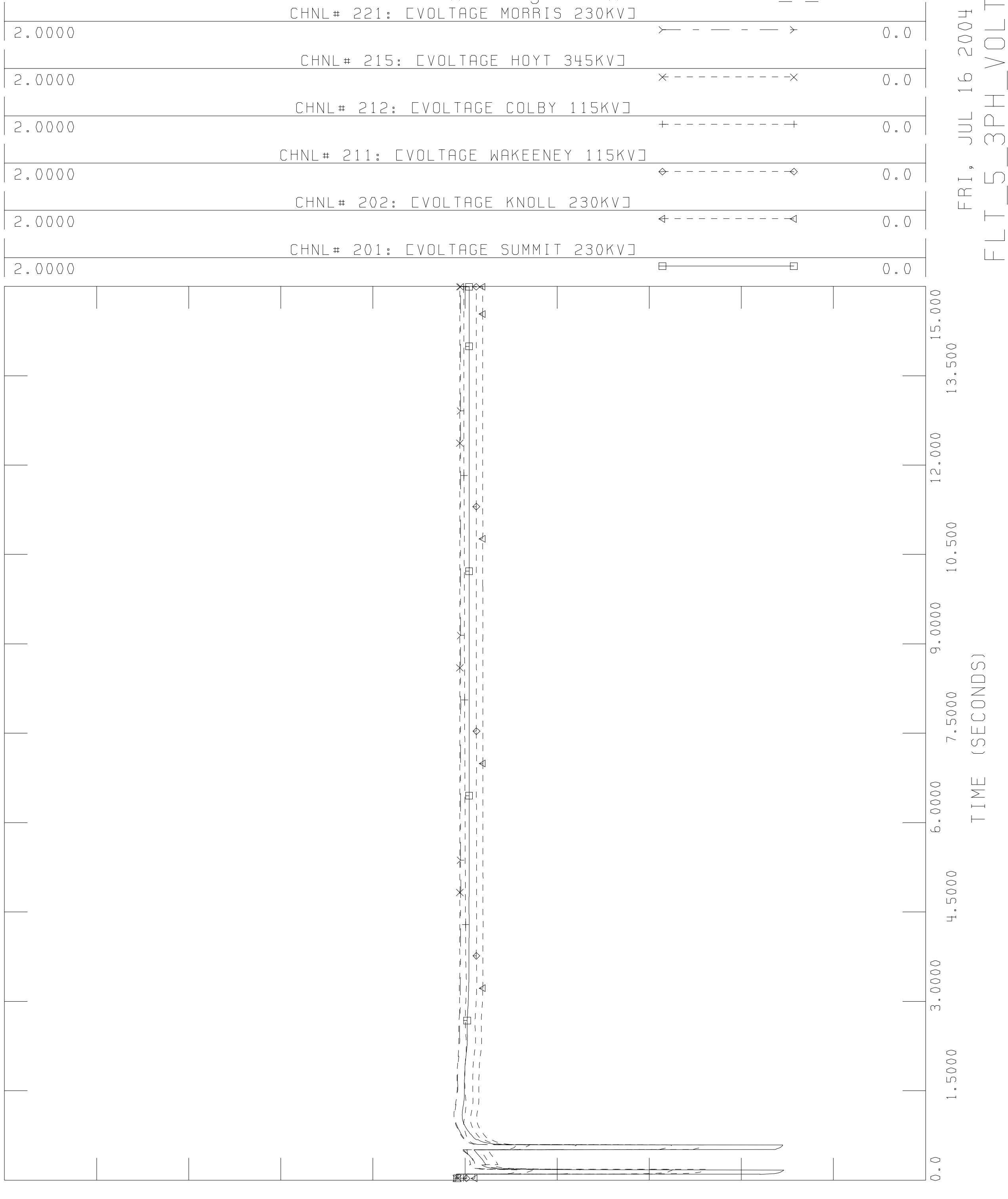


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_5_3PH.OUT

FRI, JUL 16 2004 13:51

FLT_5_3PH_VOLTAGES



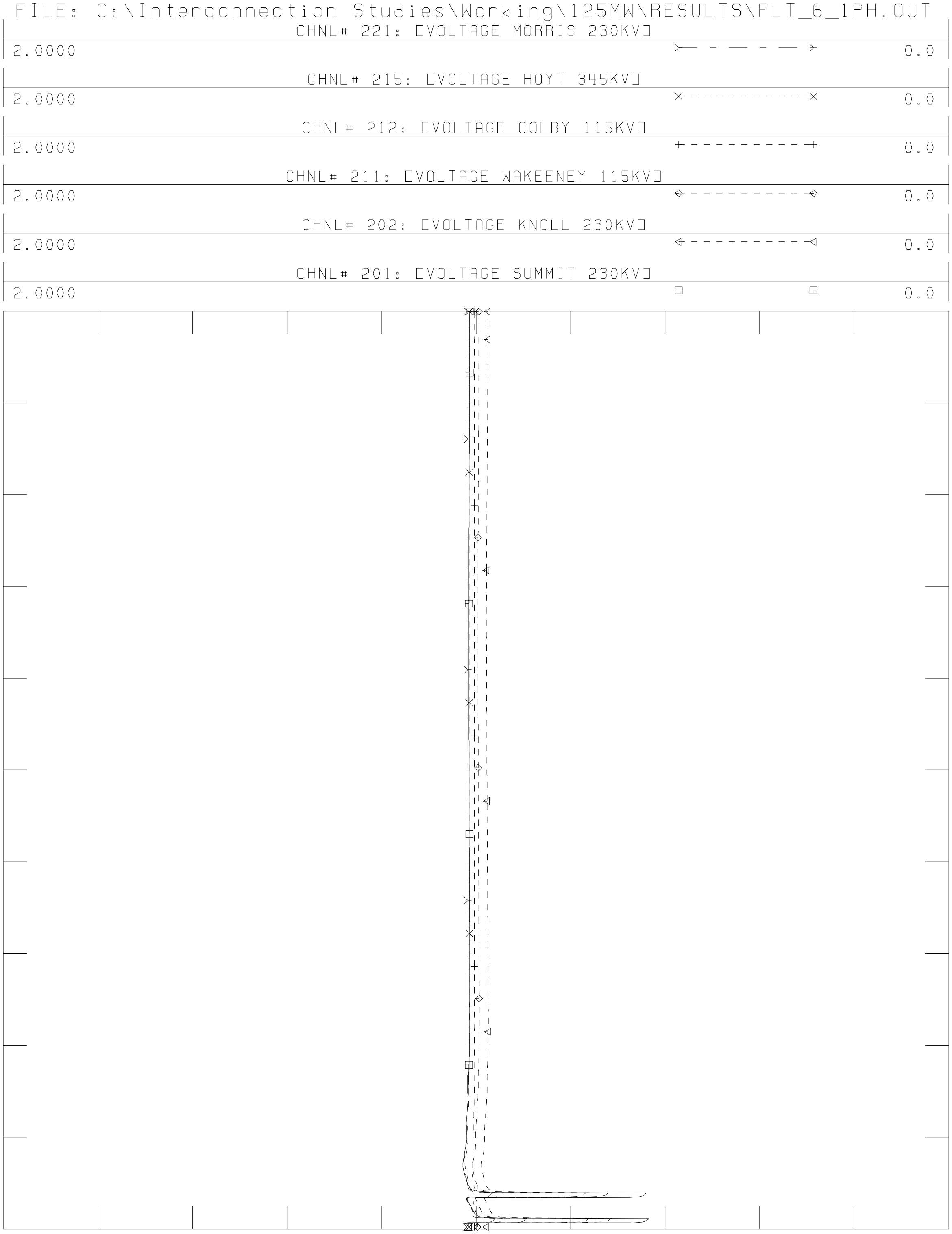
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FRI, JUL 16 2004 13:51

FLT_6_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_6_1PH.OUT



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FRI, JUL 16 2004 13:51
FLT_6_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_6_3PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 ≻ - — - — ≻ 0.0

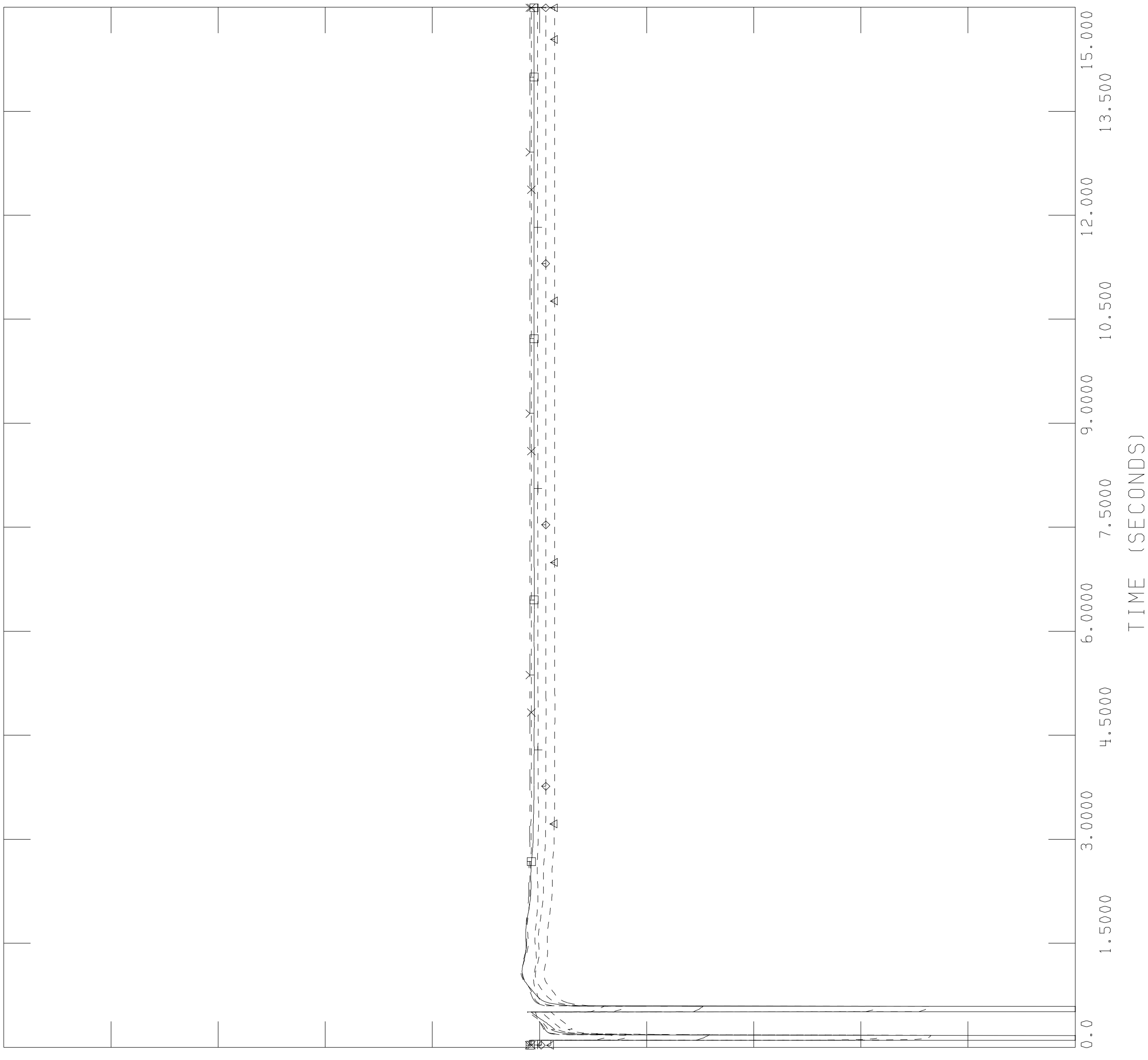
CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 ×----------× 0.0

CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 +----------+ 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 ◇----------◇ 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 ◁----------◁ 0.0

CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 □——————□ 0.0



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FRI, JUL 16 2004 13:51
FLT_7_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_7_1PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 0.0

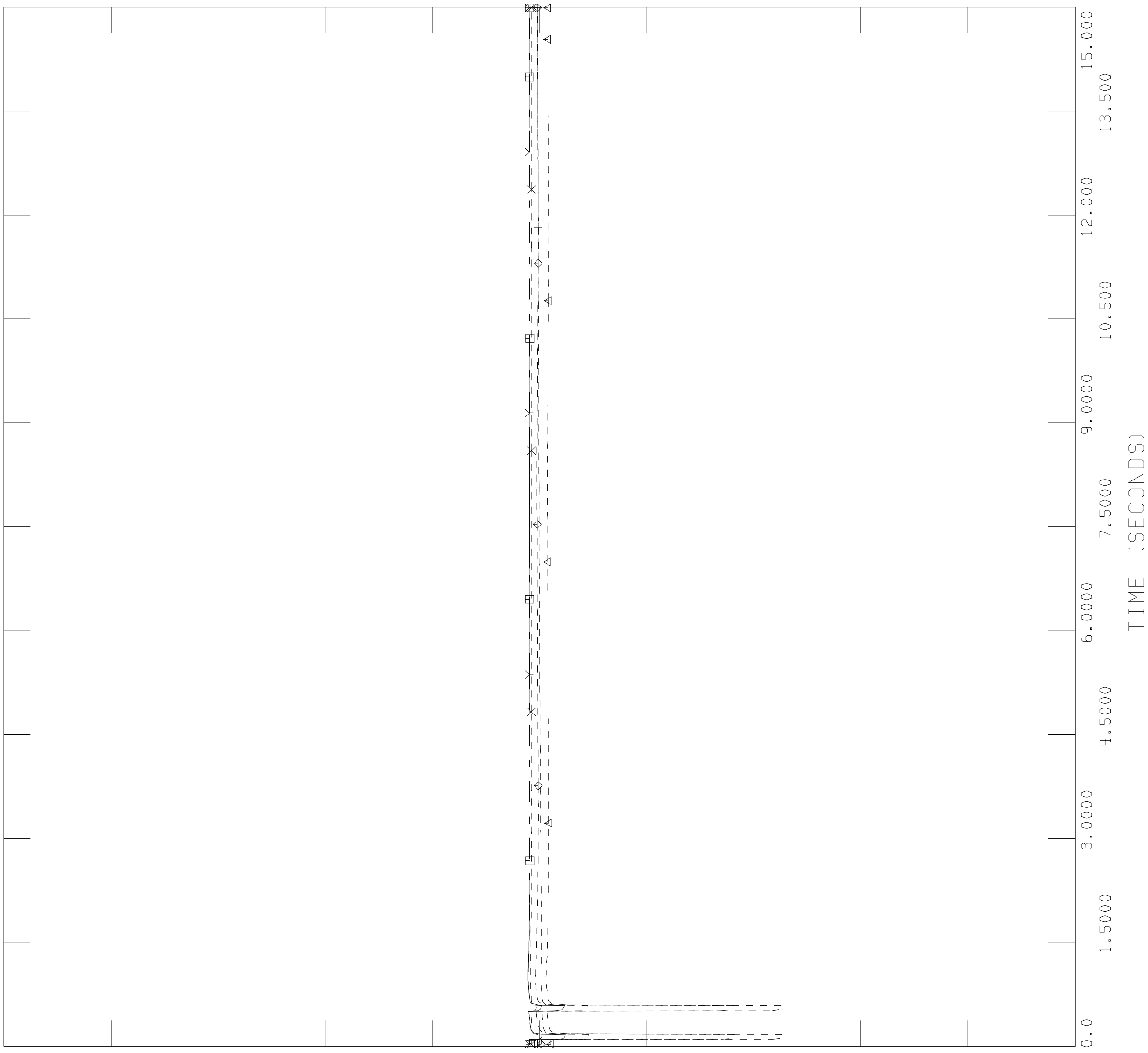
CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 0.0

CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 0.0

CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 0.0



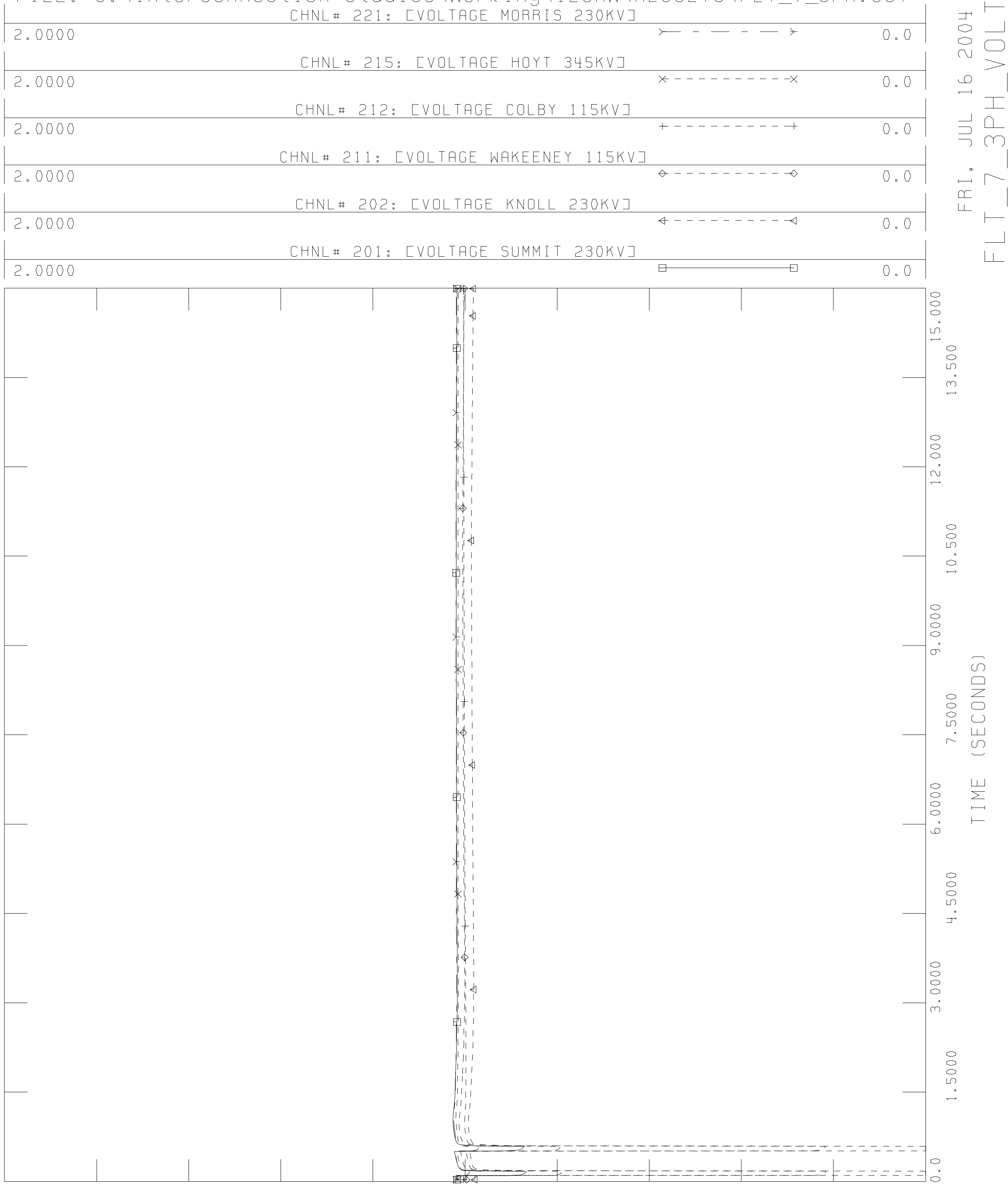
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_7_3PH.OUT

FRI, JUL 16 2004 13:51

FLT_7_3PH_VOLTAGES

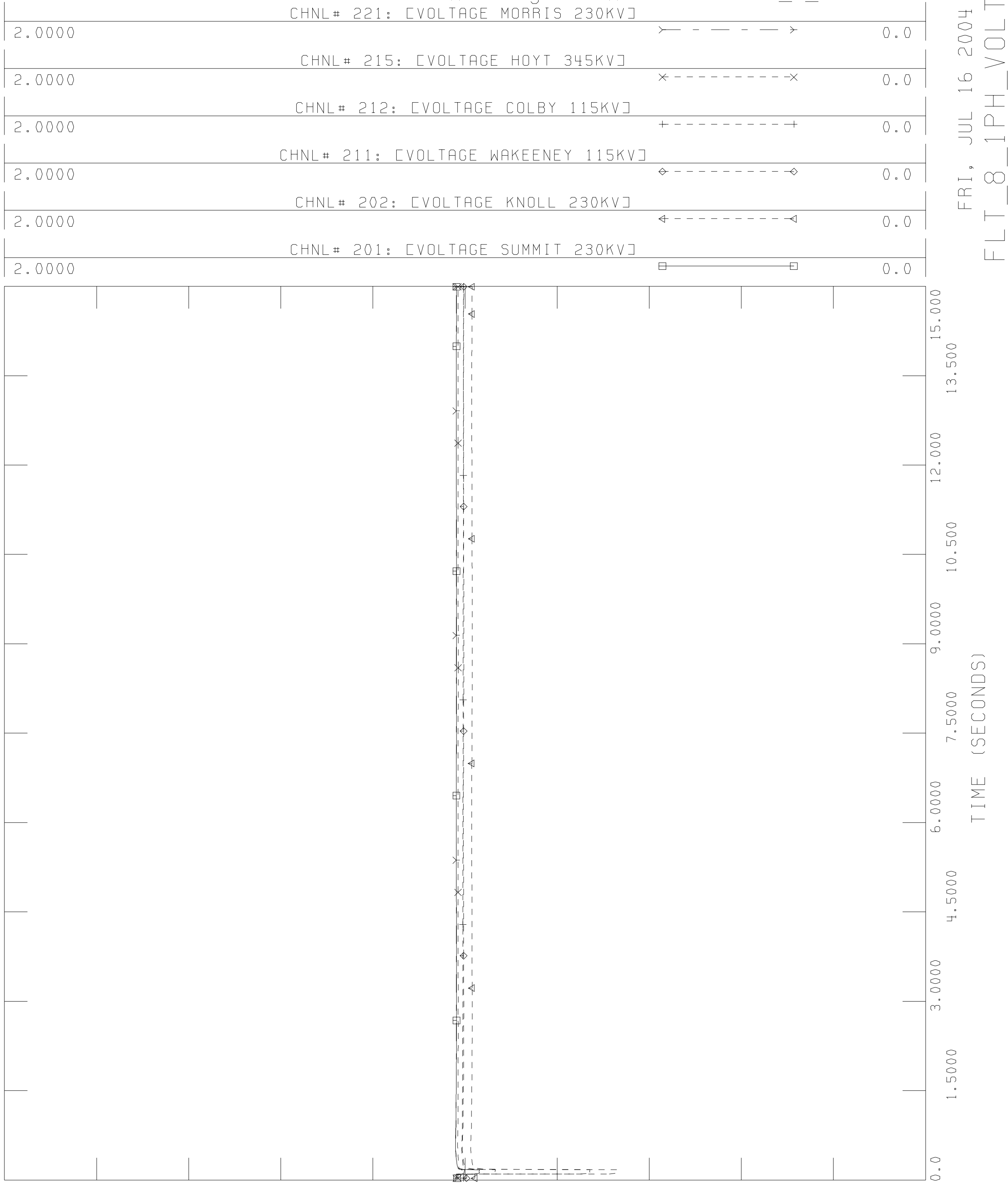


POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

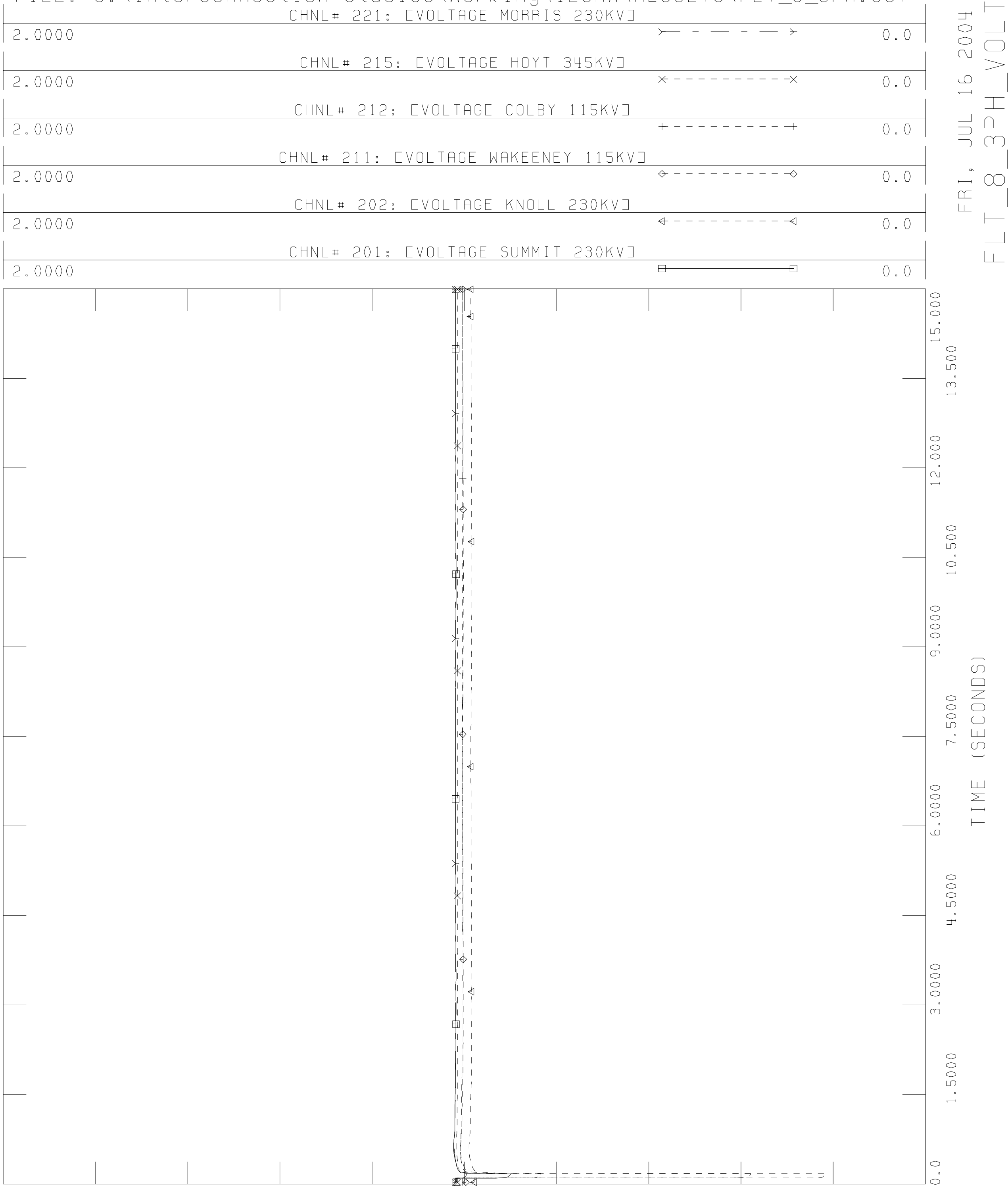
FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_8_1PH.OUT

FRI, JUL 16 2004 13:51
FLT_8_1PH_VOLTAGES



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_8_3PH.OUT



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FRI, JUL 16 2004 13:51
FLT_9_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_9_1PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 0.0

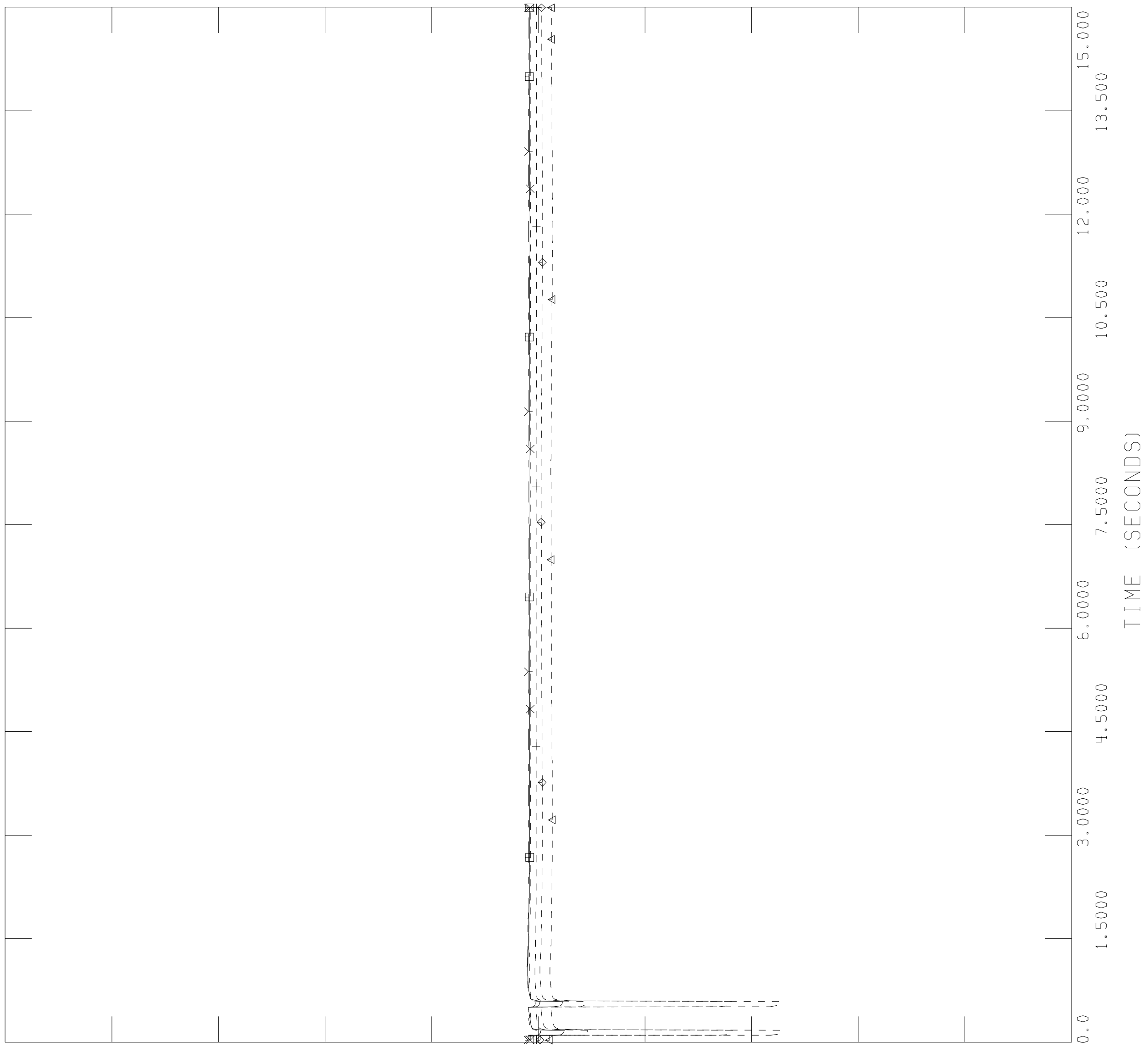
CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 0.0

CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 0.0

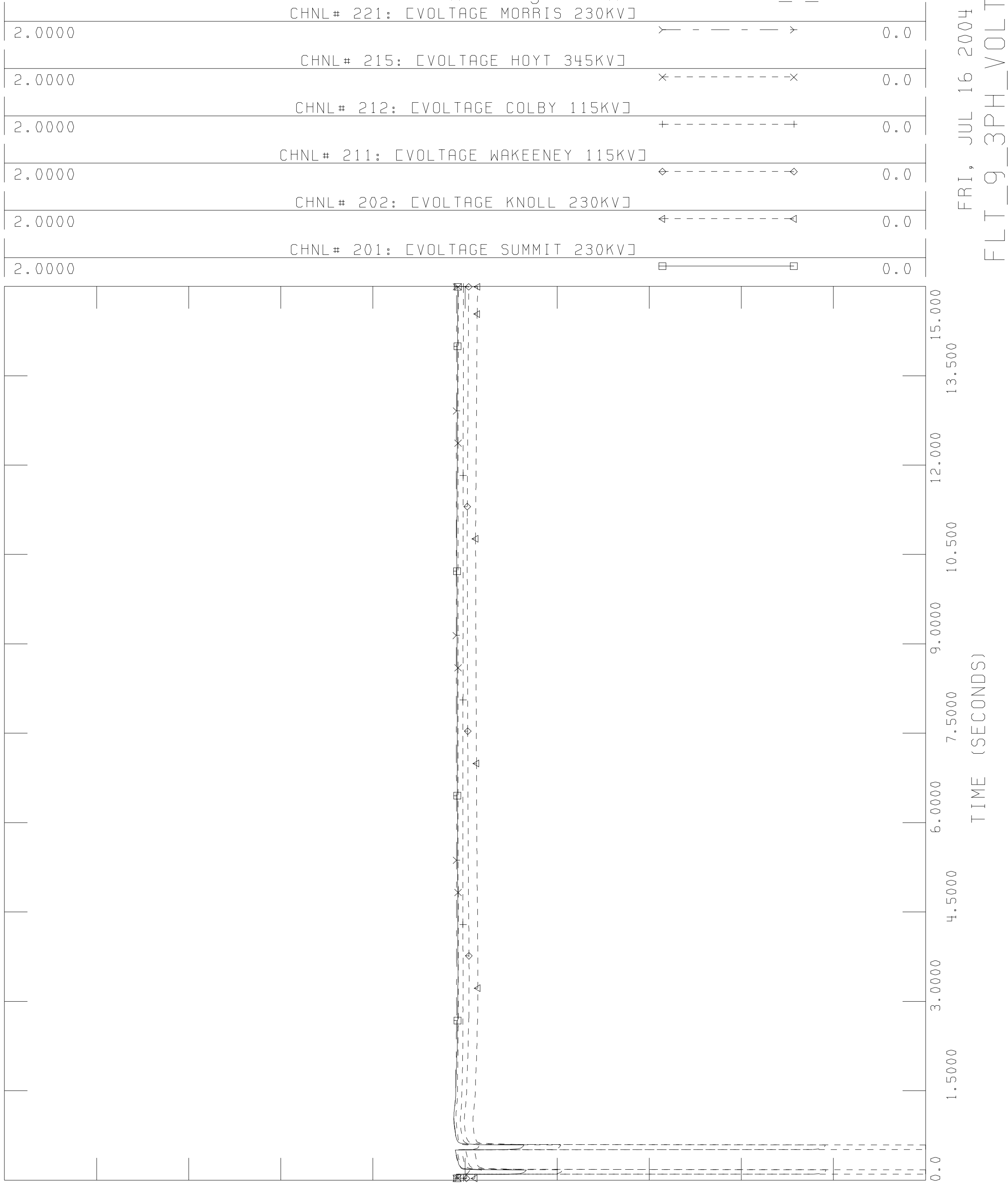
CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 0.0



