73 Review by *Bob Kosa N5LCO*

Automatic Antenna Tracking with SAT TRAK III

Dedicated hardware antenna tracking controller.

SAT TRAK III
Applied Digital Research, Inc.
PO Box 10184
Sarasota, FL 34232
Phone: (813) 378-3410
Price Class: $300 and $350

Photo A. The front. . .

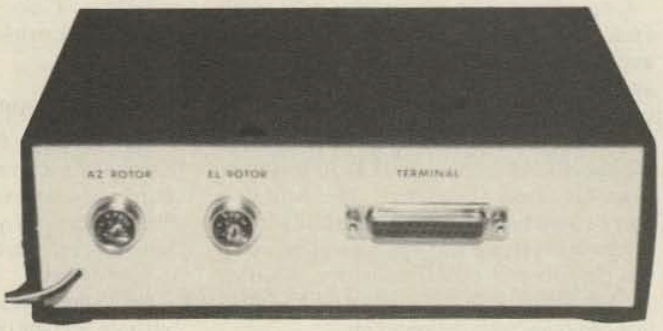

Photo B. . . .and the back panel of the SAT TRAK II controller. Note the minimum of controls.

If a group of satellite chasers were to pool their ideas into one wish list and build a controller based on those ideas, they would have the SAT TRAK III. SAT TRAK III, manufactured by Applied Digital Research, Inc., is a microprocessor-controlled automatic satellite antenna rotor controller. At last! No more paging through computer printouts of tracking information, or fumbling with the buttons on the rotor controller! Thanks to SAT TRAK III, making contacts on low orbit satellites is easy—you can concentrate totally on making the QSO.

Features

SAT TRAK III is easily interfaced to several major brands of rotors. Operation is simple, smooth, and accurate. A detailed manual and user friendly software quickly guide a new owner through the installation.

The tracking software, battery backed-up system clock, and memory, microprocessor, and relay control circuits are all assembled on one printed circuit board. To track a satellite, all you need to do is change the twelve-position rotary switch mounted on the front panel. A flashing LED indicates tracking status (satellite-above-horizon).

SAT TRAK III does not need to be connected to an external computer while tracking a satellite. You can use an RS-232 or a TTL level compatible dumb terminal to initialize the system, then disconnect the terminal from the controller until it is time to enter new Keplerian element sets.

SAT TRAK Chassis

SAT TRAK III is housed in a compact plastic box which measures 8" x 6.25" x 2.5". [This is just the right size to place underneath my Kenpro KR-5400 El-Az (elevation-azimuth) dual controller.] The inside of this box has been sprayed with a conductive coating to prevent interference to adjacent equipment in the ham shack (probably a requirement for the FCC Class B computing device certification). As a precautionary measure, I checked for interference with modes A (2 meters up, 10 meters down), B (70 cm up, 2 meters down) and J (2 meters up, 70 cm down) and did not encounter any problems. Yet, even with the excellent RFI shielding, I would still prefer a metallic box.

"To adjust the voltages to levels within range of the A/D, tweak the two trim pots on the printed circuit board. This is the only hardware adjustment required by SAT TRAK III."

Inside of SAT TRAK III is an innovative printed circuit board whose brain is an Intel 8052AH microprocessor with a BASIC interpreter. The tracking program is kept as "firmware" in a 16 Kb EPROM. This circuit board also has an accurate Timekeeper™ clock chip with 2 Kb RAM and an integral lithium battery. The station and satellite data, maintained in 8 Kb of RAM, rely on the clock battery to prevent memory loss. This battery is said to have an approximate life span of ten years under normal conditions. An 8-bit analog-to-digital converter samples the rotor potentiometer feedback voltages (stall sensor), the SATELLITE SELECT switch, and the TRACK ENABLE switch.

Five triacs mounted vertically on the board control elevation "up/down", azimuth "left/right", and azimuth braking. Adjacent to each of the triacs is a red LED which is used primarily as a troubleshooting aid for any hardware problems. Mounting the LED's on the front panel may cause unnecessary clutter, but, on the other hand, it gives the user a better understanding of the status of the tracker.

