I.D. & Associates

TS2000 Antenna Tracking and Control System

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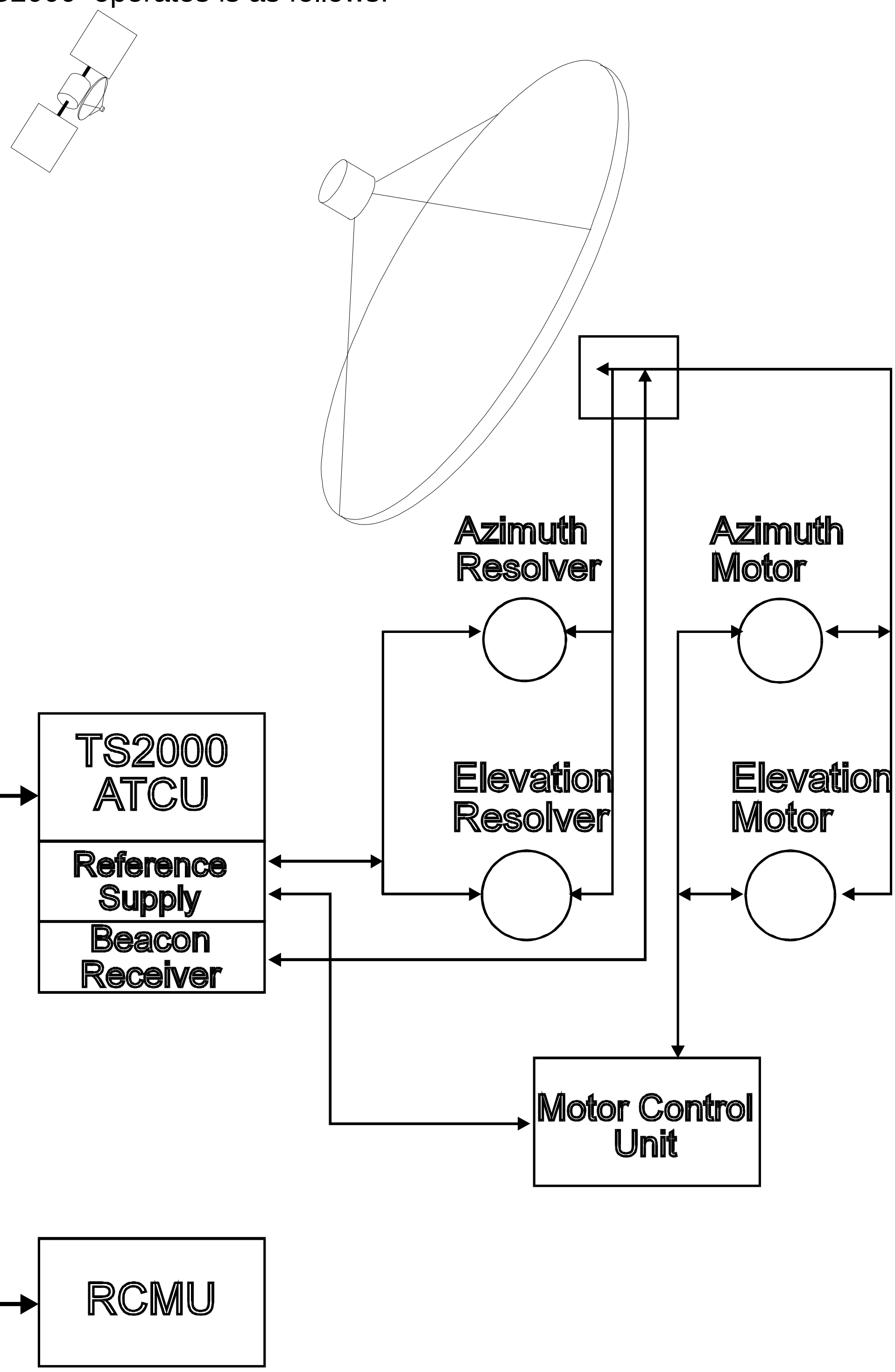
The TS2000 is a antenna control and tracking system for small to medium sized satellite communications antennna requiring antenna steering using on / off control using commercial grade quality industrial PC-based antenna tracking control unit providing a the user with reliable operation.

1.0 SYSTEM OVERVIEW

The expected system configuration (main functional connections only shown) in which the TS2000 operates is as follows:



1.1 The TS2000 Controller Configuration

The tracking controller is implemented using standard, off the shelf, multi sourced industrial PC equipment. The software for the system is written in TURBO-C + + , using wherever possible to ANSI standard C, and avoiding any specific C + + features. This allows a flexible, well tested development environment, with comprehensive, multi-sourced tools (editors, compilers, debuggers) readily available.