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_9_3PH.OUT



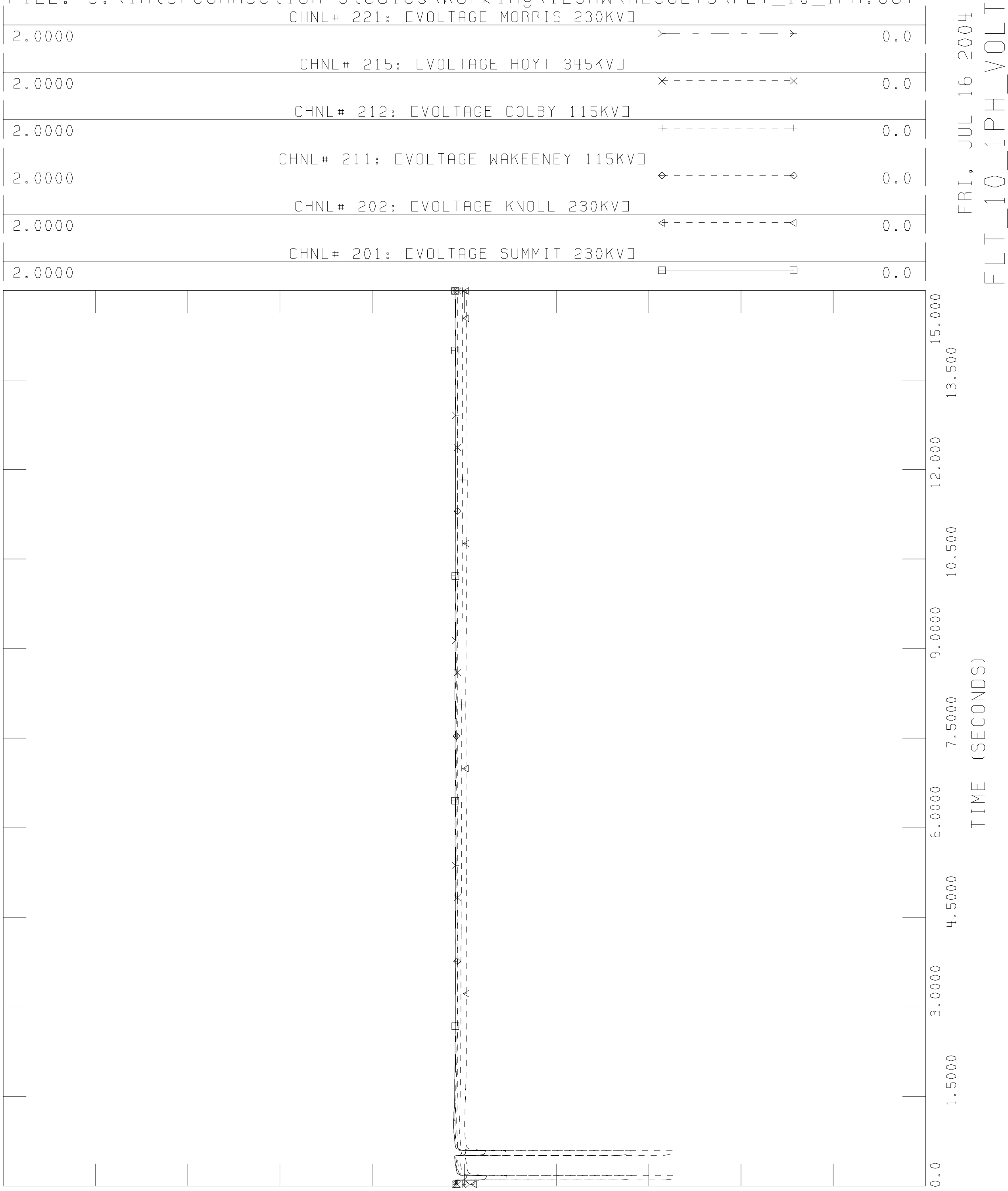
FRI, JUL 16 2004 13:51
FLT_9_3PH_VOLTAGES

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

POWER
TECHNOLOGIES
INC.®

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_10_1PH.OUT

FRI, JUL 16 2004 13:51
FLT_10_1PH_VOLTAGES



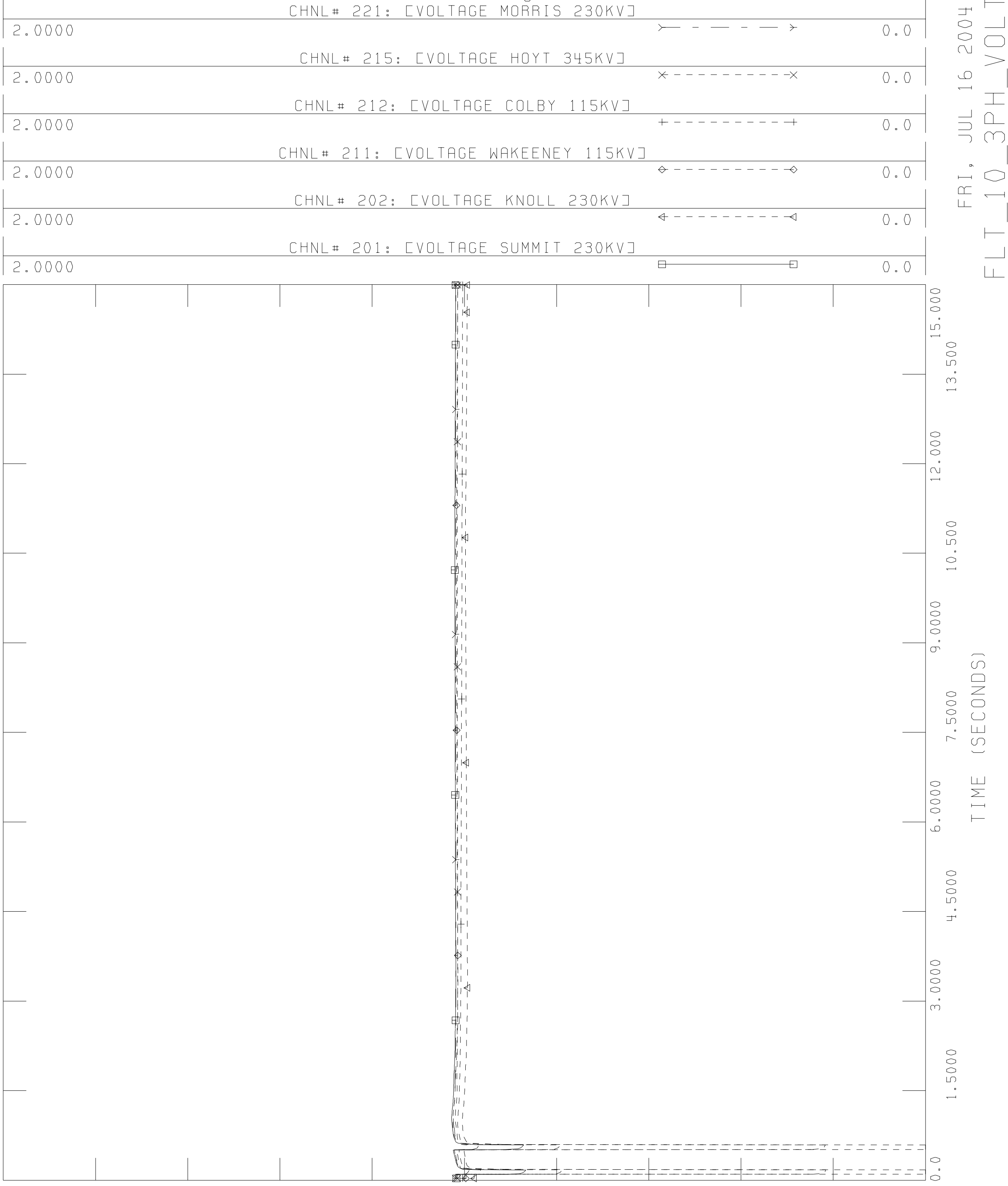
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_10_3PH.OUT

FRI, JUL 16 2004 13:51

FLT_10_3PH_VOLTAGES



Appendix E-2

Plots of Fault Simulations

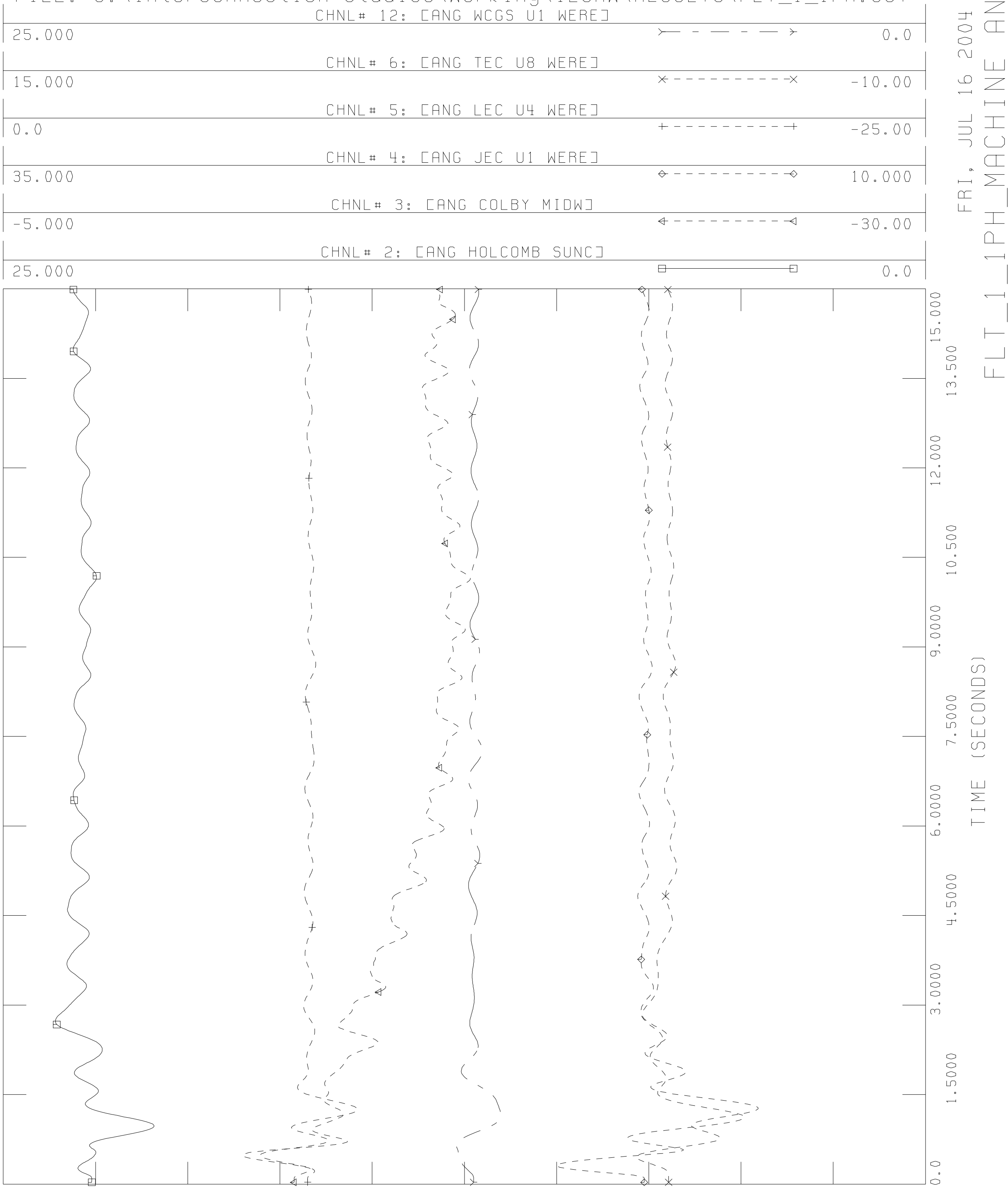
Plots of selected machine phase angles during faults

Scenario:
2005 Summer Peak
Wind Farm at 125MW (50% rated power)
Standard Protection Settings

POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_1_1PH.OUT



FRI, JUL 16 2004 14:07

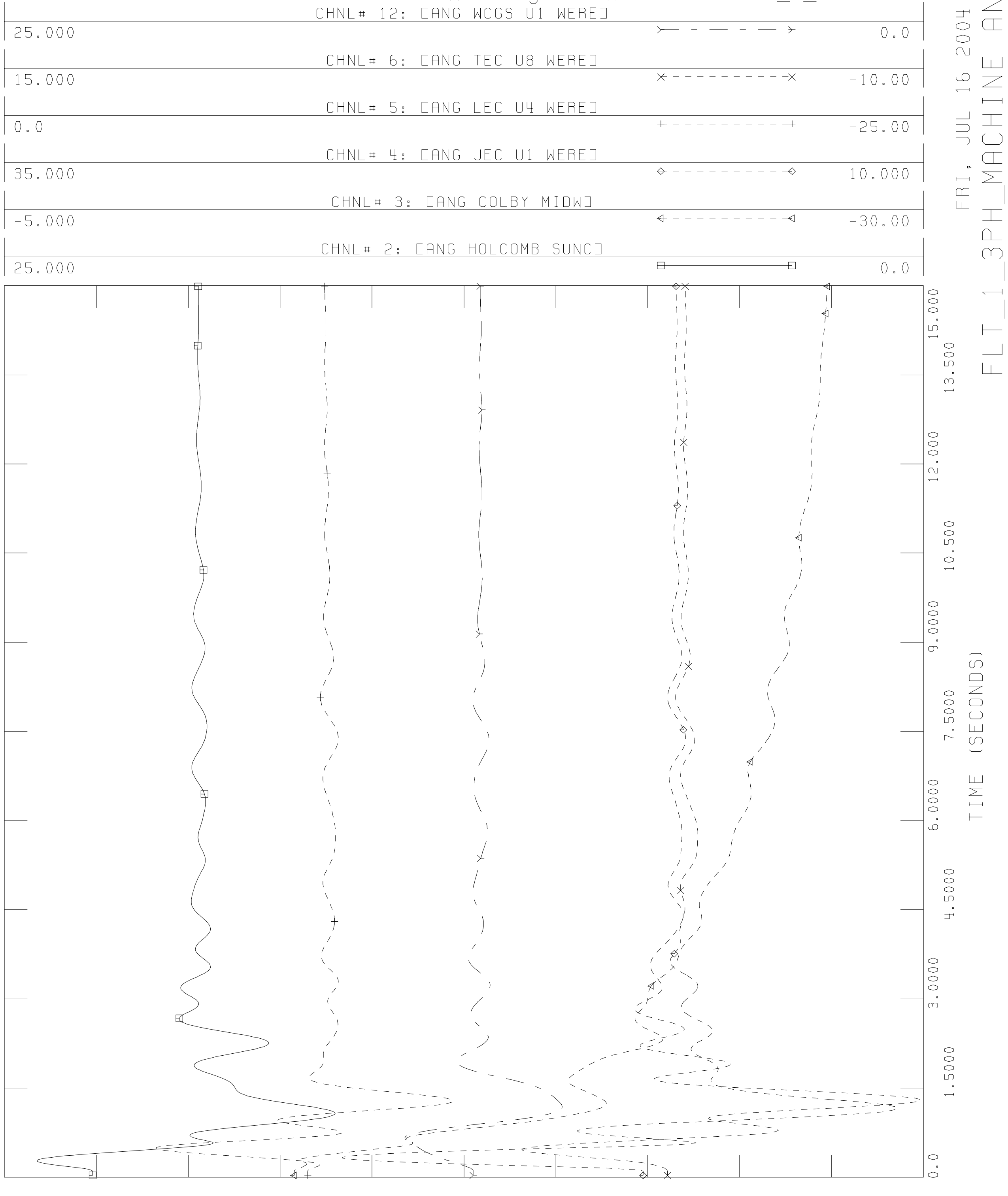
FLT_1_1PH_MACHINE ANGLES

POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

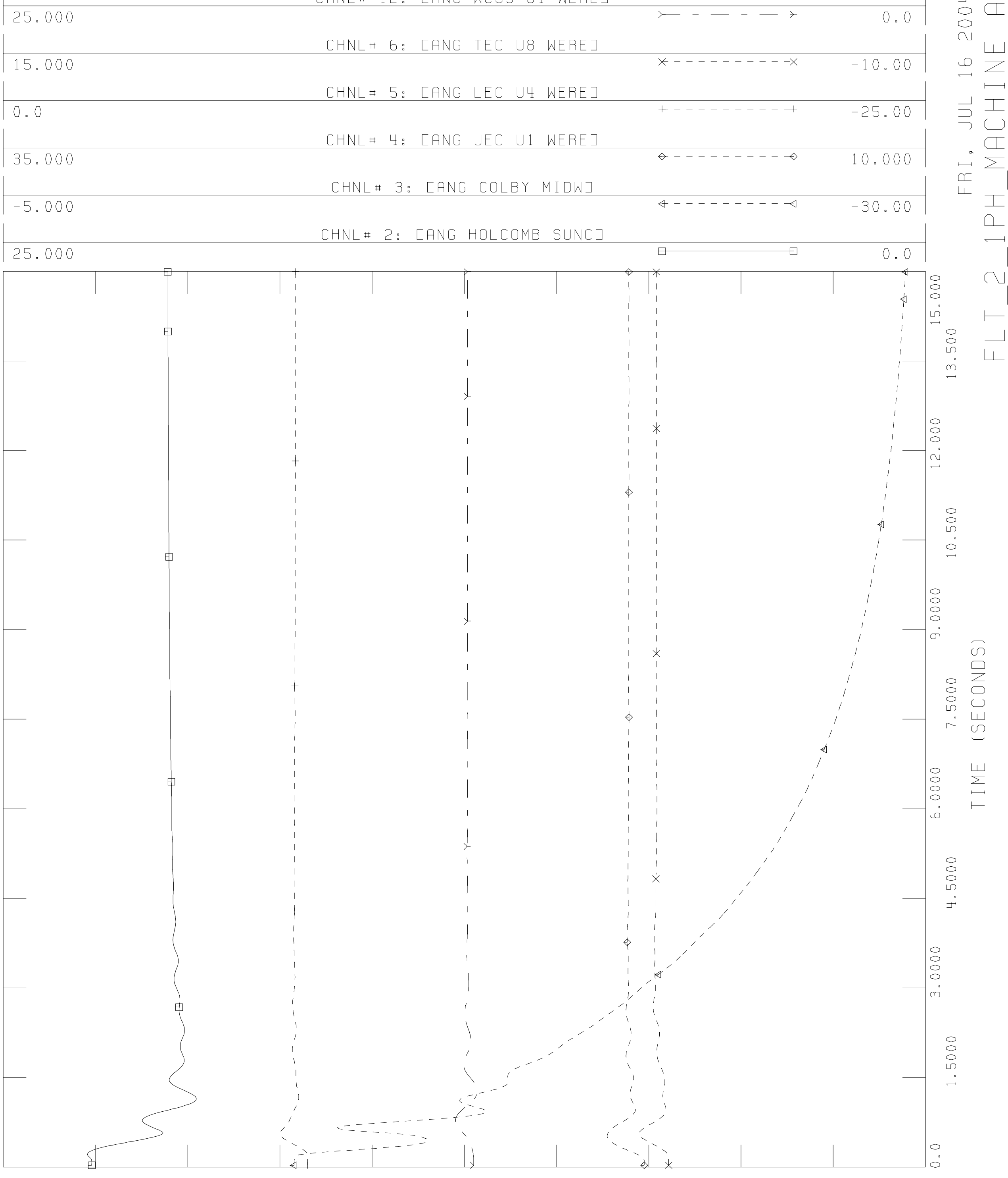
FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_1_3PH.OUT



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_2_1PH.OUT



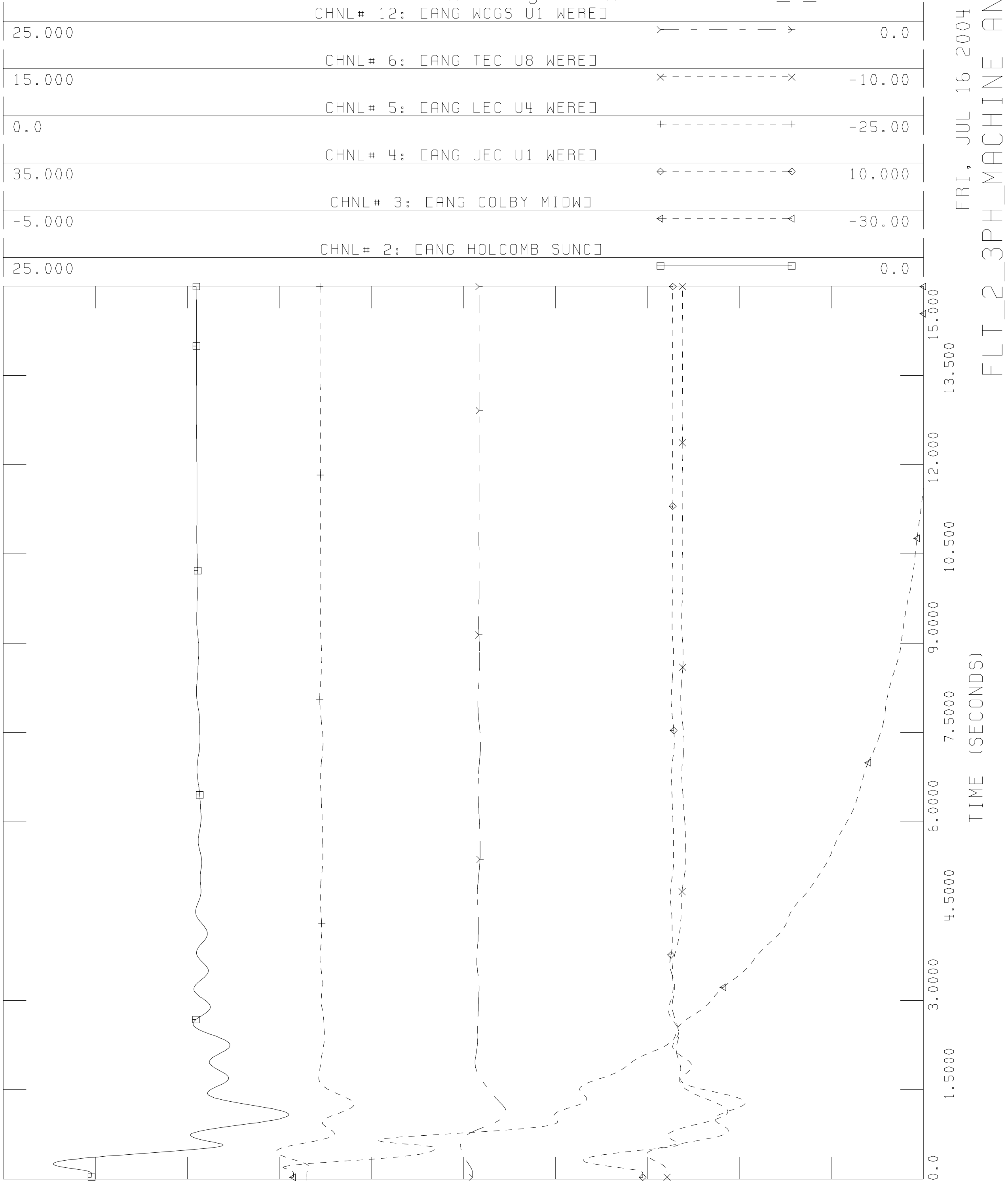
FRI, JUL 16 2004 14:07

FLT_2_1PH_MACHINE ANGLES

POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_2_3PH.OUT



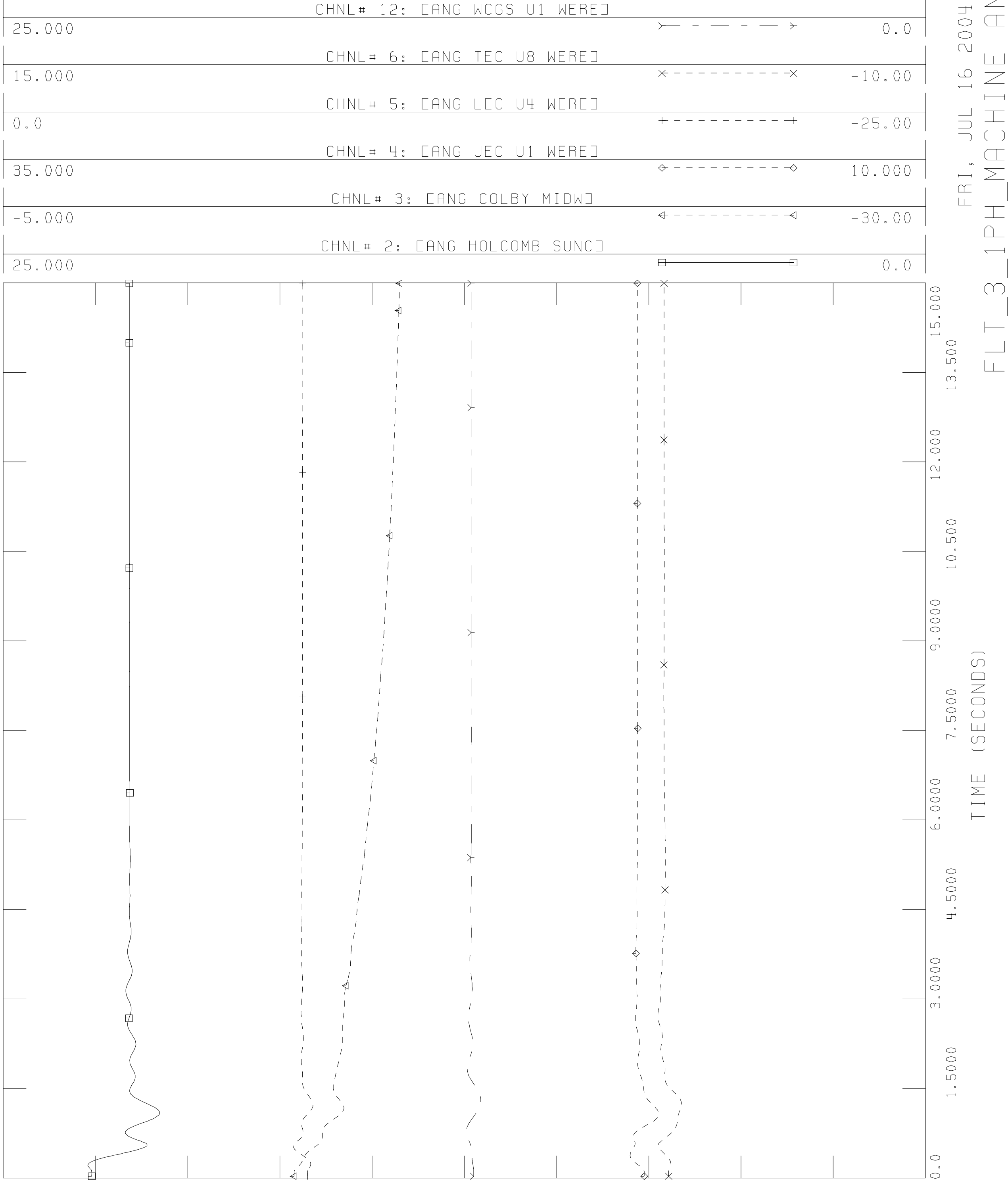
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_3_1PH.OUT

FRI, JUL 16 2004 14:07

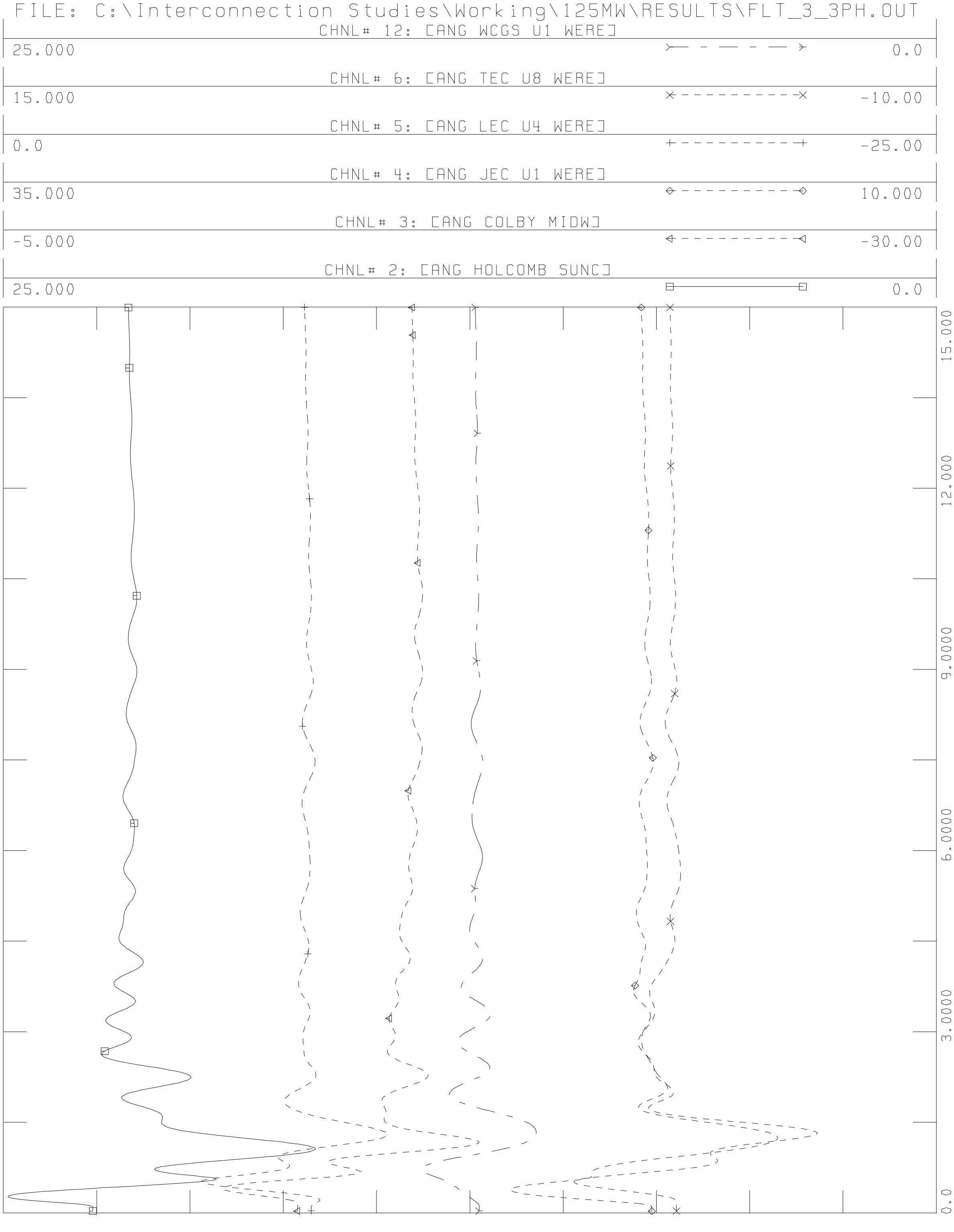
FLT_3_1PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_3_3PH.OUT



FRI, JUL 16 2004 14:07
FLT_3_3PH_MACHINE ANGLES

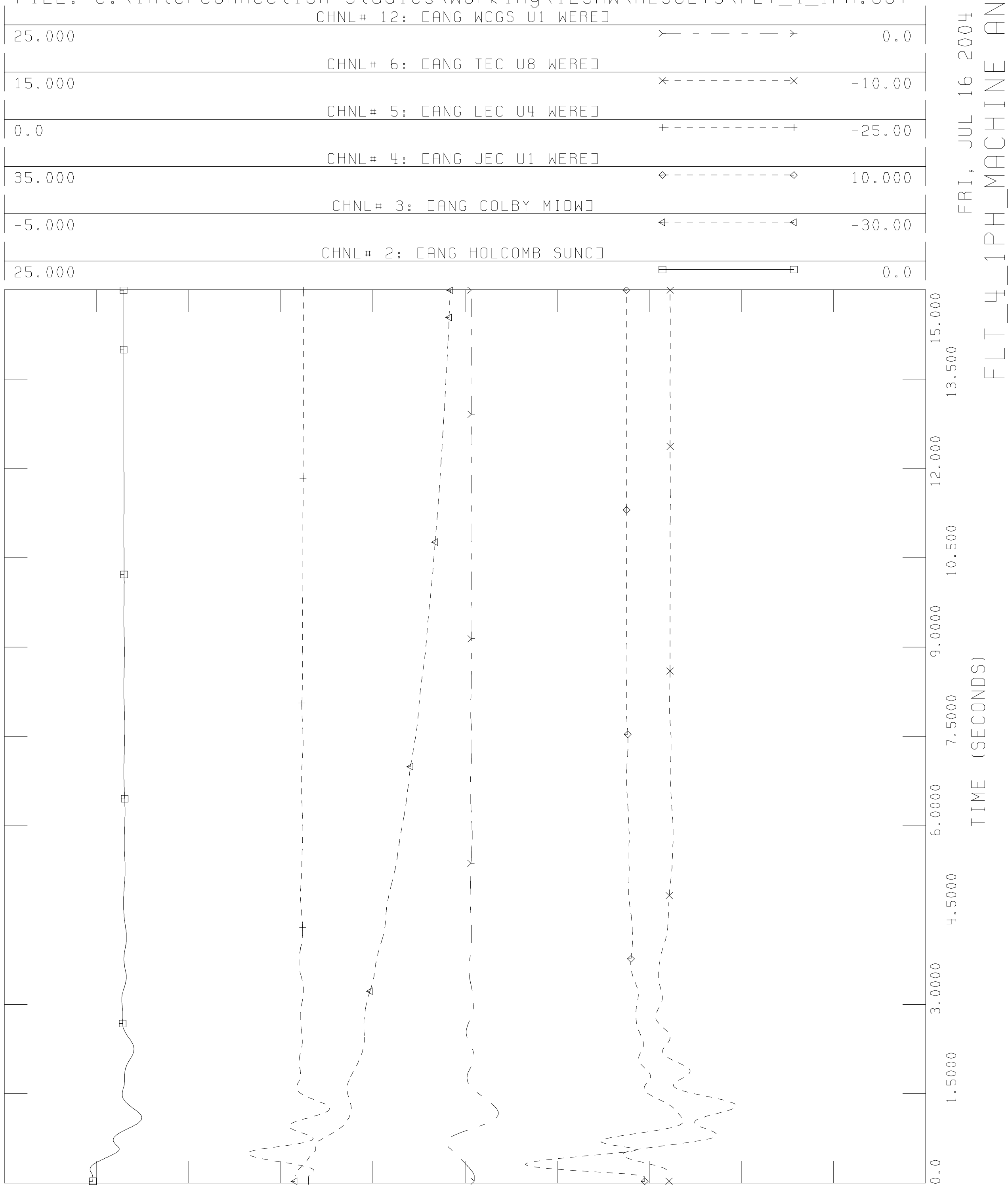
POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_4_1PH.OUT