Another very handy feature is an amber

LED which is mounted above the tracking switch. This LED will blink "on" once every 6 seconds when the satellite being tracked is below the horizon. Conversely, it will blink "off" once every 6 seconds when the satellite is above the horizon. If you like bells and whistles (in the truest sense), Applied Digital Research has provided schematics for three simple add-on alarm circuits which may be used to indicate satellite-above-horizon status.

Set Up

To install the unit, first connect an RS-232 extension cable from the DB25 socket on the back of the tracker to a serial port on a computer or terminal (see the "Features" section above). Applied Digital Research supplies a small AC/DC adapter with the tracker. Plug this into the wall. The communications software should be set to 8 bits, no parity; or 7 bits, even or odd parity; one stop bit and 4800 baud. The baud rate may be changed at a later time. When SAT TRAK power is turned on, tracking automatically begins within seconds. Entering a cr> (carriage return or the enter key) will let you leave the tracking mode and return to the main menu.

"The SAT TRAK III is an innovative and intelligent stand-alone automated antenna tracking controller."

The first time that the tracker is turned on, you will have to set the system clock by choosing the "CLOCK SETUP" command option and synchronizing the battery backed-up clock with WWV. This clock should be accurate to within a few seconds over the period of a month. If any deviation does occur it may be compensated for in the "CALIBRATE" function of the CLOCK SETUP option.

Station Setup

To set up the station, you must make two cables to connect the rotor controller box to the interface of SAT TRAK III. Each cable should consist of an 8-pin mike plug and a 5-conductor shielded cable. The manual contains wiring diagrams for the Kenpro/Yaesu KR-5400 A/B, KR-400, KR-500 and CDE type rotors. Older Kenpro rotors, like the KR-5400, will require a minor modification by running a wire from the 26-volt AC tap of the transformer (switch common) to the back of the controller box. Connect the rest of the wires in parallel to the lines on the terminal boards on the back of the Kenpro El-Az controller box.

Calibration

Next, you must calibrate the unit. This is a vital part of the installation setup because it enables the microprocessor to equate the rotor feedback voltages to the azimuth and elevation angles (degrees). Before you turn on the power to calibrate SAT TRAK III for any rotor combination, make sure that the tracking switch is in the "disable" position. This prevents erroneous movement of the rotor to positions which might damage the antennas or coax.

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COMMAND OPTIONS

1 = RUN SATELLITE TRACKER
2 = LIST/UPDATE SATELLITE DATA
3 = CLOCK SETUP
4 = SETUP AND STATION DATA
5 = TEST ROUTINES

SELECT COMMAND 1-5 ?
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Figure 1. Main Menu Command Options

TRACKING DATA FOR SATELLITE #3 = RS-10/11
(hit cr> to go to setup menu)

AZ	EL	RANGE	HEIGHT	LAT	LON	PHASE	DOPPLER	TIME
198	1	3495	989	2.6	104.3	205	0	21 : 10 : 19
198	2	3421	989	3.3	104.2	206	561	21 : 10 : 30
199	2	3384	989	3.6	104.2	206	600	21 : 10 : 36
199	3	3348	989	3.9	104.2	206	596	21 : 10 : 43
199	3	3311	989	4.3	104.2	207	599	21 : 10 : 49
199	4	3274	989	4.6	104.2	207	608	21 : 10 : 55
199	4	3237	989	5.0	104.1	207	598	21 : 11 : 1
200	4	3195	988	5.4	104.1	207	585	21 : 11 : 7
200	5	3158	988	5.7	104.1	208	596	21 : 11 : 13

Figure 2. Tracking Data Display

Any time the power is turned on, SAT TRAK will automatically return to the tracking mode. The screen output contains all the pertinent tracking information (see Figure 2). The microprocessor performs El-Az coordinate calculations on approximately six second intervals. Simply entering a cr> will return the program to the main menu "COMMAND OPTIONS". From there, choose "TEST ROUTINES".

