

Agilent Airport ground radar System uses Agilent Acqiris PCI Digitizer cards

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Introduction

At all major airports, air-traffic controllers deal with inbound and outbound aircraft, ground traffic on runways and flight lines, and taxiing aircraft. They also must watch out for intrusion by unforeseen hazards, such as airport maintenance, fire, oil, and support vehicles.

These are daunting tasks, particularly when weather is poor and controllers have limited visibility of ground operations. Yet, today, many airports, both large and small, do not have an automated warning capability for ground operations.

To address this need, the Raytheon Air Traffic Control Business in Lexington, MA, has developed advanced surface-movement radar (ASMR) capable of locating objects as small as 1 m². The system incorporates a continuously spinning radar transceiver that sweeps the entire airport once per second (Figure 2).

It identifies and tracks all airport ground traffic and automatically alerts controllers to potentially hazardous situations.

System Requirements

The radar images identify individual aircraft and track movements of the ground traffic in real time. Built-in collision-alert software automatically sounds alarms in the event of problems. Potentially, these problems would be visually undetectable by air-traffic controllers from the tower during inclement weather, darkness, or fog. A waveform digitizer card incorporated in a Silicon Graphics workstation acquires radar return signals 4,096 times per second. The digitizer samples at 60 MS/s and take records with a length of 2,048 points. Each signal-acquisition cycle, comprising transmitting, receiving, digitizing, and transferring to the computer, must be completed in 244 μs.



Figure 1. Agilent Acqiris U1067A PCI digitizer card

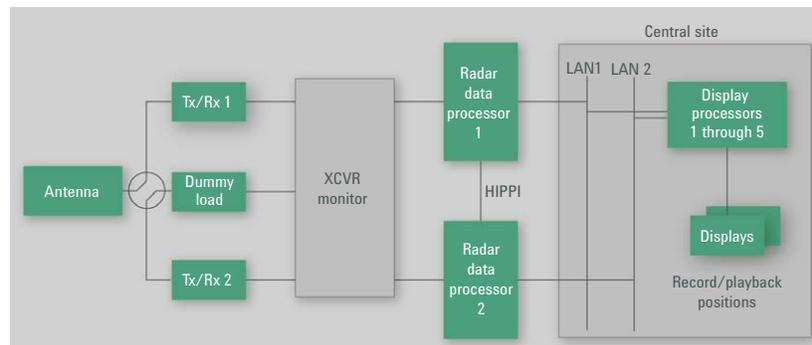


Figure 2. Radar system

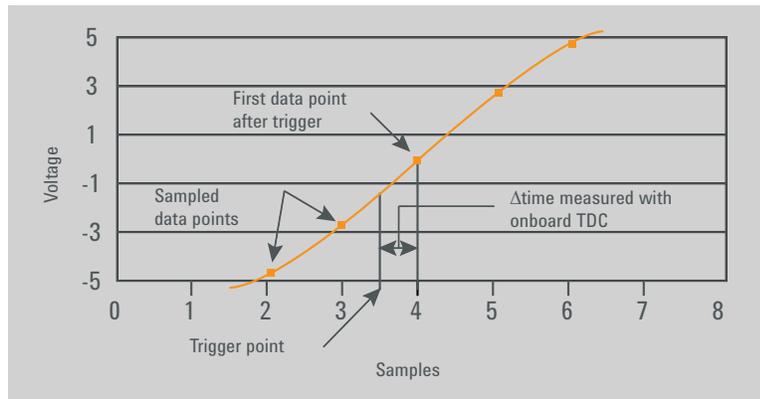
The ASMR system runs on a Silicon Graphics Origin 3200 Workstation with the IRIX operating system, processing data recorded by the digitizer and converting it into radar images of the entire airport grounds. The ASMR at each airport is fully redundant: one system is active online while the other is in hot-standby mode.

Once activated, these systems run continuously, acquiring radar data for months at a time between scheduled test, calibration, and maintenance periods. Precision and reliability are top requirements for all elements of the ASMR.