FRI, JUL 16 2004 14:07

FLT_4_1PH_MACHINE ANGLES

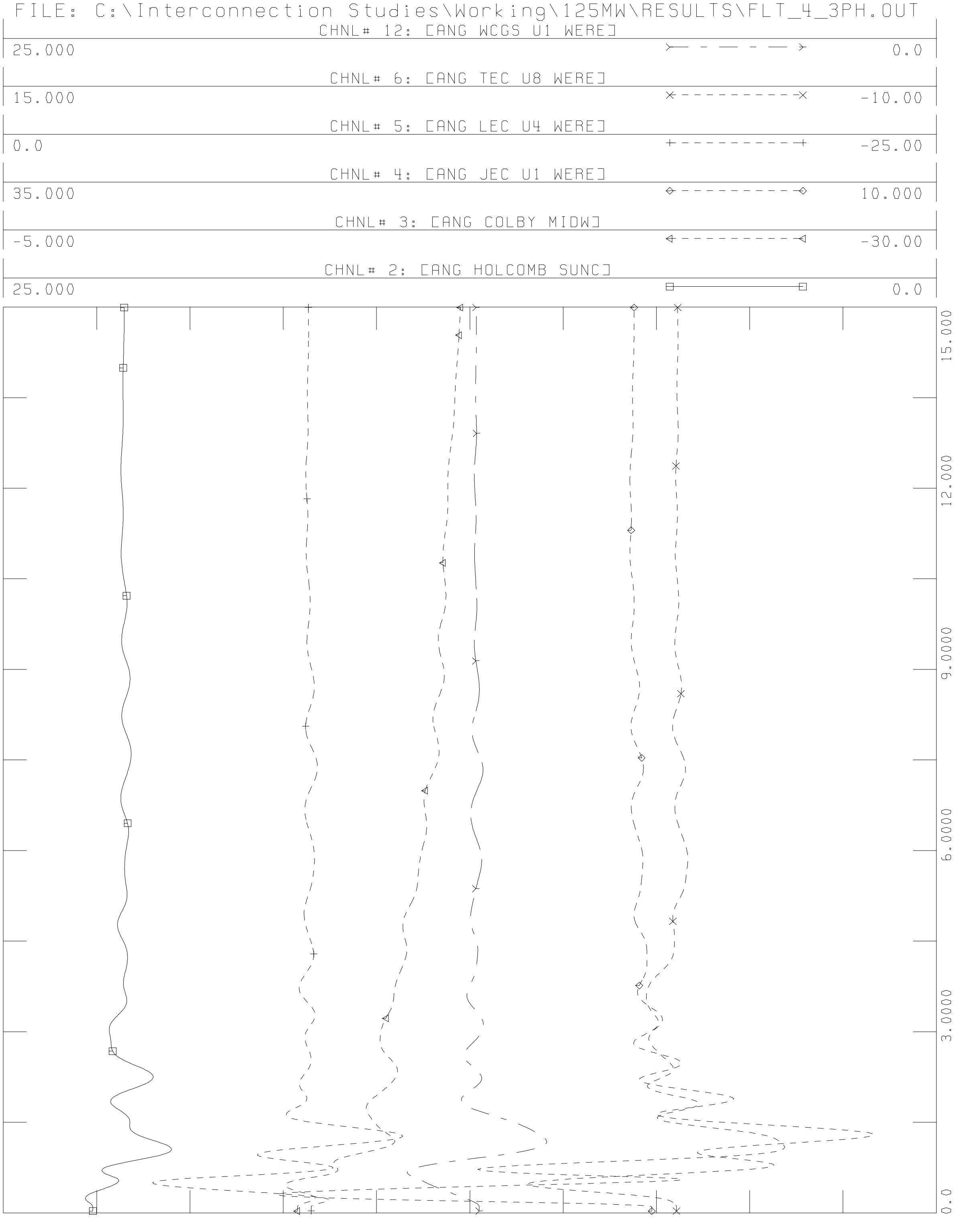


POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_4_3PH.OUT



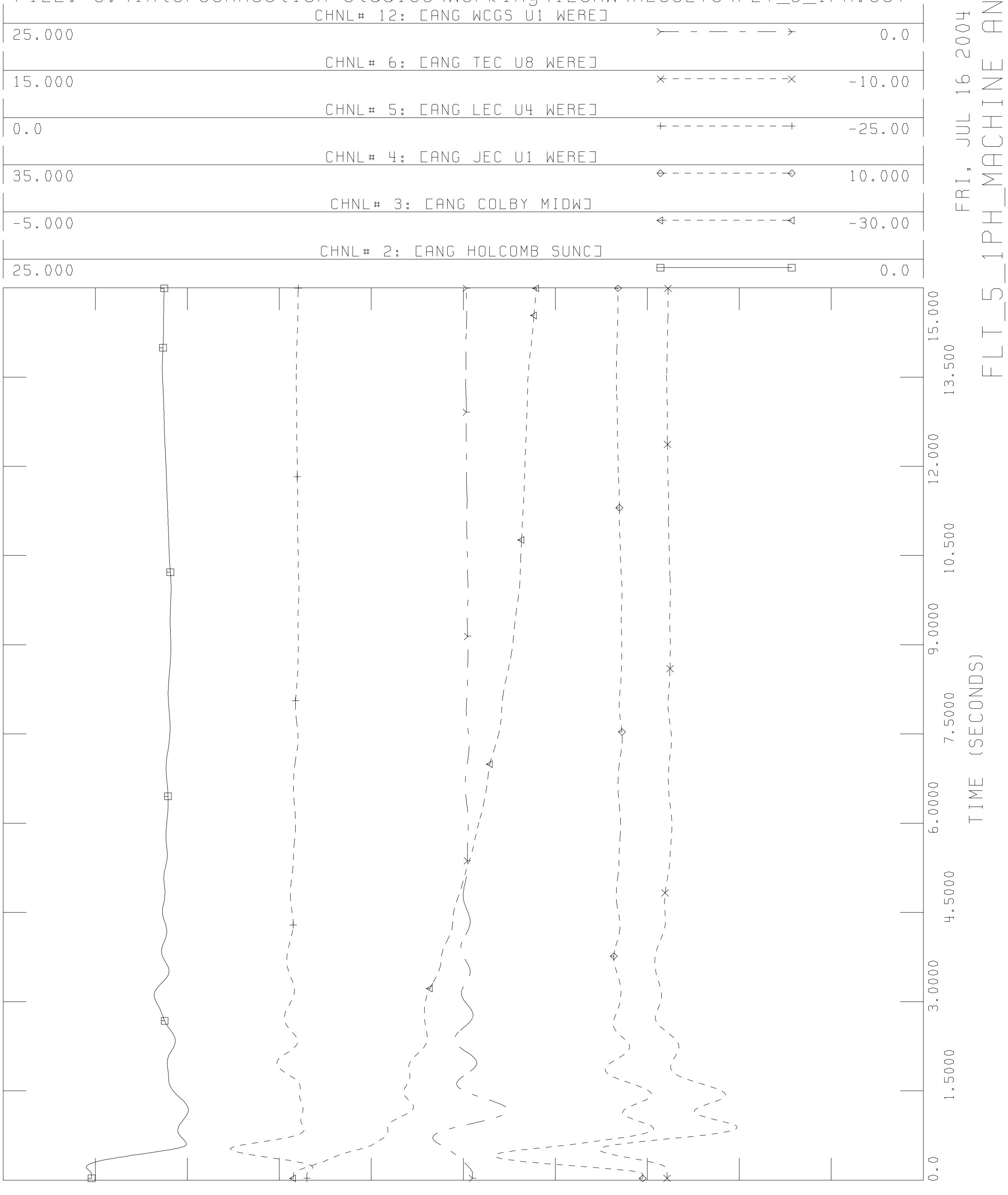
FRI, JUL 16 2004 14:07

FLT_4_3PH_MACHINE ANGLES

POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_5_1PH.OUT

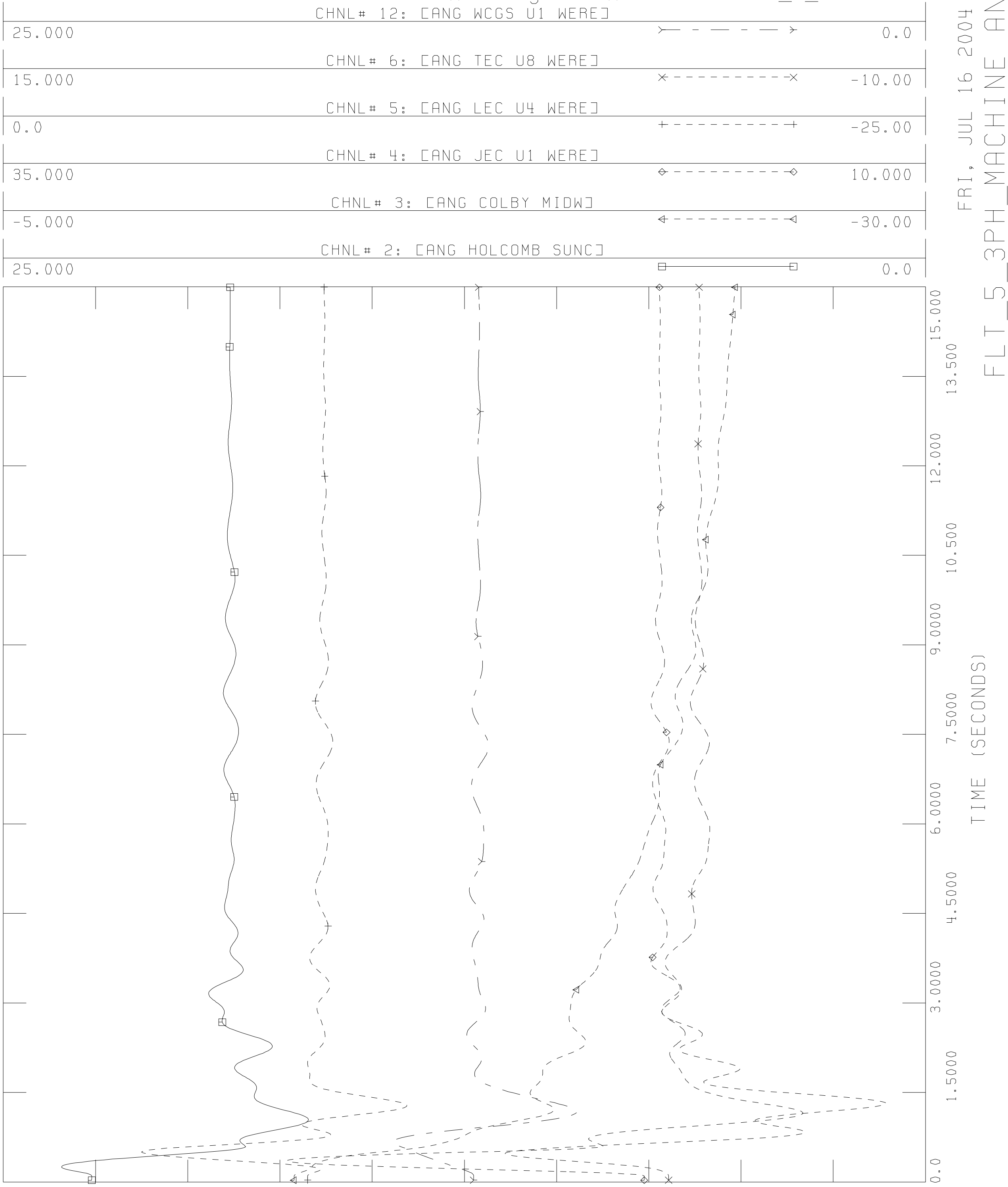


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_5_3PH.OUT

FRI, JUL 16 2004 14:07

FLT_5_3PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_6_1PH.OUT

CHNL# 12: [ANG WCGS U1 WERE]
25.000 ≻ - — - — ≻ 0.0

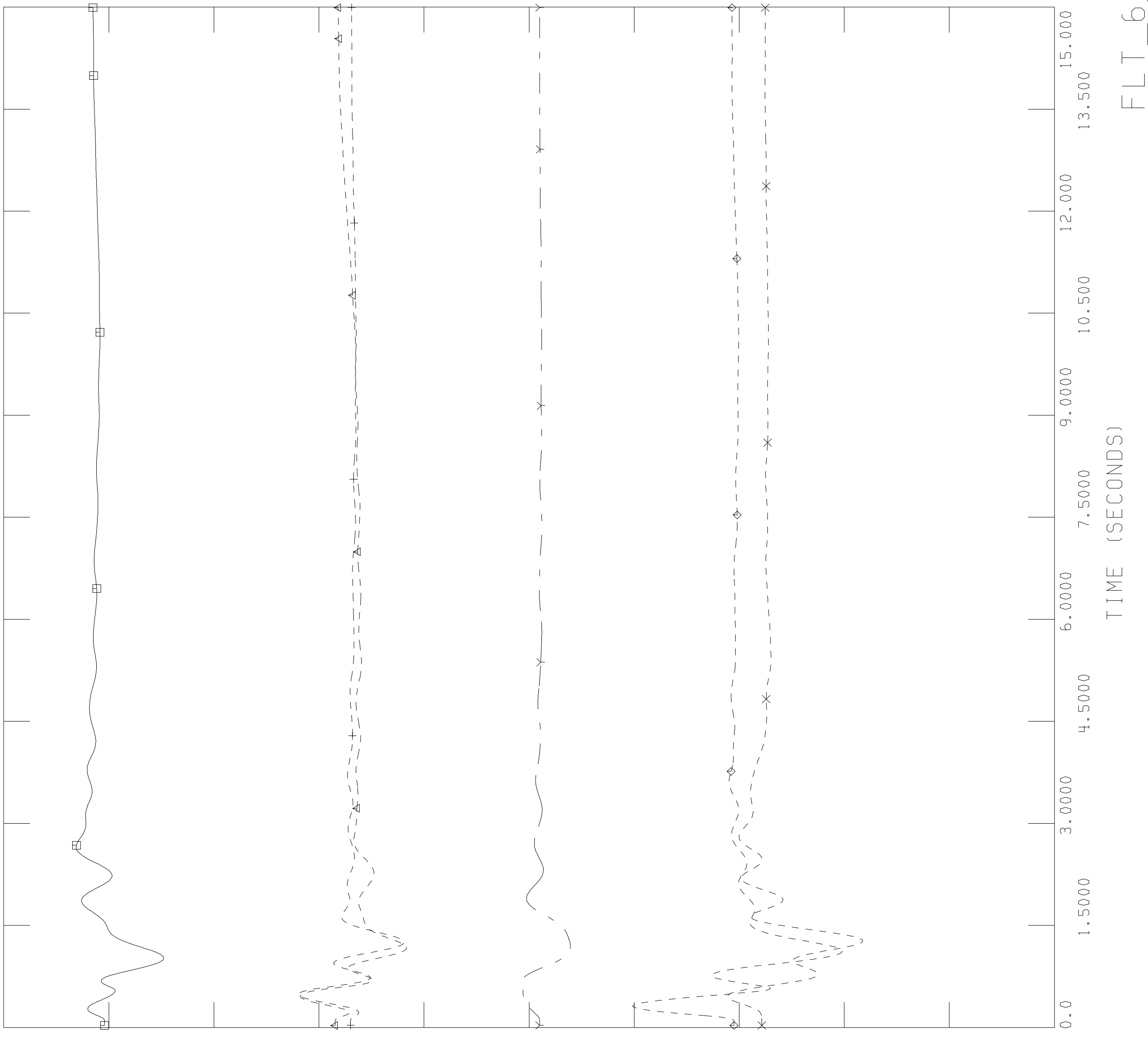
CHNL# 6: [ANG TEC U8 WERE]
15.000 ×-----------× -10.00

CHNL# 5: [ANG LEC U4 WERE]
0.0 +-----------+ -25.00

CHNL# 4: [ANG JEC U1 WERE]
35.000 ◇-----------◇ 10.000

CHNL# 3: [ANG COLBY MIDW]
-5.000 ◁-----------◁ -30.00

CHNL# 2: [ANG HOLCOMB SUNC]
25.000 □———————□ 0.0



FRI, JUL 16 2004 14:07

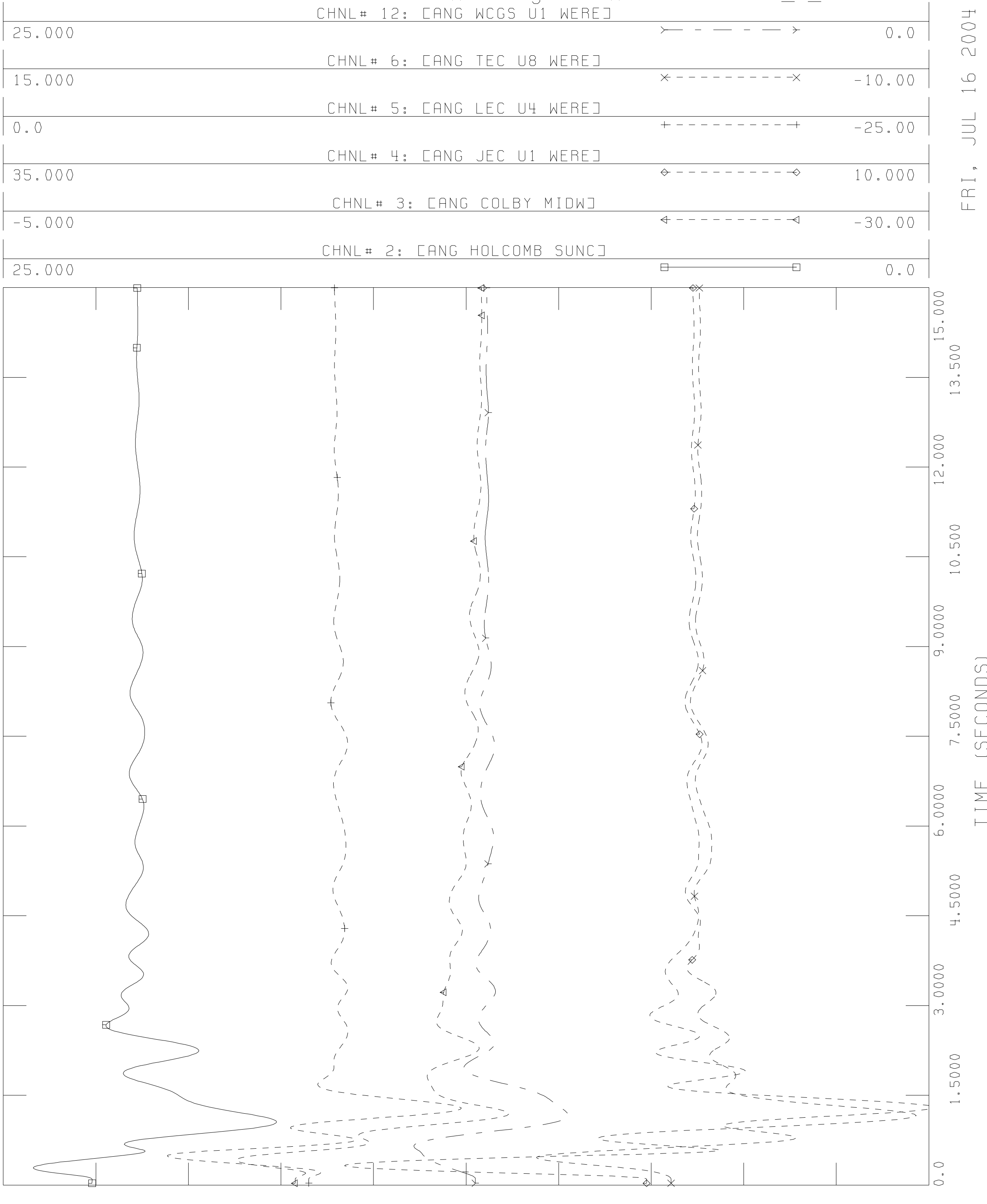
FLT_6_1PH_MACHINE ANGLES

POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_6_3PH.OUT

FRI, JUL 16 2004 14:07
FLT_6_3PH_MACHINE ANGLES

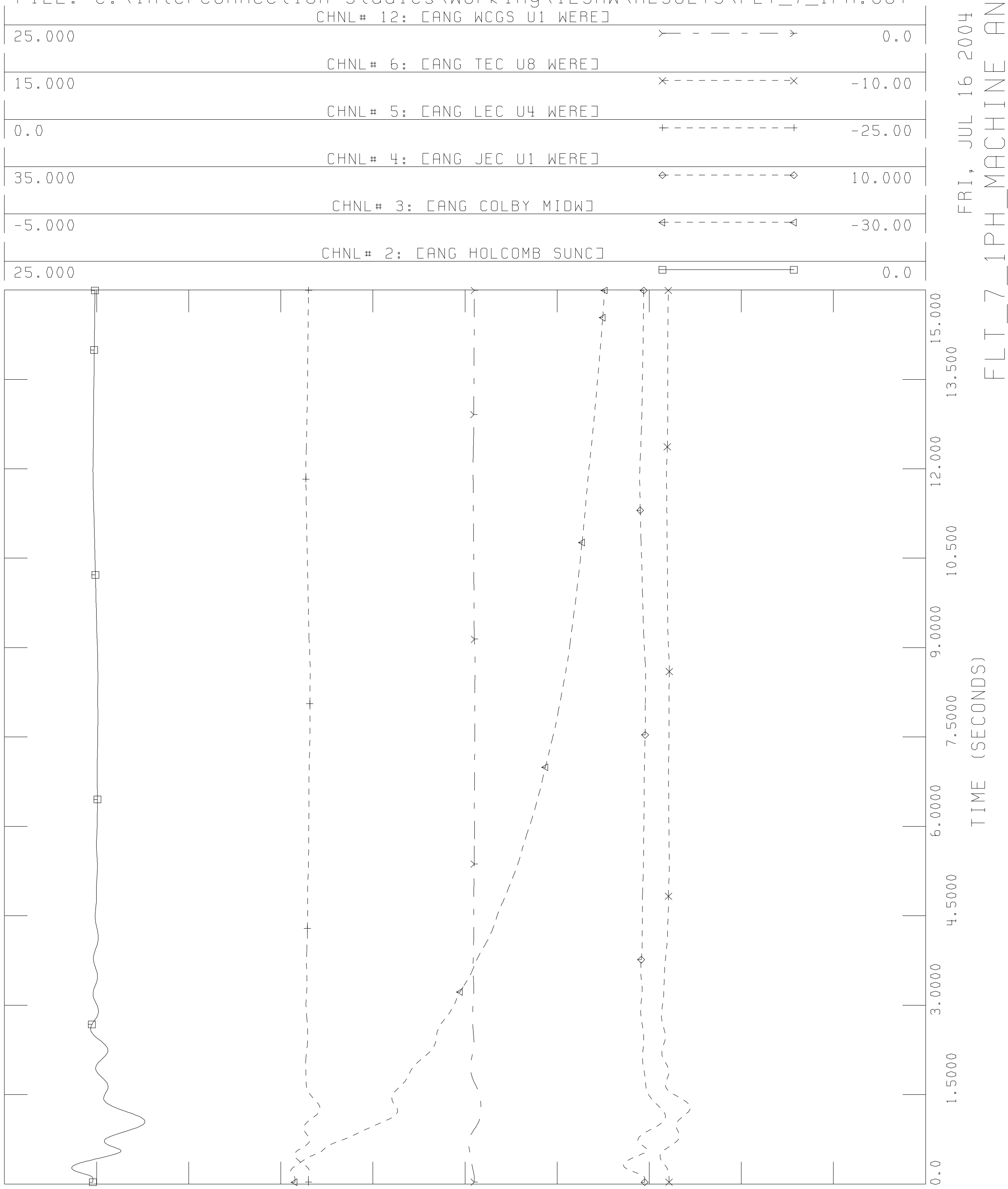


SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_7_1PH.OUT

FRI, JUL 16 2004 14:07

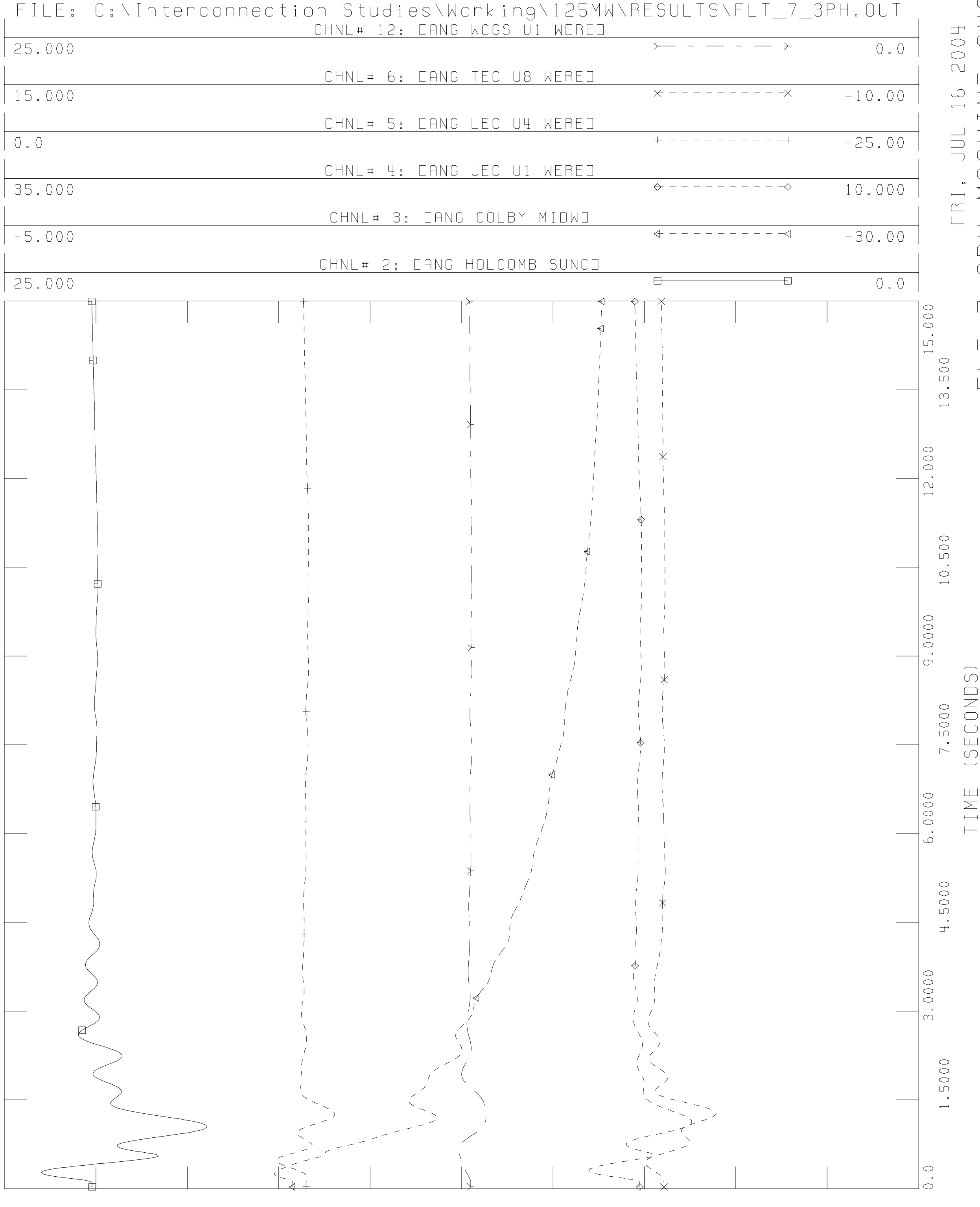
FLT_7_1PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_7_3PH.OUT



FRI, JUL 16 2004 14:07

FLT_7_3PH_MACHINE ANGLES

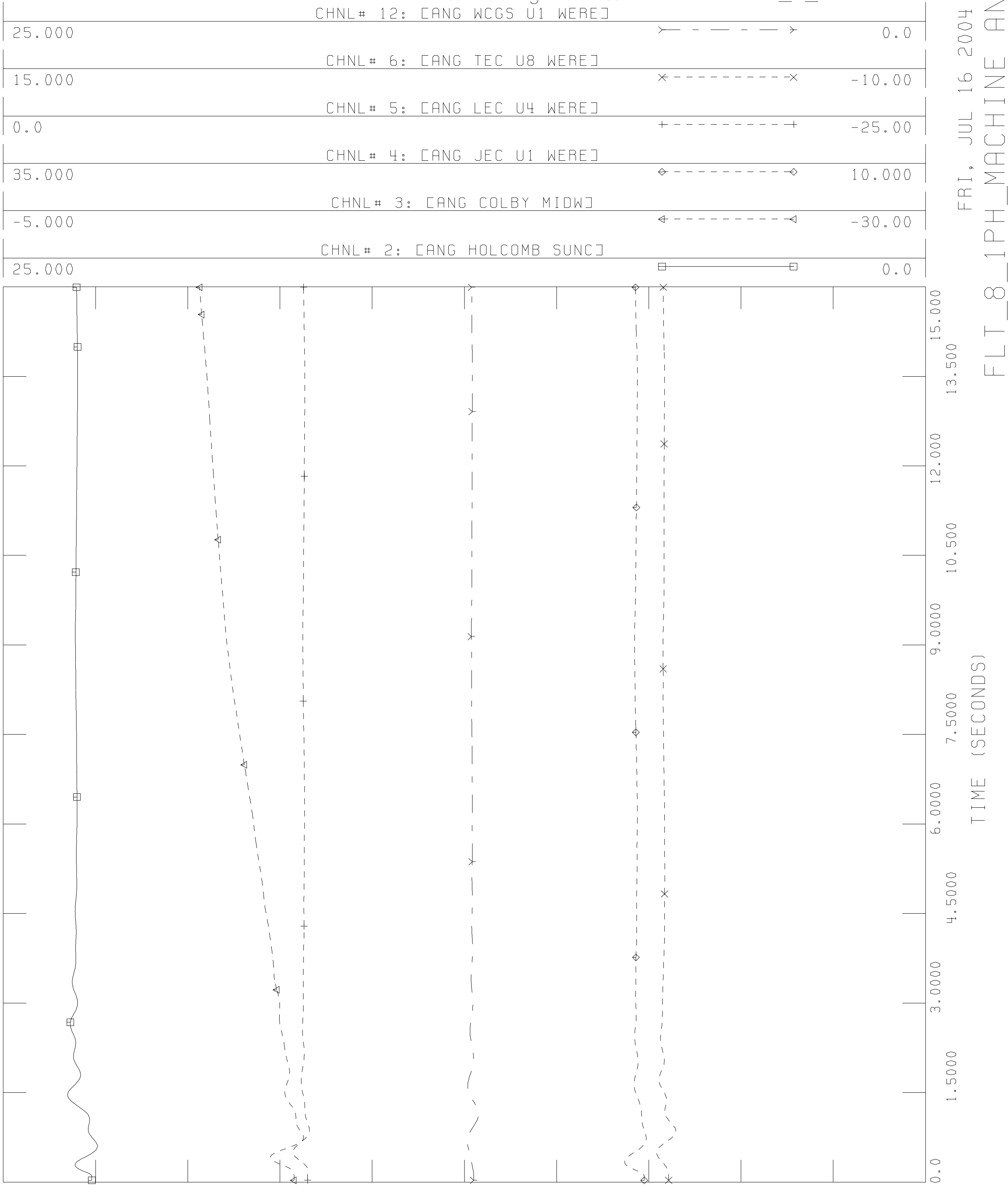
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FRI, JUL 16 2004 14:07

FLT_8_1PH_MACHINE ANGLES

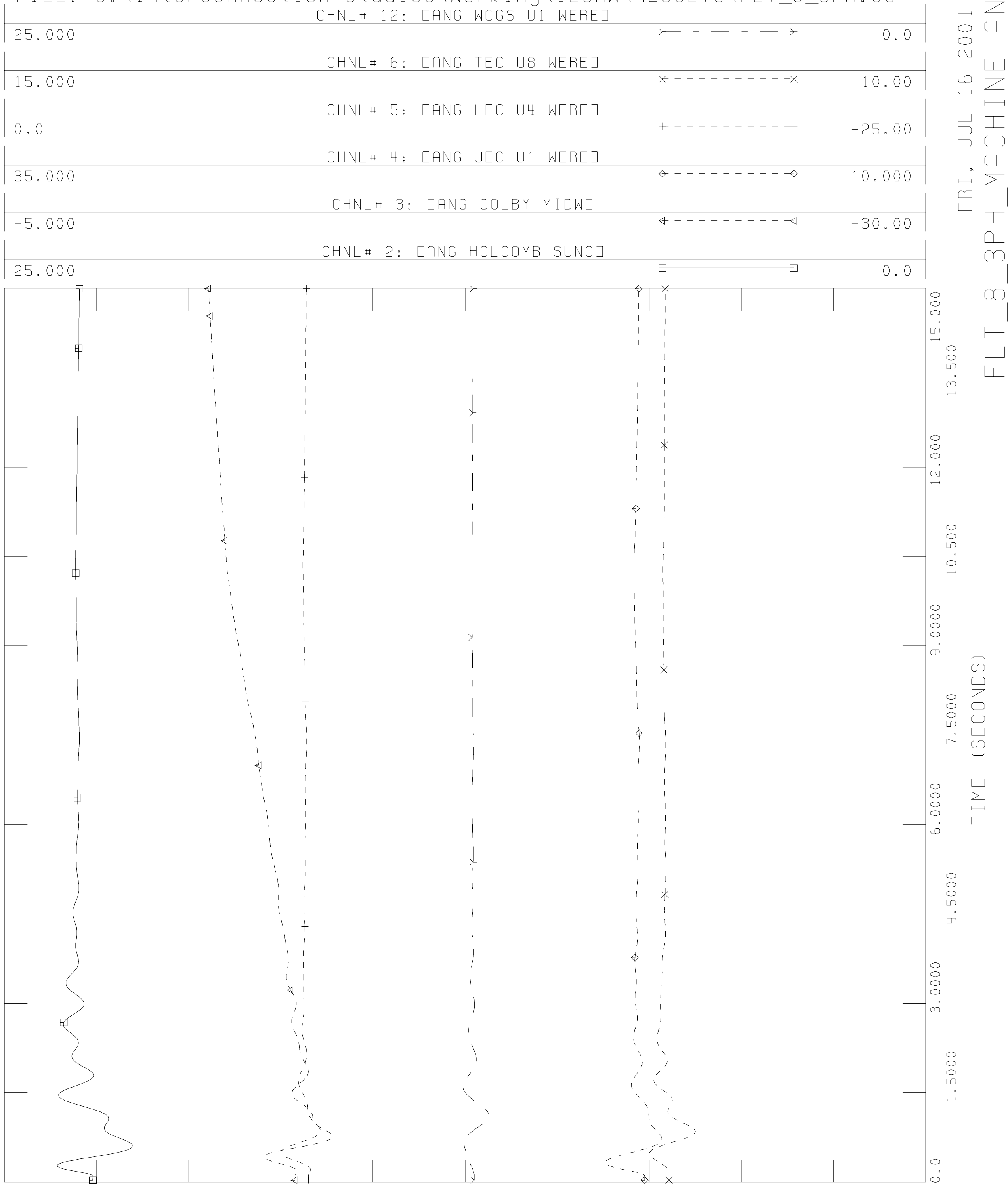
FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_8_1PH.OUT



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_8_3PH.OUT



FRI, JUL 16 2004 14:07

FLT_8_3PH_MACHINE ANGLES

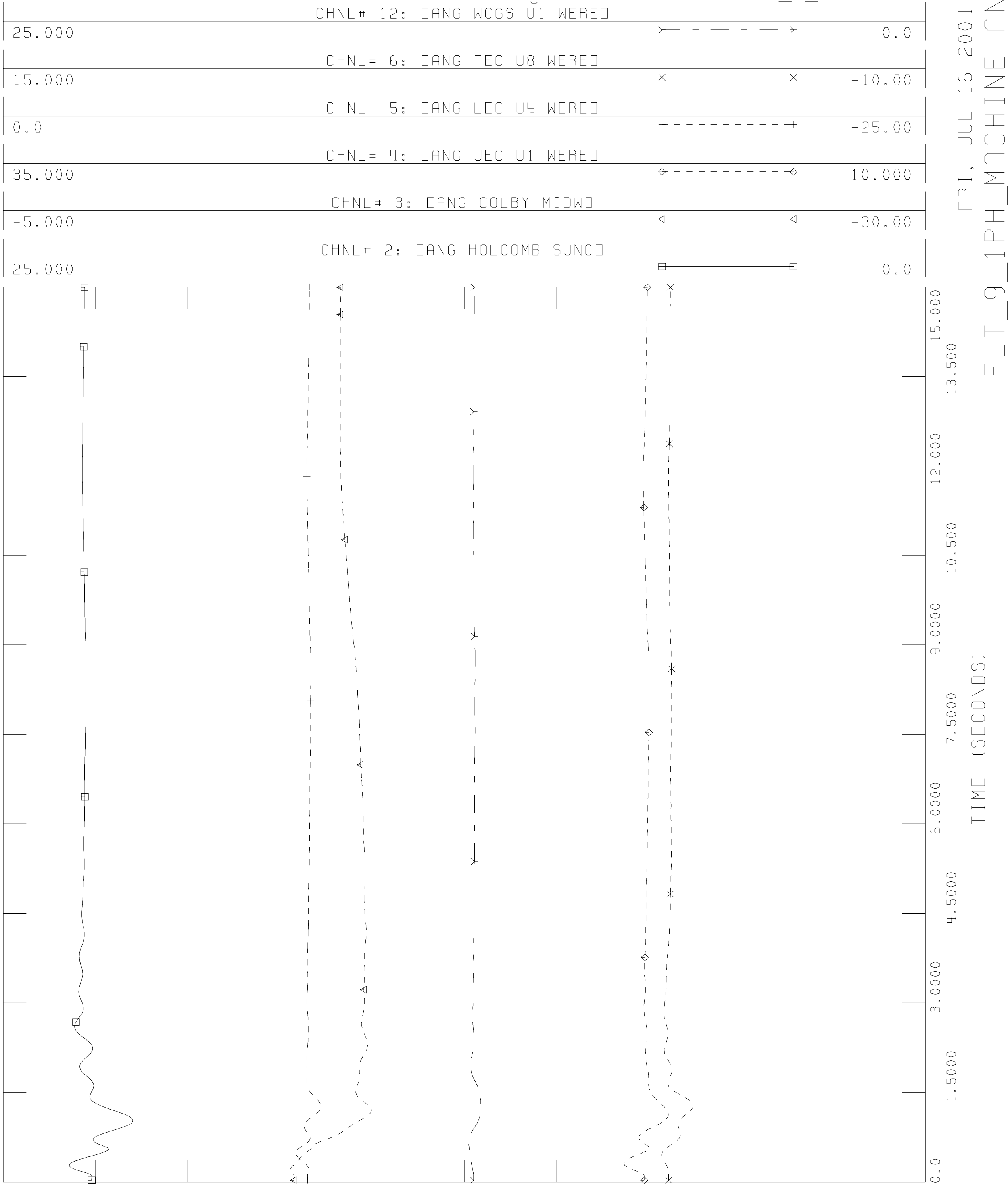
POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FRI, JUL 16 2004 14:07

