marcOgram

Official Publication of The Montreal Amateur Radio Club Inc.
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NEXT MEETING

Tuesday 29 September 2020 via ZOOM.

As you are all aware by now, covid-19, and its 2nd wave has made it unwise to hold in-person meetings right now. Instead, we will hold General Meetings via the Zoom platform. The September meeting will be the first virtual meeting held by the MARC. Below are the details you need to join the meeting. Please note that to avoid chaos, participants will be muted for portions of the meeting. This is to avoid background noises interfering with the meeting, and its presentation.

Join Zoom Meeting: https://zoom.us/j/92218952458?pwd=N1gyREJwYTVkdUdYN0F2RUJXZmdNZz09

Meeting ID: 922 1895 2458 Passcode: 076888 Or by phone 438-809-7799 using the above meeting ID and passcode.
Important: Please use a headset or headphones and make sure to test your mic/camera ahead of the meeting.

We hope to see you there.

Marc-Andre Gingras, VE2EVN
President - Montreal Amateur Radio Club

From the Editor's Desk

So, as you will read on page 4, not only is the largest hamfest in Quebec, the South Shore Ham Fest in Longueuil, cancelled, the place where it is normally held, Place Desaulniers, has been sold and will be demolished for more housing.

DRAT! This COVID-19 thing is wreaking havoc with everyone's "normal" lives. The Longueuil hamfest committee and the South Shore Amateur Radio Club are in the same boat as MARC; we both need to find another venue to hold another potential hamfest once indoor groups are permitted.

In brighter news, on this page you will find the new improved ways of renewing your membership. If you renew on the MARC web site, you can use PayPal or Interac; the paper version is for payment **by cheque only**.

73 de Nora, VA2NH

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Membership Time!

It is that time of the year again! September 1st is the start of the new membership year. We'd like to see you back.

You can either complete the form online at
https://marc.ca/memform/
and pay with PayPal or Interac e-Transfer (new this year), or you can print the membership form and post it with your cheque.
You'll find the pdf form here:
https://marc.ca/membership/marcform2021.pdf

We hope to see you soon.

Marc-Andre Gingras, VE2EVN
President - Montreal Amateur Radio Club

The MARCogram is published nine times per year on the second to last Wednesday of September through June, excepting December by the Montreal Amateur Radio Club. Advertising and copy deadline is one week prior to publication.

Annual fees are:

General Members	... ...	$30.00
Family Members (per family)	...	$35.00
Postal delivery of MARCogram	…	$ 5.00

The membership year runs from September 1 to August 31. Memberships received on or after June 1 commence immediately and extend through the subsequent membership year - covering a period of up to fifteen months.

Directors

President:	Marc-André Gingras, VE2EVN… ve2evn@marc.ca
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Club Call Sign: VE2ARC

Club Website: http://www.marc.ca

Repeaters

VE2BG 147.06 MHz (+)

Owned and operated by the Montreal Amateur Radio Club. Currently OFF AIR, looking for a new location..

VE2RED 147.27 MHz (+) 103.5

On the air from Ridgewood Ave. in Montreal; CTCSS tone of 103.5 Hz for access. Thanks to Claude Everton, the VE2RMP group and Metrocom for making this possible.

The repeaters are open to all amateurs.

Meetings of the Board of Directors

Meetings of the Board of Directors are held on the first Tuesday of the month (Aug to June) at 19:30 on-line using the Zoom platform. The club no longer holds in-person board meetings. If you have questions, concerns or suggestions for the Board to discuss, please send an email to ve2arc@marc.ca for inclusion to the meeting agenda.

Club Activities

Monthly Meetings are by ZOOM

(last Tuesday of the month)

Sep 29 - Marc-André, VA2EI, Operating in Ireland.
Oct 27 - AGM
Nov 24 - Leo, VE2SI, TBA

Every Wednesday, @ 20:00 (00:00Z), go to the net on VE2RED. See page 3.

Radio Classes

A basic level course is held starting in January of each year. If you know of anyone interested in taking the course they should send a message to: classes@marc.ca

MARC Hamfest

The 2020 MARC flea market has been cancelled.

