Computer Control of High-Power Transmitters

R. L. Leu
R. F. Systems Development Section

The objectives of this task are to develop techniques and equipment for complete control, monitor, and fault isolation for minimum recovery time from a fault and to reduce the skill level required for operation and maintenance. This report covers the computer program for control, monitor, and major fault isolation of the Venus Deep Space Station high-power transmitters.

I. Introduction

The objective of this task is to develop techniques and equipment for complete control, monitoring, and fault isolation for minimum recovery time from a failure. Initially a very simple control program and the associated interface hardware were developed to gain experience in computer control of high-power transmitters. From this experience a new control, monitor, and major fault isolation program was written. A computer-transmitter interface was designed and built to utilize full capability of the software program.

A PDP-11/20 computer with peripherals is the principal device used for controlling the high-power transmitters. Since the transmitters have been built for several years, no attempt was made to modify existing equipment to provide a more desirable interface. All new equipment shall be designed for direct access to the computer.

II. Program

The software was written to control, monitor, and isolate major faults of the R&D 450 kW transmitter at DSS 13. The main program (Fig. 1) is broken into three major groups: mission parameters, system turn-on, and mission monitor. During the last two parts of the main program, several subroutines are used or are available if required. These are too numerous to list and some will be referred to later. However, a very important subroutine is called "TTYCON" which means teletype control of the program. A simplified flow diagram of the main program is shown in Fig. 2 and the TTYCON subroutine in Fig. 3. All data input from the teletype (TTY) could easily be input from a master computer; therefore the TTY simulates a master computer.

III. Description

To provide the operator of the TTY with all the input and output options, a brief instruction procedure can be printed out at the start of the program.

The mission parameters must be input by the operator. These parameters are klystron serial number, power level, and frequency. The program is written to store data from only one klystron. If a different klystron is used, its parameters must be loaded into memory. If the input serial number from the TTY does not match the number in storage, the operator is told to load the data. The klystron data includes maximum or minimum parameters, power out versus beam voltage at several frequencies, and initial klystron perveance data.

The serial number, the required RF power, and operating frequency are input at the TTY. The computer then extracts from the stored klystron data a nominal beam voltage level and the program is ready for part two: transmitter turn-on.

During the initial phase of the turn-on, the computer activates the control power and coolant assembly and verifies the appropriate responses. Then the computer draws on an X-Y plotter, a representative of the initial perveance of the klystron.

Next the arc detector is tested for interlock (I/L) faults. If there are interlocks, one reset cycle is tried; if not successful, the computer goes to TTYCON mode. If arc detector faults are clear or cleared, the drive is raised to the maximum limit. The drive power level is then compared to the minimum limit required to operate the klystron. Insufficient drive causes an error message to be printed and the program goes to TTYCON mode. Otherwise the drive is lowered, and the filament voltage and current and the magnet current are tested. If not at the correct level, the necessary adjustments are made. Next the filament time delay (TD) is tested for completion, and when the TD has cleared, the "beam ready" indication is verified. If beam ready, the program goes to TTYCON mode. Otherwise it tests for I/L open indication. If I/L is open, one reset cycle is attempted and error messages are printed if they still are present after the reset. When the beam ready and I/L open indications are not present, the program prints "safe-run key off."

With the beam ready and the program in the TTYCON mode, the program is continued by striking the CR key on the TTY. On the initial turn-on, the beam voltage is set to 20 kV dc. At this point the crowbar (CB) test circuit is activated. If the CB fired, the I/Ls are reset and the beam voltage is turned on again. Should the CB not fire, the CB logic indicator is tested to determine if it activated and the appropriate messages are printed. The program goes to TTYCON mode to await further commands.

After the CB has test fired and the beam voltage is on, the voltage is run up to maximum, and a continuous plot of beam voltage versus beam current is recorded (the drive is tested to verify it is at its lower limit). The beam voltage is then set to the value for the required mission, and the drive is raised until the klystron is saturated.

At this point all analog voltages and currents are printed for reference. The program now goes into its monitor routine and should a fault occur or an adjustment be required, an appropriate message is printed. Should the mission requirements need changing or the system shut off, pushing any key on the TTY interrupts the program. At this interrupt the program jumps to the TTYCON mode to allow changes or commands.

IV. Computer-Transmitter Interface

The computer/transmitter interface at present consists of 216 discrete command circuits, 216 discrete monitor circuits, and 16 analog monitor circuits. The PDP 11/20 has an interface card (DR 11) that has 16 bits of output and 16 bits of input each on a separate connector. These inputs and outputs are transistor-transistor logic (TTL) compatible. However, the transmitter, due to its high noise environment, has a digital control and monitor system that operates on +28 Vdc.