FLT_9_1PH_MACHINE ANGLES

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_9_1PH.OUT



POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_9_3PH.OUT

CHNL# 12: [ANG WCGS U1 WERE]
25.000 ≻— - — - —≻ 0.0

CHNL# 6: [ANG TEC U8 WERE]
15.000 ×- - - - - - - - - -× -10.00

CHNL# 5: [ANG LEC U4 WERE]
0.0 +- - - - - - - - - -+ -25.00

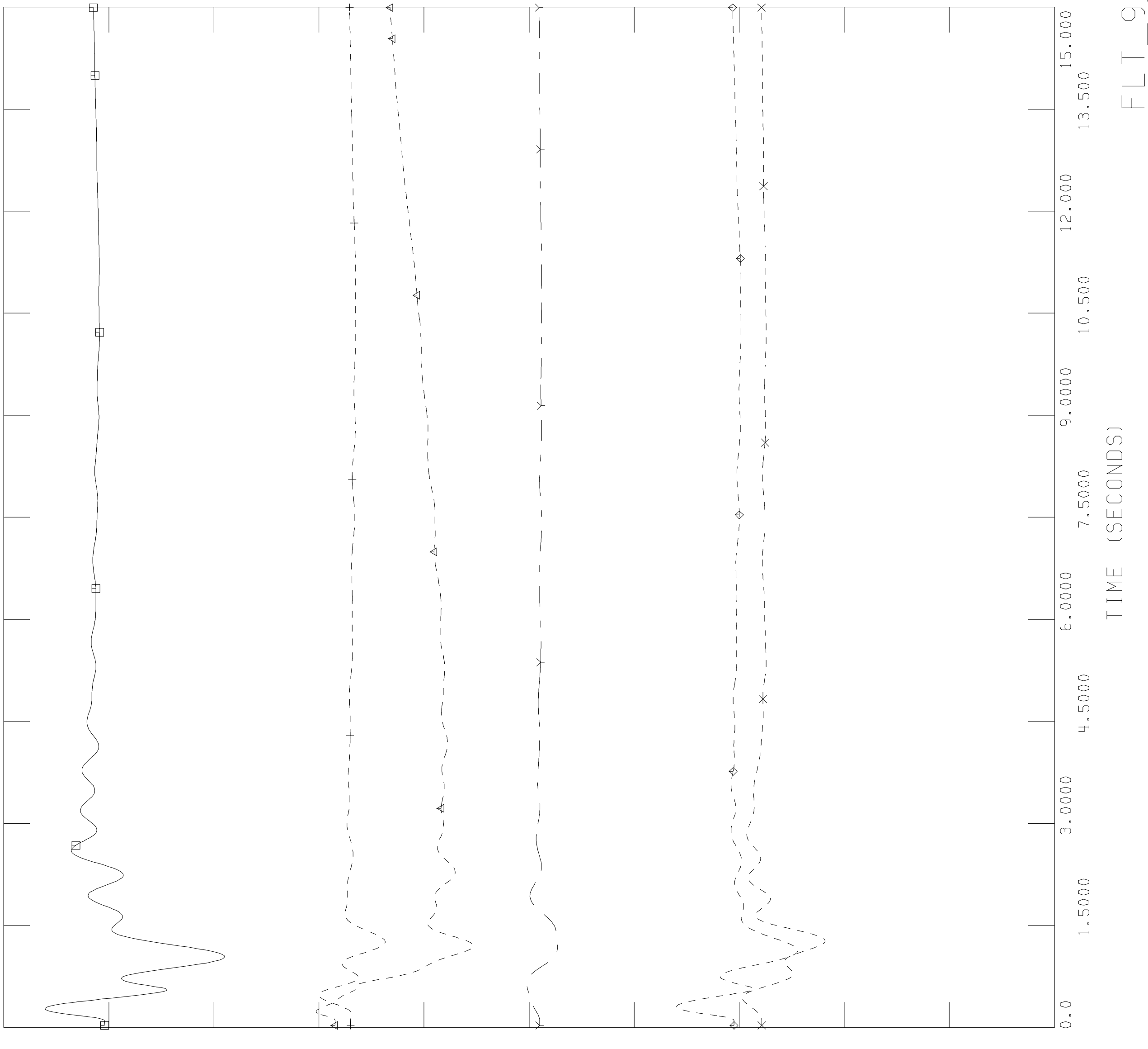
CHNL# 4: [ANG JEC U1 WERE]
35.000 ◇- - - - - - - - - -◇ 10.000

CHNL# 3: [ANG COLBY MIDW]
-5.000 ◁- - - - - - - - - -◁ -30.00

CHNL# 2: [ANG HOLCOMB SUNC]
25.000 □———————□ 0.0

FRI, JUL 16 2004 14:07

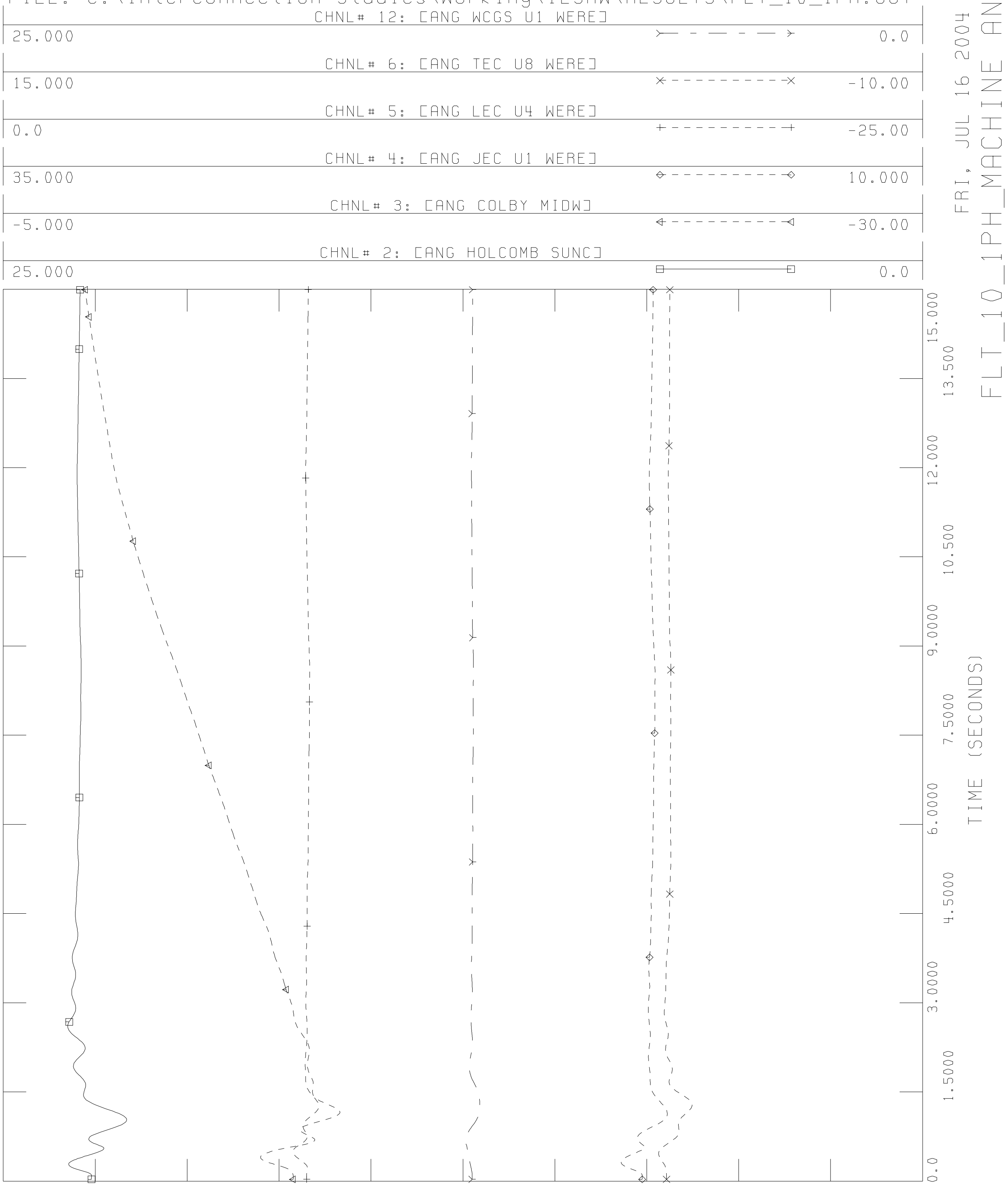
FLT_9_3PH_MACHINE ANGLES



POWER
TECHNOLOGIES
INC.®

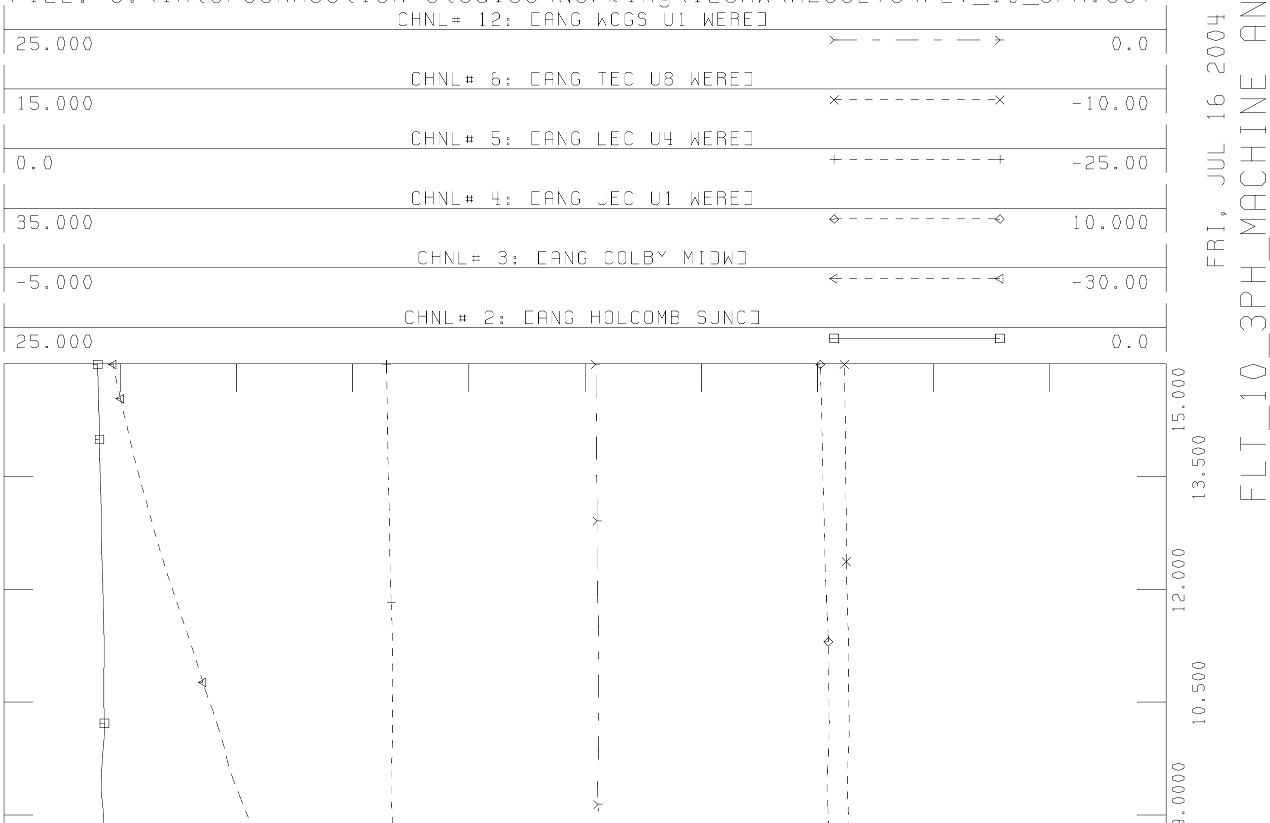
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_10_1PH.OUT



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW\RESULTS\FLT_10_3PH.OUT



FRI, JUL 16 2004 14:07

FLT_10_3PH_MACHINE ANGLES

Appendix F-1

Plots of Fault Simulations

Plots of selected bus voltage response during faults

Scenario:
2005 Summer Peak
Wind Farm at 125MW (50% rated power)
AGO4 Protection Settings

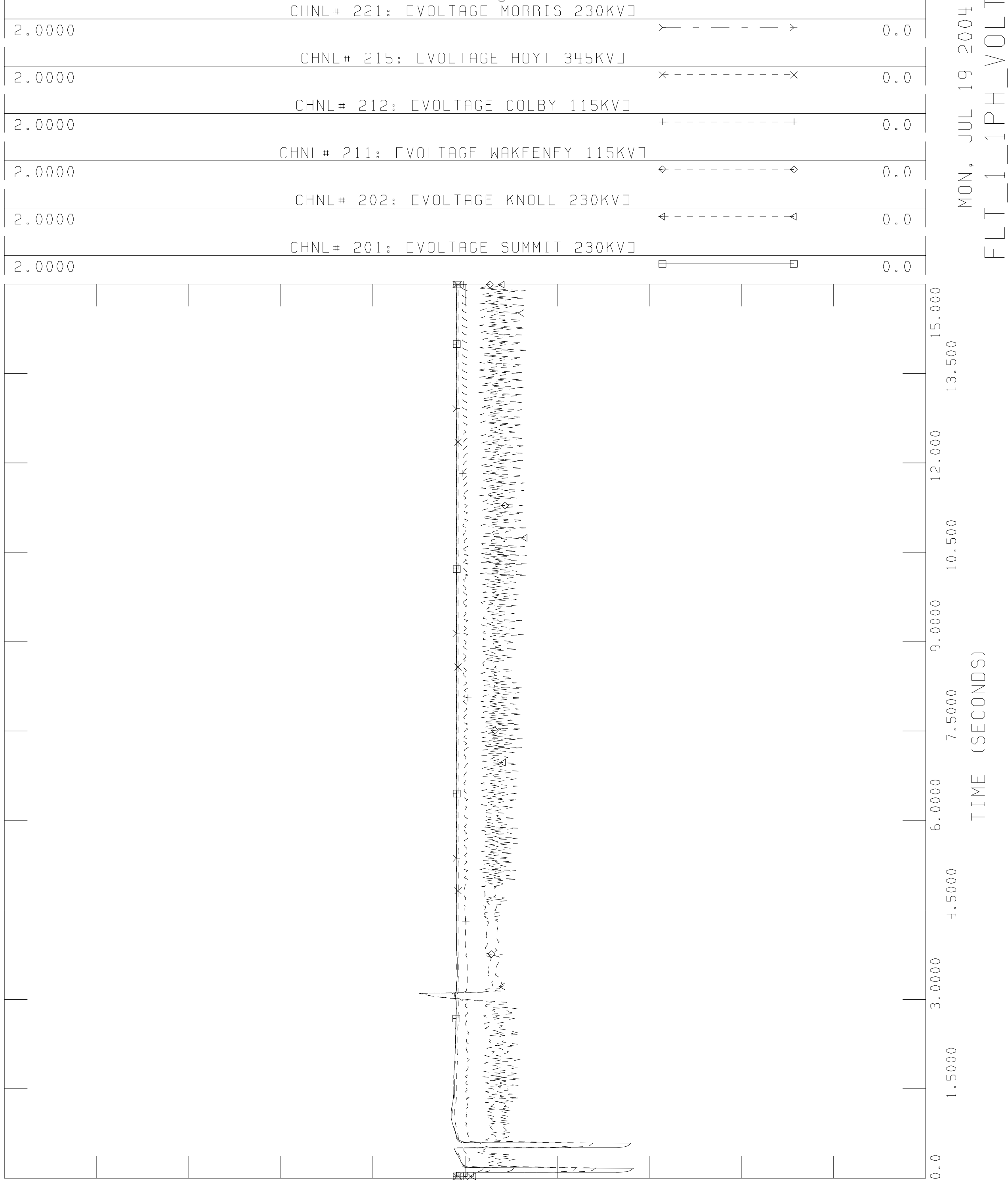
SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

MON, JUL 19 2004 12:40

FLT_1_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_1_1PH.OUT

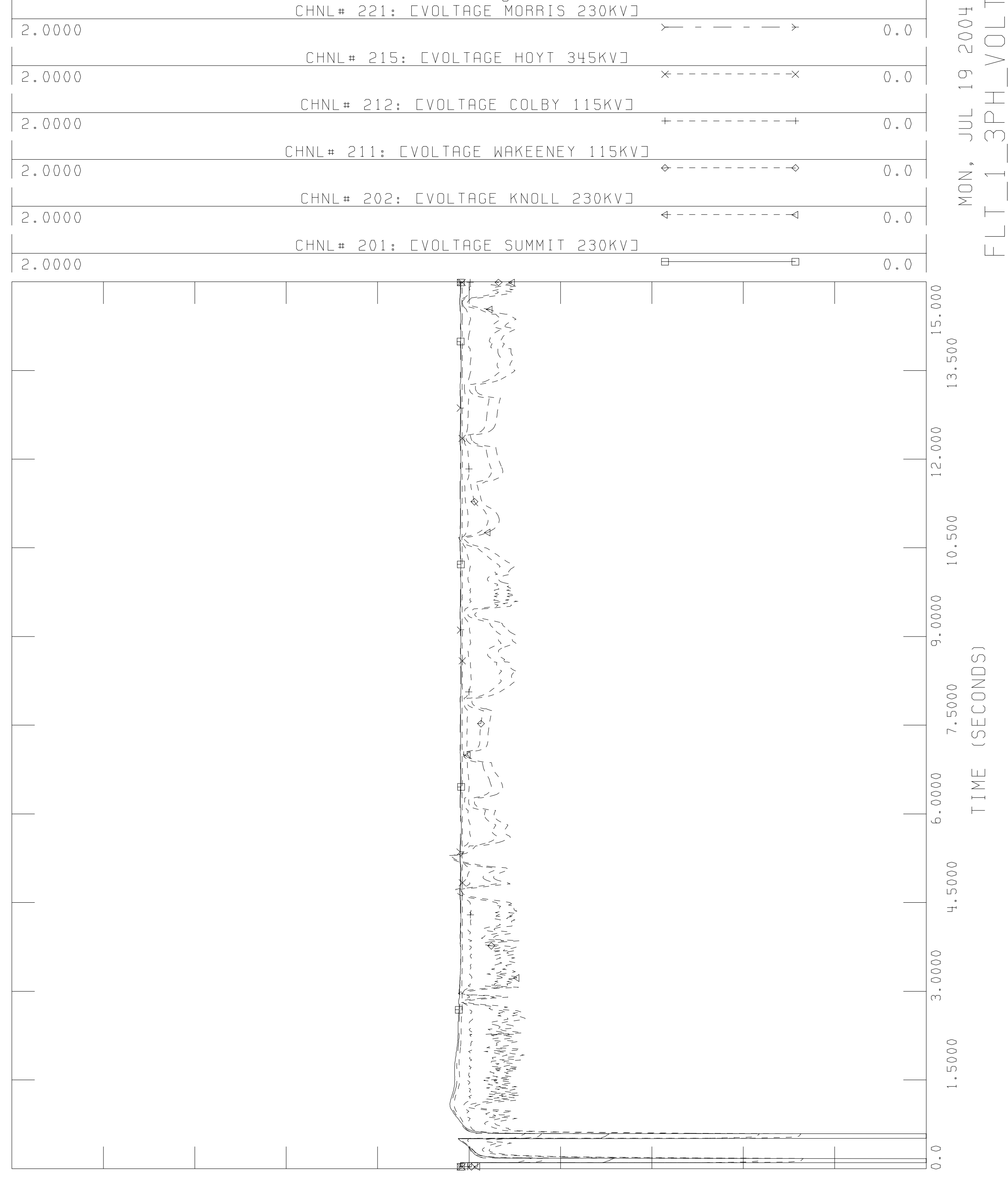


SHAW POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

MON, JUL 19 2004 12:40
FLT_1_3PH_VOLTAGES

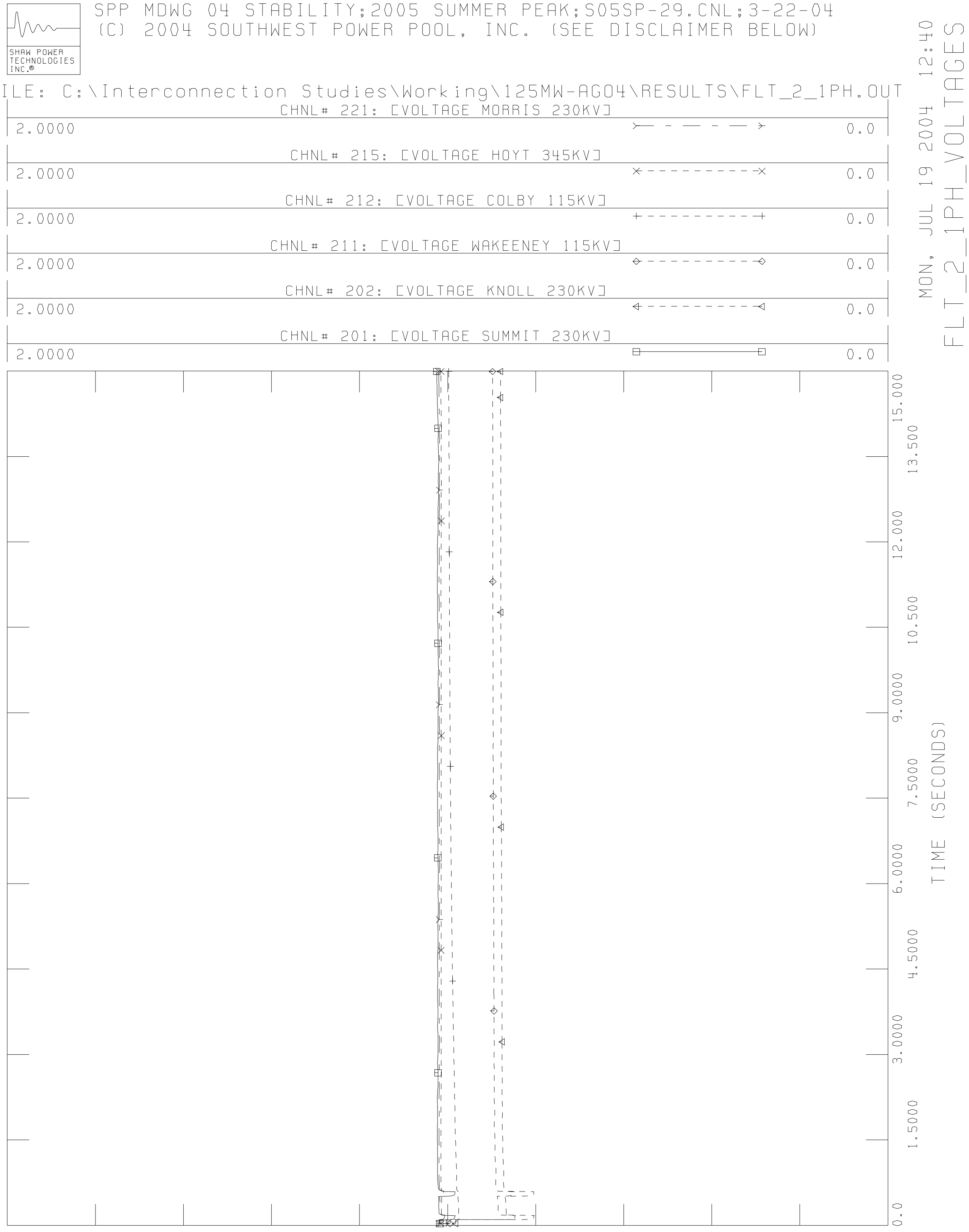
FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_1_3PH.OUT



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

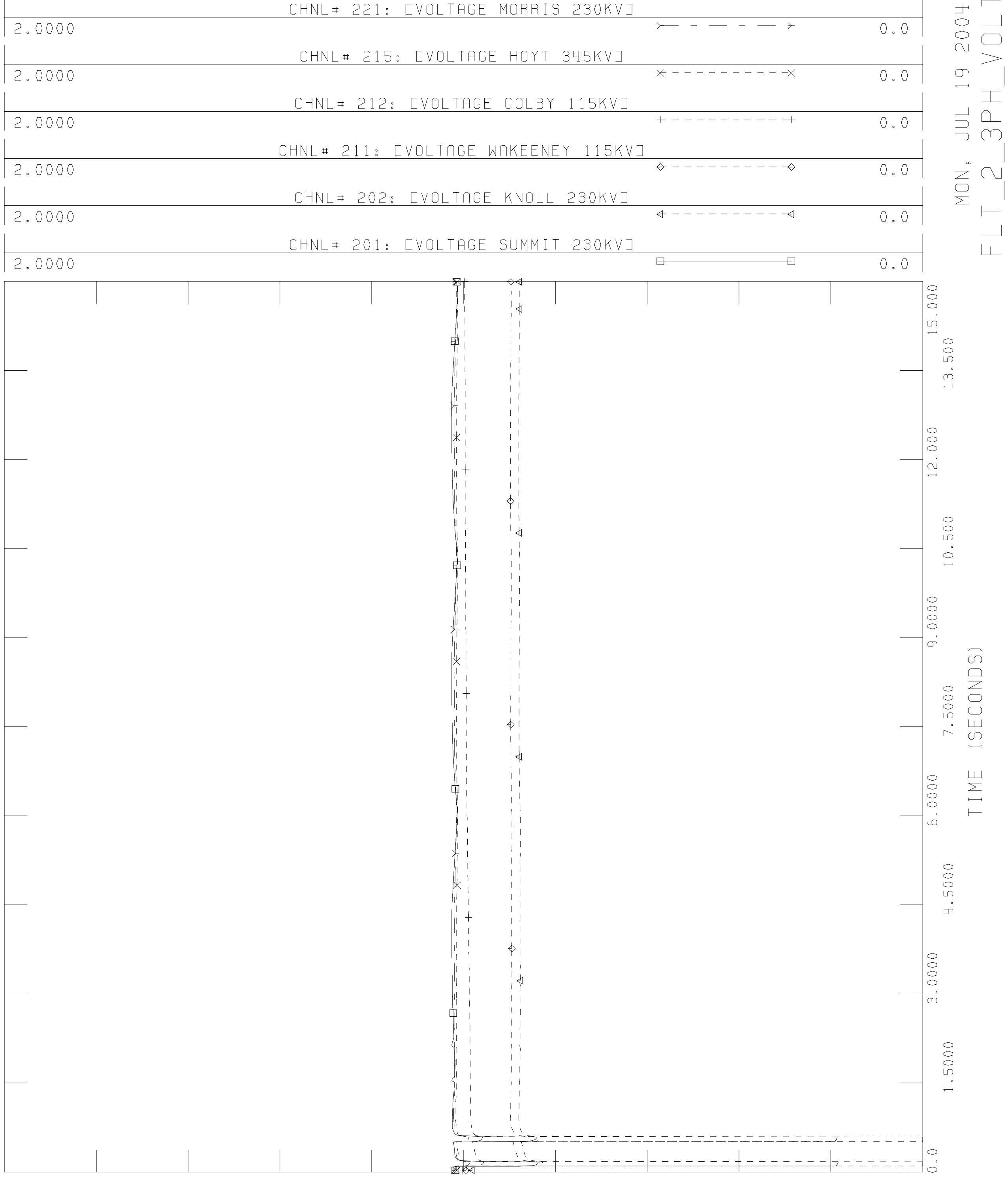
FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_2_1PH.OUT



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_2_3PH.OUT

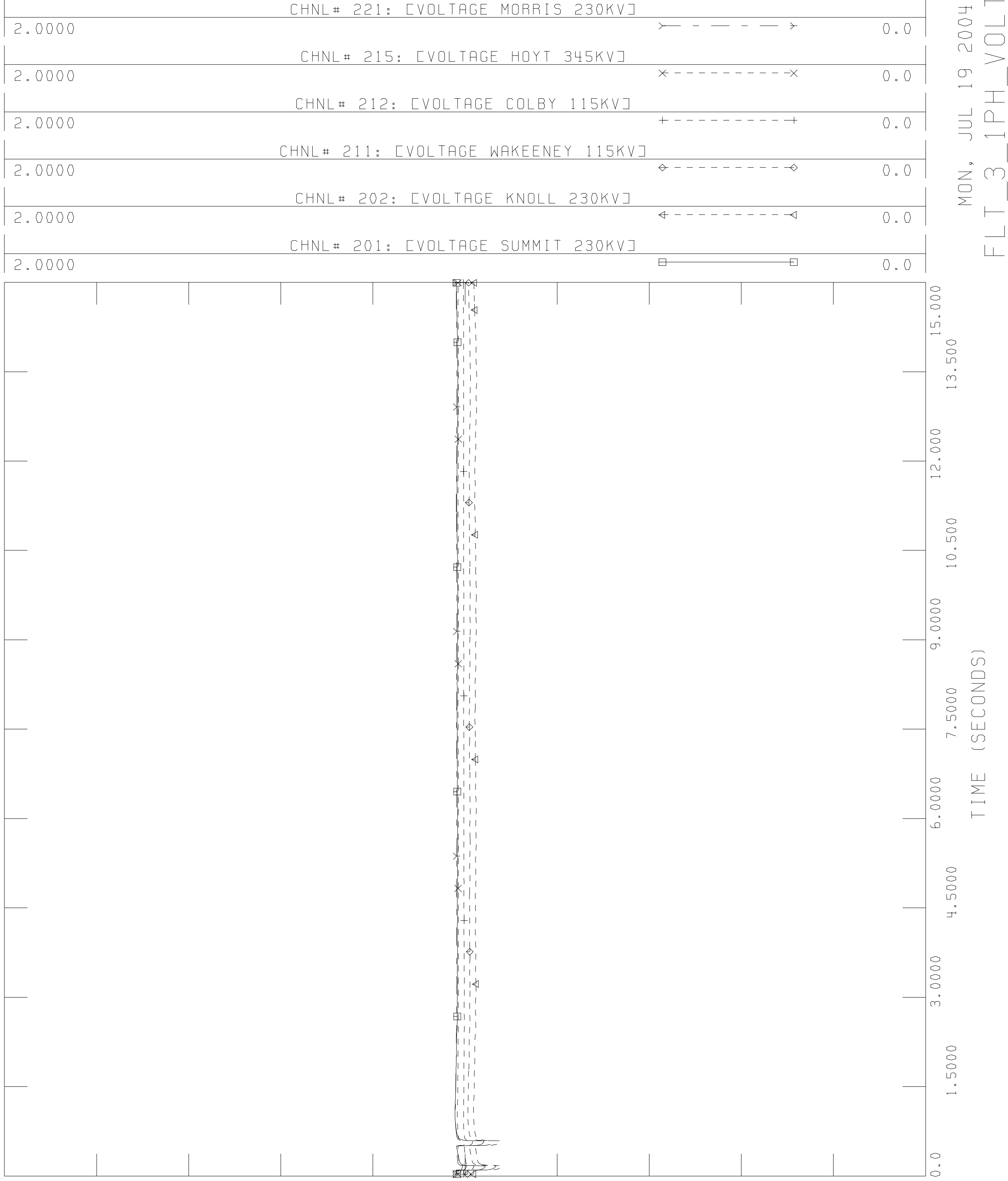


SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

MON, JUL 19 2004 12:40
FLT_3_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_3_1PH.OUT



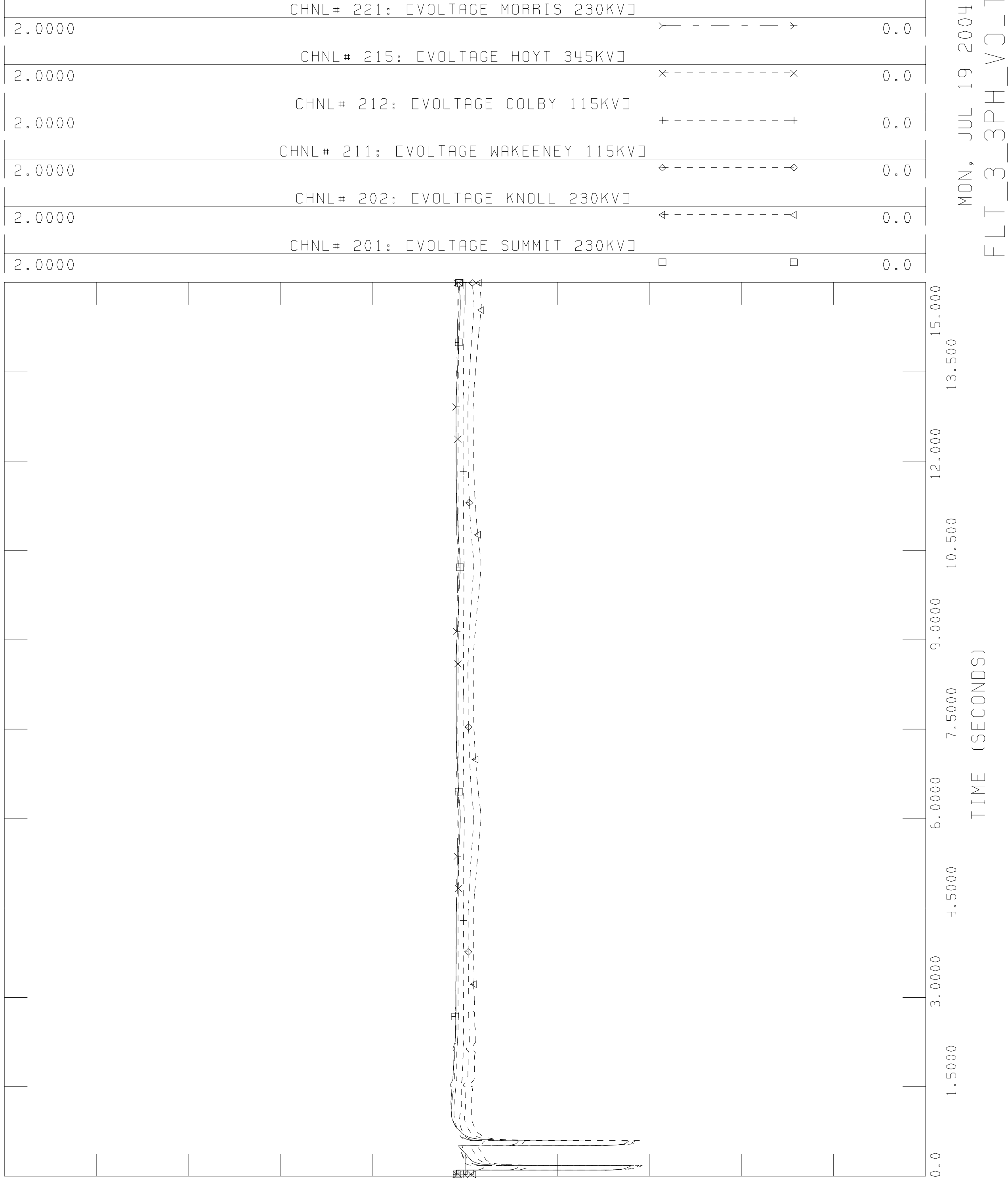
SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