It will be back next year but we still need a good location. Any ideas? Please contact any of the board members.

Ideas are welcome!

Go to http://www.marc.ca/fest/fest.html for more information as it happens.

Incoming QSL card service

As has been mentioned in previous MARCograms, we are resuming the club's service of having incoming QSL cards sent to the club for members to pick up at meetings. This is a service which we are offering to our members which both saves the individual members money as well as makes more efficient use of our collective resources.

If you would like to avail yourself of this service please send an e-mail to qsl@marc.ca and we will add you to the list of cards that the incoming bureau sends to the club and bring them to the monthly meetings.

CW Classes

By Leo VE2SI

Some members have expressed an interest in learning what is now called the International Morse Code and adding CW to their operating capabilities.

If you're interested send an email to VE2ARC@marc.ca and indicate your level of interest.

SolderSpot

Group build Power Supply Project - By Leo VE2SI

If you're interested and even if you've spoken with me before, please send an email to VE2ARC@marc.ca and indicate your level of interest.

Participation is open to everyone and MARC membership is not a requirement.

Upcoming Fleas/Events

2020

What: HARC Hamfest 2020
Who: Hamilton Amateur Radio Club
When: **CANCELLED**
(03 Oct, 2020)
Where: Ancaster Fair Grounds, Ancaster, ON

What: NEAR-Fest XXVIII
Who: New England AR Festival
When: **CANCELLED**
(16-17 Oct, 2020)
Where: Fair grounds, Deerfield NH

What: Montreal South Shore Hamfest
Who: Club RA Rive-Sud de Montréal
When: **CANCELLED**
(17 Oct, 2020)
Where: Place Desaulniers, Longueuil, QC
MORE DETAILS PAGE 4.

2021

What: Iroquois ARC Fleamarket
Who: Iroquois Amateur Radio Club
When: Saturday, 3 Apr 2021
Where: Iroquois ON

What: NEAR-Fest XXIX
Who: New England Amateur Festival, Inc
When: Fri & Sat, 30 Apr & 1 May, 2021
Where: Deerfield Fairgrounds Deerfield, NH

What: London Vintage Radio Club Flea Market
Who: London Vintage Radio Club
When: Tuesday, 8 Jun, 2021
Where: Guelph, ON

Test Equipment: The Basics and Beyond

By Leo Nikkinen, VE2SI
leo49@videotron.ca

Chapter 4, Analogue to Digital Converters.

Introduction.
Previously, we've looked at some basic test equipment, such as voltmeters and ammeters, and encountered both analogue and digital displays. While the most obvious difference was the display - a meter or numbers, the electronics behind a digital display allows for an improvement in performance.

Analogue meters are limited by the mechanics of a coil rotating in a magnetic field and the precision to which the position of the needle or pointer can be read relative to the scale. Reading a value that's between the marks on the scale requires some interpolation by the observer. The accuracy of the scale, the rotation of the coil as a function of current and reading error all combine to limit the accuracy of mass-produced analogue meters to no better than +/-2% of full scale.

(Continued on page 5)

VE2RED Tuesday Net Report

Any discrepancies, please inform Leo, VE2SI

Please join us every Wednesday evening at 20:00 local on VE2RED on 2m output frequency of 147.270 MHz (+600 kHz input offset) CTCSS tone of 103.5 Hz. Everyone is welcome.

We have a few Net operators hosting it, but we're always interested in adding to this team if you're interested. Send me an email if you would like to try out Net Operations for an evening.

Marc-Andre, VE2EVN
President - Montreal Amateur Radio Club

2020-08-05 (Tue) & 2020-08-12 (Tue), No records

2020-08-19 (Wed) Net commenced 20:00 local, 00:00Z
Net control Marc-André, VE2ARC (VE2EVN)
VE2ZPZ Pawel
VA2LEQ, Lee, Laval
VE2WRH, Wayne, Cote St. Luc
VE2MVY, David, Oka
20:41 Net closed
5 check-ins

(Continued on page 4)

(Continued from page 3)

2020-08-26 Net commenced 20:02 local, 00:02Z
Net control Marc-André, VE2ARC (VE2EVN)
VE2SI, Leo, St-Lazare
VE2EGN, Eamon
VE2WRH, Wayne, Cote St. Luc
VA2LY, Lubo
VA2EJC, Chris
VE2BQS, Norm
VE3???
20:54 Net closed.
7 1/2 check-ins
Discussion: latency for VOIP applications., lightning storm, ant disconnect or not?

