

MICROPROCESSOR BASED ANTENNA CONTROL UNIT MEETS A WIDE VARIETY OF APPLICATIONS

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ABSTRACT

A very powerful and flexible antenna control unit is described. This control unit is built around a Z-80A microprocessor, the STD Bus, and optional math processor. It is designed to work with many existing antenna/pedestals. The unit features modular construction, low profile, intelligent controls, programmability, self-test and self-calibration. The controller is easily customized to specific requirements and user preferences for displays, switch legend and location, and is easily extensible with standard extension panels for additional controls and displays or with custom extension hardware. The controller can be remotely controlled via the IEEE-488 Bus or a variety of serial data link configurations.

INTRODUCTION

The purpose of this paper is to present an overview of the flexibility and intelligence of an antenna control unit, the EMP Model ACU-6.

The ACU-6 functional definition was a synthesis of requirements and recommendations from two entirely different application markets: the Broadcast Industry for Electronic News Gathering Station, and the Military for remotely controlled telemetry tracking systems. The ENG application requires one or more remotely located single axis antenna positioners or autotracker controlled from a central location. The antenna stations, at "high-ground" locations, receive video data transmitted from ground vehicles and/or helicopters that are dispatched to the "news scene." These antenna stations, which include a tracker and two remotely tunable receivers, are typically controlled from the news studio via serial data links implemented using private telephone lines or radio links.

The military requirements were defined by a poll of many users. These applications include: remote control of single and dual axis autotracking systems and associated receivers, computer control via GPIB or RS232 links of two single or one dual axis

system(s), and either of the above with computational ability to perform either parallax correction, coordinate conversion or ship board antenna stabilization. In addition, the unit had to be cost effective to compete with existing analog or dedicated serial data link controllers. Obviously, to meet all the above requirements, the unit must be designed with flexibility in mind. Indeed, not only must the hardware be modularized but so must the associated software.

HARDWARE DESCRIPTION AND FEATURES

The Model ACU-6 Antenna Control Unit shown in Figure 1 is a standard rack mounted chassis fitted with slide mounts and 5-1/4 inch high front panel. The 30 pound unit can be controlled manually (Local) or via a computer (Remote). The ACU-6 provides complete control of the antenna, pedestal and associated receivers). Pedestal or rotator control includes Manual, Search, Slave, Designate, and Autotrack modes with Auto-acquire, Position and Rate memory submodes. The Designate modes include Immediate and Pre-Programmed Designate. Receiver controls include Acquire Threshold Adjust, Noise Floor and Hysteresis setting, and Manual and Automatic receiver selection (RHCP or LHCP). Antenna controls provide Manual and Automatic selection of the High Gain or Low Gain tracking antenna. The Control Unit houses up to two power supplies, two card cages (containing up to eight PC boards) a rear panel subassembly, and a front panel assembly composed of a thick aluminum panel and three PC boards. Figure 2 shows the architecture of the unit. One card cage utilizes the 55 pin industry standard bus which allows many off-the-shelf PC boards to be used in rapid response to many special interface requirements. The second card cage utilizes the EMP 50 pin party line bus which can be extended to devices outside of the chassis. The front panel assembly is entirely PCB based for fast repair. The Display PCB (highest failure rate) is easily removed. The entire front panel assembly can be removed from Remote units that are slaved via the RS232/modem serial data link. Ribbon cable and internal power connectors allow quick module removal and replacement.

The generic front panel can accommodate up to 37 control switches, 18 seven segment Numeric displays and 60 LED annunciators which allows customized location and legend nomenclature for backlighted switches and indicators. Cutouts for front panel switches and back panel connector are tape mill selected. All switch actions are independent of indicators. Switch actions are defined by table driven software for momentary, alternate, trinary and multi-mode capabilities. All indicator lamps and LED's are assigned by table driven software. Dead-front displays are seen only when active/valid.

The STD bus card cage employs only four cards for a standalone unit. Add one PC board for computational capability, or an additional card for GPIB or RS232/Modem interface.

Two 16 Bit (TTL compatible) slave angle words can be inputted (or outputted) by the addition of a single standard card.

The PLI card cage employs only three cards for standalone Antenna/Rotator control. Add one LSI module to an existing PC board, and one more card for two axis Antenna/Pedestal control. A fifth card is required to interface with the auxiliary Handwheel panel and Commanded Position Display panel. The addition of one more card provides primary power control of four remote pieces of equipment. This card cage can be located and operated in another chassis up to 10 feet away from the Party Line Interface PC Board on the STD bus.

