PSEP Power Transient Analysis

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INTRODUCTION

The purpose of this EATM is to describe the transient performance of the EASEP/PSEP system during the first lunar day, sunset, and sunrise on the second day. The results of this study have been used to determine the best system configuration and to help in operational planning.

SUMMARY

As results of this study it has been determined that:

1. The PCU hold-off circuit must be permanently shorted out
2. The PSE must not be turned off at sunset
3. The back-up heater thermostat should be shorted
4. The transmitter should be turned off at sunset
5. The 29 volt line must not be unloaded by any sequence of commands
6. The 29 volt line voltage will probably not exceed 29 volts during sunrise.

SEE PSEP TEAM 2 CDR ACTION ITEM 9.

SOLAR PANEL CHARACTERISTICS

The time dependence of the solar panel array open circuit voltage and short circuit current are shown in Figures 1 and 2 respectively. These curves were derived by using solar cell characteristics and accounting for the number of series and parallel cells, panel temperatures and sun angles. These characteristics are basic to the derivation of system transient performance.

FIRST DAY OPERATIONS

Fundamental to EASEP is simple deployment which does not include use of tools. As a result the astronaut switches have been eliminated from the central station. Astronaut switch # 1 (S1) was provided to short out the hold-off circuit in the PCU after the RTG had warmed up sufficiently to operate the system with the PCU in regulation. The system would start automatically when the RTG voltage reached 24 $\pm$3 volts. After the automatic start there would be no need for the hold-off circuit. In fact, the 50% over voltage transient caused by switching from PC 2 to PC1 with the hold off circuit operating is undesirable. Therefore, the rotation of S1 is a mandatory operation for ALSEP.