2020-09-02 Net commenced 20:00 local, 00:00Z
Net control Leo, VE2ARC (VE2SI)
VA2ASS, Andy, Cote St. Luc, 25W
VE2ZPZ, Pawel
VA2NH, Nora, St-Lazare
VE2FSE, Frank, Lachine
VA2LEQ, Lee, Laval
VE2LJV, Sam, DDO
KD????
20:43 Net closed.
7 1/2 check-ins
Discussion: tubes vs. solid state equipment.

2020-09-09 Net commenced 20:02 local, 00:02Z
Net control Pawel, VE2ARC (VE2ZPZ)
VE2SI, Leo, St-Lazare (in rush to buy PC)
VA2NH, Nora, St. Lazare (in rush to buy PC)
VA2ASS, Andy, Cote St. Luc
VE2FSE, Frank, Lachine
VA2LY, Lubo, CW on the repeater
VE2PVI, Pardo
21:28 Net closed.
7 check-ins.
Discussion: directories of nets, CW on repeater.

2020-09-16 Net commenced 20:01 local, 00:01Z
Net control Leo, VE2ARC (VE2SI)
VE2ZPZ, Pawel
VA2LEQ, Lee, Laval
VE2WRH, Wayne, Cote St. Luc
VE2MVY, David, Oka
21:06 Net closed.
5 check-ins.
Discussion: 6m ants, GT890, necessary tools, battling COVID-19, contacting ISS repeater.

Longueuil 2020 Hamfest Cancelled.

Please be informed that the 27th edition of the Longueuil Hamfest, scheduled for October 17, 2020, has been cancelled.

After reflection on the possibility of holding this event, taking into account the social distancing measures related to COVID-19 and keeping in mind the age of our volunteers and visitors we doubted the possibility of holding the event safely.

We have now learned that Place Desaulniers has been sold and that the new owners cannot host our activity in 2020. The building will be demolished to make way for housing.

On July 10, we have also received an email from Pierre, at Radioworld, informing us that Radioworld would no longer participate in any hamfest in 2020.

The Longueuil hamfest Committee and the board of directors of the Montreal South Shore Amateur Radio Club are sorry to take the decision to cancel the largest hamfest in Quebec.

We are already working on the organization of Hamfest 2021.

To contact us : info@ve2clm.ca

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(Continued from page 3)

While methods for converting of a voltage, current or other physical parameter into a numerical value have been known for at least 70 years, the widespread application of that technology didn't occur until the development of integrated circuits and economical digital displays. Key to the digital voltmeters and oscilloscopes that dominate today's electronics market is the analogue-to-digital converter, or ADC. An ADC takes a continuously variable parameter, such as a voltage, and converts it into a numerical, or digital, value. ADCs use a variety of techniques to accomplish this conversion, each with advantages and drawbacks, and areas of applicability. Modern ADCs can provide a resolution of 1 part in 2,000,000 or 0.00005%, although overall measurement accuracy will be reduced by factors other than resolution, including measurement technique and calibration uncertainties.

For simplicity the following discussion will refer to the conversion of a voltage into a digital value, however the basic technique can be used to convert any electrical parameter into a numerical value. Practical digital voltmeters include resistive dividers to extend the measurement range of the ADC beyond the ADC's maximum input voltage and a high-impedance buffer amplifier to isolate the device under test (DUT) from any circuit loading effects produced by the ADC.