MON, JUL 19 2004 12:40

FLT_3_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_3_3PH.OUT



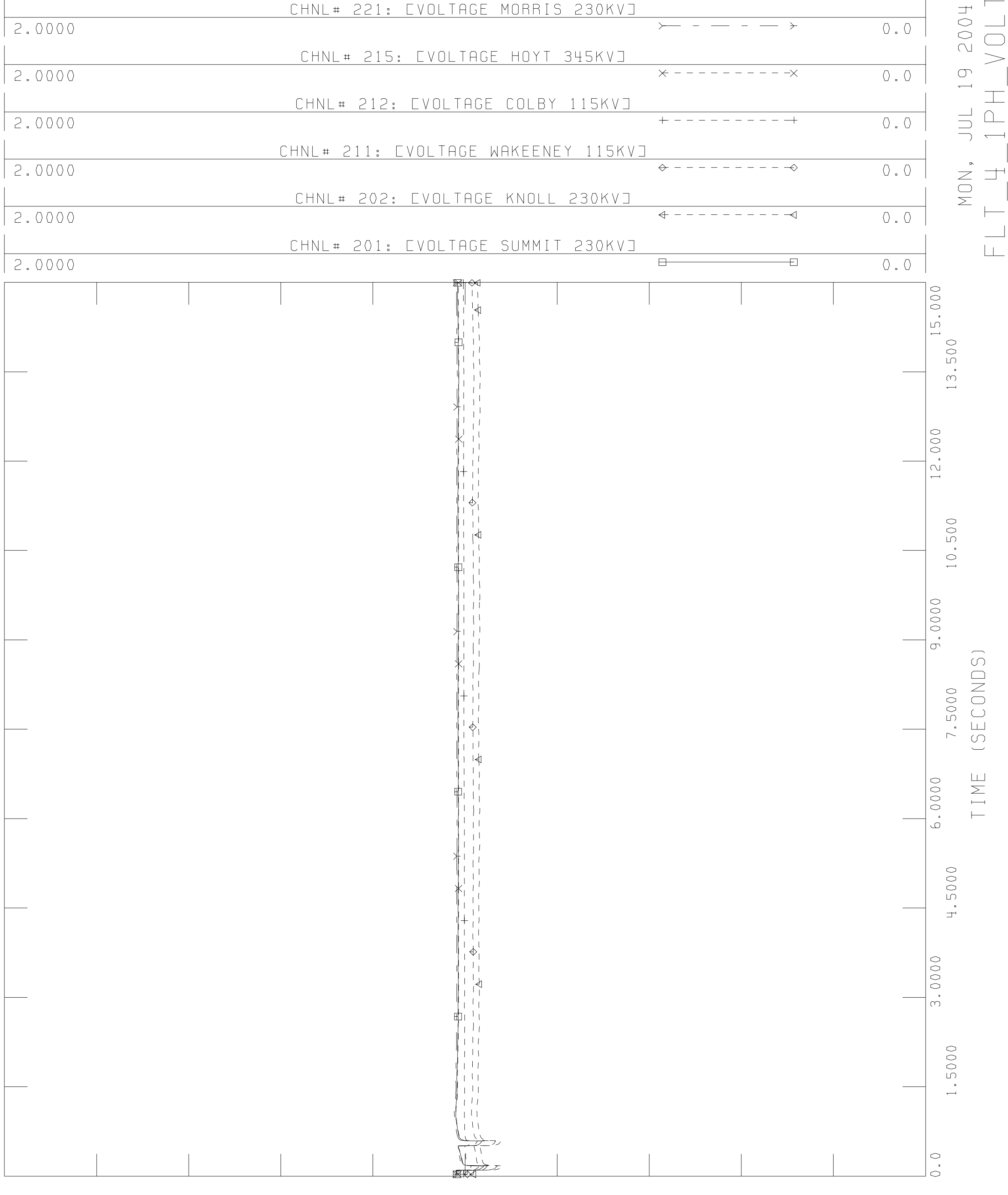
SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_4_1PH.OUT

MON, JUL 19 2004 12:40

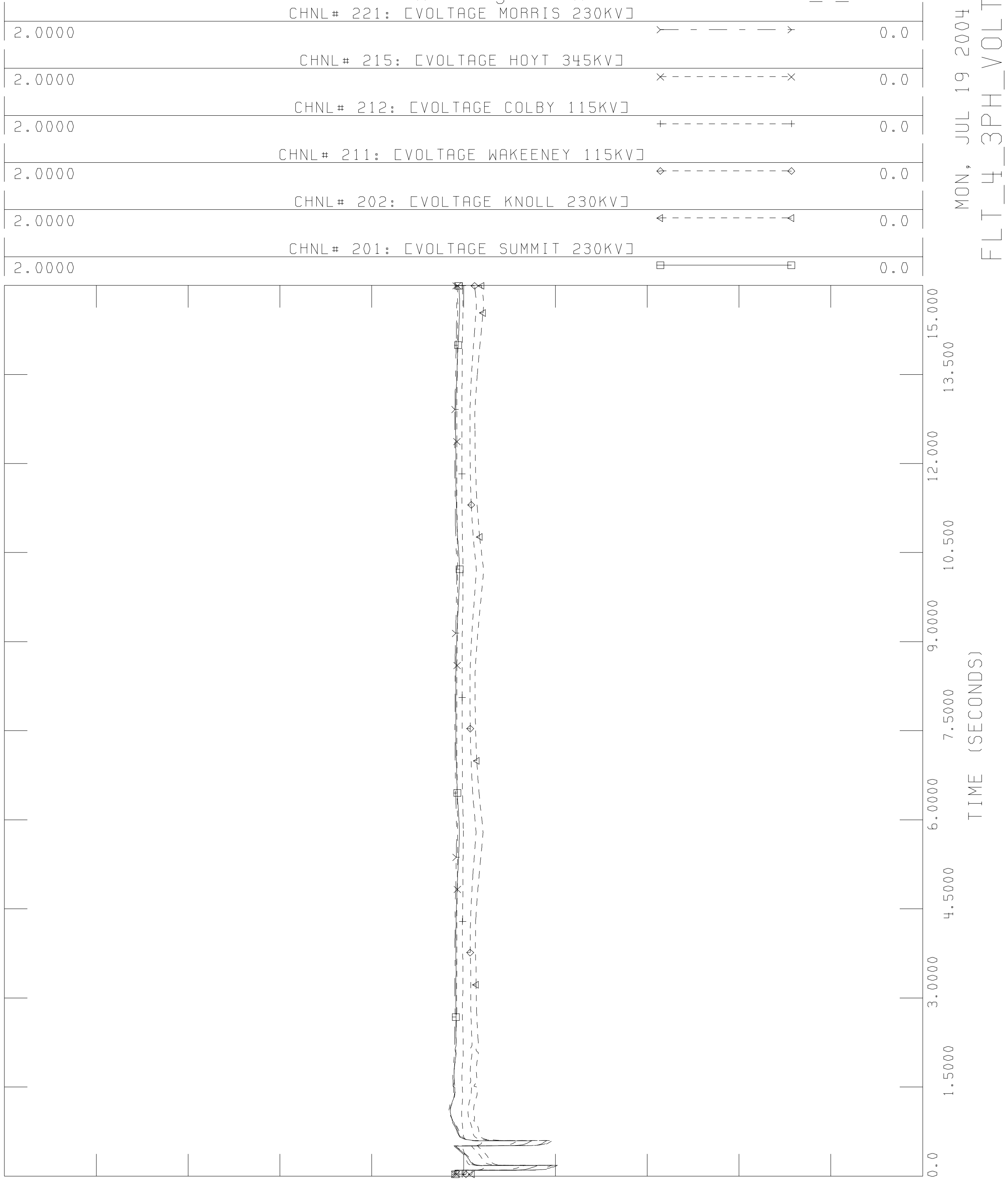
FLT_4_1PH_VOLTAGES



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_4_3PH.OUT



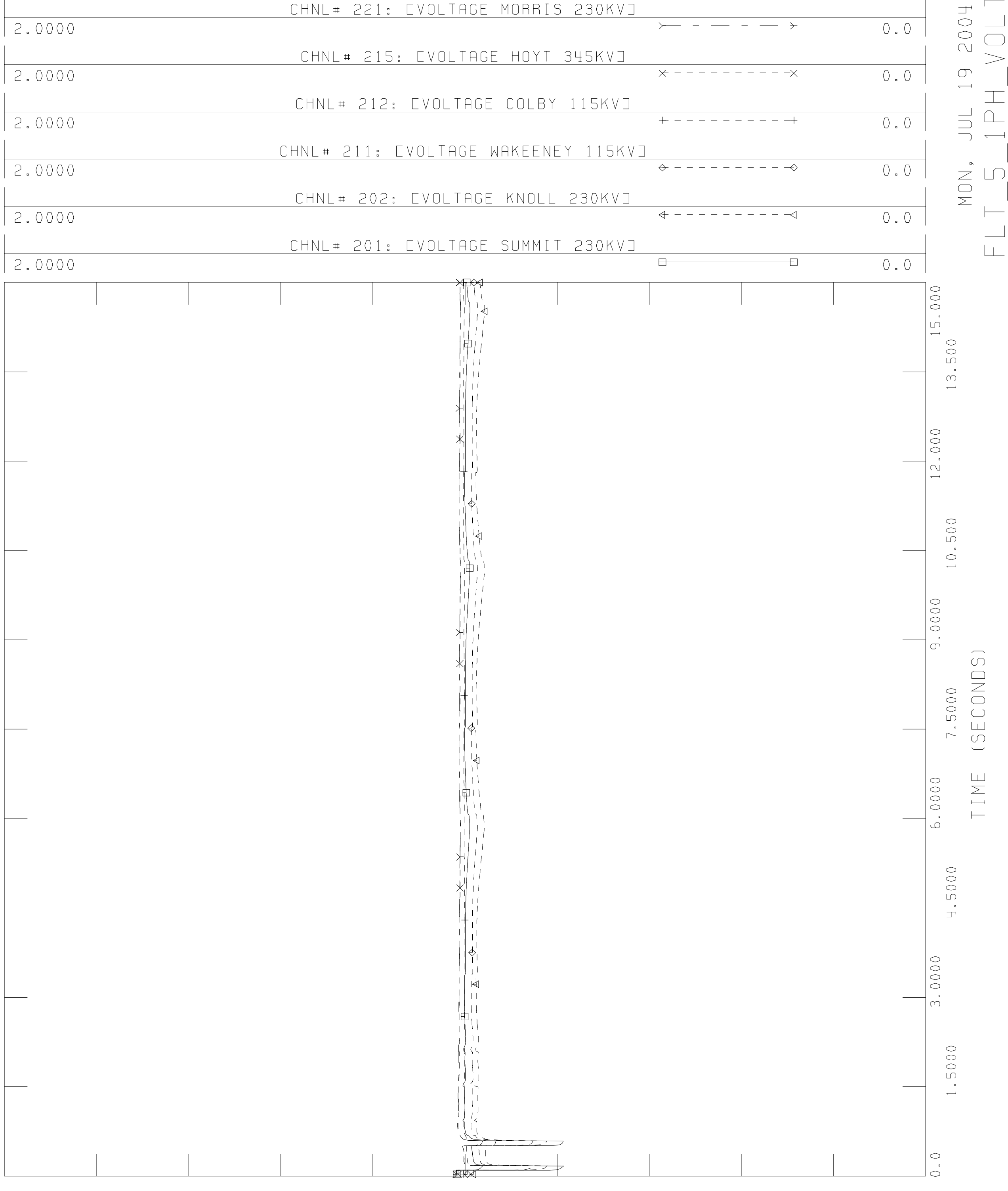
SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

MON, JUL 19 2004 12:40

FLT_5_1PH_VOLTAGES

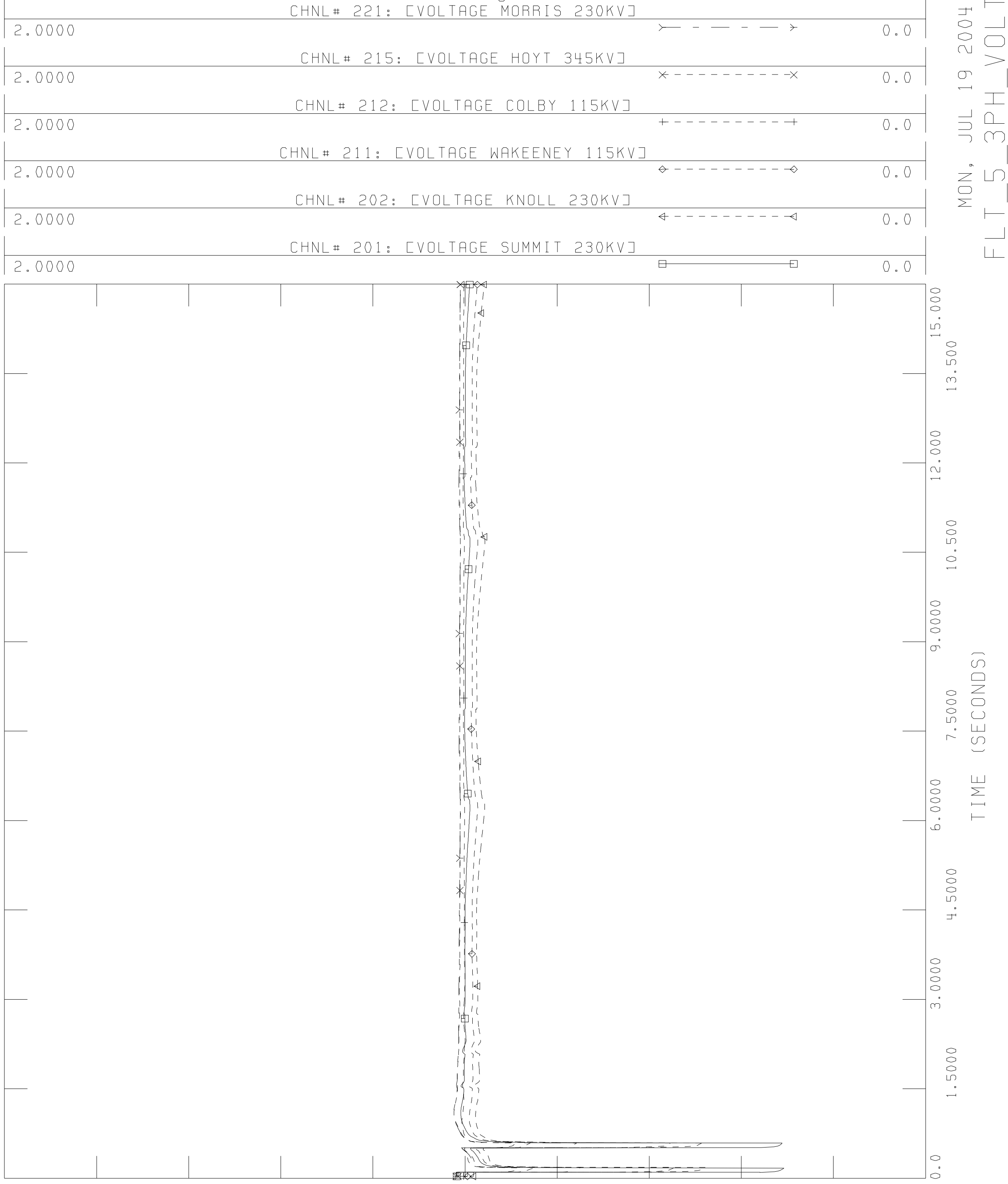
FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_5_1PH.OUT



SHAW POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_5_3PH.OUT



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

MON, JUL 19 2004 12:40

FLT_6_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_6_1PH.OUT

CHNL# 221: [VOLTAGE MORRIS 230KV]
2.0000 ≻— - — - —≻ 0.0

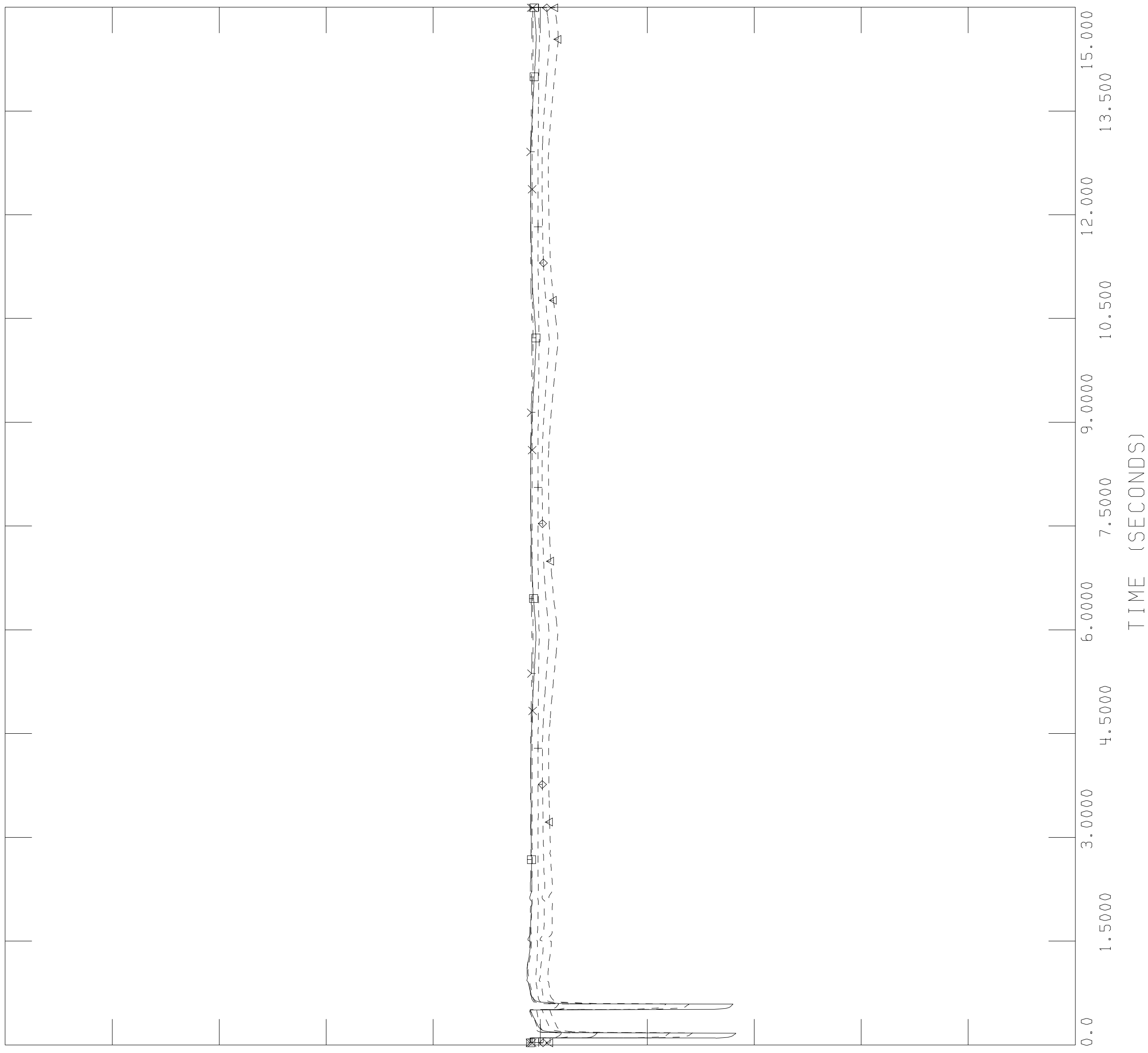
CHNL# 215: [VOLTAGE HOYT 345KV]
2.0000 ×----------× 0.0

CHNL# 212: [VOLTAGE COLBY 115KV]
2.0000 +----------+ 0.0

CHNL# 211: [VOLTAGE WAKEENEY 115KV]
2.0000 ◇----------◇ 0.0

CHNL# 202: [VOLTAGE KNOLL 230KV]
2.0000 ◁----------◁ 0.0

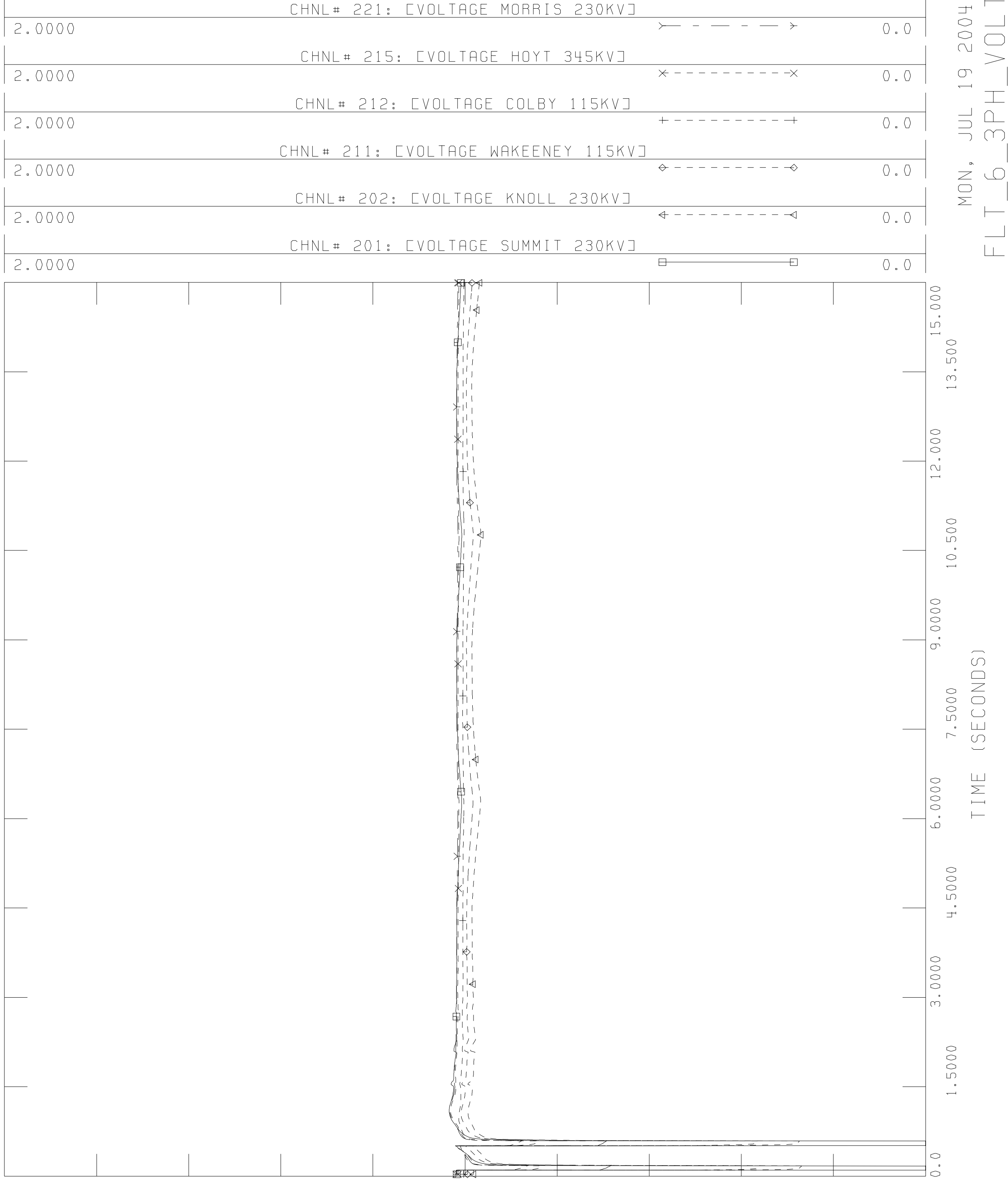
CHNL# 201: [VOLTAGE SUMMIT 230KV]
2.0000 □——————□ 0.0



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_6_3PH.OUT



MON, JUL 19 2004 12:40
FLT_6_3PH_VOLTAGES

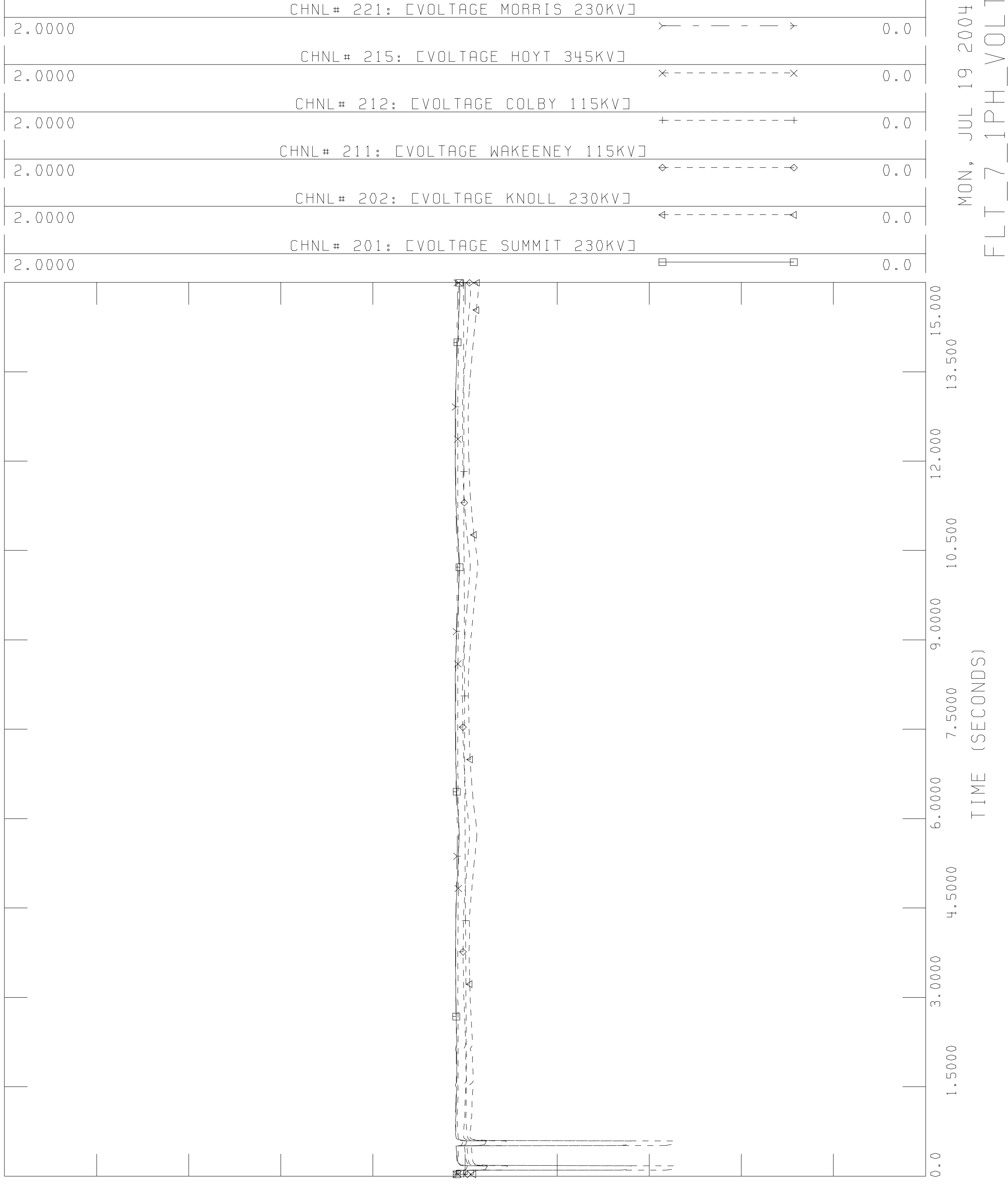
SHAW POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

MON, JUL 19 2004 12:40

FLT_7_1PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_7_1PH.OUT

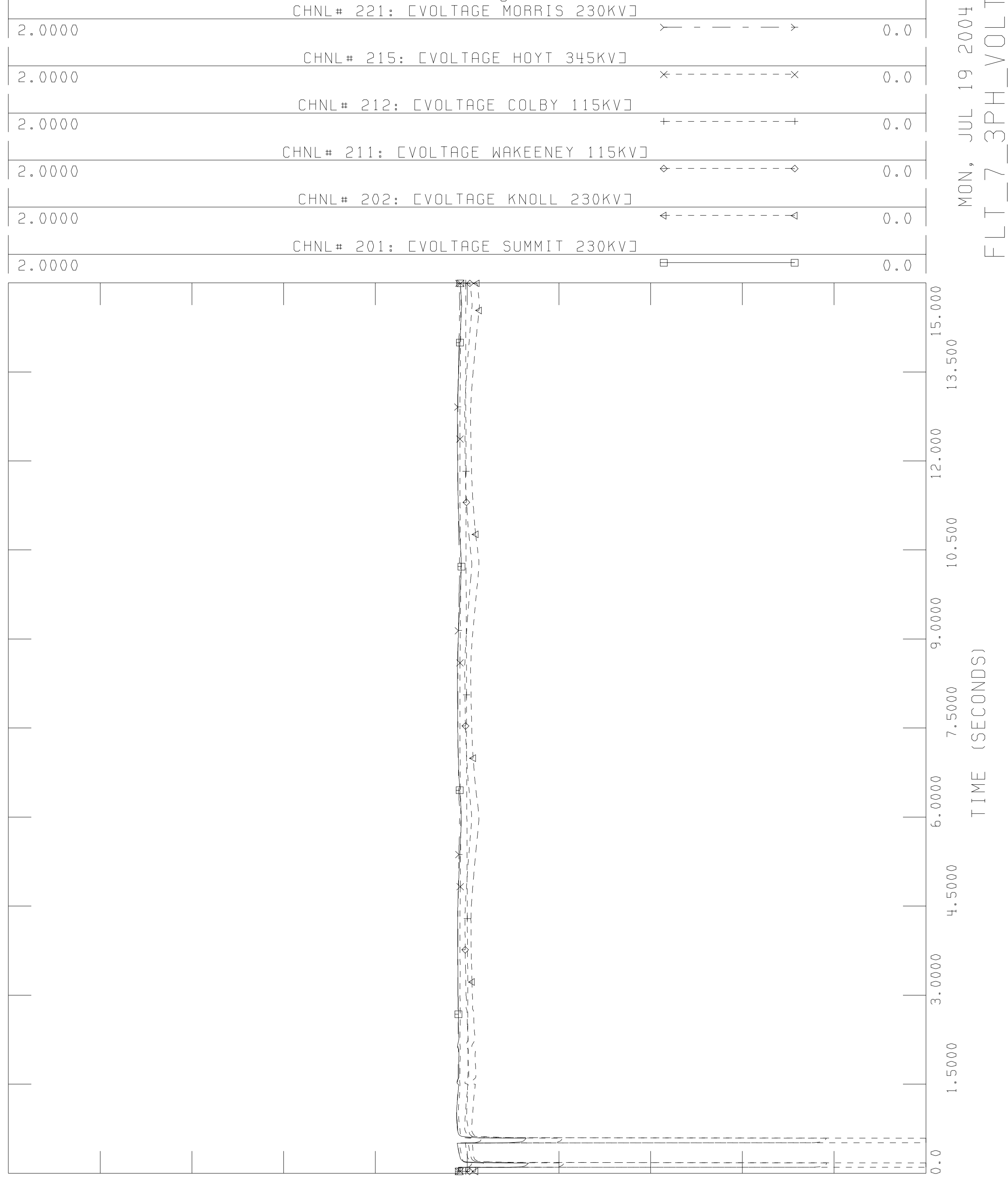


SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

MON, JUL 19 2004 12:40
FLT_7_3PH_VOLTAGES

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_7_3PH.OUT

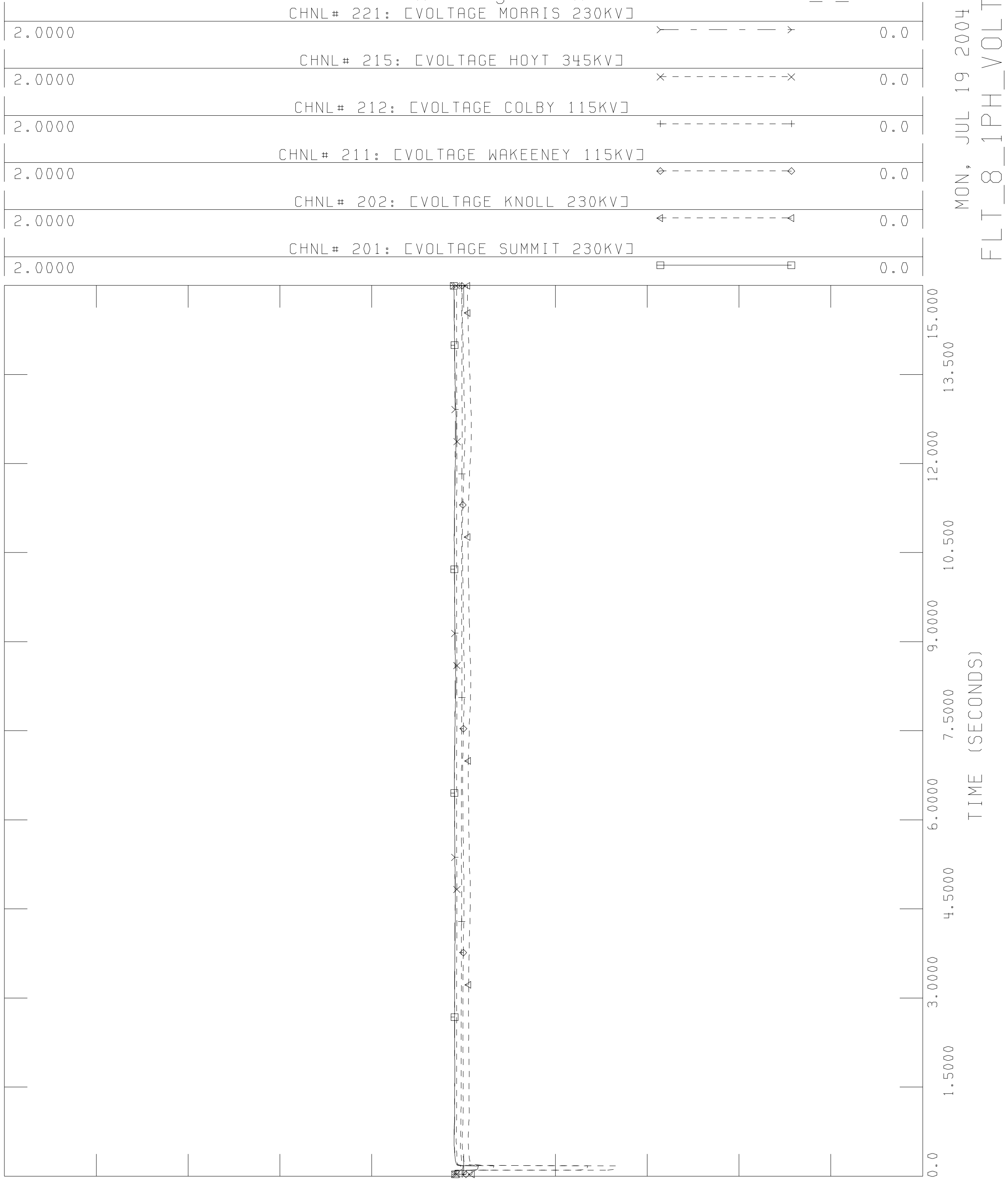


SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

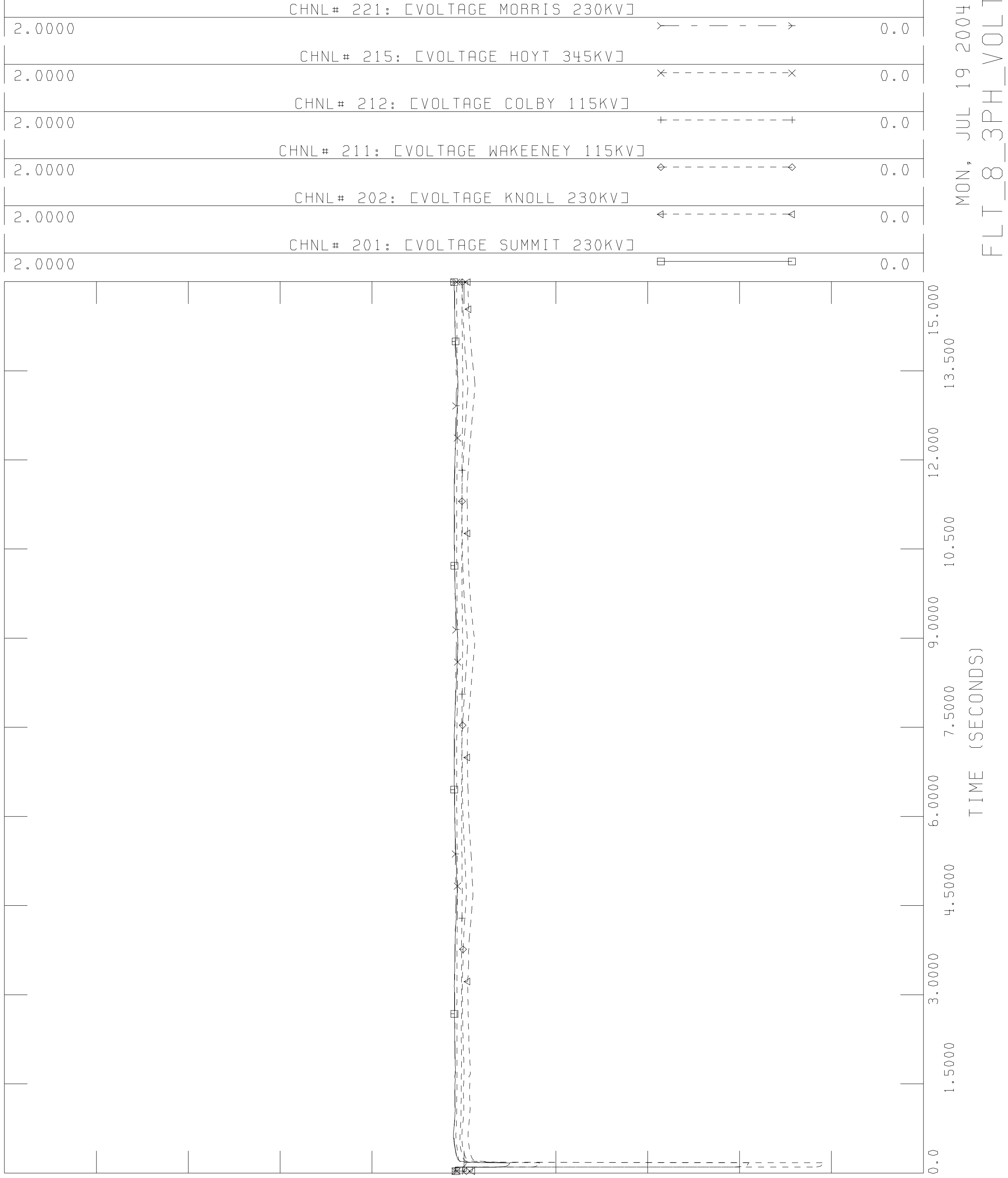
FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_8_1PH.OUT



