ITEM 14
Analogue to Digital Converters

Analogue-to-Digital Converters

Analogue-to-digital converters, usable in the systems in Item 1, having either of the following characteristics:

(a) Designed to meet military specifications for ruggedized equipment; or,

(b) Designed or modified for military use; and being one of the following types:

  (1) Analogue-to-digital converter "microcircuits," which are "radiation-hardened" or have all of the following characteristics:

    (i) Having a quantisation corresponding to 8 bits or more when coded in the binary system;

    (ii) Rated for operation in the temperature range from below minus 54 degrees C to above plus 125 degrees C; and

    (iii) Hermetically sealed.

  (2) Electrical input type analogue-to-digital converter printed circuit boards or modules, with all of the following characteristics:

    (i) Having a quantisation corresponding to 8 bits or more when coded in the binary system;

    (ii) Rated for operation in the temperature range from below minus 45 degrees C to above plus 55 degrees C; and

    (iii) Incorporating "microcircuits" listed in (1), above.

Produced by companies in

- France
- Germany
- Israel
- Japan
- Russia
- Sweden
- United Kingdom
- United States

Nature and Purpose: Analog-to-digital converters (ADCs) are electronic devices for converting an analog signal, which is a continuously varying voltage, to digital data, which are patterns of "1s" and "0s." These converters allow the analog outputs of various devices such as sensors, accelerometers, and gyros to be understandable to digital devices, such as digital signal processors (DSPs) and computers.

Method of Operation: In its simplest form, an ADC is a voltmeter with a binary "word" as its output. The longer the word (i.e., the more "bits" per word), the more accurately the input voltage can be represented. For example, an 8-bit word representing a voltage range of zero to one volt provides 256 discrete values. With one word assigned to zero, this results in 255 increments of just over 3.92 millivolts each. Increments of 3.92 millivolts limit the theoretical accuracy to plus or minus 1.96 millivolts or 0.196

percent. Raising the frequency at which an ADC can update the output word to reflect rapid changes in the input voltage allows the ADC to convert input signals with high-frequency content. Manufacturers use one of several different circuit design approaches to make the conversion.

Most ADCs are designed to have a linear input-to-output relationship. However, in more elaborate schemes, input voltages are mapped to digital values according to calibration data previously taken from the analog instrument to which the ADC is mated. This mapping allows the ADC to compensate for nonlinearities in the analog measurement.

Typical Missile-Related Uses: Any missile using a digital computer requires ADCs. The ADCs need to work over the temperature range specified above and be hermetically sealed if, like ballistic missiles, they are flown exoatmospherically.

Other Uses: ADCs are in widespread use, with ruggedized parts common in all aircraft, automobile electronic ignition systems, and engine sensors. Other commercial applications include a variety of sensor systems, electronic cameras, and radios. Long-duration spacecraft and satellites stationed in or near the radiation belts require radiation-hardened ADCs, which operate over the temperature extremes indicated. Although the space application requirements are about five times lower than the Annex specification, such systems often use MTCR-controlled ADCs.

Photo Credit: Datel, Inc.

Figure 14-1: The military-grade (top) and commercial-grade (bottom) analogue-to-digital converters appear identical except for part numbers; pin styles are optional to both.

Appearance (as manufactured): Military ADC components are hermetically sealed metal packages in order to ensure operation in adverse environment extremes and to dissipate power associated with high data rates from sensors. Aluminum is the primary metal used for ADC board frames, structures, and heat sinks. ADCs can range from a few centimeters to about 0.3 m or more on a side and weigh from 100 g up to 25 kg. Their package density approaches one-third the density of aluminum.

Integrated ADC assemblies consist of a wide variety of electronic parts that are not readily distinguishable from those used in commercial applications. ADCs may be made of discrete electronic components and resemble other military electronics. Similar military and commercial-grade discrete ADCs are shown in Figure 14-1; they differ externally only in part number. Radiation-hardened ADCs are often packaged on a single printed integrated circuit (IC) board ideal for

use in ballistic missiles, as shown in Figures 14-2 and 14-3. These devices have special design features to make them rugged and resilient to missile environments. Although ADC circuit boards are similar to those for DSPs, they include linear ICs and discrete circuits for buffer amplifiers, multiplexing, or signal conditioning (filters, voltage limiting, etc.). As a result, a larger portion of the ADC circuit board is made up of discrete components (resistors, capacitors, diodes, operational amplifiers, etc.). Printed circuit boards are fiberglass-epoxy with copper heat sinks and traces. Electronics parts are in special metal cases (mostly copper-nickel) with aluminum or gold bond wires and silicon substrates.