As will be seen, several types of ADCs rely on an integrator (an operational amplifier with a capacitor in the feedback loop) and a pulse generator or precision oscillator to produce timing pulses that are counted to produce the ADC's digital output.
The conversion process requires that the unknown voltage not vary over the measurement period. This condition would be severely limiting but, fortunately, techniques for measuring the voltage of a rapidly varying signal are, as we will see, available.

Wilkinson ADC

One of the first techniques for converting an analogue voltage into a numerical value was developed in 1950 by D.H. Wilkinson, a British nuclear physicist. Nuclear research frequently requires the accurate recording of pulse heights, essentially the energy of alpha, beta or gamma rays. Measurement and recording of the pulse height by digital circuitry with a resolution much greater than that of analogue circuitry is needed. The essential elements of the Wilkinson ADC are shown above.
The analog input signal, usually buffered by an amplifier, is used to

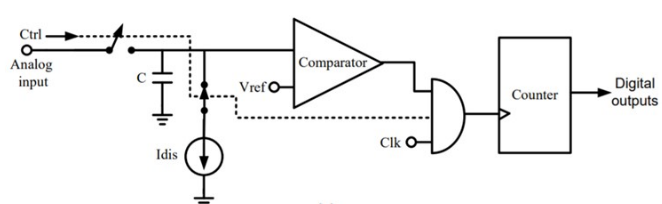

Figure 1. Wilkinson ADC.

charge a capacitor (C) to the input voltage. Digital conversion involves disconnecting the analog input from the capacitor (using an electronic switch) and then using a current source (Idis) to discharge the capacitor. During discharge, clock signals (Clk) will be counted by a digital counter. The comparator will change state when the capacitor reaches the reference voltage Vref (set to 0 volts) and the counting of clock pulses will stop. The net result is that the clock pulse count in the digital counter will be a measure of the time it took to discharge the capacitor which is proportional to the analog input voltage. Either through calibration or by calculation, a conversion factor relating the analog input voltage to the pulse count can be derived.

The Wilkinson ADC circuit has largely been replaced by other conversion methods.

Single-Slope ADC

The simplest ADC uses the voltage to be measured to charge the capacitor (C) in an integrator circuit, as shown below. The time required to charge the capacitor is determined by the value of the resistor (R), the capacitor and the applied voltage (Vin). The voltage across the capacitor and the integrator's output voltage increase linearly with time. The analogue-to-digital conversion process involves measuring the time required for the integrator's output to reach a reference value (Vref), as determined by a voltage comparator connected to the integrator output. Time is a parameter that can be measured easily by digital circuitry and involves nothing more complex than counting the number of clock pulses produced by a digital clock during the integration of the unknown voltage.

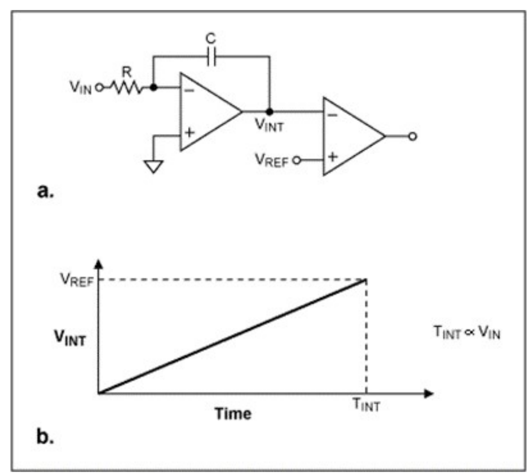

Figure 2. Single-Slope ADC.

Put simply, count the number of clock pulses for the integrator's output to reach the Vref value and that count will be proportional to the input voltage Vin. Calibration with a known voltage source will yield a time-to-voltage calibration factor. Knowing the component values, R and C, it is also a simple matter to calculate the pulse count (time)-to-voltage conversion factor.
The single-slope ADC is easy to implement but it suffers from a number of weaknesses. Crucial to the conversion process are the temperature and time stability of the resistor and capacitor used in the integrator. While stable resistors are relatively easy to obtain, capacitance usually varies with temperature and can drift with time (aging). This will result in a conversion factor that changes with time and temperature. Non-ideal behaviour of the integrator and

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comparator (input offset voltage and offset current) will also affect the conversion obtained with a single-slope ADC.