The transmitter/computer interface was designed to take the TTL logic level commands from the computer and convert them to +28 Vdc. The TTL inputs to the computer are obtained in the interface by shifting the +28 Vdc indication to TTL logic level.

The analog voltages used in the transmitter have previously been conditioned to ±5 Vdc full scale, directly compatible with the PDP 11/20 analog-to-digital converter (AD01).

V. Preliminary Testing

The program was initially tested using a simulator for the transmitter digital controls and monitors and dc power supplies to simulate the analogs. At this time the computer and interface are being integrated into the transmitter at DSS 13. Due to the high noise environment of the transmitter, considerable care is being taken to isolate the computer from this noise environment.

The present plans are to complete the initial phase of computer operation; that is, the control, monitoring, and major fault isolation. The transmitter will then be operated for several weeks to establish a high confidence in this type operation. The computer is only an automatic operator; at any time the system can be run manually. The next step will be to start software development of detailed fault isolation of the various major assemblies in the transmitter.

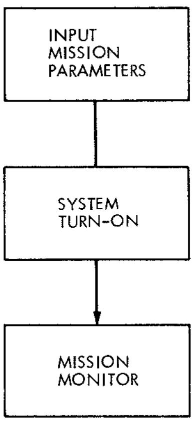


Fig. 1. Transmitter control block diagram

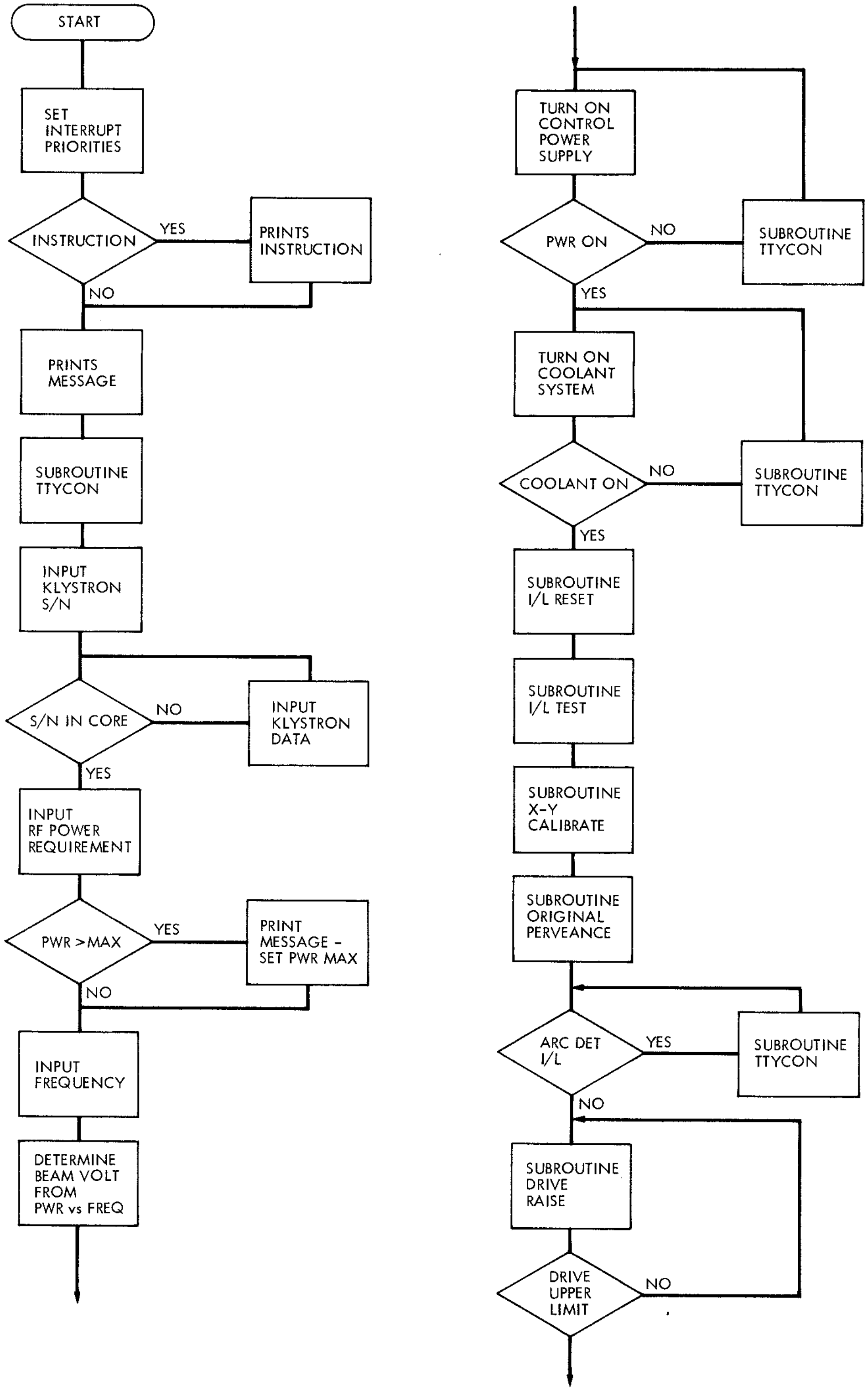
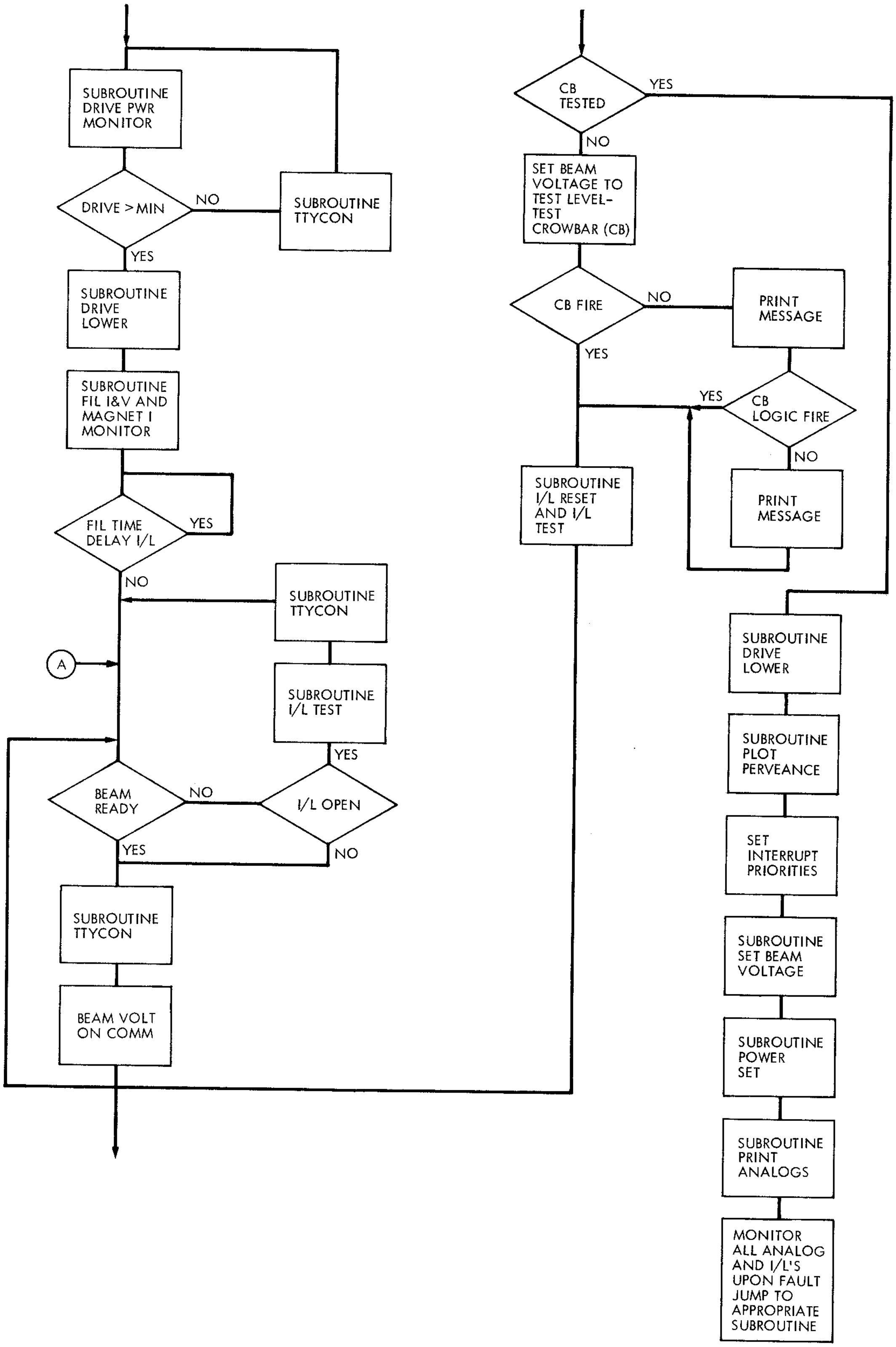