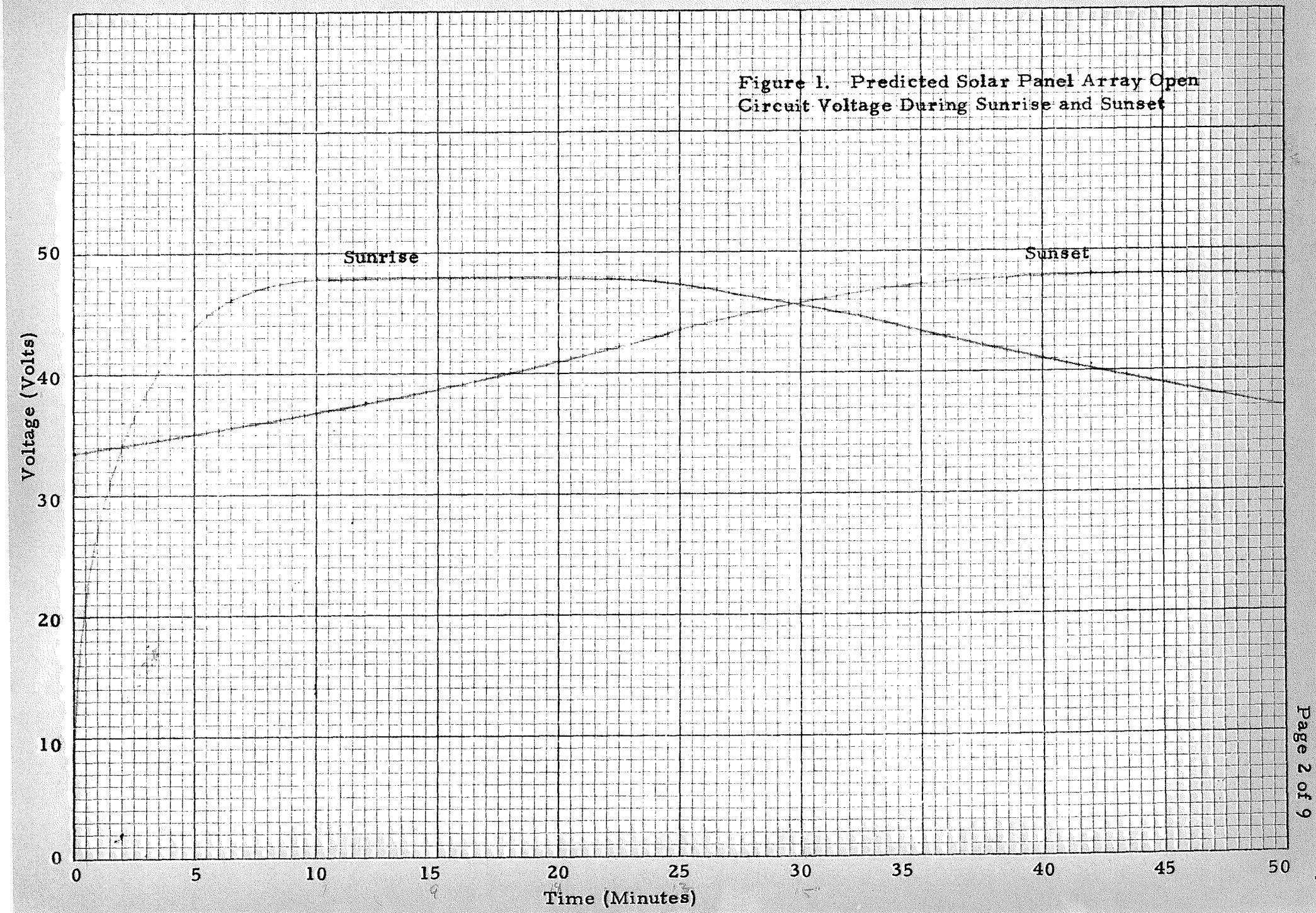


Figure 1. Predicted Solar Panel Array Open Circuit Voltage During Sunrise and Sunset

