Information Technology

⊃ Monitoring of International Space Station Telemetry Using Shewhart Control Charts

This technique can be applied to monitoring critical systems such as electrical power generation and manufacturing equipment.

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Shewhart control charts have been established as an expedient method for analyzing dynamic, trending data in order to identify anomalous subsystem performance as soon as such performance would exceed a statistically established baseline. Additionally, this leading indicator tool integrates a selection methodology that reduces false positive indications, optimizes true leading indicator events, minimizes computer processor unit duty cycles, and addresses human factor concerns (i.e., the potential for flight-controller data overload). This innovation leverages statistical process control, and provides a relatively simple way to allow flight controllers to focus their attention on subtle system changes that could lead to dramatic off-nominal system performance. Finally, this capability improves response time to potential hardware damage and/or crew injury, thereby improving space flight safety.

Shewhart control charts require normalized data. However, the telemetry from the ISS Early External Thermal Control System (EETCS) was not normally distributed. A method for normalizing the data was implemented, as was a means of selecting data windows, the number of standard deviations (Sigma Level), the number of consecutive points out of limits (Sequence), and direction (increasing or decreasing trend data). By varying these options, and treating them like dial settings, the number of nuisance alerts and leading indicators were optimized. The goal was to capture all leading indicators while minimizing the number of nuisances. Lean Six Sigma (L6S) design of experiment methodologies were employed. To optimize the results, Perl programming language was used to automate the massive amounts of telemetry data, control chart plots, and the data analysis.

This work was done by Jeffery T. Fitch, Alan L. Simon, John A. Gouveia, Andrew M. Hillin, and Steve A. Hernandez of United Space Alliance for Johnson Space Center. Further information is contained in a TSP (see page 1). MSC-24530-1

⊃ Theory of a Traveling Wave Feed for a Planar Slot Array Antenna

A design procedure was developed for the coupling slots between the feed waveguide and the radiating waveguides.

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Planar arrays of waveguide-fed slots have been employed in many radar and remote sensing applications. Such arrays are designed in the standing wave configuration because of high efficiency. Traveling wave arrays can produce greater bandwidth at the expense of efficiency due to power loss in the load or loads. Traveling wave planar slot arrays may be designed with a long feed waveguide consisting of centered-inclined coupling slots. The feed waveguide is terminated in a matched load, and the element spacing in the feed waveguide is chosen to produce a beam squinted from the broadside.

The traveling wave planar slot array consists of a long feed waveguide containing resonant-centered inclined coupling slots in the broad wall, coupling power into an array of stacked radiating waveguides orthogonal to it. The radiating waveguides consist of longitudinal offset radiating slots in a standing wave configuration. For the traveling wave feed of a planar slot array, one has to design the tilt angle and length of each coupling slot such that the amplitude and phase of excitation of each radiating waveguide are close to the desired values. The coupling slot spacing is chosen for an appropriate beam squint. Scattering matrix parameters of resonant coupling slots are used in the design process to produce appropriate excitations of radiating waveguides with constraints placed only on amplitudes.

Since the radiating slots in each radiating waveguide are designed to produce a certain total admittance, the scattering (S) matrix of each coupling slot is reduced to a 2×2 matrix. Elements of each 2×2 S-matrix and the amount of coupling into the corresponding radiating waveguide are expressed in terms of the element S_{11}. S matrices are converted into transmission (T) matrices, and the T matrices are multiplied to cascade the coupling slots and waveguide sections, starting from the load end and proceeding towards the source.

While the use of non-resonant coupling slots may provide an additional degree of freedom in the design, resonant coupling slots simplify the design process. The amplitude of the wave going to the load is set at unity. The S_{11} parameter, r' of the coupling slot closest to the load, is assigned an arbitrary