SOFTWARE DESCRIPTION AND FEATURES

Just as the hardware had to be modularized to meet the many diverse industry and customer requirements, yet hold cost and complexity to a minimum, the software used for generating the CPU firmware had to be partitioned. Through this technique the sampling speed was held to better than 50 per second and the firmware was held to 18K and 28K bytes of memory space for a full up standalone single and dual axis autotracker, respectively. Use of a real time executive program, which uses a proprietary priority interrupt scheme, allowed sampling rates as high as 200 per second for critical parameters. The software has been divided into over 30 different tasks. Each task is an independent program that shares the transition processor with other tasks required by the system. These tasks are executed by real time executive and machine state processor. The task transaction processor supports a wide variety of hardware configurations by providing a set of modular software components that allows quick and easy implementation of customer requirements. The customer requirements are entered into system definition file (through use of keyboard and a System Definition program) which is linked into all basic tasks. Through this technique, new software modules can be easily added to expand system capability. Some of salient features provided by the software design are:

Software Position Loop Closure

- Eliminates pedestal drift or wind induced position error (Manual mode)

- Allows automatic gain/bandwidth scheduling based on signal strength or range data interface

- Provides automatic rate limiting in Sidelobe Compare and Search modes

- Makes possible advanced transfer-function design as need arises

Intelligent Mode Interactions

Mode memorization from Autotrack and Designate modes

Rate memory goes to “target lost” position after time-out if position memory also enabled, always resumes previous mode

Position memory goes to “target acquired” position if rate memory not enabled, resumes previous mode

Sidelobe comparison commands rate limiting and functions while in any pedestal mode

Both auto-acquire and forced autotrack

Time-out confirmation cycle on mode switching when in autotrack, and on other critical functions

Error flash of current mode indicator when an invalid operation is commanded (e.g., INC while in Manual causes MAN indicator to flash)

Intelligent Signal Strength Functions

Scaling of AGC voltage to signal strength/noise ratio in dB

Value used/displayed is biased to user-programmed level, allowing true use of signal/noise ratio

Saturation indicator

Hysteresis indicator

Loss indicator

Auto-acquire threshold adjustable in operate mode from front panel

Fault Tolerance Features

Conditional assembly means only required code/data will be in system

System has fall back modes for bad slave data, bad A/D data

Spurious interrupt handling, built-in ROM execution traps

Power-fail is sensed to insure orderly shut-down, and warm start performed (previous mode/activity resumed) if power restored within 10 seconds

Spurious interrupts, unused ROM, unused RWM traps catch erroneous execution paths

Sanity (watch-dog) timer will reset system if for some reason (nearby lightning strike) the processor halts or “gets lost”

Math-pack Computation Capabilities

Parallax correction

Ship-board antenna stabilization/trailer auto-leveling

Full coordinate conversion

Tilted pedestal operation for vertical target tracking

Ephemeris generation capability

CONTROL UNIT INTELLIGENCE FEATURES

Not only has the design approach for the above described hardware and firmware lead to a flexible and extensible system with friendly and versatile control panel, but many selected constants and parameters can now be easily programmed by the user. (These constants are retained in battery backed-up RAM for a period exceeding one year.) Further, not only has high reliability been attained, but the internal pre-programmed operation of the CPU has been made highly tolerant of hardware and software faults. The many features of the ACU-6 Control Unit are:

Self-Test

Read only memory and battery-backed memory sum checks

Hard and soft fail RWM checks

Party Line bus checks

Front Panel lamps check

Pedestal/Rotator function checks

Self-Calibration

Autotrack position loop gain

Dual axis tracking antenna

Crosstalk

Cable wrap display calibration and self-aligning on counterclockwise limit (designate functions “unwrap” cable wrap automatically)

Field Programming Capability

Bias angles (eliminates data pack alignment)

Cable wrap soft limits (eliminates cable wrap potentiometer and makes system triple safe)

Warning sector (for controlling transmitter or flagging blockage sectors)

Rate Memory time-out period

Multipath clipping elevation active angle

Auto-acquire Hysteresis range

Signal strength noise floor setting

16 Angle coordinate pairs

Antenna Control

High or low gain tracking antenna selection based on signal strength or optional range data

Sidelobe lock prevention based on signal strength from sidelobe reference antenna

Polarization selection control (Manual or Automatic)

Preamp bypass control

Receiver or Downconverter Control

ON/OFF control

Frequency selection

IF bandwidth selection

AGC time constant selection

Receiver Selection

Selects optimum AM signal for tracking and base band signal for data reduction based on relative signal strength (back up for dual polarization or frequency combiner).