There are two functions within the TEST ROUTINES: "ROTOR FEEDBACK VOLT METER", and "MANUAL POSITION CONTROL". If you choose the ROTOR FEEDBACK VOLT METER function, SAT TRAK will display the voltages seen by the Á/D for both azimuth and elevation. To adjust the voltages to levels within range of the A/D, tweak the two trim pots on the printed circuit board. This is the only hardware adjustment required by SAT TRAK III. Next, to establish some validity to the calculations performed by the micro, you must return to the main COMMAND OPTIONS menu and from there choose the "SETUP AND STATION DATA" option. (Figure 3, reproduced from the manual, illustrates the simple and precise path of the software.) After entering the station latitude, longitude and elevation, SAT TRAK begins to ask several other questions, such as "ACTIVATE ANTENNA FLIP?" and "AZIMUTH ROTOR STOP AT NORTH OR SOUTH?" in order to determine the exact configuration of the rotors in the station.

After you have determined the physical configuration, you must calibrate the system by recording the voltages at the minimum and maximum meter readings. The microprocessor samples the rotor pot feedback voltages and stores them as calibration data in the random access memory. The final question in the setup option is "CHANGE BAUD RATE?" No

DATA FOR SATELLITE 3 = RS-10/11

MEAN MOTION (ORBITS/DAY)	13.719267
MEAN ANOMALY (DEG)	220.6177
INCLINATION (DEG)	82.9264
ARG PERIGEE (DEG)	139.5954
RAAN (DEG)	358.7229
EPOCH YEAR (YY)	89
EPOCH DAY AND FRACTION	4.9602995
ECCENTRICITY	1.2783 E-3
DECAY (ORBITS/DAY^2)	2.64 E-6
BEACON FREQUENCY (MHZ)	29.407