Appearance (as packaged): ADC printed circuit board assemblies and modules weigh less than 25 kg. They are encased in plastic bags that are marked to indicate electrostatic sensitive devices, and they are packed in rubber foam or bubble wrap for shock protection inside cardboard boxes.

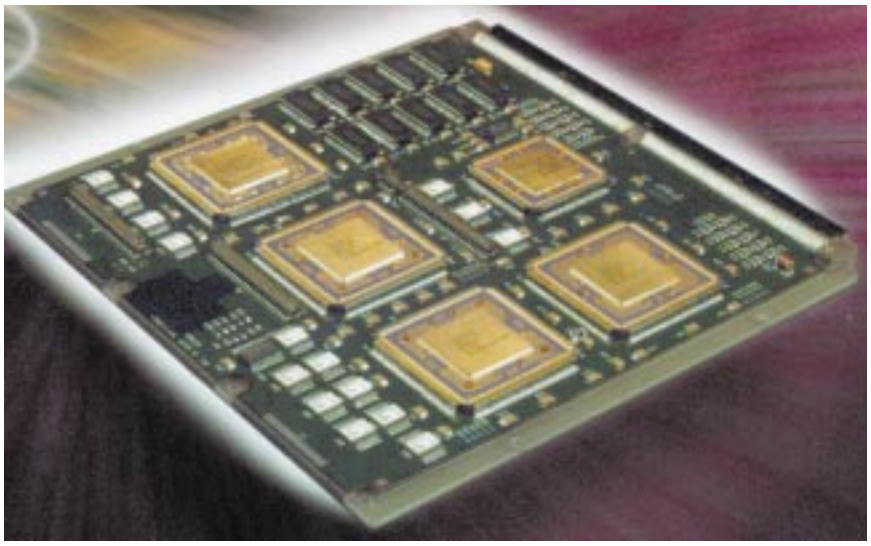

Figure 14-2: Typical analogue-to-digital converter/digital signal processor board.

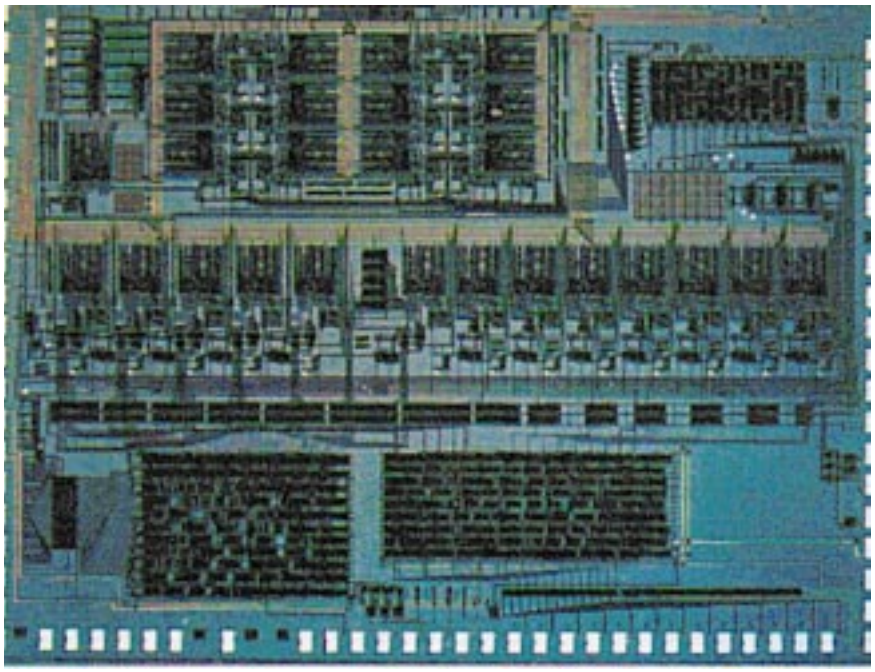

Figure 14-3: A radiation hardened 11-bit analogue-to-digital converter.