Fig. 2. Transmitter control flow diagram



SUBROUTINE DRIVE PWR MONITOR
DRIVE > MIN
NO
SUBROUTINE TTYCON
YES
SUBROUTINE DRIVE LOWER
SUBROUTINE FIL I&V AND MAGNET I MONITOR
FIL TIME DELAY I/L
YES
NO
SUBROUTINE TTYCON
A
SUBROUTINE I/L TEST
YES
BEAM READY
NO
I/L OPEN
YES
NO
SUBROUTINE TTYCON
BEAM VOLT ON COMM
CB TESTED
YES
NO
SET BEAM VOLTAGE TO TEST LEVEL–TEST CROWBAR (CB)
CB FIRE
NO
PRINT MESSAGE
YES
YES
CB LOGIC FIRE
NO
SUBROUTINE I/L RESET AND I/L TEST
PRINT MESSAGE
SUBROUTINE DRIVE LOWER
SUBROUTINE PLOT PERVEANCE
SET INTERRUPT PRIORITIES
SUBROUTINE SET BEAM VOLTAGE
SUBROUTINE POWER SET
SUBROUTINE PRINT ANALOGS
MONITOR ALL ANALOG AND I/L'S UPON FAULT JUMP TO APPROPRIATE SUBROUTINE

Fig. 2. (contd)

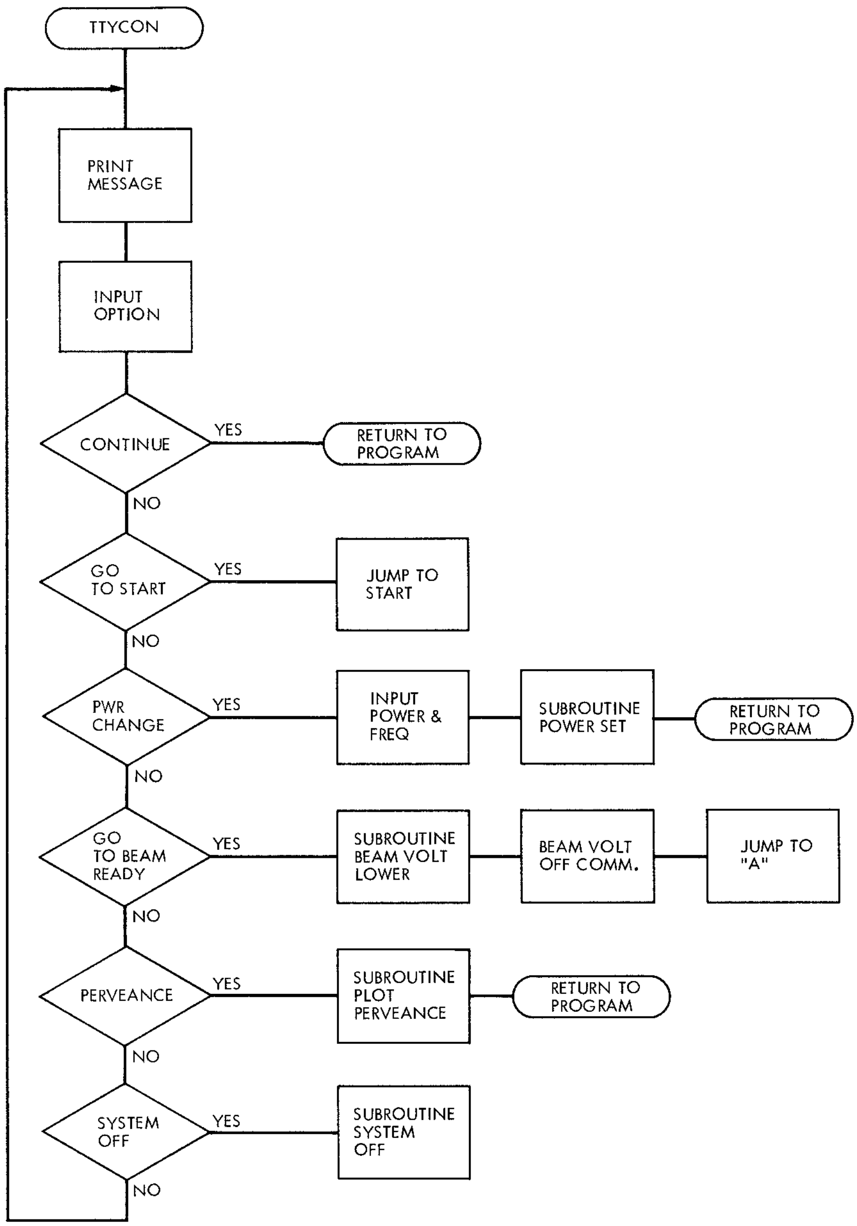


Fig. 3. TTYCON subroutine flow diagram