Successive analogue-to-digital conversions are performed by discharging the integrating capacitor which poses some problems as capacitors do not discharge fully when their terminals are shorted together. The conversion time for a single-slope ADC also varies with Vin. Although stable clocks are easy to produce, this method works best when using a clock source with quartz oscillator stability.

Dual-Slope ADC

The basic approach of the single-slope ADC is sound, in that it uses easily counted clock pulses to effect the analogue-to-digital conversion. The problems arise from the non-ideal characteristics of the integrating capacitor and other integrator components. The dual-slope converter uses the basic circuit of a single-slope converter (an integrator and comparator) and a slightly more complex measurement process to cancel out the effects of component drift and voltage offsets.

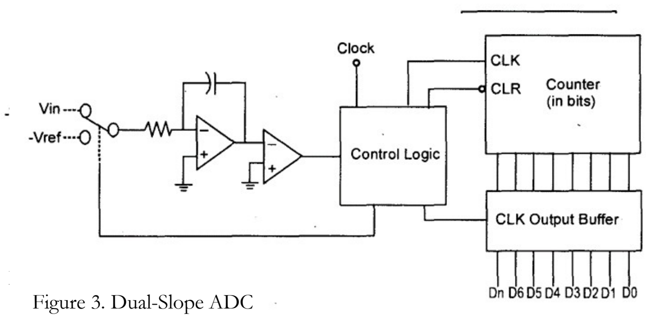

Figure 3. Dual-Slope ADC

Shown above, the dual-slope converter is a single-slope converter in which the integrator input can be switched between the unknown input voltage and a reference voltage Vref. The Vref voltage is usually opposite in polarity to Vin.

Let's take a dual-slope ADC through one measurement cycle and see how it works. A measurement starts with the integrator's capacitor in a discharged state; a measurement cycle starts when the integrator's input switches to Vin. The integrator's capacitor then charges for a known period, as determined by counting a pre -set number of pulses from the clock oscillator. The integrator's output voltage will be determined by the resistor (R), capacitor (C) values, and Vin, the voltage that we wish to measure. At the end of the charging cycle, the integrator input is switched to a reference voltage -Vref and the integrator's capacitor is now discharged until it reaches zero volts. The number of clock pulses required for the integrator output to reach zero volts is proportional to Vin. Problems associated with capacitor aging are now eliminated since it is the ratio of the number of (fixed length) charging and (variable) discharge clock pulses that provides the measurement of Vin. While the actual voltage that is reached during the charge cycle will change with any variations in the value of C, the ratio of the number of charge and discharge clock pulses will remain unchanged. Likewise, input offsets in the integrator and comparator will occur for both the charge and discharge cycles of the dual-slope ADC and will cancel out. Variations in clock frequency also have no effect on the measured value of Vin since it is the ratio of the number of clock pulses that is used to calculate Vin.

The dual-slope ADC is significantly more stable against changes in temperature and aging of circuit components. As with single-slope ADCs, the time required for a conversion is limited by the speed of the integrator and other analogue components, and the time required for the stepwise discharge of the integrating capacitor.

Most digital voltmeters/multimeters and other equipment that must provide accurate and precise measurements use dual-slope ADCs. Dual-slope ADCs can easily achieve precision into the 5-1/2 (200,000 counts) and 6-1/2 digit range (2,000,000 counts).

Successive Approximation Register (SAR) ADC

The ADCs that we have examined thus far involve counting clock pulses and have a conversion rate (conversions/second) that is limited by the need to count a large number of clock pulses. The complementary device to an ADC, the digital-to-analogue converter (DAC), has no such limitation. A DAC uses a digital input (a binary or binary-coded decimal number) to produce a voltage proportional to the binary number. We will omit discussion of DAC operation, and point out that high-speed DACs are able to achieve conversion rates of hundreds of MHz and higher, depending on the resolution required.