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

SHAW POWER TECHNOLOGIES INC.®

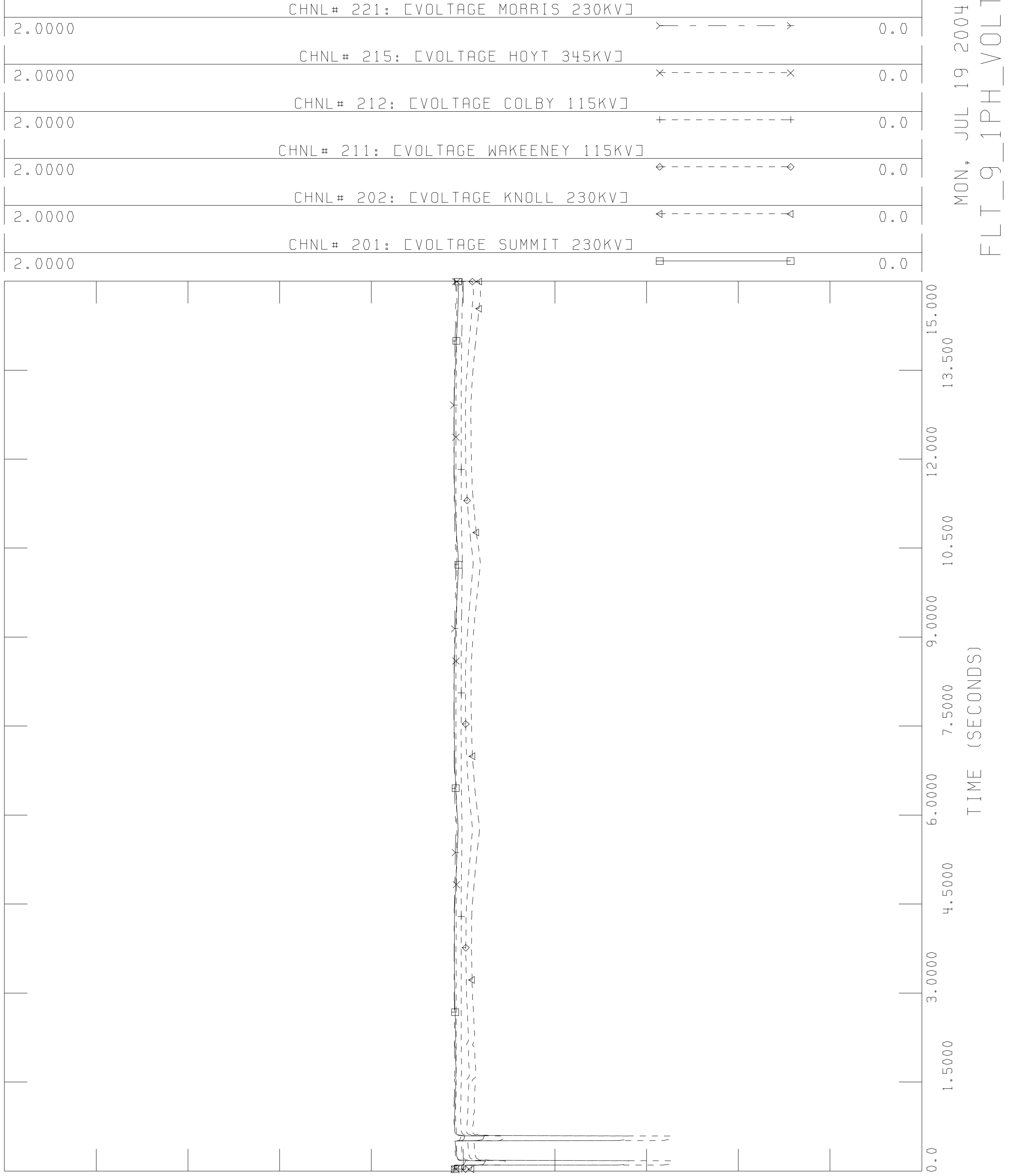
FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_8_3PH.OUT



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

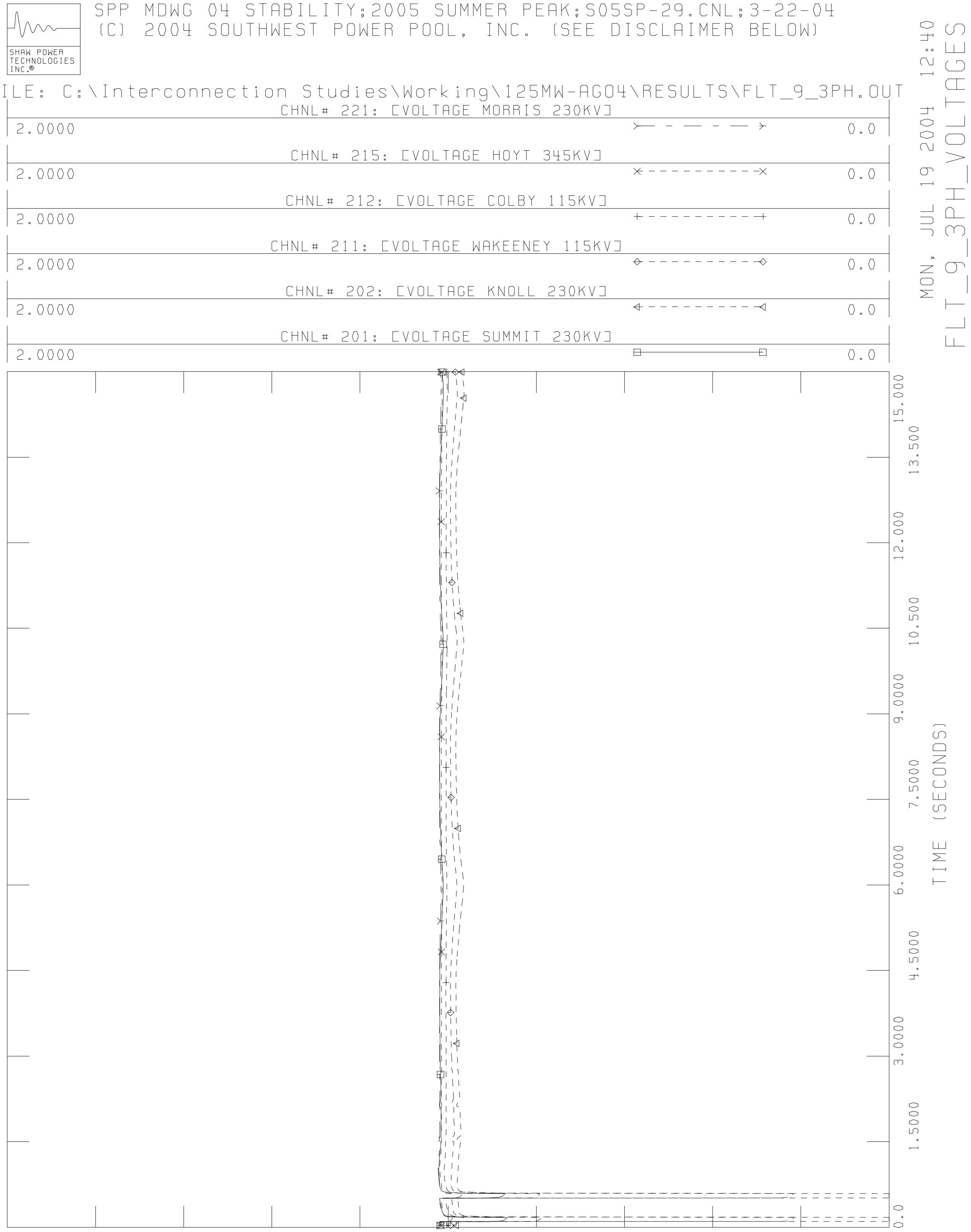
FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_9_1PH.OUT



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_9_3PH.OUT



SHAW POWER
TECHNOLOGIES
INC.®

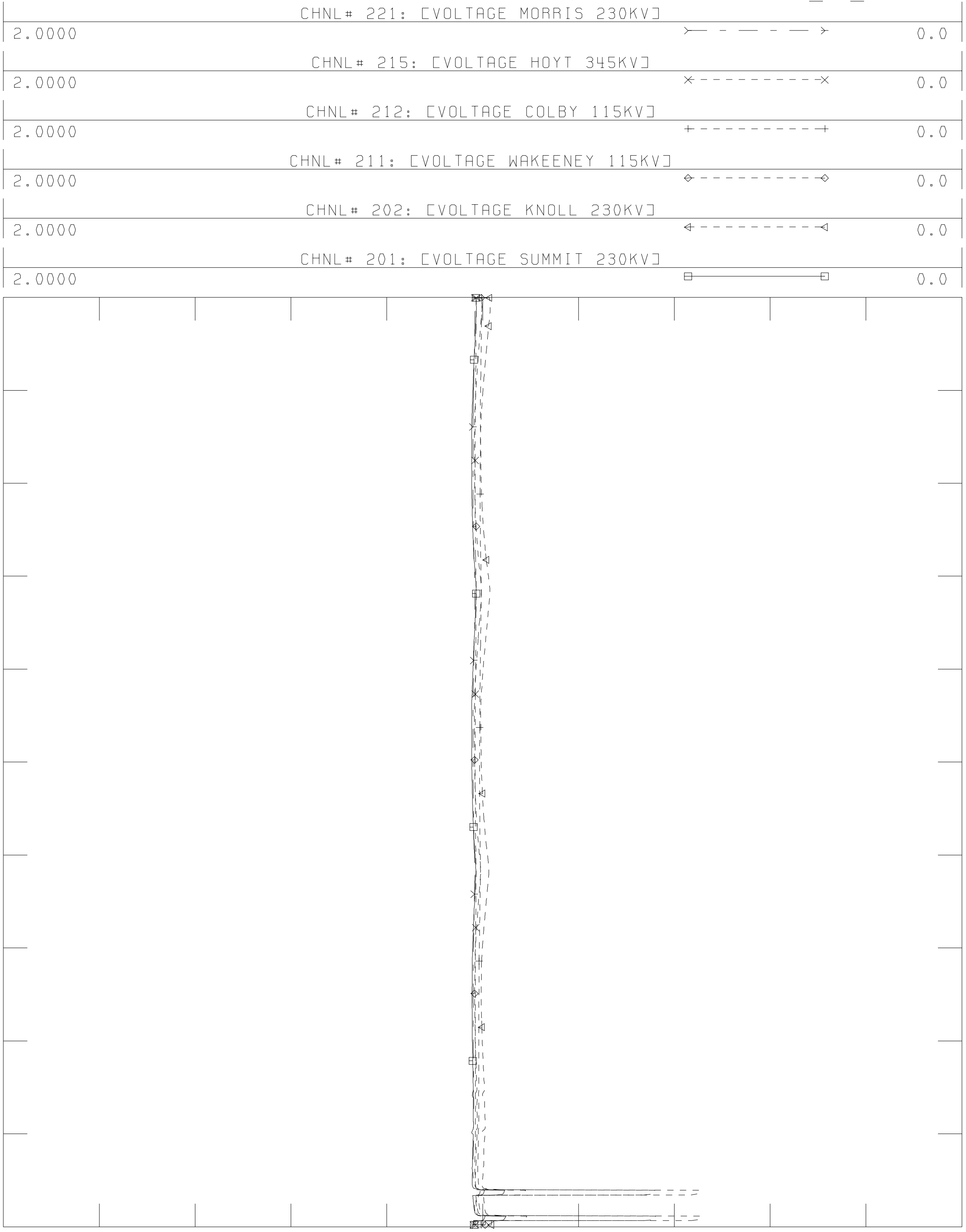
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

MON, JUL 19 2004 12:40

FLT_10_1PH_VOLTAGES

FILE: C:\Interconnection Studies\...\125MW-AG04\RESULTS\FLT_10_1PH.OUT



SHAW POWER
TECHNOLOGIES
INC.®

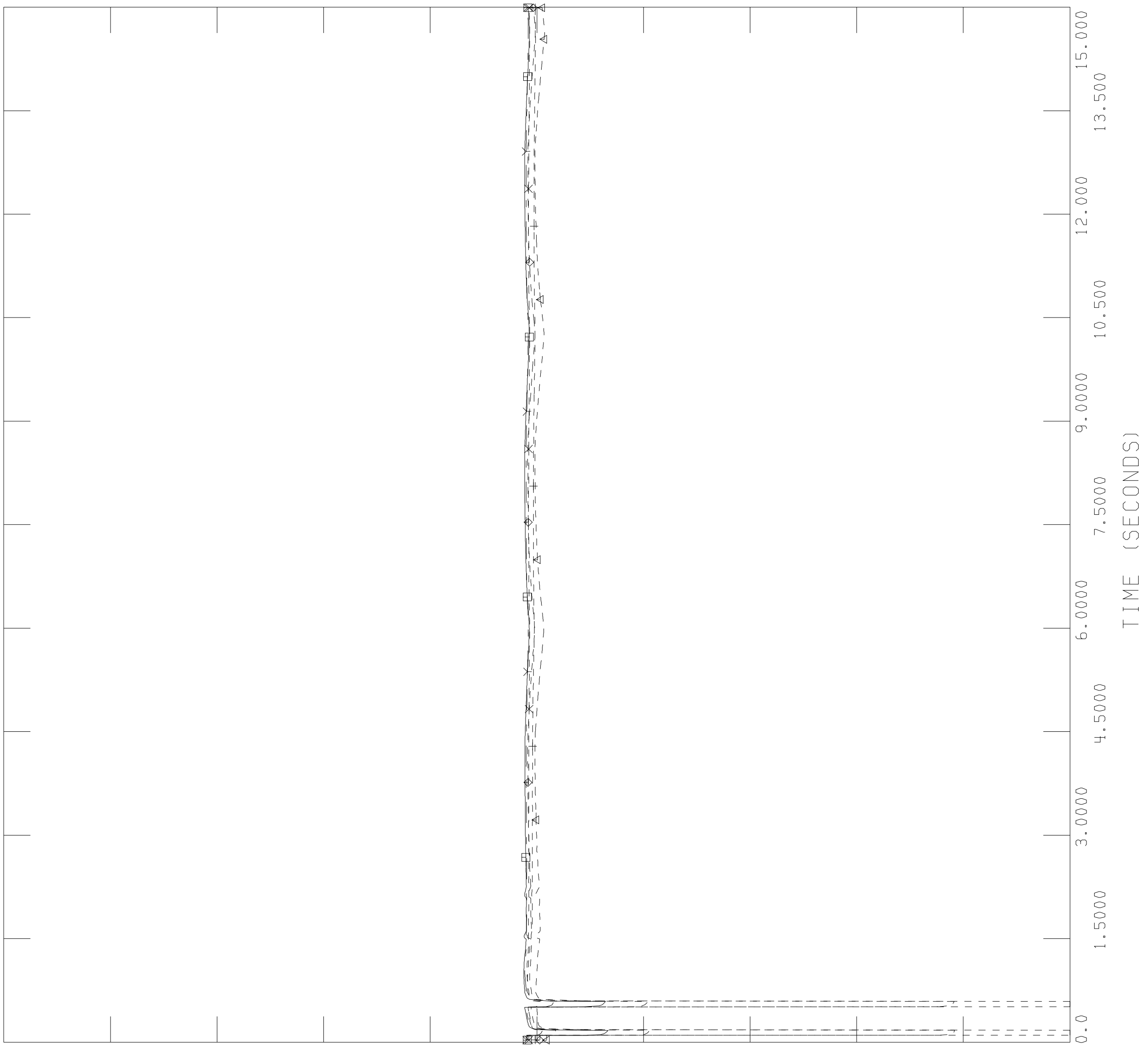
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\...\125MW-AG04\RESULTS\FLT_10_3PH.OUT

MON, JUL 19 2004 12:40

FLT_10_3PH_VOLTAGES

CHNL# 221: [VOLTAGE MORRIS 230KV]		
2.0000	≻— - — - —≻	0.0
CHNL# 215: [VOLTAGE HOYT 345KV]		
2.0000	×- - - - - - - - - -×	0.0
CHNL# 212: [VOLTAGE COLBY 115KV]		
2.0000	+- - - - - - - - - -+	0.0
CHNL# 211: [VOLTAGE WAKEENEY 115KV]		
2.0000	◇- - - - - - - - - -◇	0.0
CHNL# 202: [VOLTAGE KNOLL 230KV]		
2.0000	◁- - - - - - - - - -◁	0.0
CHNL# 201: [VOLTAGE SUMMIT 230KV]		
2.0000	□———————□	0.0



Appendix F-2

Plots of Fault Simulations

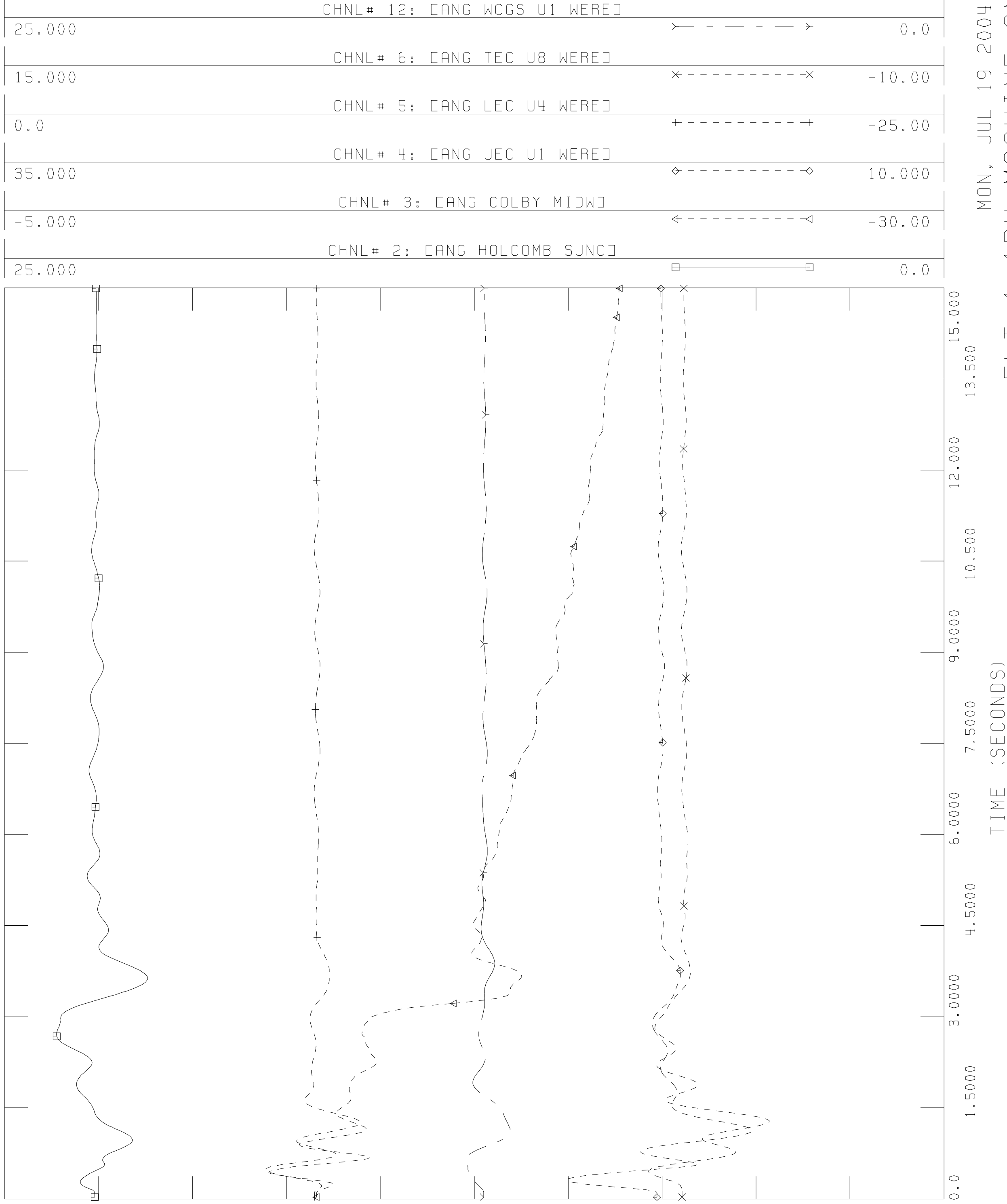
Plots of selected machine phase angles during faults

Scenario:
2005 Summer Peak
Wind Farm at 125MW (50% rated power)
AGO4 Protection Settings

SHAW POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_1_1PH.OUT



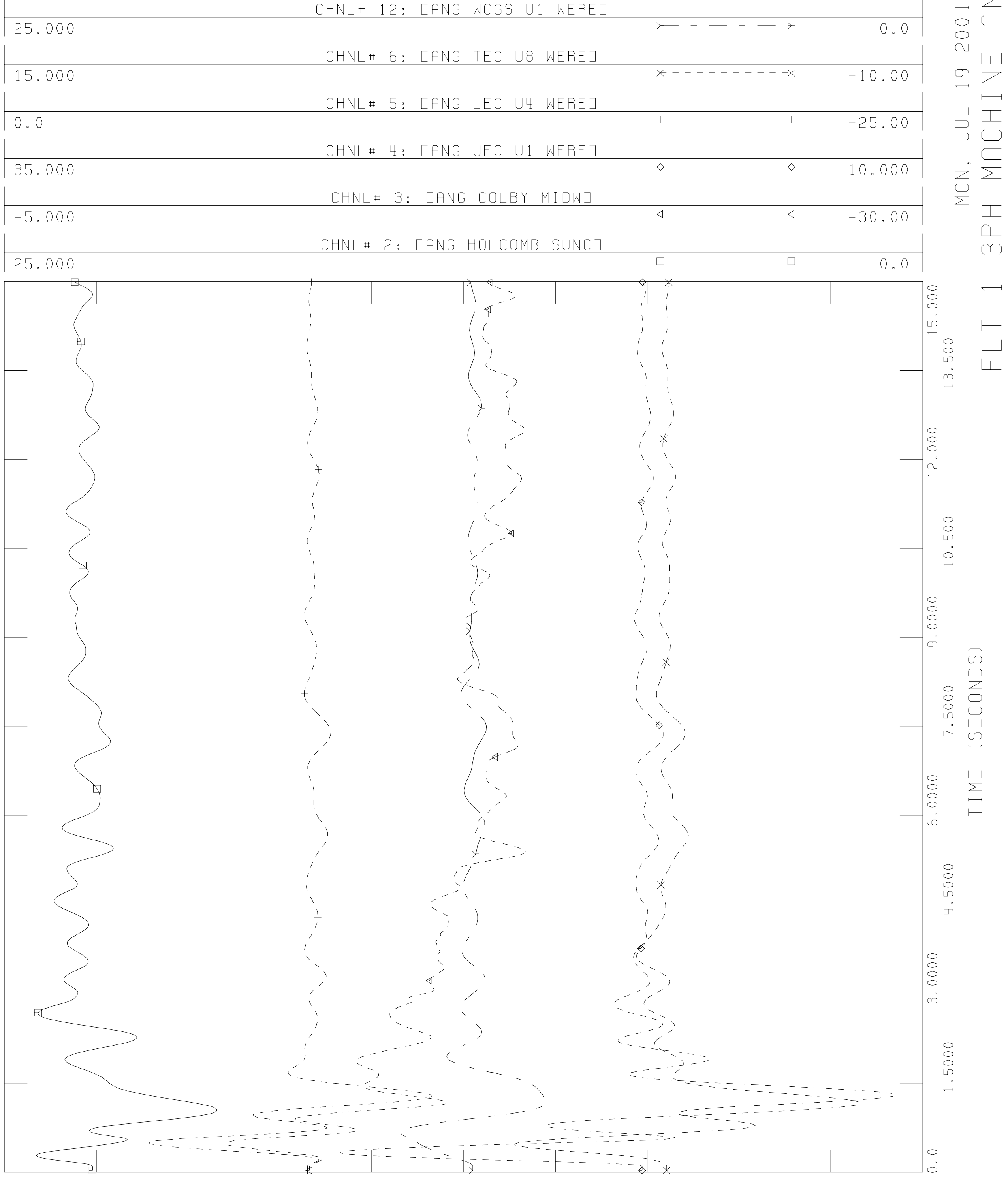
MON, JUL 19 2004 12:46

FLT_1_1PH_MACHINE ANGLES

SHAW POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_1_3PH.OUT

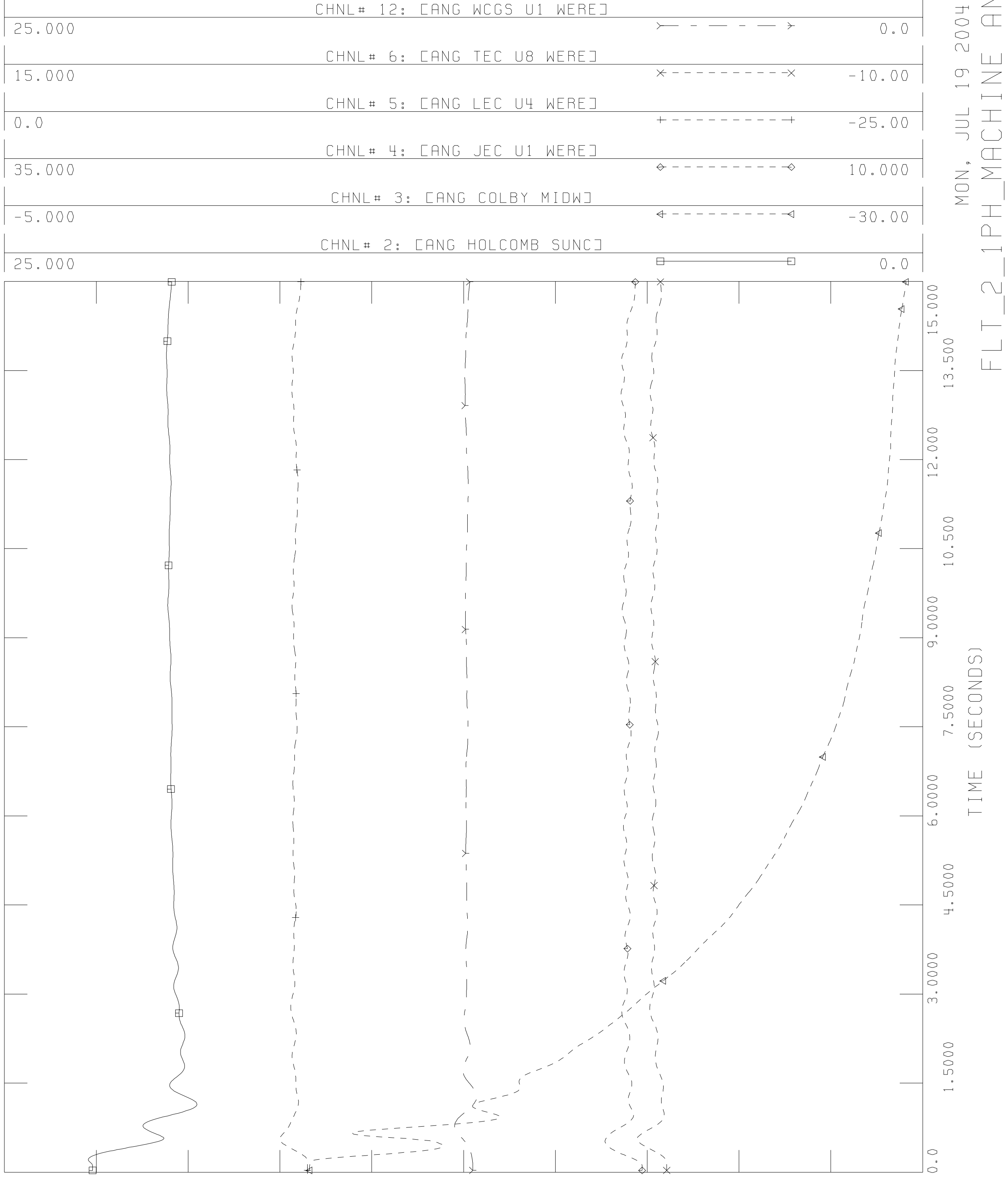


SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_2_1PH.OUT



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_2_3PH.OUT

MON, JUL 19 2004 12:46

FLT_2_3PH_MACHINE ANGLES

CHNL# 12: [ANG WCGS U1 WERE]
25.000 ≻ - — - — ≻ 0.0

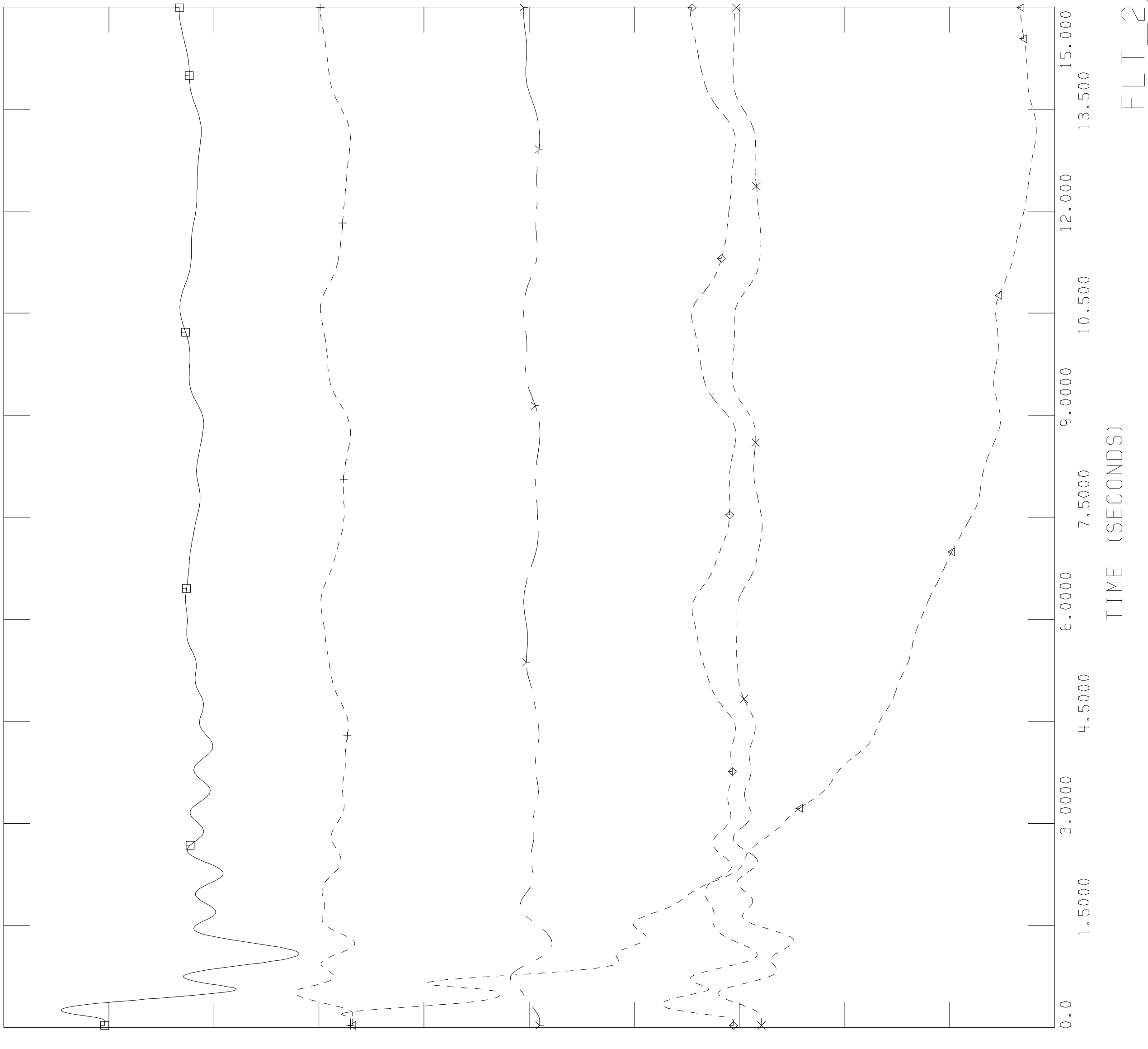
CHNL# 6: [ANG TEC U8 WERE]
15.000 × - - - - - - - - × -10.00