Table 1. Typical Keplerian Element Data

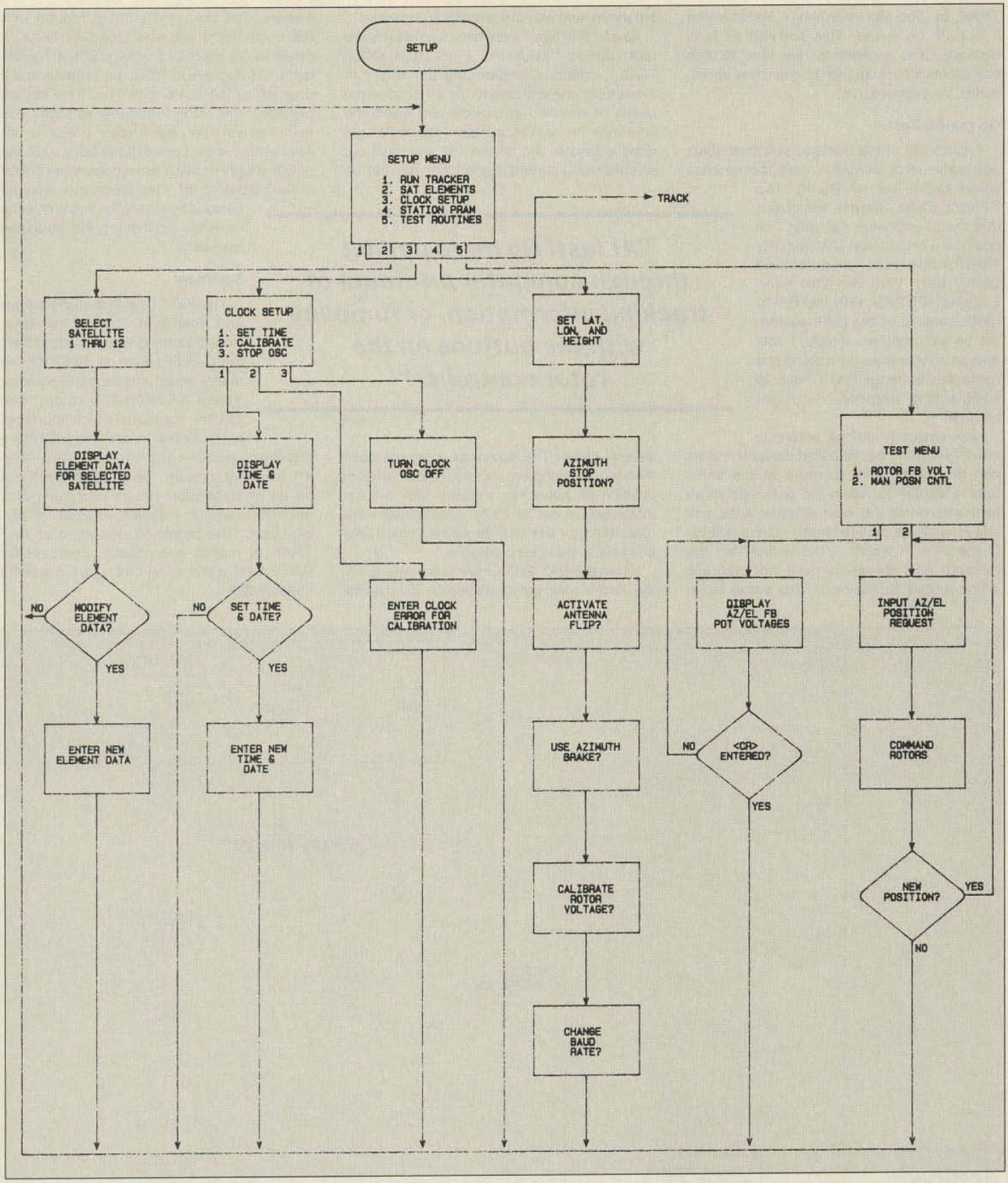

Figure 3. Flow chart for tracker setup and station data.

thanks, 4800 baud should be fast enough.

Now you must add some credibility to the tracking data. Return to the main menu and choose the "LIST/UPDATE SATELLITE DATA" option. This will display a list of satellite-select switch positions, and the corresponding satellite names. The tracking algorithm uses Keplerian element data (see Table), sets consisting of strange numbers with even stranger names like "Mean Motion", "Mean Anomaly", "Inclination", and "Epoch Day", to name but just a few. You can get the background information that you need on several computer bulletin boards, in AMSAT news letters, and from NASA. Then, simply select the satellites of choice and enter the new values when prompted.

Ready to Track

Is SAT TRAK calculating valid El-Az data? A quick comparison with AMSAT's QUIK-

TRAK, by Bob McGwier N4HY, reveals that it is right on target. This software is fast, accurate, and as near to real time as can be expected. No leap year bug to worry about, either. Very impressive!

On-the-Air Test

A quick flip of the tracking switch enables automatic rotor control. I had the satellite select switch set for RS-10. The Kenpro El-Az meters indicated that the beams were swinging into position. Time to play! CW from the RS-10 robot came in at around 29.407 MHz. With very little effort I logged 12 QSOs with the RS-10 robot, peaking at, but not breaking, the 55 wpm barrier. Finally, I was able to concentrate on making the contacts. No longer do I have to fumble with up/down, left/right buttons!

How smoothly do the antennas move? Both the azimuth and elevation rotors can be commanded to move at the same time. I wanted to watch the antennas move so I waited for the next satellite pass and this time, like a devoted ham, I stood outside in the rain to watch. I did notice that the azimuth and elevation were not typically commanded to move at the same time, but movement was still smooth and precise.

As a further test, I went back inside to try the test routine "MANUAL POSITION CONTROL" option. Commanding the rotors to move from one extreme to the other gave me plenty of time to run outside and watch the antennas move. Once again, the antennas drew a smooth arc across the sky. Just out of curiosity, I turned the tracker off and on several times. The antennas were not commanded to swing around wildly to a random position on power-up. Instead, they did not move until a set of El-Az coordinates were calculated for the current system clock time and sent to the rotor controller.

"At last! No more paging through computer printouts of tracking information, or fumbling with the buttons on the rotor controller!"

When the SAT TRAK interface power is off, the rotors may be controlled in the normal manner. The only problem that I found with this controller is that when the SAT TRAK III power is off, there is a voltage offset equivalent to 45 degrees at full-scale azimuth and 2 degrees at full scale elevation. This occurs because the rotor feedback voltages are pulled down when the tracker power is off. Apparently, some current flows back up to the power supply through two diodes when power to the tracker is off. This annoyance may be avoided by simply turning both units on when positioning the antennas manually.

