Power Line Anomalies as They Affect the Operation of a DSN Station — Overview

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The problem of providing a sufficiently stable and reliable power source for the equipment in a DSN station appears to be getting more serious. The potential for the occurrence of damaging commercial power variations is increasing, while the need for a more precise power source seems to be greater. Local generation of electrical power helps the situation but is made difficult due to increasing fuel costs and decreasing availability of fuel. Frequently, user-created voltage distortions are blamed on the supplier of the power. Increased study and understanding of the underlying factors are needed.

I. Introduction

Within each station of the Deep Space Network (DSN) is a substantial array of data collection and processing equipment ranging from precision timing sources to minicomputers and digital recorders. Each station is powered with highly reliable engine-driven diesel generators. The Goldstone Complex also has a source of commercial power which is used for all but the critical periods of mission support. The electrical energy being drawn from the power circuits within a DSN station has long been considered a fundamental and never changing resource. Variations in this power were frequently considered as non-existent or extremely rare. During those periods when the highest order of quality and reliability was needed it was simply a matter of scheduling the stations to be powered by generators and at that time a "best" situation would exist.

The designers and operators of the early DSN power systems took great pride in the fact that their equipment seldom failed or was unavailable. Indeed the first DSN stations enjoyed a very high order of reliability on locally generated power. Even the first exposure to commercially generated electricity was relatively free of problems. However, recent years have brought about a changing situation which appears to indicate the following trends:

(1) The overall reliability of commercial power is decreasing, raising the specter of complete outages at unknown times for unknown lengths of times. The highest probability of these outages will occur during the summer months when the chances of system overload due to air conditioning, etc., are the greatest.

(2) The current generation of DSN station equipments seems to display an increased sensitivity to power line anomalies. Digital computers with low-level digital logic are prime targets of power line "spikes."

(3) The generation of power line noise within the stations is increasing. Switching power supplies and electric servo drives are suspect, as are the starting and stopping of large electric motors.

II. Power Anomalies and Definitions

It is felt that certain types of problems being experienced within the DSN are created by relatively obscure and heretofore unrealized factors. Computer halts that occur at the stations many times are associated with power disturbances. Also transmitter "kickoffs" have been traced to sags in line voltage. The following set of definitions is descriptive of the types of anomalies experienced:

(1) *Sags and Surges*. Rapid changes in the amplitude of the ac line voltage, persisting for a fraction of a second, and frequently caused by the application or removal of large electrical loads from the system.

(2) *Transient Impulses*. Deviations from the ideal ac voltage with a very short duration compared with the length of one cycle. The initial impulse may either increase or decrease the instantaneous amplitude of the voltage waveform. Lightning is a primary cause of these disturbances; certain types of machinery also generate impulses of this nature.

(3) *Long-Term Voltage Fluctuations*. Slow variations in the voltage level, measured over a substantial time period (usually 10 seconds or more). Brownouts are an example of this type of disturbance. Both overvoltage and undervoltage conditions are to be guarded against and represent real hazards to equipment in a DSN station.

(4) *Line Interruption*. Cases where the line voltage drops to zero. This is generally considered to be an absence of line voltage for a period ranging from seconds to minutes or even longer. It should be understood that dropouts as short as one cycle (16 msec) are common on even the best commercial power sources. Most of these interruptions are caused by switching at the powerhouse or automatic fault clearing on the high-voltage transmission lines.

(5) *Frequency Variations*. Normally considered as a change in frequency of the power line waveform and averaged over hundreds if not thousands of cycles. Rapid variations of this parameter are not expected due to the high intertia of the rotating machinery used to generate the power. Massive application or removal of electrical load from a system would cause a change in this parameter.

(6) *Waveform Distortions*. Changes in the normal shape of the power line waveforms that do not affect the average voltage amplitude and are independent of frequency variations, sags, surges, and transients.

III. Measurements and Observations

At the Goldstone Stations of the Deep Space Network a variety of measurements, observations and recordings are employed to help insure the presence and continuance of a uniform and stable primary power source. The type of equipment being powered at a Deep Space Station falls generally into the following broad catagories:

(1) Low noise radio frequency amplifying and detection systems.

(2) Ultrastable frequency and timing sources.

(3) Microwave data transmission and reception equipment.

(4) Minicomputers, floppy and fixed discs, tape drives and data transmission modems.

(5) Voice communications.

(6) Motor driven hydraulic pumps (10 to 200 hp).

(7) DX refrigeration (1 to 75 ton).

(8) Resistance heating (1 to 50 kW).

(9) Incandescent and flourescent lighting.

Most, if not all, of the above-mentioned equipments are required during the day-to-day operation of a station. A power outage or instability in the voltage would be a matter of concern and could easily result in a direct loss of primary data from one or more of the various NASA spacecraft operating in deep space. At the Goldstone stations the power parameters are monitored and recorded as per Tables 1 and 2. Table 3 presents a preliminary result of the data collected during the past 12 months with regard to actual loss of information from the stations. In addition, it should be noted that the anomalies tabulated are only those which actually impacted station performance.

IV. Conclusion

It can be seen that the trend is toward an increase in station interruptions due to commercial power anomalies. Whether these anomalies are becoming more frequent or greater in magnitude is yet to be determined. Also, an increase in station equipment sensitivity would explain, at least in part, the effects

being seen. A continued collection of data is planned. This data will help to answer the following questions:

(1) Is the absolute number of commercial power anomalies increasing?

(2) Are these anomalies becoming more severe as time goes on?

(3) Are certain pieces of equipment within a DSS more susceptible to power anomalies?

(4) To what extent are self-generated problems clouding the data?

(5) Could special measures be taken within the station to minimize these effects?

As the need becomes confirmed, appropriate engineering recommendations will be made and further reports will be made with the latest findings.

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Table 1. Goldstone power monitoring capability

	DSS 11		DSS 12		DSS 14	
	G-1	G-3	G-24	G-26	G-80	G-81
Strip chart recordings						
Voltage, V		X	X			X
Current, A		X	X			X
Power, W		X	X			X
Power, factor, %		X	X			X
Frequency		X	X			X
Panel indicators						
Voltage, V		X	X			X
Current, A		X	X			X
Power, W		X	X			X
Power factor, %		X	X			X
Frequency		X	X			X
Power analysis						
Average voltage	X		X[a]	X	X	
Sags	X		X[a]	X	X	
Surges	X		X[a]	X	X	
Impulses	X		X[a]	X	X	
Frequency	X		X[a]	X	X	

[a]Continuous monitoring and analysis of commercial power provided.

Table 2. Building location key

Pioneer Station generator bldg.	G-3
Pioneer Station control bldg.	G-1
Echo Station generator bldg.	G-24
Echo Station control bldg.	G-26
Mars Station generator bldg.	G-81
Mars Station control bldg.	G-80

Table 3. Data interruptions due to commercial power anomalies

1979/80	DSS 11	DSS 12	DSS 14
May	–	1	1
Jun	1	–	1
Jul	1	1	2
Aug	3	1	3
Sep	1	–	1
Oct	–	1	2
Nov	1	1	1
Dec	1	1	1
Jan	–	1	–
Feb	6	4	5
Mar	3	4	1
Apr	2	2	NA

NA: not applicable; station down for modifications.