How does a DAC make it possible to perform an analogue-to-digital conversion? The basic process is fairly straightforward, and it does require some circuitry in addition to the DAC. As shown in the diagram below, the SAR ADC compares the output of a DAC to Vin, the voltage to be measured.

As mentioned above, DAC's convert a binary input into a voltage (or current) proportional to the binary number. The SAR ADC's logic successively varies the DAC input (one bit at a time), starting

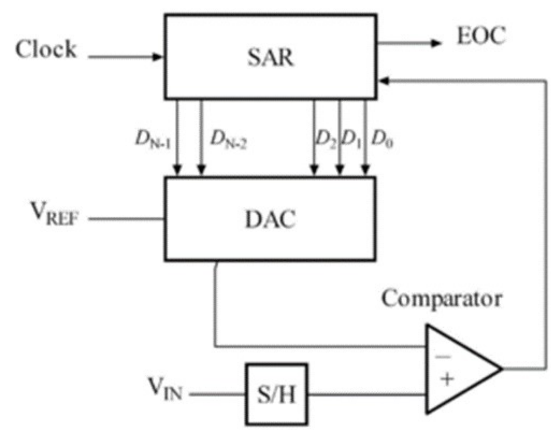

Figure 4. Successive approximation ADC

with the most significant bit, while comparing the DAC output to Vin. By adjusting the DAC's binary input D0, D1, D2, … the DAC's output voltage will be made equal to Vin, and that binary number will, once the least significant bit has been set, be equal to

(Continued on page 7)

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the input voltage Vin.

A SAR ADC requires at least one clock pulse per DAC bit but the conversion process takes much less time than (single-slope or dual-slope) integrating ADCs. However, the process isn't as precise as a dual-slope ADC. When all the DAC bits have been set, the End Of Conversion (EOC) signal is asserted and the Register will then contain the final converted Vin.

Direct Conversion (Flash) ADC

A single voltage comparator can be used to determine if a voltage is above or below a given value. A voltage below the reference value will produce a logical output of 0 and a voltage above the reference value will produce a logical output equal to 1. This is essentially a one-bit ADC.

As shown below, additional voltage comparators can be used to increase the resolution of the array of comparators. The advantage of direct conversion is that the voltage comparison process proceeds in parallel in all the voltage comparators, and relatively simple and fast logic circuitry is used to produce the final binary output.

Flash ADCs do not provide the resolution of integrating ADCs or SAR ADCs, but the technique allows high speed operation, well into the giga-conversion/second range. Digital oscilloscopes and high-speed digitizers usually employ flash ADCs.

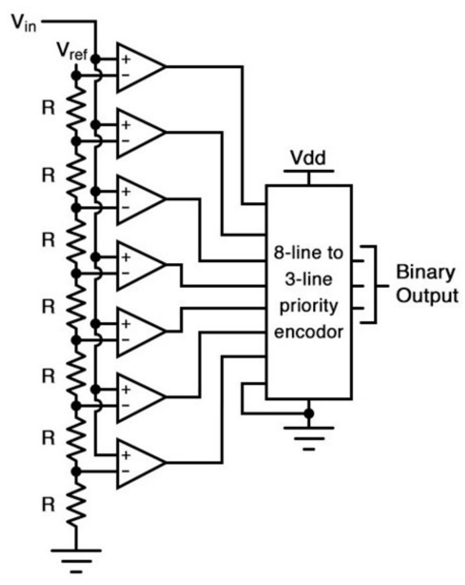

Figure 5. Flash ADC

Novel Technique for an ADC

The semiconductor electronics required for the manufacture of high-speed ADCs, with rates in the range of 1 giga-conversion/second, were not available in the 1960s and 1970s. However, oscilloscopes with bandwidths into the giga-Hertz range were available. In response to emerging requirements for a high-speed digitizer (transient pulses produced by a rapidly evolving nuclear event), Tektronix built an oscilloscope cathode-ray tube (CRT) with a 512 x 512 element silicon diode charge storage array (target) in place of the CRT's usual phosphor screen. Amplifiers could be built to operate in the GHz range and the electron beam in the CRT can be made to deflect at that speed.