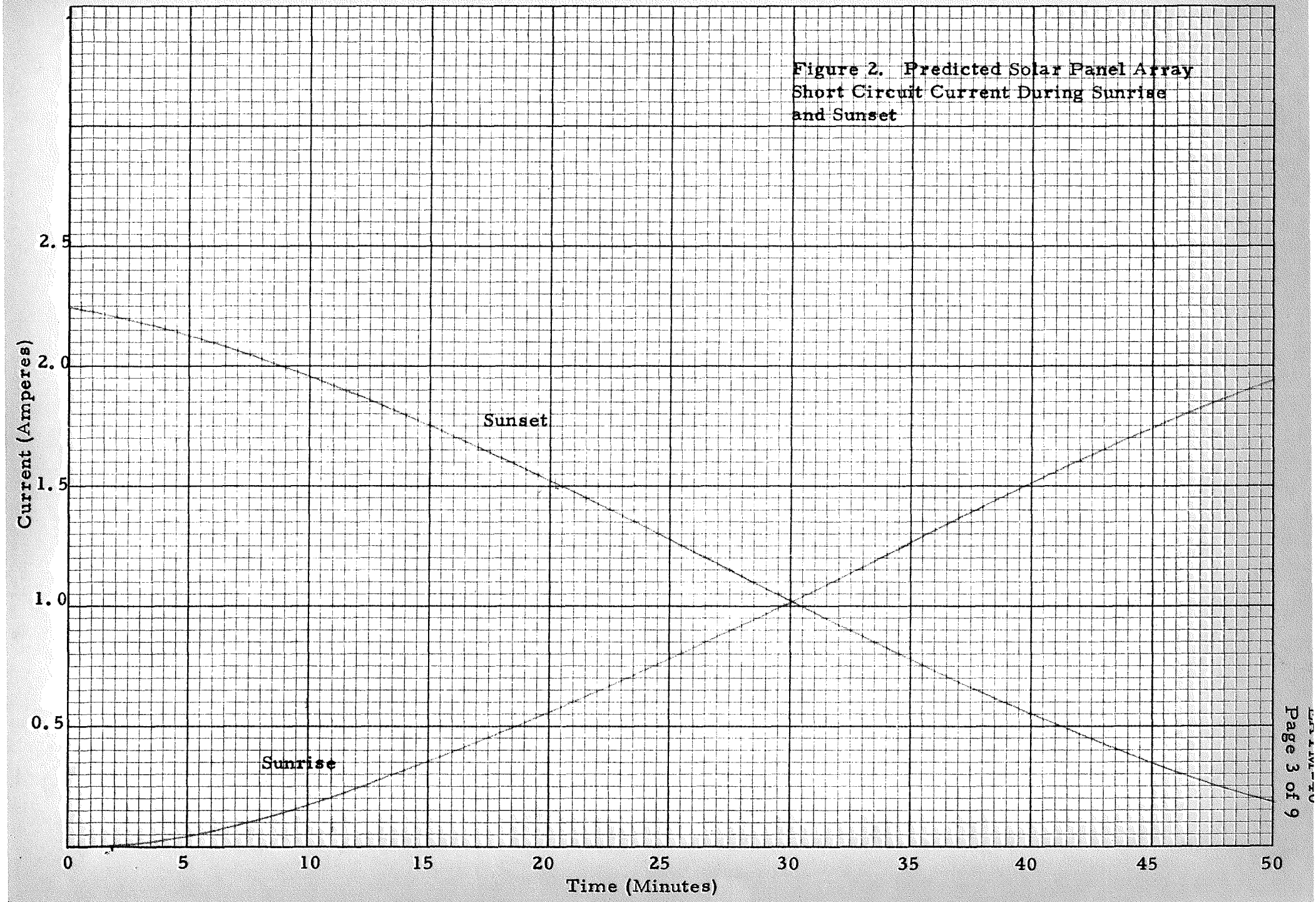


Figure 2. Predicted Solar Panel Array Short Circuit Current During Sunrise and Sunset

The solar panel array I-V curves are shown in Figure 3. These curves show an open circuit voltage of 29.6 and 27 volts for 15° and 30° sun angles respectively. These are the sun angles expected during deployment. The hold-off circuit requires a maximum of 27 volts before automatically starting the system. Any degradation of the solar panel could delay first day operation of EASEP until very near sunset or could prevent any operation at all.

It is therefore mandatory that the hold-off circuit be permanently shorted on EASEP.

SUNSET CONSIDERATIONS

The solar panel output voltage (PCU input voltage) as a function of time and load during sunset is shown in Figure 4. These curves were derived from load considerations and Figures 1 and 2. The PCU performance with the input voltage below approximately four volts is unpredictable and is not shown. The PCU oscillator will stop and start many times in this region, however this is normal and no damage will occur.

The optimum load curve must satisfy two conditions:

1. The rate of voltage decay must be slow enough to avoid switching power conditioners.

2. There must be enough fixed load for proper sunrise performance and it is desirable to have internal loads connected.

The rate of voltage change required to avoid power conditioner switch-over was determined, by test, to be 1.88 volts per minute or less. The trip point is 10.8 volts on the 12 volt line. This corresponds to 14.4 volts on the input line. Thus the slope of the voltage decay at the 14.4 volt point must be less than 1.88 volts per minute. A line with a slope of 1.88 volts per minute is shown on Figure 4. None of the load curves have slopes that high. Therefore, any of the loads shown are permissible. However, curve #1 is more desirable than #7. It is desirable that the transmitter be turned off at sunset to prevent the possibility that the transmitter might operate without command control.

The PSE will be rippled-off to standby when the reserve power approaches 0.5 watt. Note that the ripple-off circuit places the PSE in standby regardless of whether the experiment is on or off. Therefore, the PSE should not be commanded to off at sunset since the ripple-off to standby would present a 4.5 watt load on the system with only 0.5 watt reserve power.