CHNL# 5: [ANG LEC U4 WERE]
0.0 + - - - - - - - - + -25.00

CHNL# 4: [ANG JEC U1 WERE]
35.000 ◇ - - - - - - - - ◇ 10.000

CHNL# 3: [ANG COLBY MIDW]
-5.000 ◁ - - - - - - - - ◁ -30.00

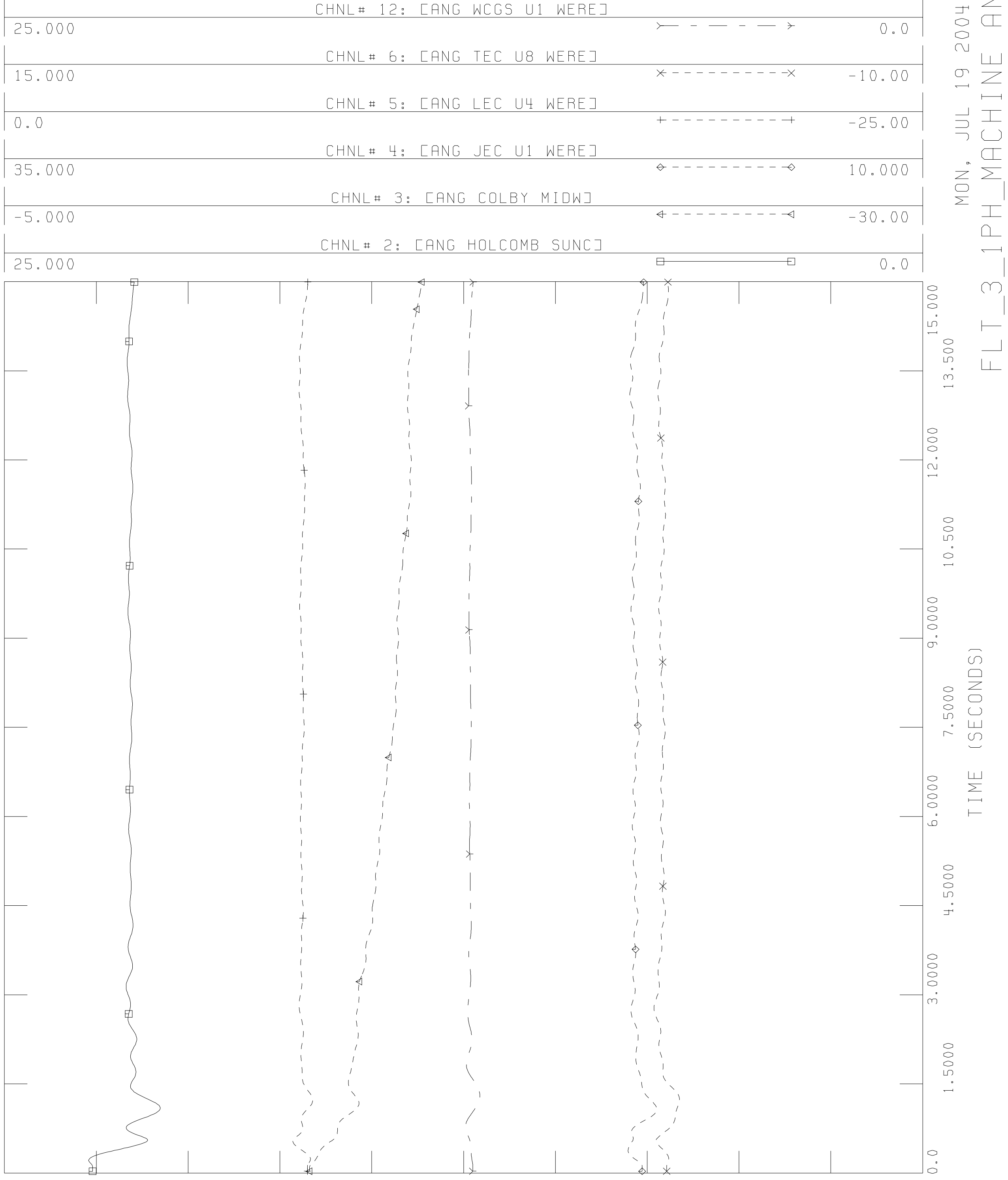
CHNL# 2: [ANG HOLCOMB SUNC]
25.000 □———□ 0.0



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_3_1PH.OUT



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_3_3PH.OUT

MON, JUL 19 2004 12:46

FLT_3_3PH_MACHINE ANGLES

CHNL# 12: [ANG WCGS U1 WERE]
25.000 ≻— — — —≻ 0.0

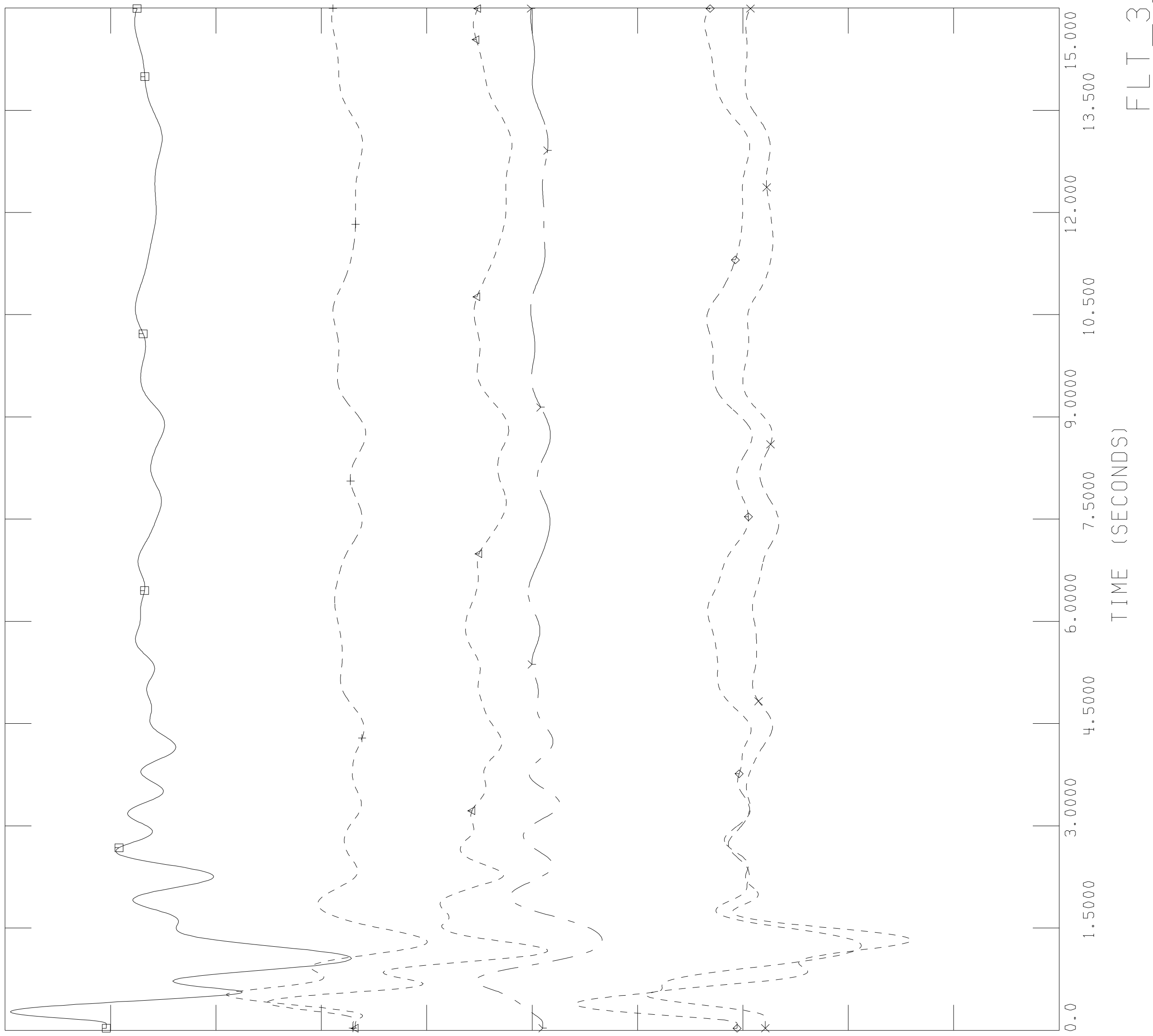
CHNL# 6: [ANG TEC U8 WERE]
15.000 ×- - - - - - - - - -× -10.00

CHNL# 5: [ANG LEC U4 WERE]
0.0 +- - - - - - - - - -+ -25.00

CHNL# 4: [ANG JEC U1 WERE]
35.000 ◇- - - - - - - - - -◇ 10.000

CHNL# 3: [ANG COLBY MIDW]
-5.000 ◁- - - - - - - - - -◁ -30.00

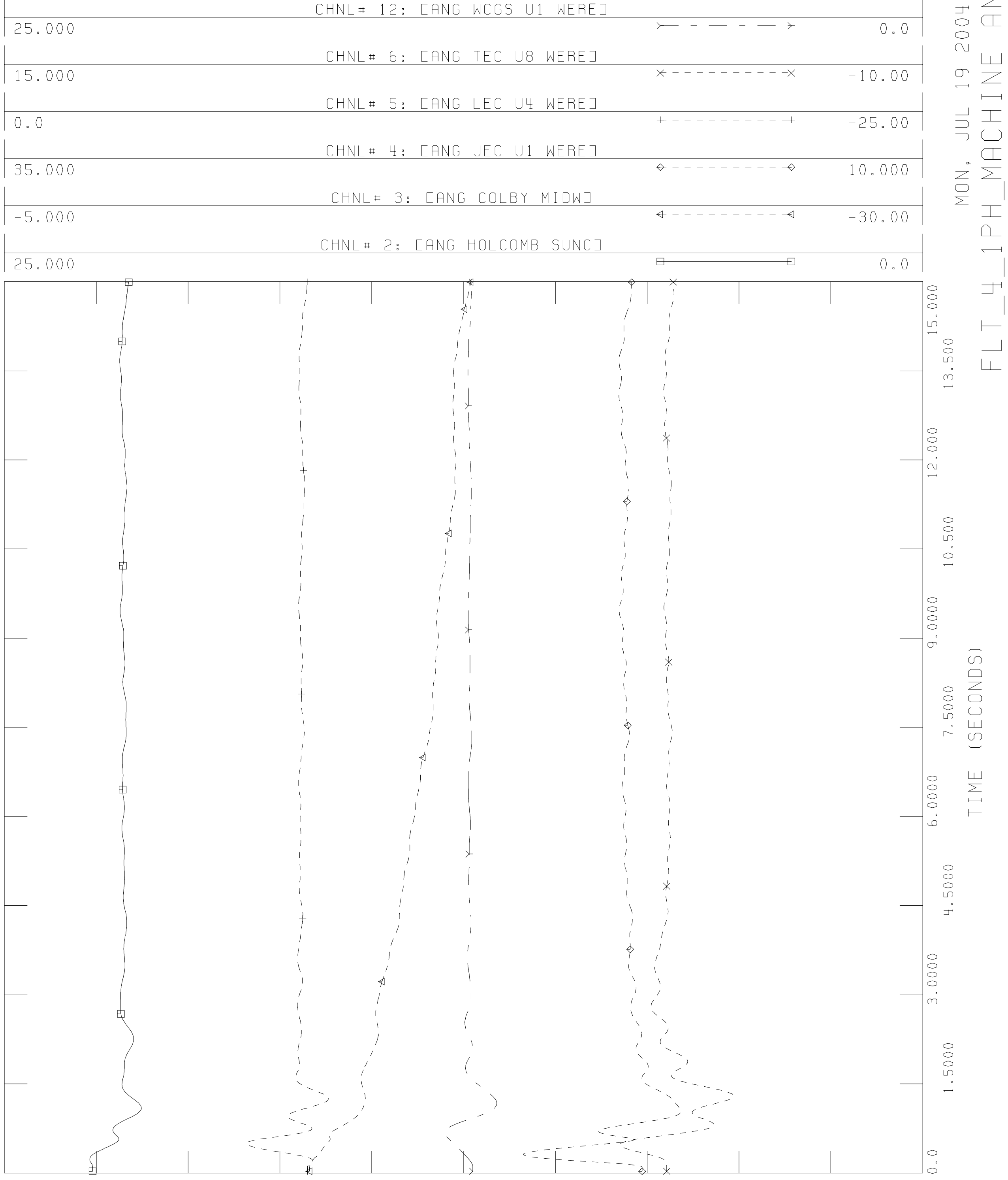
CHNL# 2: [ANG HOLCOMB SUNC]
25.000 □————————□ 0.0



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_4_1PH.OUT



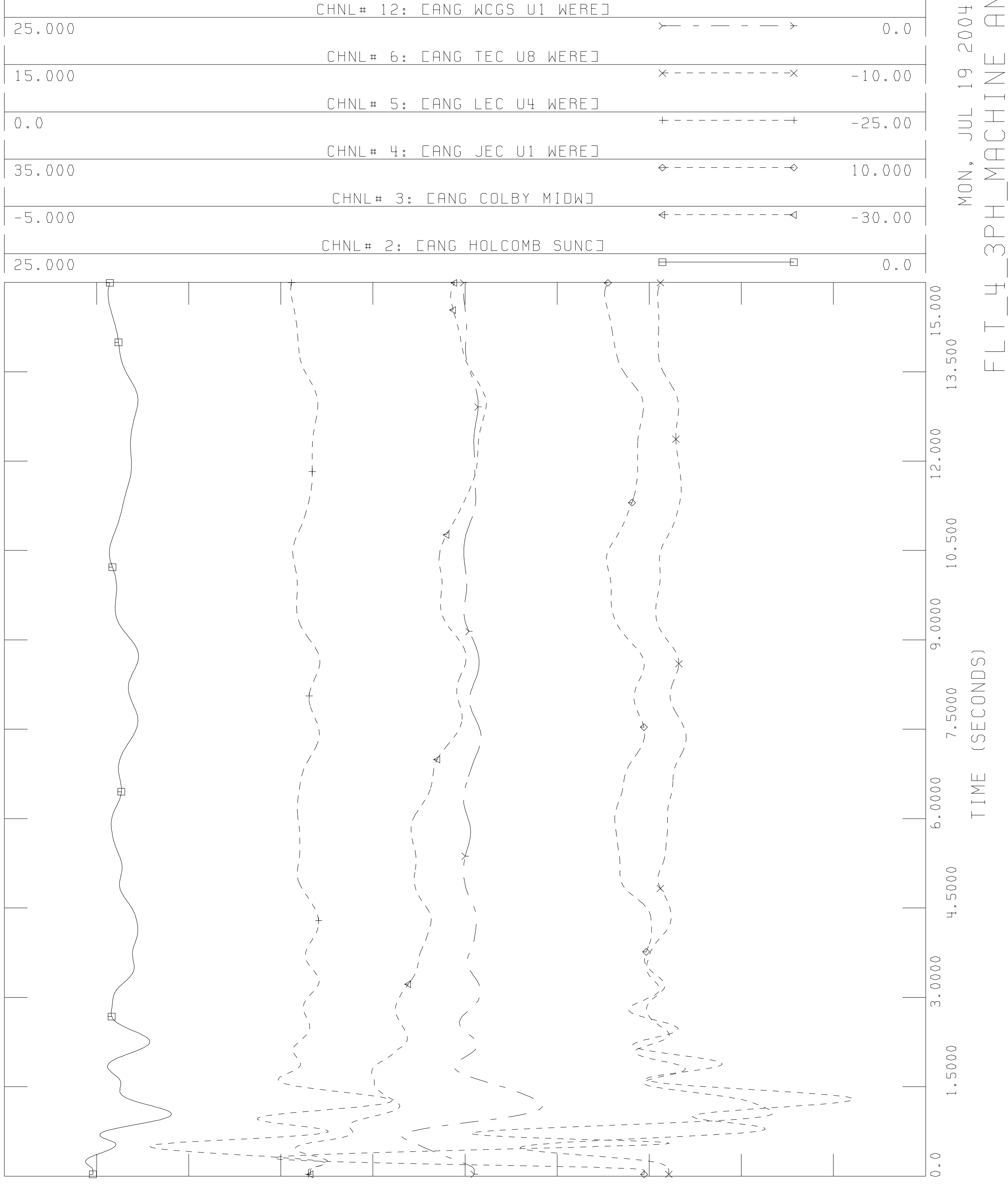
SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_4_3PH.OUT

MON, JUL 19 2004 12:46

FLT_4_3PH_MACHINE ANGLES



SHAW POWER
TECHNOLOGIES
INC.®

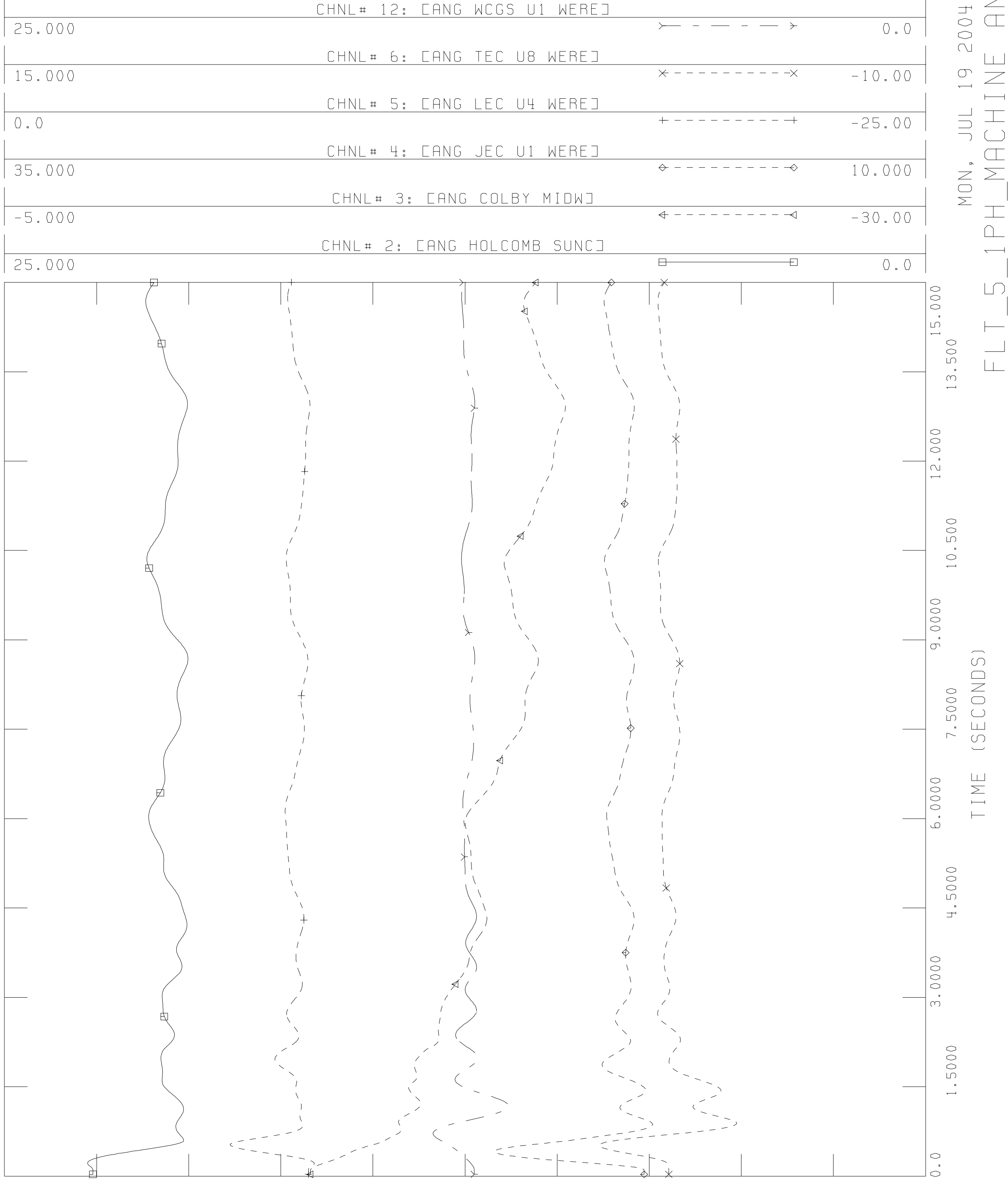
SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04

(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_5_1PH.OUT

MON, JUL 19 2004 12:46

FLT_5_1PH_MACHINE ANGLES



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_5_3PH.OUT

MON, JUL 19 2004 12:46

FLT_5_3PH_MACHINE ANGLES

CHNL# 12: [ANG WCGS U1 WERE]
25.000 ≻- - — - — - ≻ 0.0

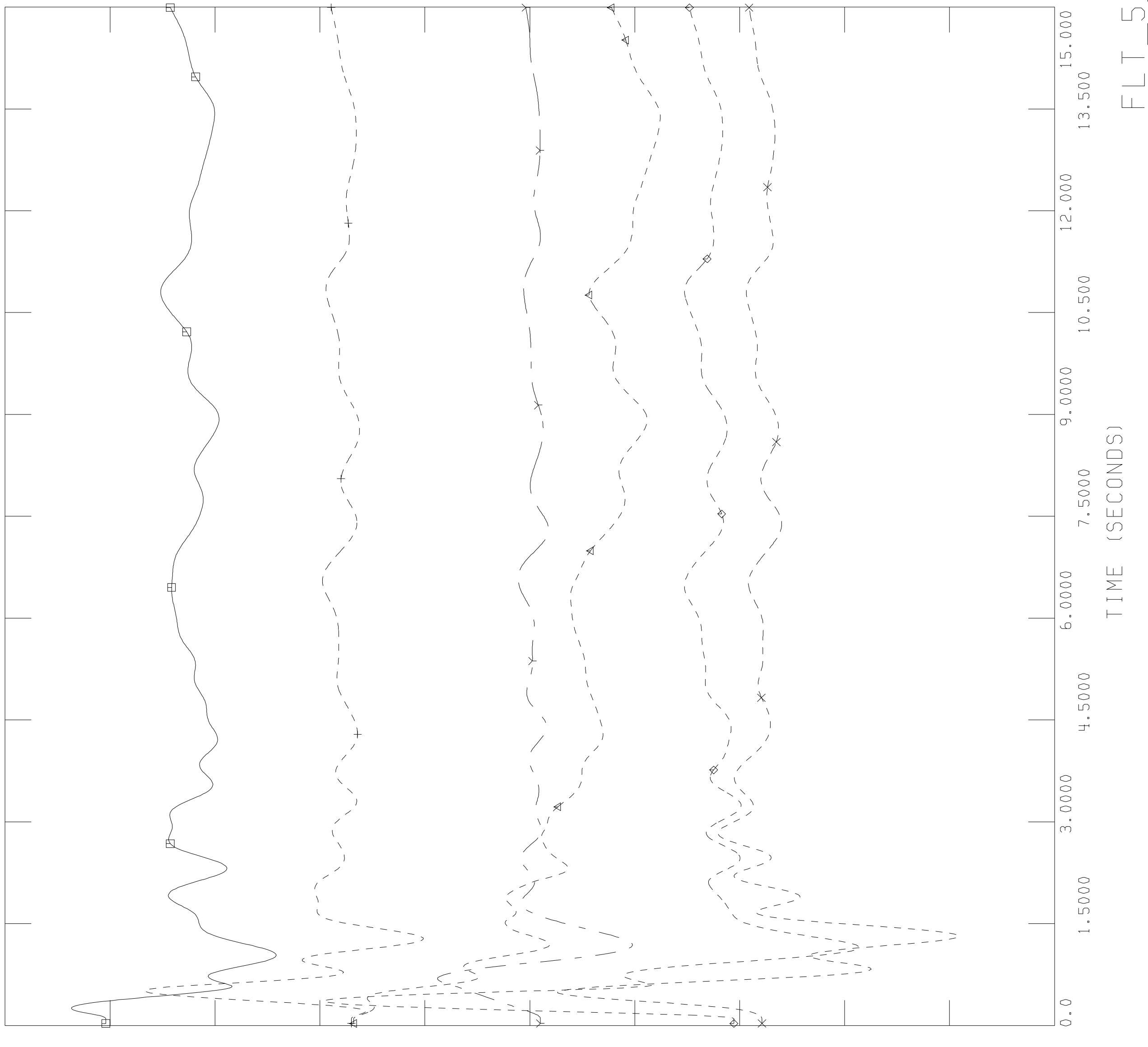
CHNL# 6: [ANG TEC U8 WERE]
15.000 ×- - - - - - - - - -× -10.00

CHNL# 5: [ANG LEC U4 WERE]
0.0 +- - - - - - - - - -+ -25.00

CHNL# 4: [ANG JEC U1 WERE]
35.000 ◇- - - - - - - - - -◇ 10.000

CHNL# 3: [ANG COLBY MIDW]
-5.000 ◁- - - - - - - - - -◁ -30.00

CHNL# 2: [ANG HOLCOMB SUNC]
25.000 □————————□ 0.0



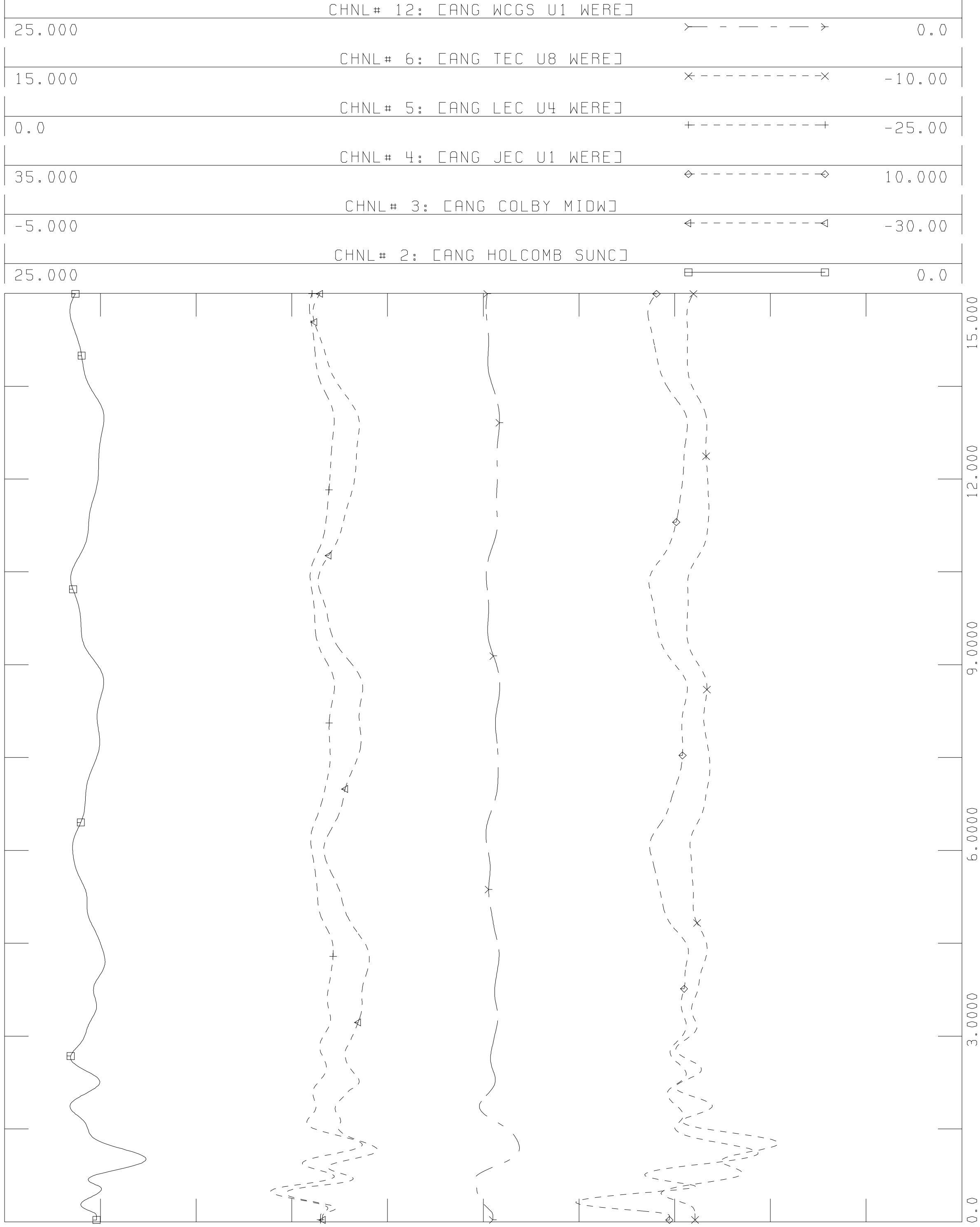
SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

MON, JUL 19 2004 12:46

FLT_6_1PH_MACHINE ANGLES

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_6_1PH.OUT



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_6_3PH.OUT

MON, JUL 19 2004 12:46

FLT_6_3PH_MACHINE ANGLES

CHNL# 12: [ANG WCGS U1 WERE]
25.000 0.0

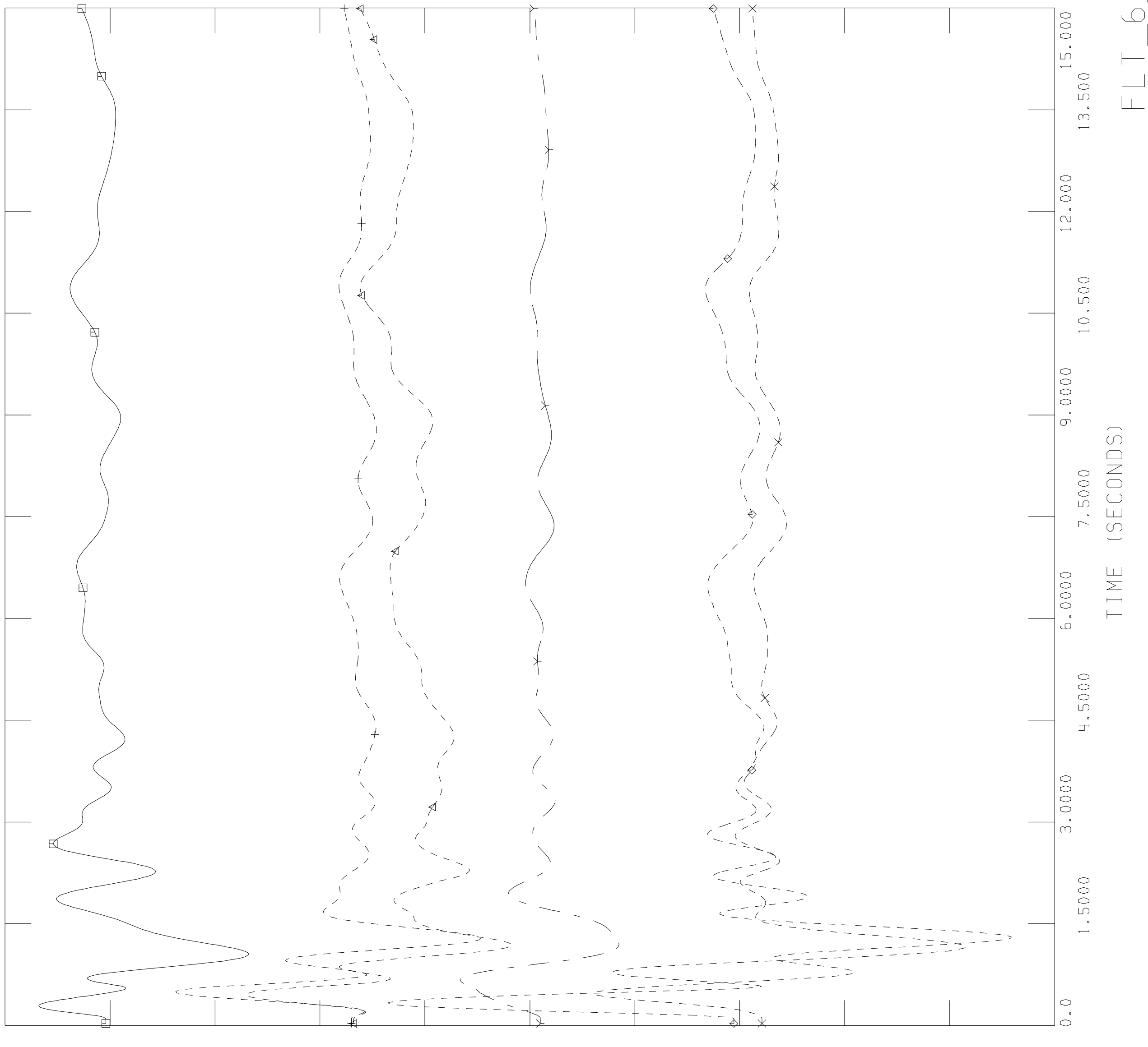
CHNL# 6: [ANG TEC U8 WERE]
15.000 -10.00

CHNL# 5: [ANG LEC U4 WERE]
0.0 -25.00

CHNL# 4: [ANG JEC U1 WERE]
35.000 10.000

CHNL# 3: [ANG COLBY MIDW]
-5.000 -30.00

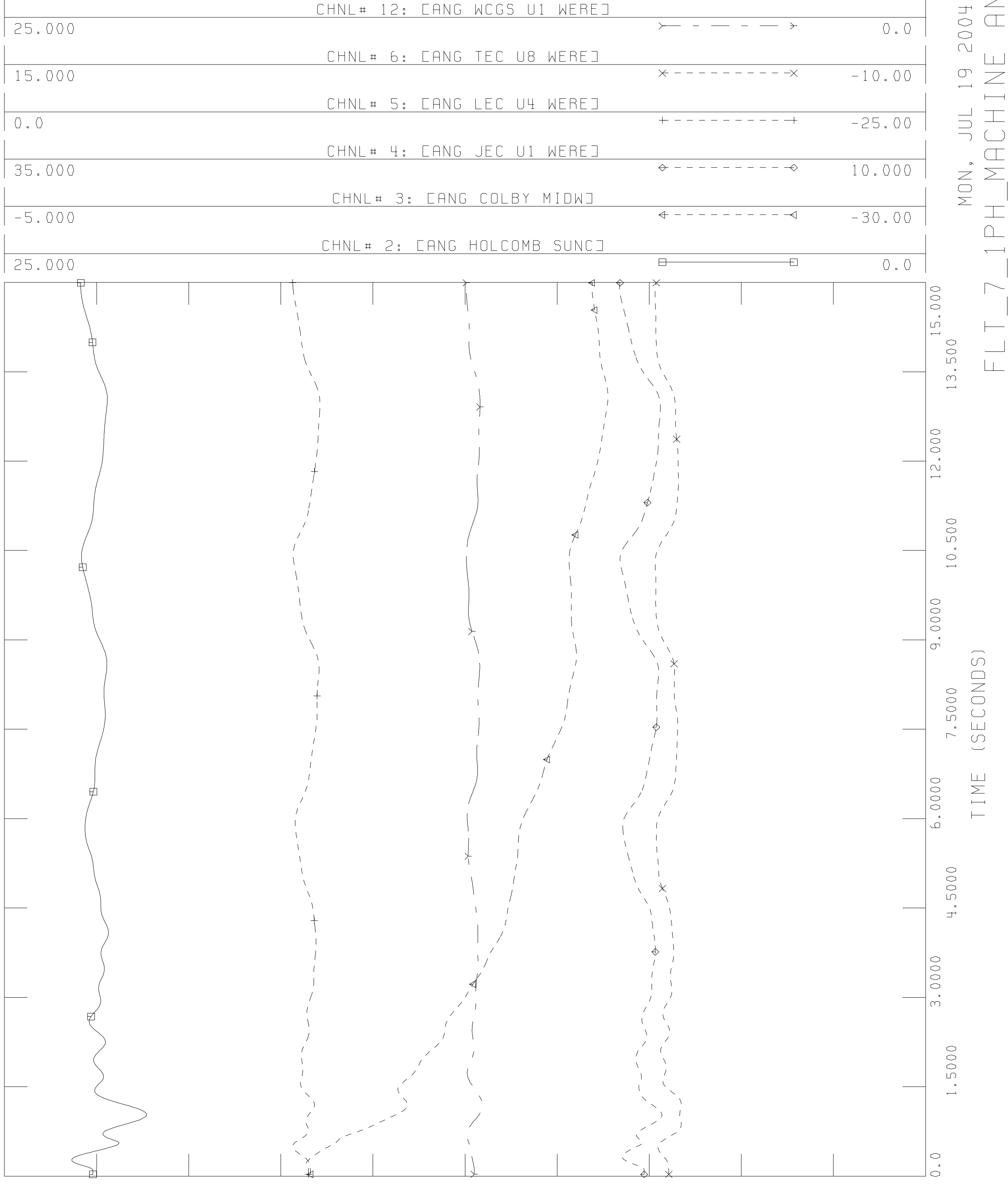
CHNL# 2: [ANG HOLCOMB SUNC]
25.000 0.0



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_7_1PH.OUT



MON, JUL 19 2004 12:46

FLT_7_1PH_MACHINE ANGLES

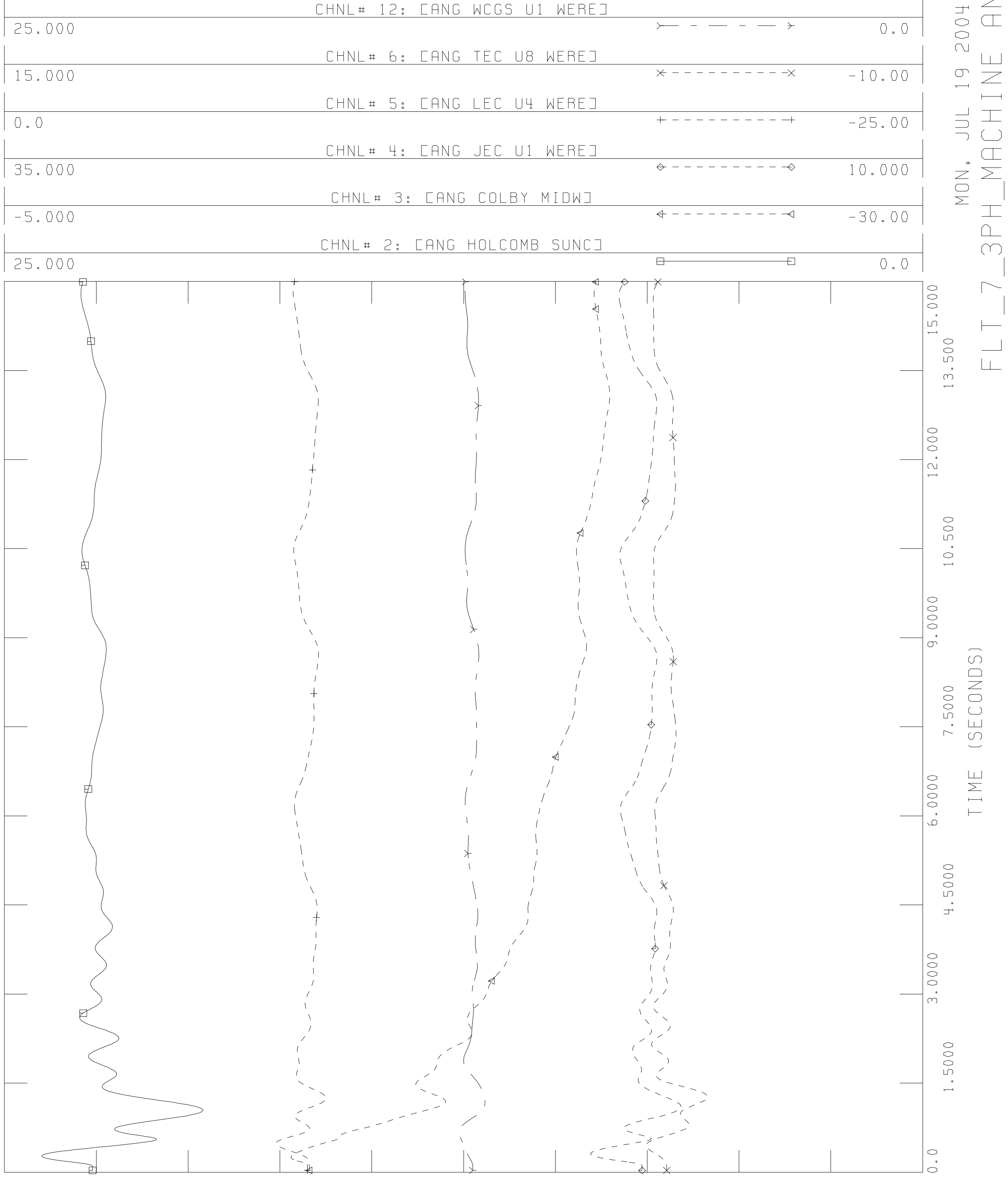
SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_7_3PH.OUT

