This article describes the Rockwell Collins airline industry automatic test equipment (ATE) and a North Atlantic Instruments (NAI) VXI Commercial-Off-the-Shelf (COTS) tester card. The Collins ATE is used for testing Seller Furnished Equipment (SFE) and Buyer Furnished Equipment (BFE) in accordance with industry standard ARINC 608A requirements. The NAI VXI Synchro/Resolver Simulation and Measurement card is a module of both the SFE and the BFE ATE.

Collins ITS-701 general-purpose digital emphasis tester is used to test SFEs such as the Automatic Flight Director System, Maintenance Access Terminal, and Standby Instruments. The company’s RFT-1000 general purpose RF emphasis tester is used to test BFE such as the RF Sensors, HF Transceiver, and SATCOM Units.

NAI’s model 5390 is a precision Synchro/Resolver Simulation and Angle Position Measurement VXI COTS tester card. Interfacing to rugged reliable synchros, the 5390 functionality is based upon highly accurate synchro-to-digital conversion and digital-to-synchro simulation.

Introduction
The Rockwell Collins ATE is used at Collins engineering, manufacturing, and service centers to test SFE and BFE. The same ATE is used at airframe manufacturers and airlines to test and troubleshoot a variety of Line Replaceable Units (LRUs). Collins ATE supports a variety of aircraft, including Boeing 7xx, Fokker 100 and Lockheed L1011.

ATE for SFE is usually configured around an aircraft type. For example, the ITS-701 contains all of Collins’ Boeing 777 SFE test equipment. ATE for BFE is usually configured around a specific technology that extends across many aircraft types. For example, the Collins RFT-1000 for SATCOM and Sensors specializes in testing RF technology across multiple types of aircraft in a fleet.

Increasingly, Collins has used a variety of VXI COTS tester cards in their ATE designs. Typical of these designs are an RF counter, an Arbitrary Function Generator, and a Synchro/Resolver Simulator and Measurement unit. Collins uses the NAI model 5390 VXI COTS Synchro/Resolver Simulator and Measurement card in both its SFE and BFE ATE.

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Rockwell Collins ATE
The Collins ITS-701 and the RFT-1000 ATE are designed based upon the industry standard ARINC 608A specification. A set of core resources, each suitable for both SFE and BFE, are used in these ATEs. The core resources are assigned 608A pins/positions that are the same on the ITS-701 and the RFT-1000, so test unit adapters can be common for both. Core resources include a control computer, a switching system, AC and DC power supplies, a digital multimeter, a digital storage oscilloscope, a VXI mainframe, ARINC 429 transceivers, and HF counter.

Specialized resources are added to the core resources to implement the ITS-701 SFE ATE and the RFT-1000 BFE ATE. A photograph of the RFT-1000 BFE ATE is shown in Figure 1.

ITS-701 SFE ATE
The ITS-701 SFE ATE is a general-purpose automatic test station built on the Collins 608A Core Station design, with additional resources included to implement tests for the Autopilot Flight Director System, the Maintenance Access Terminal, and the Standby Instruments.

Charts listing Boeing 777 LRUs that can be tested by the ITS-701 and RFT-1000 are shown in Tables 1 and 2.

RFT-1000 BFE ATE
The RFT-1000 ATE is a general-purpose automatic test station intended for ARINC

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<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>LRU</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFDS</td>
<td>AFDC-770</td>
<td>Autopilot Flight Director Computer</td>
</tr>
<tr>
<td></td>
<td>MCP-770/771</td>
<td>Mode Control Panel</td>
</tr>
<tr>
<td>MAT/SD</td>
<td>DTD-950</td>
<td>Data Terminal Display</td>
</tr>
<tr>
<td></td>
<td>SDD-950</td>
<td>Standard Disk Drive</td>
</tr>
<tr>
<td></td>
<td>CCU-950</td>
<td>Cursor Control Unit</td>
</tr>
<tr>
<td></td>
<td>KBU-950</td>
<td>Keyboard Unit</td>
</tr>
<tr>
<td>SI</td>
<td>FPI-9330</td>
<td>Flat Panel Instruments (Attitude)</td>
</tr>
<tr>
<td></td>
<td>FPI-9331</td>
<td>(Attitude and Air Speed)</td>
</tr>
</tbody>
</table>

Table 1. Aircraft LRUs Tested by the ITS-701 SFE ATE

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>LRU</th>
<th>NAME</th>
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</thead>
<tbody>
<tr>
<td>Sensors</td>
<td>VHF-900/700</td>
<td>Very High Frequency Transceiver</td>
</tr>
<tr>
<td></td>
<td>VOR-900/700</td>
<td>VHF Omni Directional Range</td>
</tr>
<tr>
<td></td>
<td>ILS-900/720/700</td>
<td>Instrument Landing System Receiver</td>
</tr>
<tr>
<td></td>
<td>ADF-900/700</td>
<td>Automatic Direction Finder</td>
</tr>
<tr>
<td></td>
<td>LRA-900/700</td>
<td>Low Range Altimeter</td>
</tr>
<tr>
<td></td>
<td>DME-900/700</td>
<td>Distance Measuring Equipment</td>
</tr>
<tr>
<td>HF</td>
<td>HFS-900/700</td>
<td>High Frequency System Receiver</td>
</tr>
<tr>
<td>SATCOM</td>
<td>SDU-906</td>
<td>Satellite Data Unit</td>
</tr>
<tr>
<td></td>
<td>HPA-901/900</td>
<td>High Power Amplifier</td>
</tr>
<tr>
<td></td>
<td>RFI-900</td>
<td>Radio Frequency Unit</td>
</tr>
</tbody>
</table>

Table 2. Aircraft LRUs Tested by the RFT-1000 BFE ATE
RF products. It is built on the Collins 608A Core Station design, with additional resources included to implement tests for sensors (VHF, VOR, ILS, ADF, LRA, DME), HF COM, and SATCOM (SDU, HPA, RFU).