Pedestal Control

Manual mode provides:

Exponential (single button) slew control (axis independent)

Aided rate or position control from handwheel driven incremental optical encoders in optional handwheel control panel.

Dial-in designation angles

Memorized (16) angle coordinate pairs for quick designation

Search mode provides:

Raster mode in dual axis systems - major axis selected on relative sector values (horizontal or vertical raster)

Search window moves in increments of one-half antenna beamwidth

Search window increased/decreased in units on antenna beamwidth

Makes possible circular and random walk search patterns

Slave Mode Option Provides

Synchro (single and dual speed)

Parallel TTL (14 to 16 bits)

Parallel RS422 (differential)

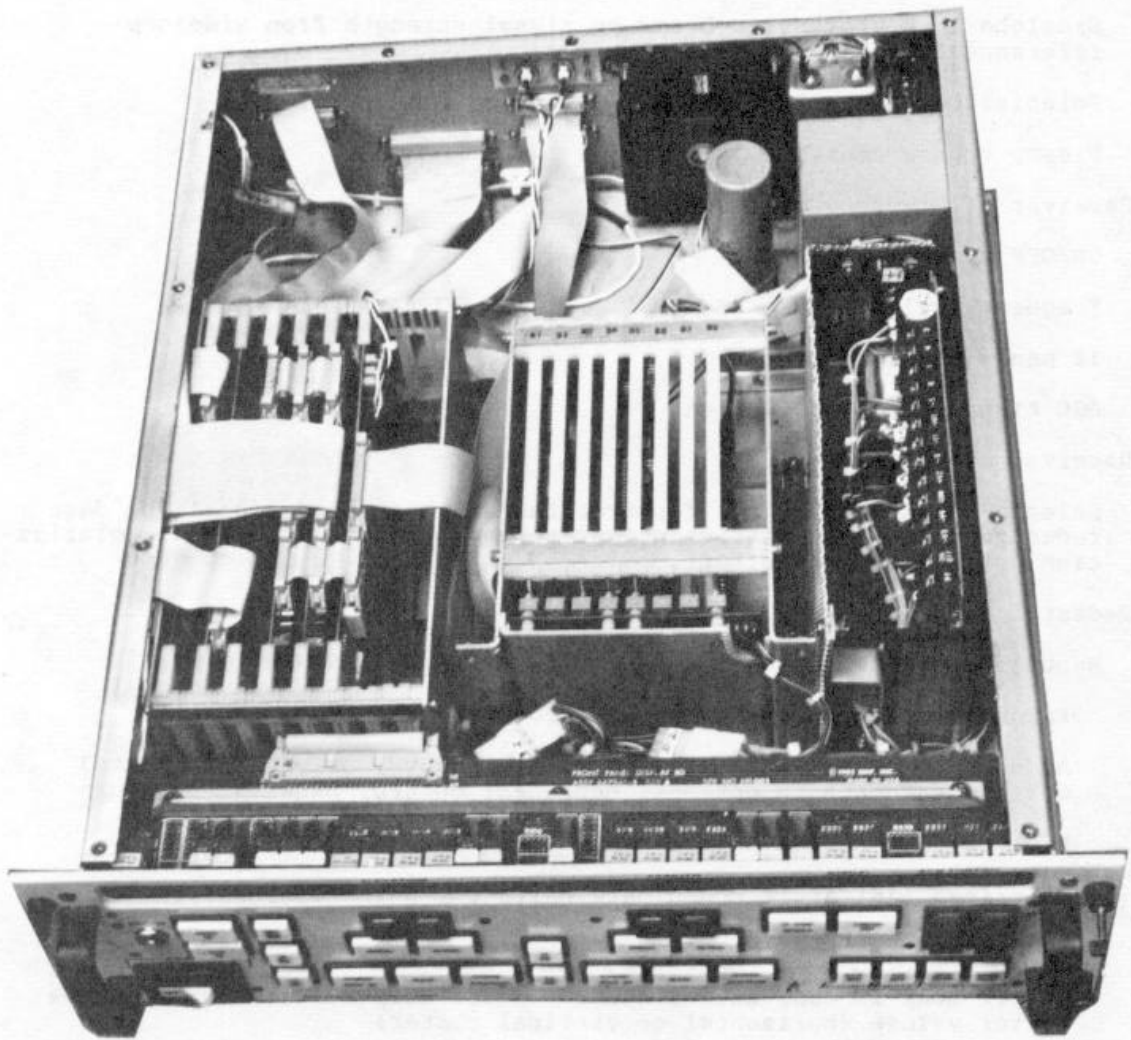
Serial, asynchronous and synchronous (byte oriented)