2.0 Benefits

The TS2000's sophisticated algorithms provide highly accurate low-cost and proven tracking performance with minimal antenna movement, meaning reduced mechanical wear and power consumption.

Suited to attended and especially to unattended and remote sites, the TS2000's self-teaching abilities allow it to 'learn' and predict any orbit without any initial information. If the satellite beacon signal is lost, the TS2000 maintains contact for at least 5 days, with minimal change in performance.

The TS2000 offers full power supply and beacon drop-out recover, allowing essential communications contact to be maintained.

User-friendly interfaces mean the TS2000 is easily operated, and the TS2000's unique in-built antenna satellite system simulator, accessed through a PC makes operator training simple.

The TS2000 provides enhanced position encoder resolution and full remote control from an earth station master control computer.

Available as a separate product, ORBSIM is a satellite antenna simulator interfacing directly to the TS2000 which can be used for performance evaluation and quality control testing of a range of antenna tracking control units.

The TS2000's advanced features provide modes of operation which allow reliability, accuracy and ease of use, including:

? Standby Mode
? Autotrack Mode
? Position Mode
? Initialisation Mode
? Intelsat Mode
? Scanner Mode

3.0 Features

? Highly accurate and reliable tracking for inclined orbit satellites.
? Resilience to tracking signal disturbances and gusting wind effects.

- Low dish movement frequency while maintaining tracking accuracy. Operator selectable 'move size' to allow tracking accuracy and dish movements to be traded off.
- Auto recovery after beacon loss or power outage.
- Storage for up to 10 satellite models (Autotrack and Intelsat).
- Operator selectable software limit protection.
- Operation with a range of geared or ungeared synchros, resolvers and absolute encoders.
- Rapid 'acquisition' of a new satellite.
- Rejection of solar outages.
- Allowance for tilted antenna mounts.
- Beacon channel selection (4 bit + strobe) interface, with operator specified channel for each satellite model.
- Multi-level alarm generation, reporting and handling.
- Watchdog timer hardware and software.
- Non-volatile memory for storage of important data and parameters.
- Internationally accepted software and manufacturing standards.
- Polariser control and tracking.

4.0 Product Description

4.1 Inputs

Two axis antenna and polariser position from synchros, resolvers or absolute encoders. Tracking signal from beacon or pilot receiver.

4.2 Power

Suits most AC or DC power supplies.

4.3 Outputs

Clean contacts for azimuth and elevation control with support for travel limit switches. Able to drive a range of motor control units.

4.4 Size

19" rack (industrial PC).

5.0 Specifications

5.1 Position Encoders

Type
Synchros resolvers or absolute encoders on each axis.
Operating Frequency
Ranges 400 Hz units 360 - 1000
60 Hz units 47 - 1000
Gear ratio
From 1:1 to 99:1
Absolute accuracy
0.017/n$^{\circ}$ (n - synchro or resolver gear ratio)
Resolution
0.00549/n$^{\circ}$ (n = synchro or resolver gear ratio

5.2 Tracking Signal Input

Indication
Level of received signal in dB.
Level Range
-10V to +10V
Sensitivity
0.1 to 1.0 V/dB

5.3 Satellite Trajectory

Trajectory
Geosynchronous within 0.5%
Inclination
10° maximum to the equatorial plane
East/West motion
0.03° per day (maximum)
Elevation
80° maximum relative to earth station

5.4 Receiving Antenna

Geometry
Parabolic, elevation over azimuth
3 dB beamwidth
0.2° (minimum)
Sidelobes
Spaced at least one beamwidth from beam centre
Wind Gust deflection
? 5% of beamwidth (maximum)

5.5 Motors and Drives

Speed
0.005^{o}/sec to 0.05^{o}/sec
Az speed x Cos El > 0.005^{o}/sec
Dual speed - track and slew

5.6 Performance

Lock Range
Maximum initial error from which tracking will commence is 50% of beamwidth in either axis.
Tracking Accuracy
Steady rate r.m.s. tracking accuracy better than 10% of beamwidth after at least 0.5 hour of tracking.

5.7 Prediction Ability

When tracking has proceeded to two days with a valid tracking signal and the tracking signal is then lost, TS2000 will continue to predict the satellite's orbit for five days with an error not exceeding 20% of dish beamwidth.