**NAI VXI COTS Synchro tester**

Model 5390 Synchro/Resolver simulator and measurement card

The NAI model 5390 VXI COTS Synchro/Resolver simulator and angle position measurement card is used in both Collins SFE and BFE ATE. The 5390 is a message-based unit, consisting of two channels of synchro/resolver angle simulation and one channel of angle position measurement – each operating independently of the others. The unit can simulate or measure the rotor shaft angle of all popular synchros and resolvers.

Each 5390 simulator channel can drive a load of 6VA and has a resolution of 0.001 degrees. Accuracy is maintained for any reference level from 2V to 115V and for any frequency from 360 Hz to 2.0 KHz. The 5390 can be programmed to simulate a constant cw or ccw rotation, or rotation between a programmed start and stop angle, at a velocity of 0.001 to 1000 degrees per second. The velocity can be changed dynamically, the new rate starting at the current angular position. Remote sense lines are provided on the output connector to preserve simulation accuracy driving heavy loads in remote locations.

The 5390 angle-position measurement channel is accurate to 0.001 degrees. Accuracy is maintained for any reference level from 2V to 115V, and for any frequency from 47 Hz to 2.0 KHz. The 5390 has auto phase correction, which corrects for phase shifts of up to 80 degrees between reference and line-to-line inputs.

**What’s a Synchro?**

Synchros are electro-mechanical transducers that have been used in a wide variety of military and commercial motion applications for many years. They have traditionally been chosen when high reliability and environmental ruggedness are critical requirements of the system design, such as in commercial and military aircraft. The simplicity of their design and use, combined with the wide availability of synchro converters for computer interfacing, make the synchro a very attractive motion transducer.

Typical applications in military and commercial aerospace include:

- Inertial navigation reference units
- Automatic Direction Finder (ADF)
- Omirange System (VOR)
- Distance Measuring Equipment (DME)
- Flight surface positioning
- Cockpit simulators and indicators
- Jet engine control
- Landing gear positioning and control

Synchros are electrically very similar to transformers. They have a primary winding and multiple secondary windings. AC signals are transferred from primary to secondary windings by means of electromagnetic coupling. Mechanically, the synchro is very similar to a motor. The primary winding can be physically rotated with respect to the secondary windings. This rotation causes an increase or decrease in the signal coupled from primary to secondary windings.

As the shaft of a synchro is turned, the angular position of its rotor (primary) winding relative to its stator (secondary) winding is represented by the amplitude of the AC signal coupled from primary to secondary windings. A synchro is excited by an AC reference voltage applied to its rotor winding. In aircraft applications, the reference is typically 26 Vrms or 115 Vrms @ 400 Hz.

**Synchro converters**

The amplitude modulated angle information from synchros needs to be converted into digital format to be processed by the computers in typical military systems and ATE. Synchro-to-digital (S/D) converters perform this function in angle-position, measurement test equipment such as the NAI model 5390. Digital-to-synchro (D/S) converters perform the computer interface function in the angle simulation part of the model 5390.

A number of factors relating to synchro characteristics and the systems they are used in contribute to the challenge of designing very accurate synchro converters. Since synchros are electrically similar to transformers, they have inductive characteristics, phase shifts, distortions, and non-linearities. In addition, motion systems and the synchro interconnections often contain significant normal mode and common mode noise components.

Tracking S/D converters are necessary to overcome the sources of error and noise typical of synchro systems. Transformer isolation is necessary to control common mode noise and ground loops.

**Conclusion**

ATE is used by commercial airline industry suppliers in engineering, manufacturing, and service centers to test SFE and BFE. The same ATE is used by airframe manufacturers and airlines to test and troubleshoot a variety of Line Replaceable Units (LRUs). Increasingly, airline industry suppliers have been using a variety of VXI COTS tester cards in their ATE designs. Included among the needed ATE functions are a Synchro/Resolver simulator and measurement unit. The NAI model 5390 unit is an excellent choice for this function.

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North Atlantic Industries, Inc. (NAI), founded in 1955 and previously known as North Atlantic Instruments, has been a leading supplier to customers who develop and test systems used in aerospace, industrial, and defense applications. In 1992, NAI accelerated its development of innovative COTS solutions through in-house R&D and strategic acquisitions.

Recent acquisitions include the 1999 purchase of Logitek, Inc., a well-known supplier of military power supplies that are designed for a wide variety of industrial and defense programs. In the same year, NAI acquired Apex Signal Corp., which provides innovative techniques to enable the design of very high density, high accuracy, and low power boards.

NAI’s modern 30,000 square-foot facility reflects the company’s commitment to the highest standards of electronics manufacturing. Located in the heart of Long Island’s design and manufacturing community, NAI draws upon a large pool of skilled workers and supplier-partners.
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