Autotrack Mode Provides

Auto-acquire submode with front panel threshold adjustment

Rate memory submode with programmable time-out

Position (target acquired) memory submode



**FIGURE 1 - ACU-6 DUAL AXIS CONTROL UNIT
(TOP COVER REMOVED)**

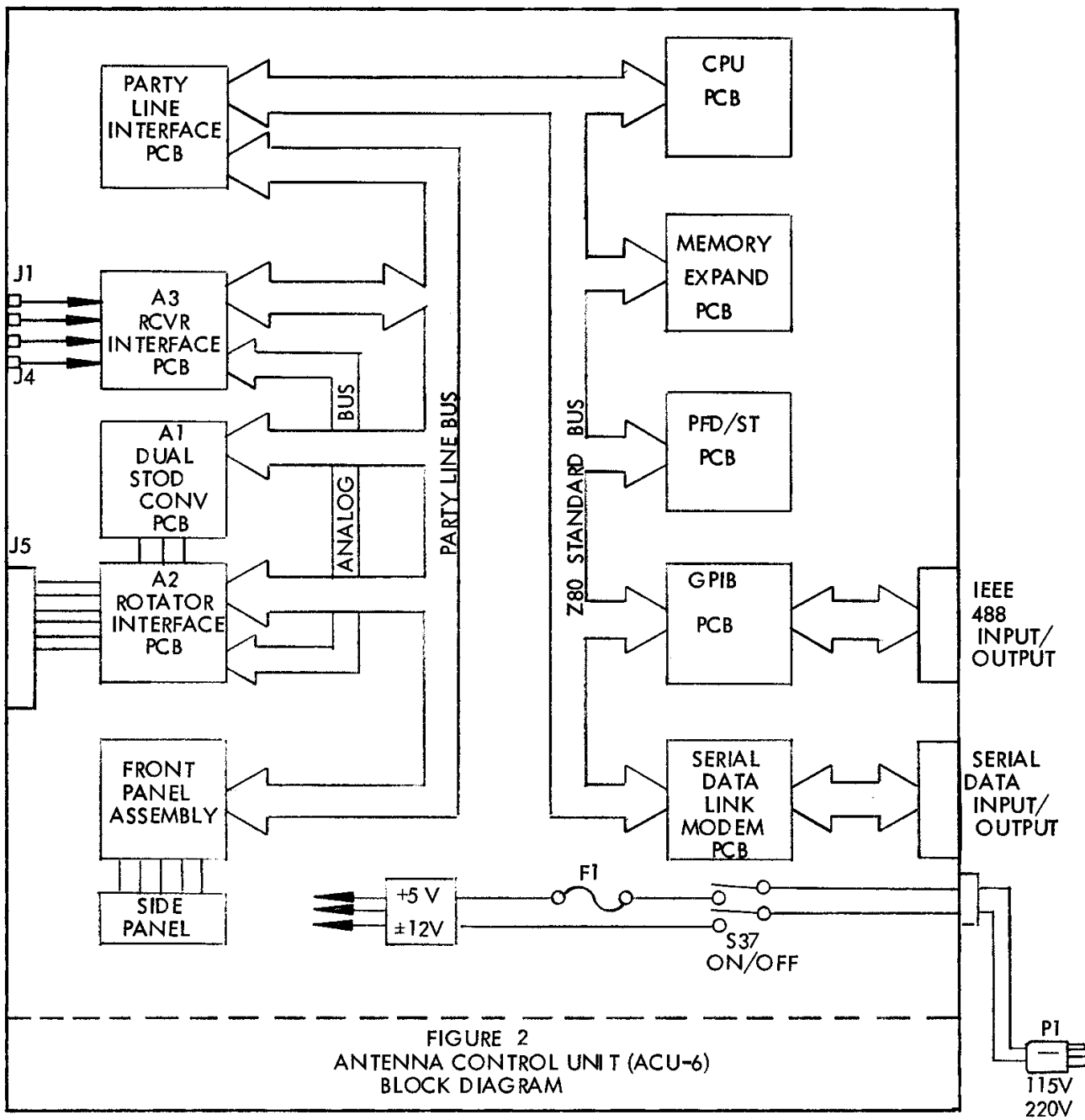


FIGURE 2
 ANTENNA CONTROL UNIT (ACU-6)
 BLOCK DIAGRAM

P1
 115V
 220V