How did it work? The voltage to be measured, Vin, was amplified and applied to the vertical deflection plates of the custom CRT. The electron beam's vertical position on one element of the 512 diode elements in a column would then be a measure of Vin. The diode

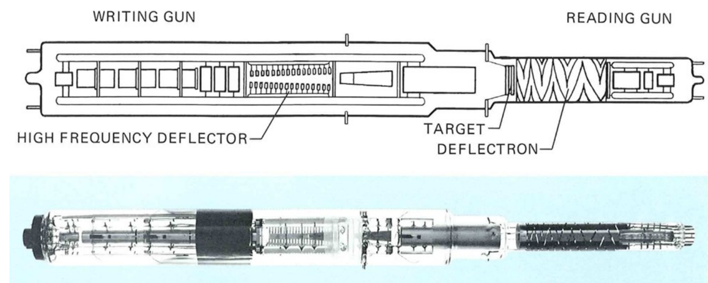

Figure 6. Tektronix R7912 CRT ADC

(target) would acquire and retain the charge deposited by the electron beam. This charge would then be amplified, by a lower speed amplifier and then read out. With 512 vertical elements into which the electron beam could write, this system produced a 9-bit ADC. The next measurement was made by sweeping the electron beam horizontally into the next 512 element vertical array of diodes. In this way it was possible to make 512 sequential 9-bit measurements, with each measurement taking 1 nanosecond. The Tektronix R7912AD Transient Waveform Digitizer was the state of the art in 1973. The work done by the 19" wide x 5.1" high x 28.3" deep, 40 pound (18kg), R7912 has now been superseded by an integrated circuit the size of a postage stamp.

Other considerations

Mentioned briefly was the requirement that Vin not vary during the conversion process. This is not always easy to accomplish, but techniques that allow the measurement of rapidly varying signals have been developed. The solution involves a sample-and-hold or track-and-hold circuit.

As the name implies, these are circuits that, when triggered, will store the voltage applied to the circuit's input and provide that stable voltage as an output. They consist of a capacitor, an electronic switch and some buffer amplifiers. Basically, the capacitor is kept charged at Vin by a buffer amplifier. There is an electronic switch, usually a MOSFET, between the input buffer and the capacitor. When triggered to hold the voltage, the MOSFET switch goes to the OPEN state and the capacitor is left charged at Vin. A high input-impedance amplifier buffers the capacitor voltage and provides a stable signal for the ADC to convert. Leakage currents will limit the time for which the capacitor will remain charged sufficiently close to Vin. With a suitable selection of components, this "hold" period can be made long enough to allow an ADC to digitize the capacitor's voltage.
I omitted discussion of any departures from ideal ADC behaviour, such as non-linearity, missing codes or quantization error as the intent was to describe the way in which ADCs work and are used in
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test equipment.

Summary

The above is not an exhaustive list of ADC technology, but it covers the essentials as they apply to most test equipment. Other methods of digitizing analogue signals exist, such as delta encoding and voltage to frequency converters, but they are used for specific applications not related to general purpose test equipment.

While traditional analogue instruments provided the measurement capability, speed, precision and accuracy required for many electronic measurements, advances in microelectronics and analogue-to-digital conversion techniques have allowed the development of digital measurement electronics that yield measurements with accuracies and at speeds that were unobtainable by earlier equipment.

Figure references:
1) PhD thesis, Analysis and Design of Analog Interface Circuits for Capacitive Detector Readout Systems, Mohammad Beikahmadi, UBC 2017
https://open.library.ubc.ca/cIRcle/collections/ubctheses/24/items/1.0351958
2) https://www.maximintegrated.com/en/design/technical-documents/tutorials/1/1041.html
3) https://electronics.stackexchange.com/questions/105751/why-charging-time-is-same-and-discharge-time-is-different-for-two-inputs-in-dual
4) https://en.wikipedia.org/wiki/Successive-approximation_ADC
5) https://www.allaboutcircuits.com/textbook/digital/chpt-13/flash-adc/
6) http://pergelator.blogspot.com/2018/04/tektronix-r7912.html