Summary

The SAT TRAK III is an innovative and intelligent stand-alone automated antenna tracking controller. With retail prices at $299 for the model which interfaces to Kenpro/Yaesu KR-5400 A/B rotors, and $349 for the model which interfaces to most other rotors, you will have a microprocessor-controlled state-of-the-art tracking system. This device will not tie up an expansion slot in your computer, nor will it require a dedicated serial or parallel port. The hands-off operation of SAT TRAK III makes it an ideal candidate for GATEWAY stations, and for all avid satellite chasers. 73

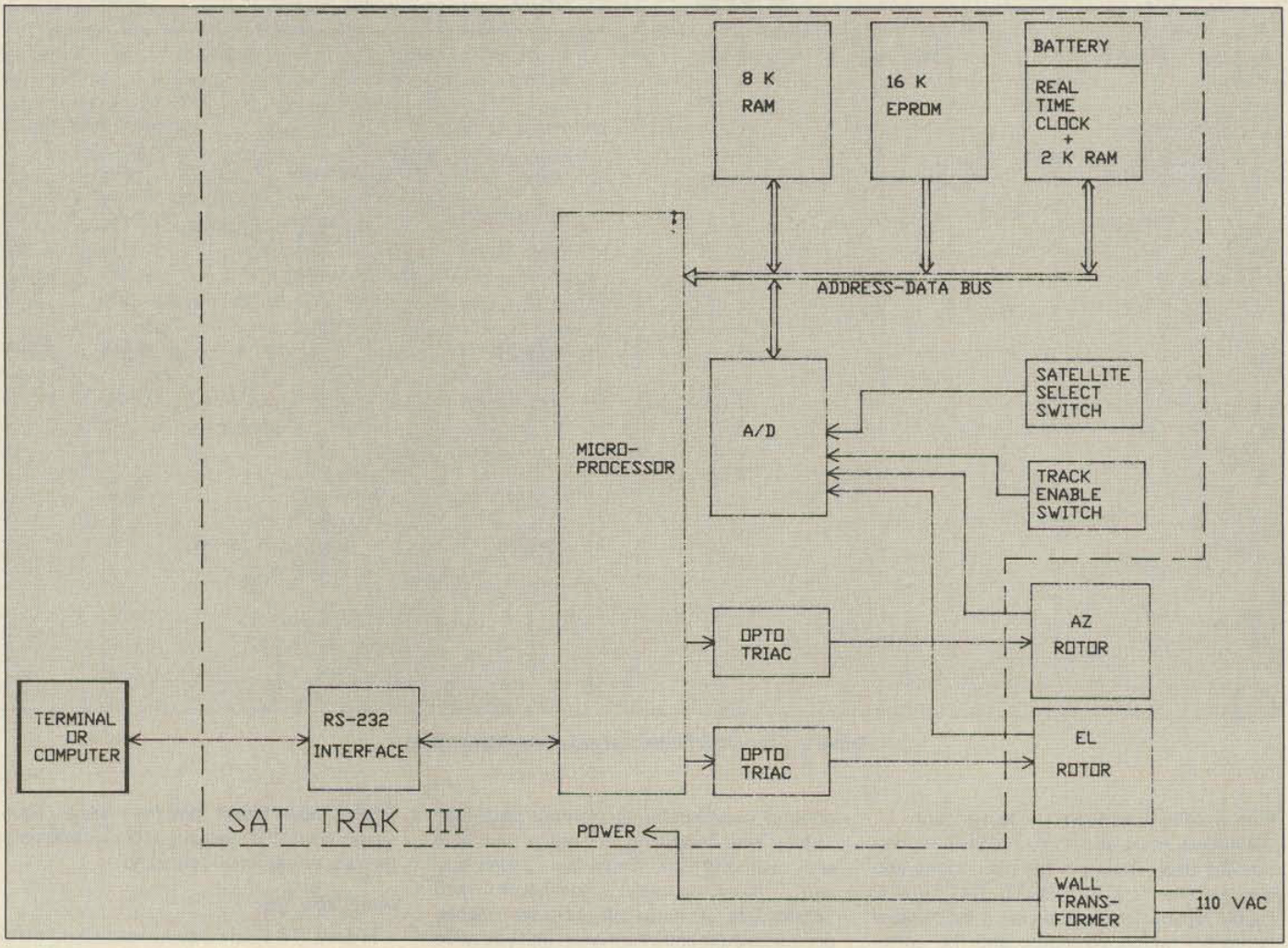

Figure 4. Block diagram of the SAT TRAK III controller.