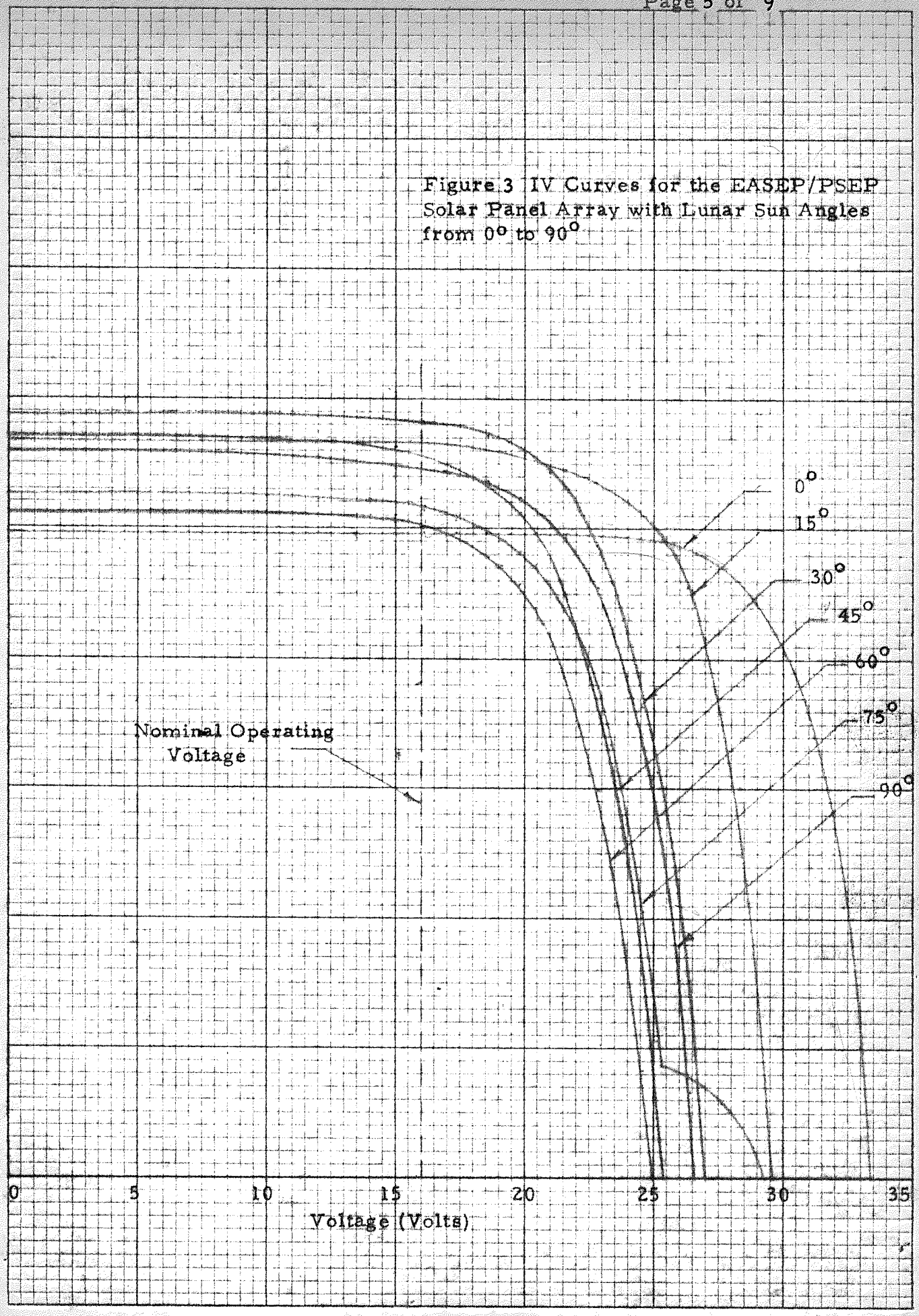


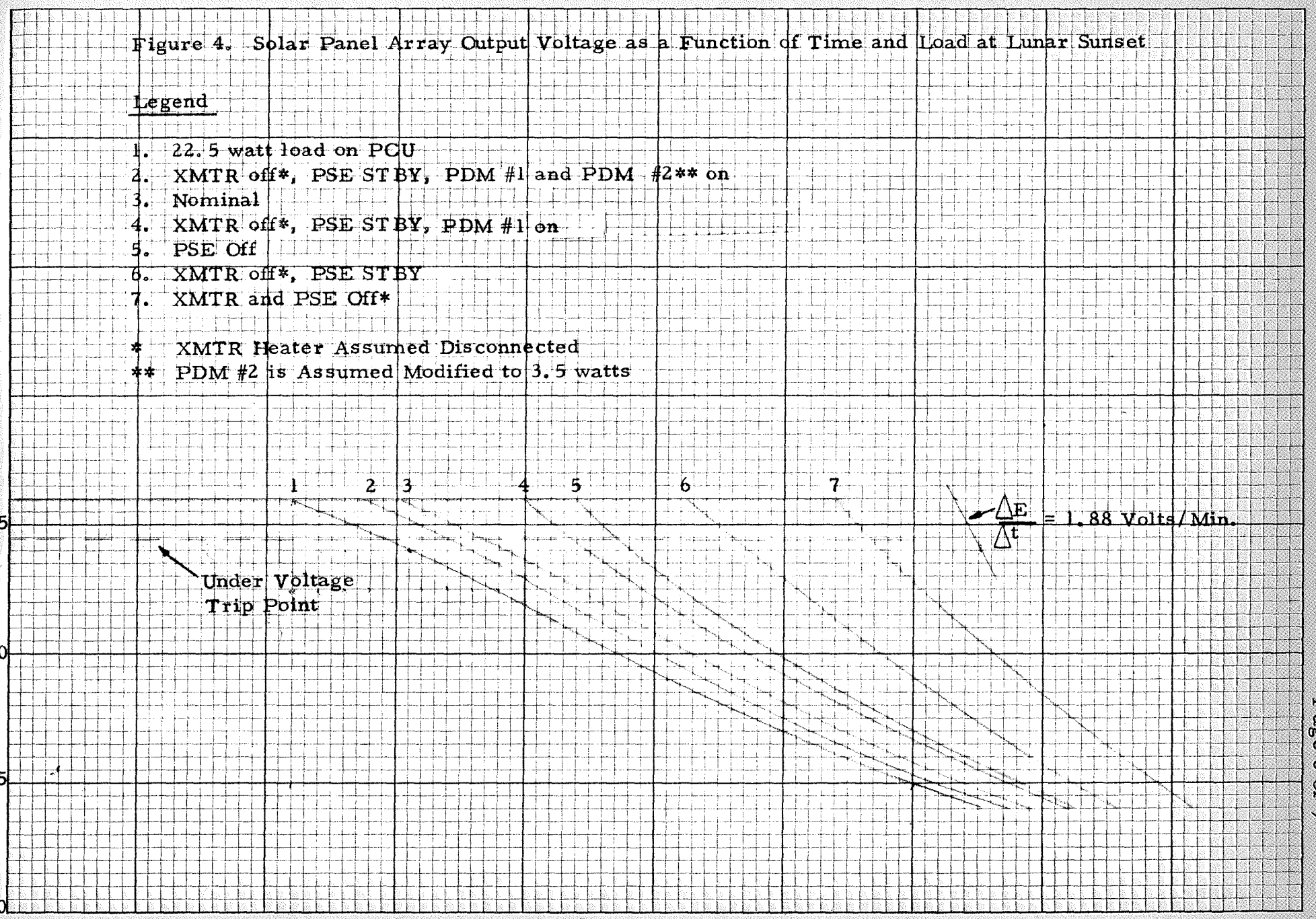
Figure 3 IV Curves for the EASEP/PSEP Solar Panel Array with Lunar Sun Angles from 0° to 90°

Figure 4. Solar Panel Array Output Voltage as a Function of Time and Load at Lunar Sunset

Legend

1. 22.5 watt load on PCU
2. XMTR off*, PSE STBY, PDM #1 and PDM #2** on
3. Nominal
4. XMTR off*, PSE STBY, PDM #1 on
5. PSE Off
6. XMTR off*, PSE STBY
7. XMTR and PSE Off*

* XMTR Heater Assumed Disconnected
** PDM #2 is Assumed Modified to 3.5 watts



This would cause power conditioner switch-over. To prevent this from occurring the PSE will be allowed to ripple to standby at sunset or will be commanded to standby.

Another possible cause of power conditioner switch-over would be closure of the thermostat on the thermal plate if the back-up heater is enabled by command. The switch-over would occur if the thermostat closed with less than 5 watts reserve power, therefore the thermostat will be shorted.

The PCU was designed to operate with at least 100 milliamperes on the +29 volt line. This is necessary to prevent spike build-up on the output filter capacitors.* The no-load voltage could approach 50 volts. This would be sufficient voltage to damage the transmitter transistors which are rated at 40 volts. Therefore, it is mandatory that commands be sent in a sequence which will not unload the 29 volt line. If the PSE is never turned off there is no problem or other loads, heaters or dumps, can be used.

SUNRISE CONSIDERATIONS

The solar panel array output voltage as a function of time and load at sunrise is shown in Figure 5. This is a mirror image of the sunset curves since the same assumptions were used for the open circuit voltage and short circuit current curves.

The PCU 29 volt line has several characteristics of interest during turn-on. The PCU uses an autotransformer to generate the +29 volt line voltage. Thus, the solar panel output voltage is present on the +29 volt line, while the other five output lines remain at zero volts until the oscillator starts. When the oscillator starts, all output voltages are proportional to the solar panel voltage. The maximum voltage during turn on is of interest because of the transmitter transistors, which are rated at 40 volts.

*None of the six output lines are designed to operate at no load, however the 29 volt line is the only one which can be unloaded by command. This is not possible on ALSEP since either the transmitter or the transmitter heater is connected to the 29 volt line at all times.