6.0 Modes of Operation

The TS2000 systems has six (6) basic modes of operation as follows:

6.1 Standby Mode

This mode inhibits computer activated control of the motor drives. This mode is designed to be used during set-up, maintenance and diagnostic procedures for the tracking system. Tracking system parameters can be altered from this mode, though not generally from any other mode. All user variables will be reported using the station control protocol while in any mode, including standby mode.

6.2 Position Mode

The term position is preferred as the term "manual" may create some confusion between this mode of operation, and a mode whereby the motor controller is controlled "manually" (e.g. by jog switches on a tracking unit, or on the motor controller). In position mode, the tracking system responds as a "slave" processor, to command angles sent from the serial interface in real time. The tracking system, when sent a set of angle data, will generate commands for the motor controller which will drive the antenna to the specified positions. At any time during, or after driving to a position, the tracking system can be interrogated by the station control protocol (serial interface). The position mode does **not** provide for loading time tagged trajectory data (program track data), nor does it provide for tracking of such time-tagged data.

6.3 Intelsat Mode

This mode allows the user to install Intelsat 11-Parameter ephemeris data, and Earth station location data, which is used to automatically generate pointing data. At a regular, user specified time interval, this data is used to predictively move the antenna to the optimum pointing position. The accuracy of this mode is limited by: The fundamental accuracy of the Intelsat data/model; the user specified time interval; the absolute accuracy of the antenna mount, encoder and encoder conversion electronics; and the positioning accuracy of the tracking system, and the accuracy of the system clock.

6.4 Autotrack Mode

Autotrack mode uses optimum predictive tracking, based on a tracking signal measurement, typically a beacon, pilot or AGC level made available to the tracking system. This system allows automatic tracking to continue during temporary (of the order of a few hours) and/or longer term tracking signal outages, by using its predictive model, and when a valid tracking signal is available regularly (every time the automatic tracking system moves the dish through a "sequence") updates the predictive model to maintain optimum pointing.

6.5 Initialisation

This is the mode used to denote the nine point initialisation procedure used to perform a cold start. On successful completion of this procedure, the mode is automatically changed to Autotrack.

6.6 Scanner Mode

The Scanning Mode moves the antenna in a counter-clock-wise "square" spiral. The track separation and box limit are set by the operator. The scan mode will continue until:

(a) The deviation from the initial position "X" exceeds 1/2 the box limit.

(b) The time since commencing the scan exceeds the user specified limit.

(c) The Beacon signal becomes valid. The Beacon signal returns to within the user specified limits, and the signal's rate of change is not positive.

Inialisation will commence upon reception of a valid beacon beacon signal is found, the ATCU will fall back into Standby mode.

7.0 TRACKING SYSTEM PERFORMANCE DESIGN

7.1 Autotrack Mode Accuracy

7.1.1 Example Error Budget

System parameters :
Antenna Beamwidth = 0.6 deg (with an error of up to +/- 10% in the value in the tracking controller)
Tracking Signal Variation = 0.1 db r.m.s. (variations in samples taken at a 3 sec average)
A.C. Encoder readout errors = 0.02 deg r.m.s. (this includes A.C. wind effects, and encoder non-repeatability errors)
Move size = 0.03 deg (user selectable)
50 tracking sequences per hour (modest rate for a 10 degree inclined satellite)

Results of computations :
model determination = 0.011 deg r.m.s.(per axis) (errors caused by noise effects (beacon or angle), causing inaccurate estimates of the parameters in the autotrack model.
tracking sequences = 0.024 deg r.m.s.(total) (errors caused by the infrequency of dish motions, and computed as $\left(\frac{move\_size}{\sqrt{3}}\right)$ r.m.s. per axis)
model inaccuracy = 0.0010 deg r.m.s.(per axis) (errors caused by the fundamental inaccuracy of the autotrack model)
a.c. angle errors = 0.02 deg r.m.s. (per axis) (A.C. wind deflections, positioning errors, encoder/converter repeatability.)
Overall bore-sight error = 0.04 degrees r.m.s.

Note that the overall r.m.s. tracking accuracy is a complicated function of the system parameters, and it is not a simple matter to give a complete analytical determination of the model accuracy. Also note that the major effects on the overall error are the "tracking sequence" component, and the "a.c. angle errors". The tracking sequence component can be reduced by the user, by specifying a smaller move size and/or a smaller upper limit on the time between tracking sequences. This will, however, deteriorate the model determination error, and will also require a larger number of antenna movements. The a.c. angle errors are largely beyond the control of the autotrack software, and also represent a significant performance limitation.