MON, JUL 19 2004 12:46

FLT_7_3PH_MACHINE ANGLES



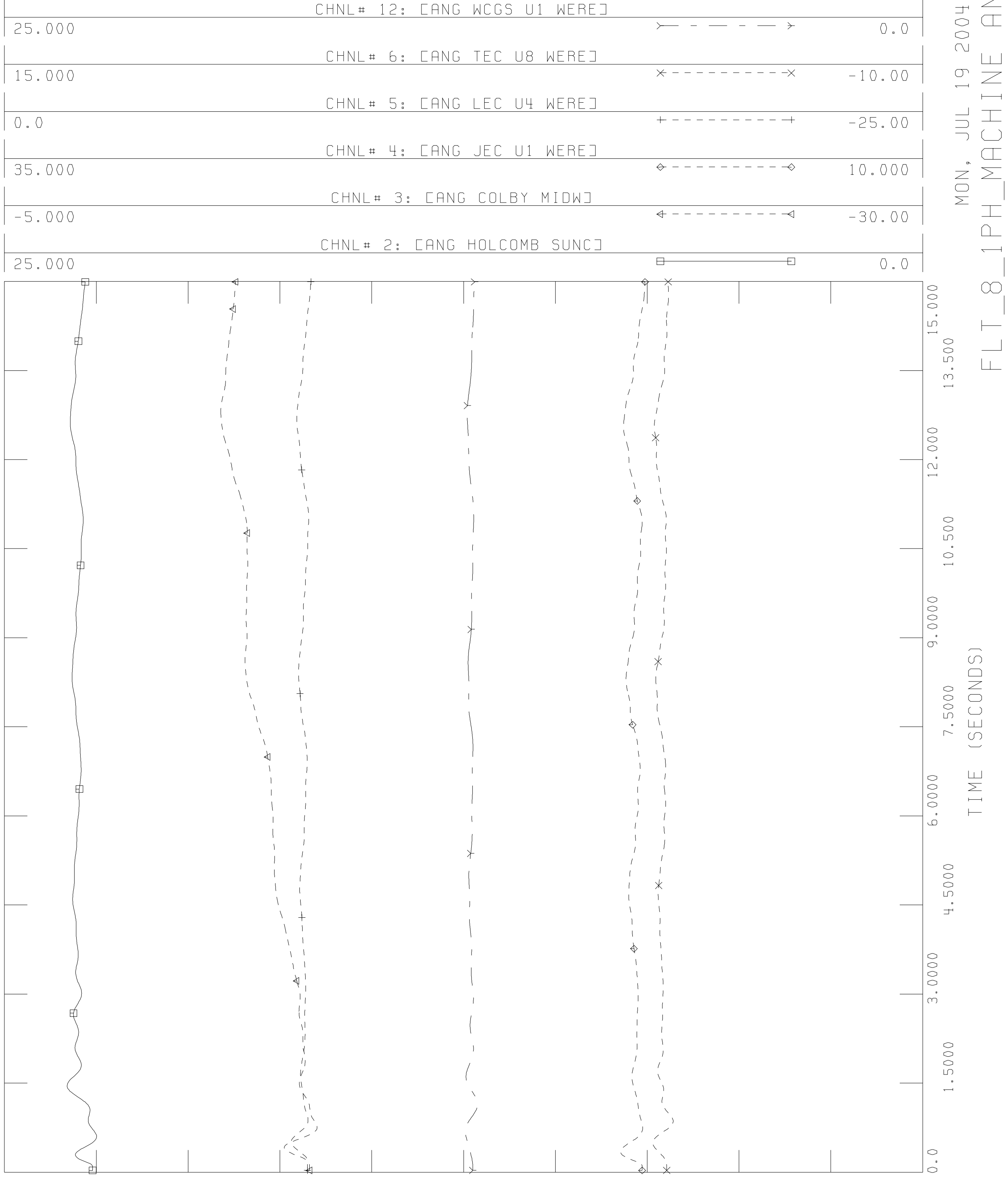
SHAW POWER TECHNOLOGIES INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_8_1PH.OUT

MON, JUL 19 2004 12:46

FLT_8_1PH_MACHINE ANGLES



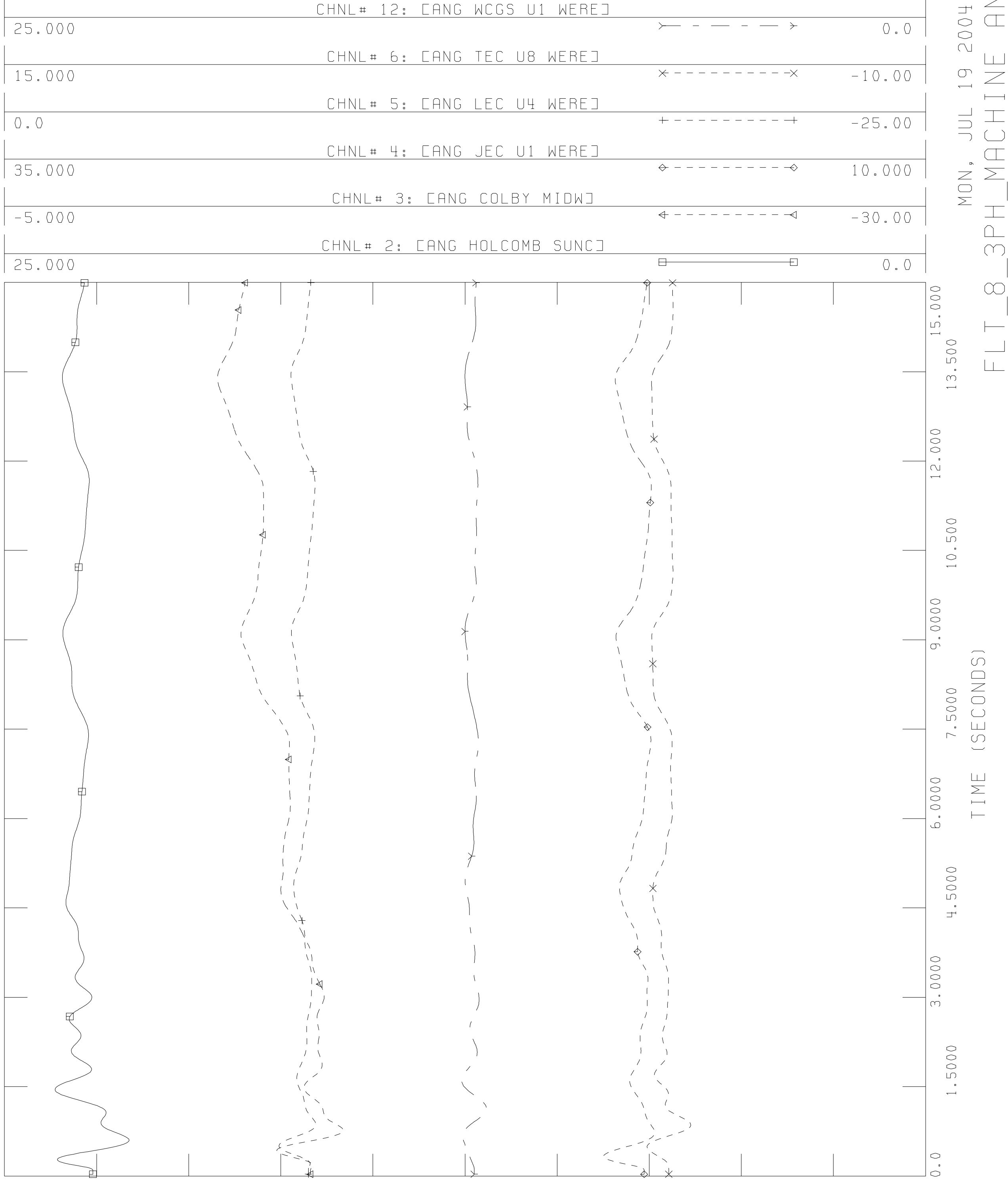
SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_8_3PH.OUT

MON, JUL 19 2004 12:46

FLT_8_3PH_MACHINE ANGLES



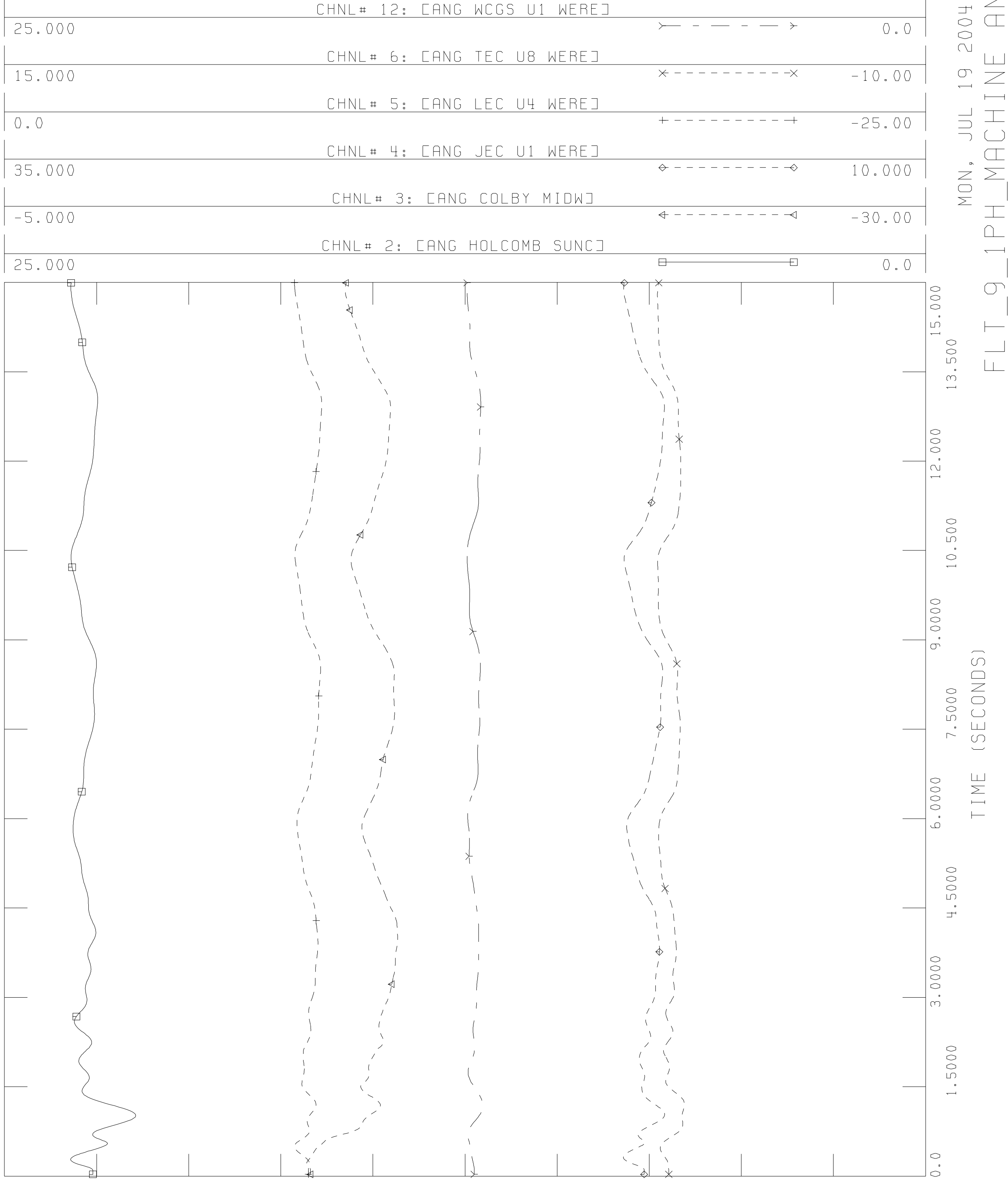
SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_9_1PH.OUT

MON, JUL 19 2004 12:46

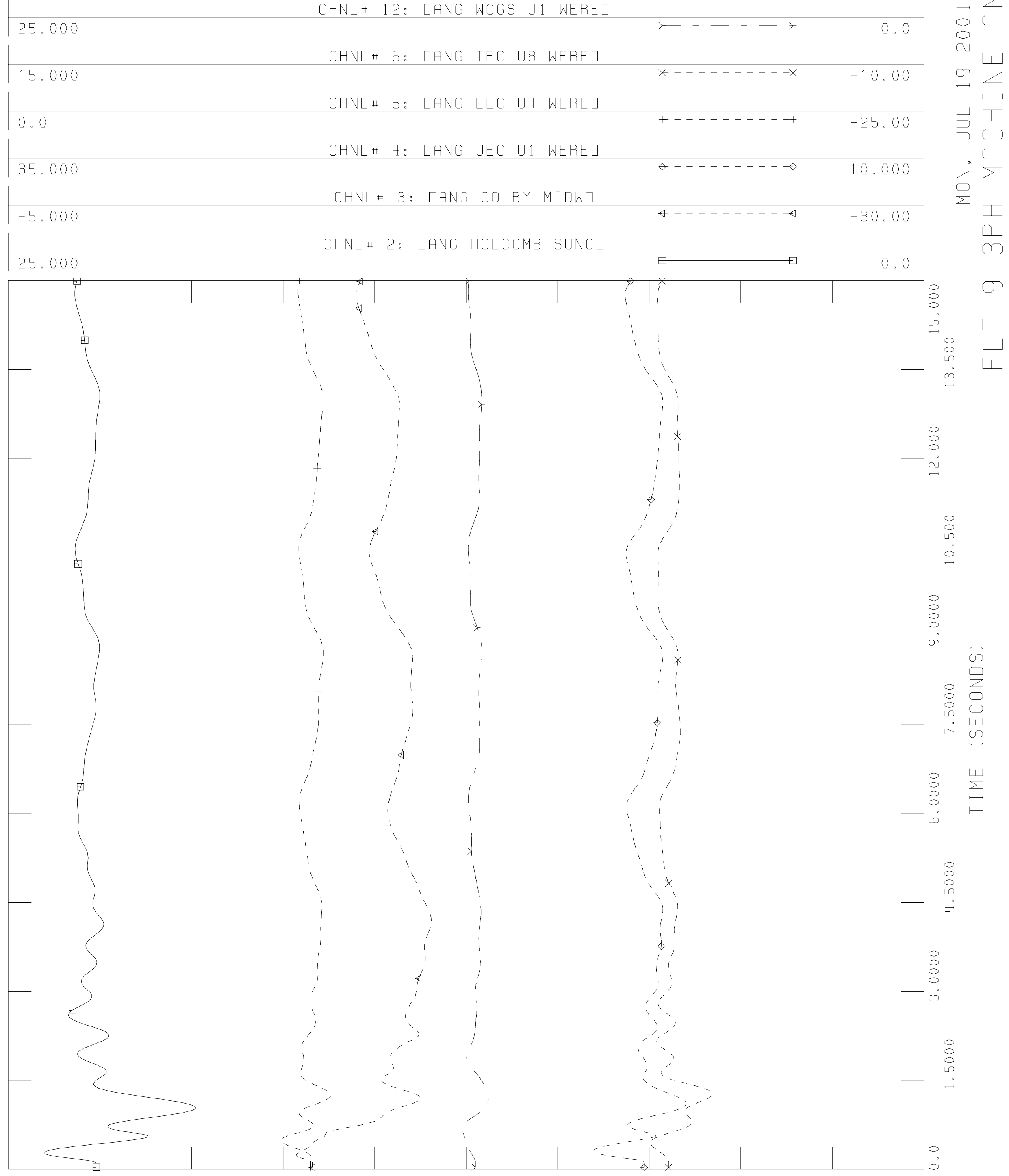
FLT_9_1PH_MACHINE ANGLES



SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

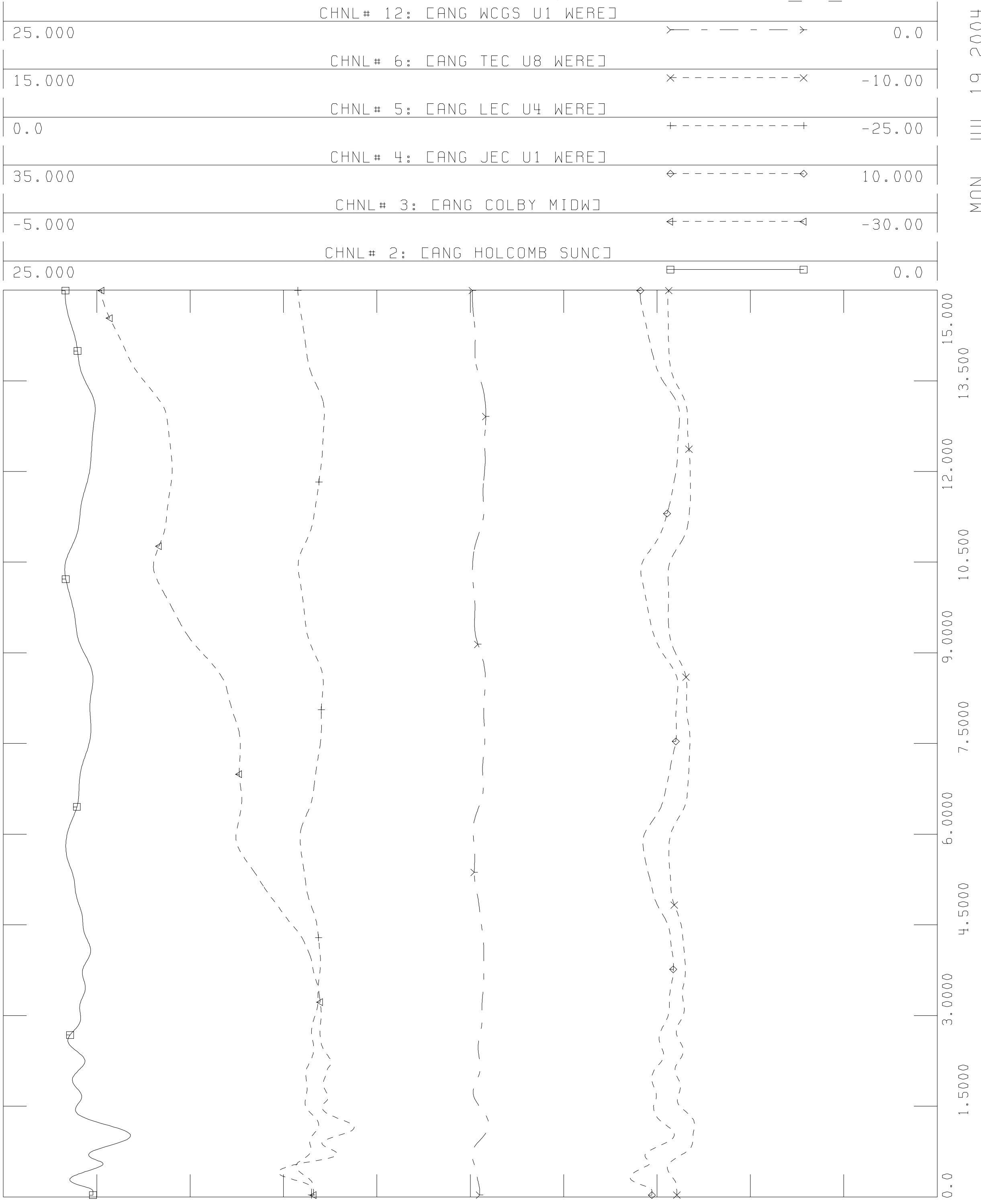
FILE: C:\Interconnection Studies\Working\125MW-AG04\RESULTS\FLT_9_3PH.OUT



SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

SHAW POWER TECHNOLOGIES INC.®

FILE: C:\Interconnection Studies\...\125MW-AG04\RESULTS\FLT_10_1PH.OUT



MON, JUL 19 2004 12:46

FLT_10_1PH_MACHINE ANGLES

SHAW POWER
TECHNOLOGIES
INC.®

SPP MDWG 04 STABILITY;2005 SUMMER PEAK;S05SP-29.CNL;3-22-04
(C) 2004 SOUTHWEST POWER POOL, INC. (SEE DISCLAIMER BELOW)

MON, JUL 19 2004 12:46

FLT_10_3PH_MACHINE ANGLES

FILE: C:\Interconnection Studies\...\125MW-AG04\RESULTS\FLT_10_3PH.OUT

CHNL# 12: [ANG WCGS U1 WERE]
25.000 ≻— - — - —≻ 0.0

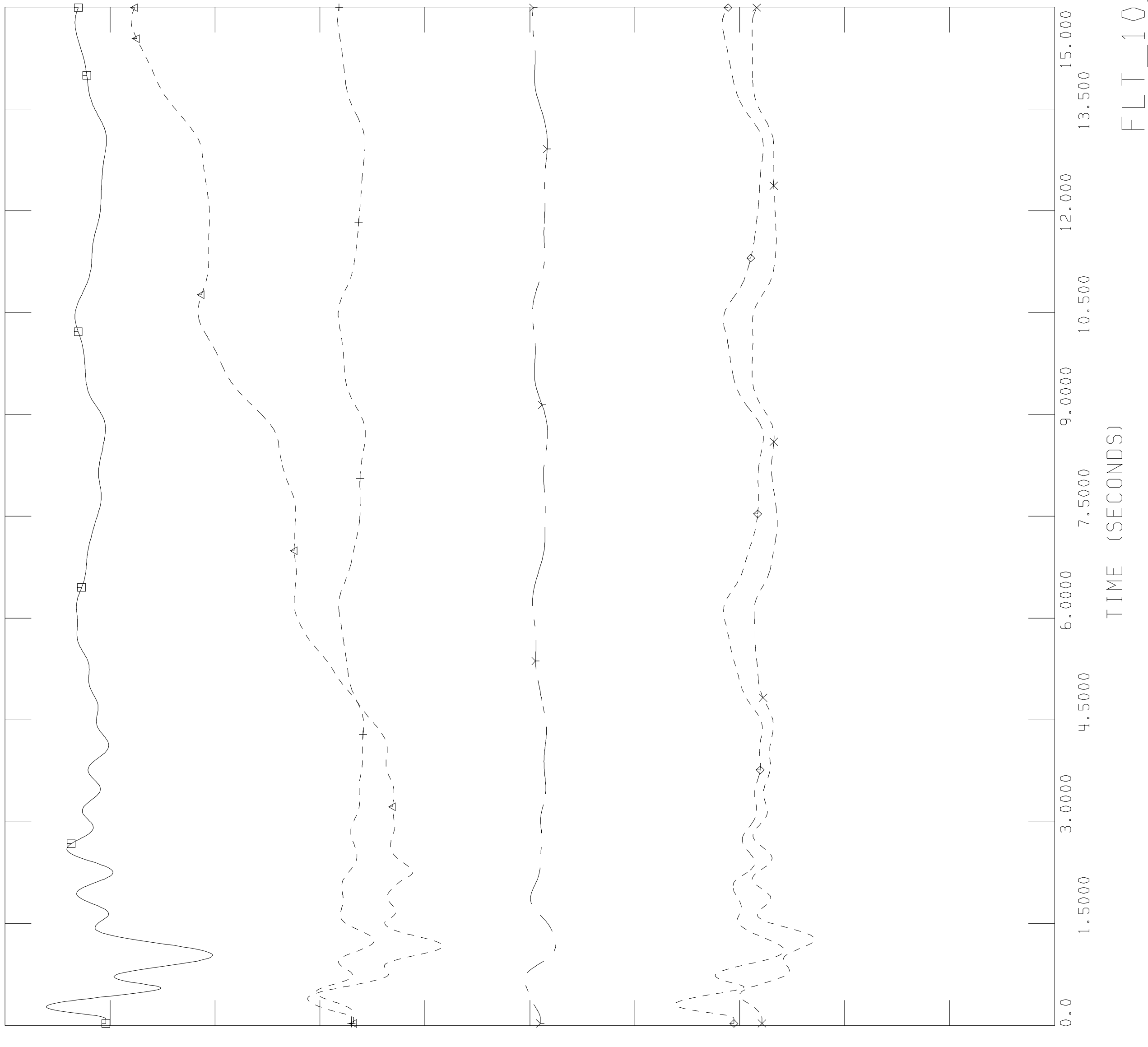
CHNL# 6: [ANG TEC U8 WERE]
15.000 ×----------× -10.00

CHNL# 5: [ANG LEC U4 WERE]
0.0 +----------+ -25.00

CHNL# 4: [ANG JEC U1 WERE]
35.000 ◇----------◇ 10.000

CHNL# 3: [ANG COLBY MIDW]
-5.000 ◁----------◁ -30.00

CHNL# 2: [ANG HOLCOMB SUNC]
25.000 □——————□ 0.0



Appendix G

PSS/E 29.5
PSAS Files

Fault Simulations

Sequence of Events for Each Fault Simulation

FLT_1_1PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT SUMMIT BUS 56873 ADMITTANCE 318.33 -2049.75 MVA
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT SUMMIT
DISCONNECT LINE FROM WINDFARM BUS 90000 TO SUMMIT BUS 56873 CKT
1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT SUMMIT BUS 56873 ADMITTANCE 318.33 -2049.75 MVA
RECLOSE LINE FROM WINDFARM BUS 90000 TO SUMMIT BUS 56873 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT SUMMIT
DISCONNECT LINE FROM WINDFARM BUS 90000 TO SUMMIT BUS 56873 CKT
1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_1_3PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT SUMMIT BUS 56873
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT SUMMIT
DISCONNECT LINE FROM WINDFARM BUS 90000 TO SUMMIT BUS 56873 CKT
1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT SUMMIT BUS 56873
RECLOSE LINE FROM WINDFARM BUS 90000 TO SUMMIT BUS 56873 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT SUMMIT
DISCONNECT LINE FROM WINDFARM BUS 90000 TO SUMMIT BUS 56873 CKT
1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_2_1PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT KNOLL BUS 56558 ADMITTANCE 51.90 -192.48 MVA
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM WINDFARM BUS 90000 TO KNOLL BUS 56558 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT KNOLL BUS 56558 ADMITTANCE 51.90 -192.48 MVA
RECLOSE LINE FROM WINDFARM BUS 90000 TO KNOLL BUS 56558 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM WINDFARM BUS 90000 TO KNOLL BUS 56558 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_2_3PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT KNOLL BUS 56558
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM WINDFARM BUS 90000 TO KNOLL BUS 56558 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT KNOLL BUS 56558
RECLOSE LINE FROM WINDFARM BUS 90000 TO KNOLL BUS 56558 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM WINDFARM BUS 90000 TO KNOLL BUS 56558 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_3_1PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT CIRCLE BUS 56871 ADMITTANCE 189.55 -441.53 MVA
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT CIRCLE
DISCONNECT LINE FROM MULLERGREN BUS 58779 TO CIRCLE BUS 56871 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT CIRCLE BUS 56871 ADMITTANCE 189.55 -441.53 MVA
RECLOSE LINE FROM MULLERGREN BUS 58779 TO CIRCLE BUS 56871 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT CIRCLE
DISCONNECT LINE FROM MULLERGREN BUS 58779 TO CIRCLE BUS 56871 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_3_3PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT CIRCLE BUS 56871
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT CIRCLE
DISCONNECT LINE FROM MULLERGREN BUS 58779 TO CIRCLE BUS 56871 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT CIRCLE BUS 56871
RECLOSE LINE FROM MULLERGREN BUS 58779 TO CIRCLE BUS 56871 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT CIRCLE
DISCONNECT LINE FROM MULLERGREN BUS 58779 TO CIRCLE BUS 56871 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_4_1PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT MANHATTAN BUS 56861 ADMITTANCE 183.09 -1256.01 MVA
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT MANHATTAN
DISCONNECT LINE FROM CONCORDIA BUS 58758 TO MANHATTAN BUS 56861 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT MANHATTAN BUS 56861 ADMITTANCE 183.09 -1256.01 MVA
RECLOSE LINE FROM CONCORDIA BUS 58758 TO MANHATTAN BUS 56861 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT MANHATTAN
DISCONNECT LINE FROM CONCORDIA BUS 58758 TO MANHATTAN BUS 56861 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_4_3PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT MANHATTAN BUS 56861
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT MANHATTAN
DISCONNECT LINE FROM CONCORDIA BUS 58758 TO MANHATTAN BUS 56861 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT MANHATTAN BUS 56861
RECLOSE LINE FROM CONCORDIA BUS 58758 TO MANHATTAN BUS 56861 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT MANHATTAN
DISCONNECT LINE FROM CONCORDIA BUS 58758 TO MANHATTAN BUS 56861 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_5_1PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT SUMMIT BUS 56773 ADMITTANCE 163.18 -1503.95 MVA
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT SUMMIT
DISCONNECT LINE FROM JEC BUS 56766 TO SUMMIT BUS 56773 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT SUMMIT BUS 56773 ADMITTANCE 163.18 -1503.95 MVA
RECLOSE LINE FROM JEC BUS 56766 TO SUMMIT BUS 56773 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT SUMMIT
DISCONNECT LINE FROM JEC BUS 56766 TO SUMMIT BUS 56773 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_5_3PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT SUMMIT BUS 56773
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT SUMMIT
DISCONNECT LINE FROM JEC BUS 56766 TO SUMMIT BUS 56773 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT SUMMIT BUS 56773
RECLOSE LINE FROM JEC BUS 56766 TO SUMMIT BUS 56773 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT SUMMIT
DISCONNECT LINE FROM JEC BUS 56766 TO SUMMIT BUS 56773 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_6_1PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT SUMMIT BUS 56873 ADMITTANCE 318.33 -2049.75 MVA
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT SUMMIT
DISCONNECT LINE FROM MORRIS BUS 56863 TO SUMMIT BUS 56873 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT SUMMIT BUS 56873 ADMITTANCE 318.33 -2049.75 MVA
RECLOSE LINE FROM MORRIS BUS 56863 TO SUMMIT BUS 56873 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT SUMMIT
DISCONNECT LINE FROM MORRIS BUS 56863 TO SUMMIT BUS 56873 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_6_3PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT SUMMIT BUS 56873
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT SUMMIT
DISCONNECT LINE FROM MORRIS BUS 56863 TO SUMMIT BUS 56873 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT SUMMIT BUS 56873
RECLOSE LINE FROM MORRIS BUS 56863 TO SUMMIT BUS 56873 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT SUMMIT
DISCONNECT LINE FROM MORRIS BUS 56863 TO SUMMIT BUS 56873 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_7_1PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT KNOLL BUS 56561 ADMITTANCE 108.74 -684.06 MVA
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM REDLINE BUS 56605 TO KNOLL BUS 56561 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT KNOLL BUS 56561 ADMITTANCE 108.74 -684.06 MVA
RECLOSE LINE FROM REDLINE BUS 56605 TO KNOLL BUS 56561 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM REDLINE BUS 56605 TO KNOLL BUS 56561 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_7_3PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT KNOLL BUS 56561
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM REDLINE BUS 56605 TO KNOLL BUS 56561 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT KNOLL BUS 56561
RECLOSE LINE FROM REDLINE BUS 56605 TO KNOLL BUS 56561 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM REDLINE BUS 56605 TO KNOLL BUS 56561 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_8_1PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT HAYS BUS 56562 ADMITTANCE 86.47 -466.17 MVA
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT HAYS
DISCONNECT LINE FROM VINE BUS 56591 TO HAYS BUS 56562 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_8_3PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT HAYS BUS 56562
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT HAYS
DISCONNECT LINE FROM VINE BUS 56591 TO HAYS BUS 56562 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_9_1PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT KNOLL BUS 56561 ADMITTANCE 108.74 -684.06 MVA
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM SOUTHHAYS BUS 56553 TO KNOLL BUS 56561 CKT
1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT KNOLL BUS 56561 ADMITTANCE 108.74 -684.06 MVA
RECLOSE LINE FROM SOUTHHAYS BUS 56553 TO KNOLL BUS 56561 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM SOUTHHAYS BUS 56553 TO KNOLL BUS 56561 CKT
1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_9_3PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT KNOLL BUS 56561
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM SOUTHHAYS BUS 56553 TO KNOLL BUS 56561 CKT
1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT KNOLL BUS 56561
RECLOSE LINE FROM SOUTHHAYS BUS 56553 TO KNOLL BUS 56561 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM SOUTHHAYS BUS 56553 TO KNOLL BUS 56561 CKT
1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_10_1PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT KNOLL BUS 56561 ADMITTANCE 108.74 -684.06 MVA
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM SALINE BUS 56551 TO KNOLL BUS 56561 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT KNOLL BUS 56561 ADMITTANCE 108.74 -684.06 MVA
RECLOSE LINE FROM SALINE BUS 56551 TO KNOLL BUS 56561 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM SALINE BUS 56551 TO KNOLL BUS 56561 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```

FLT_10_3PH

```
RUN TO 0.1 SECOND PRINT 0 PLOT 10
APPLY FAULT KNOLL BUS 56561
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM SALINE BUS 56551 TO KNOLL BUS 56561 CKT 1
RUN FOR 20 CYCLES PRINT 0 PLOT 3
APPLY FAULT KNOLL BUS 56561
RECLOSE LINE FROM SALINE BUS 56551 TO KNOLL BUS 56561 CKT 1
RUN FOR 5 CYCLES PRINT 0 PLOT 3 CRTPLT 0
CLEAR FAULT KNOLL
DISCONNECT LINE FROM SALINE BUS 56551 TO KNOLL BUS 56561 CKT 1
RUN TO 15.0 SECOND PRINT 0 PLOT 5 CRTPLT 0
END
```