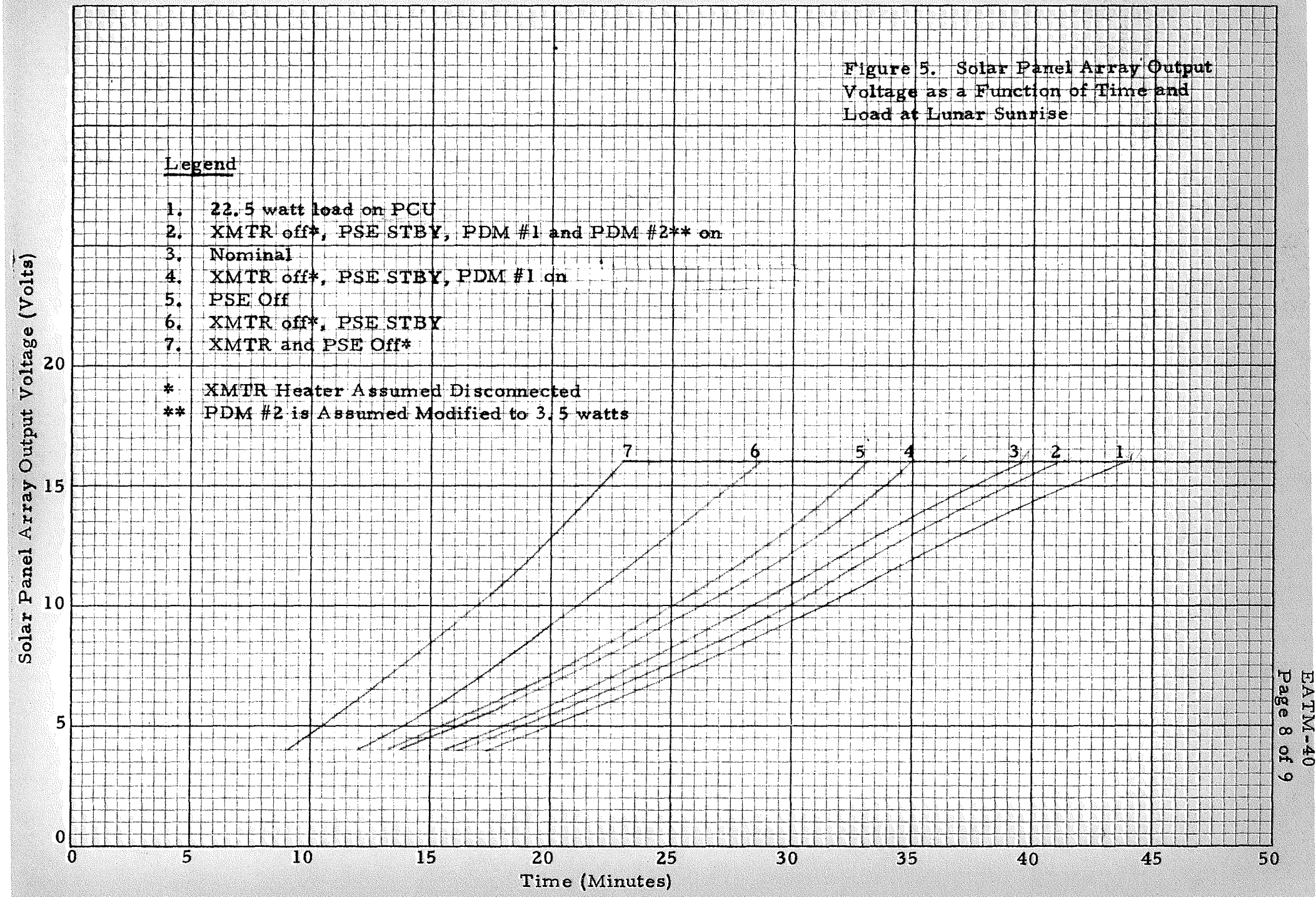


Figure 5. Solar Panel Array Output Voltage as a Function of Time and Load at Lunar Sunrise

The starting characteristics of the PCU depend on the solar panel characteristics, the load on the PCU, and the PCU temperature. The PCU solar panel simulator tests showed that the PCU will start and run properly with 22.5 watts of load at -75°F. The PCU temperature at lunar sunrise will be higher than -75°F and therefore the PCU oscillator is expected to start with less than 7 volts at its input terminals. Thus, there is little danger of excessive voltage on the 29 volt line as long as the station temperature does not get too low.