Data Acquisition Requirements

The heart of the ASMR is an Agilent Acqiris U1067A PCI digitizer card. Requirements for this card are quite extensive. The application calls for high reliability, high signal-conversion fidelity, and high throughput. An important, specific goal is to eliminate or reduce the sample jitter between the moment the digitizer triggers and the moment that the first data sample is taken.

The digitizer makes extensive use of proprietary ASICs, which support a calculated MTBF in excess of 20 years. This circuitry reduces the number of individual components, improves power management, and lessens cooling requirements. A patented cooling scheme allows the cards to run at safe and stable operating temperatures. Power consumption for the PCI card is less than 15 W.



Most PCI, CompactPCI, or PXI digitizers suffer from a sampling jitter of ± 1 sample when the digitizer triggers. To combat this problem, a time-to-digital converter (TDC) has been incorporated – one that measures the time between the trigger moment and the first data sample taken after the trigger. This time interval, measured with a resolution as low as 5 ps, allows for precise placement of the acquired waveform (Figure 3). The availability of the TDC in a waveform digitizer improves the accuracy of waveform arithmetic such as addition, multiplication, averaging, and correlation.

Figure 3. Eliminating timing uncertainties

The proprietary ASICs, such as input circuits, clock-, analog-to-digital converters (ADCs), and demultiplexers, are essential building blocks to maximize the conversion fidelity of acquired signals. The digitizer boasts an effective rating above 7 bits (8 bits nominal) at lower frequencies and well above 6.5 bits at higher frequencies. High-speed direct memory access data transfer in excess of 100 MB/s also is required for this application.

Trigger-to-Data Correlation

To maintain precise time correlation between the trigger point and the first data sample, the following applies:

Based on the ASMR system's rather unusual sampling rate of 60 MS/s, Acqiris customized the digitizer card by increasing the maximum sampling speed from 1 GS/s to 1.2 GS/s. Waveforms acquired at that rate will be sampled by a factor of 20 times faster than actually is required.

Data readout begins with the first 1.2-GS/s point acquired after the trigger. Further samples are decimated by a factor of 20 to obtain the desired virtual 60 MS/s. In this way, the uncertainty between trigger timing and the moment the first sample is taken is always less than one sample interval or $1/1.2 \text{ GS/s} = 833 \text{ ps}$, small in comparison to the overall 60-MHz cycle.

Fast Transfer Techniques

A rearrangement in the driver software allowed data to be recorded into known memory addresses rather than into circular memory buffers. This fixed address arrangement creates a so-called start-on-trigger operating mode in which the beginning of the record immediately follows the trigger event. In this mode, it is not possible to log pre-trigger data, but this is not a requirement of the ASMR application.

The great advantage is elimination of the software overhead associated with address queries. Combined with the low overhead of the IRIX operating system, reduced address overhead allows data acquisition, readout, rearming the digitizer, and real-time data analysis to occur within the 244 μ s available to process a radar signal return.

Overall Performance

Overall radar-data quality exceeded expectations. The digitizer's inherent high-fidelity data conversion and the use of x20 oversampling to reduce trigger-to-sample jitter provided very stable ASMR displays. Data fidelity and precision timing are critical for accurate position display of airplanes and other vehicles. A very low level of timing jitter avoids the appearance of objects jumping back and forth in the image, a characteristic of systems with less fine time resolution. From first indications, the actual spatial resolution of the system is around 25 cm, so the design goal for detecting of objects as small as 1 m² has been far exceeded.

Future Developments

Over the last few years, the FAA has contracted to install ASMR systems at several major airports in the nation and is expected to contract for many more. Future systems are expected to operate at twice the current resolution with 8,192 radar returns/s of 2,048 data points each. Only 122 μ s will be available to obtain and transfer data to the Silicon Graphics workstation. In this instance, the digitizer will acquire in a special PCI-triggered burst-streaming mode, allowing direct data streaming from the ADC to the PCI bus at transfer rates in excess of 100 MB/s, the sustained throughput rate of the PCI bus.

Product specifications and descriptions in this document subject to change without notice.

For more information on the Acqiris product line, sales or services, see our website at:
www.agilent.com/find/acqiris

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