Using ActiveX Controls to Enhance the Analysis Capabilities of Deep Memory and Mixed Analog/Digital Signal Oscilloscopes

Application Note 1445

Who should read this document?

This application note is for digital design engineers in R&D working with both analog and digital components. This document discusses the use of *ActiveX™ Control*, a form of software driver that lets designers control their oscilloscopes and other instruments from within popular analysis programs such as Microsoft Excel®. In particular it examines the benefits of using ActiveX controls with deep memory and mixed analog/digital oscilloscopes.

Benefits of deep-memory oscilloscopes

Many design engineers now use deep memory (> 1M byte) oscilloscopes as their primary characterization and debug tools. Deep memory is valuable because it enables a scope's sample rate to be kept high even as its sweep speed is reduced, thereby avoiding aliasing and maintaining measurement accuracy. Acquiring more points also opens the door for extensive data analysis on the part of the scope user.

No matter how complete a scope's feature set is, there will always be cases where engineers need to do their own custom analysis on the acquired data. But what's the easiest way to access the data and perform the analysis? Test engineers, who program instruments for a living, often have their own test executives and analysis tools that are optimized for ATE purposes. Design engineers, on the other hand, desire simple methods that let them perform their data analysis quickly and then move on to other design tasks.

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ActiveX controls for embedding software components

ActiveX grew out of Microsoft's Object Linking and Embedding (OLE) technology and is a way for embedding software components inside host applications, which are called *containers* in Microsoft lingo. ActiveX controls have been available from scope vendors such as Agilent, LeCroy, and Tektronix for several years, but it's worth pointing out why they are especially useful now that deep memory is so prevalent.

The short answer to this question is efficient connectivity. For years engineers have used floppy disks to transfer data from their scopes to their PCs, but deep waveform records are too large for this "sneaker net" process. Scopes with network connections allow the data to be saved to a hard drive on the PC or perhaps on the scope itself, and from there it can be read by the analysis program. But this is inefficient for deep records because the complete data set must be transferred twice, once when writing to the disk and once when reading from it. ActiveX controls make use of the network but avoid the file system, transferring the data directly to the analysis program.

Of course, PC-based scopes offer the possibility of running the analysis program on the oscilloscope itself, either as a separate application or as part of a subordinate process initiated by the scope software. This approach has some appeal, though in practice many

engineers prefer to keep their scopes and their PCs separate. They don't want to clutter their scopes with other applications and dynamic link libraries (DLLs), and they don't want to pay for additional licenses for their software packages. A scope may be shared among several users with their own preferences for how to organize their analysis programs. Additionally, the scope usually won't have the display size and resolution engineers have come to expect from their desktop PCs. For most engineers the PC is still the preferred home base for working with design documents and data, including measurement data from test instruments.

Toolbar operations

ActiveX controls capitalize on the PC-centric nature of today's engineering environment. They typically consist of an add-in toolbar for accomplishing common operations, along with an underlying control object that delivers a programming interface appropriate to the given host application. Typical host applications include Excel and MATLAB®, as well as full programming environments like Visual Basic and Visual C++.

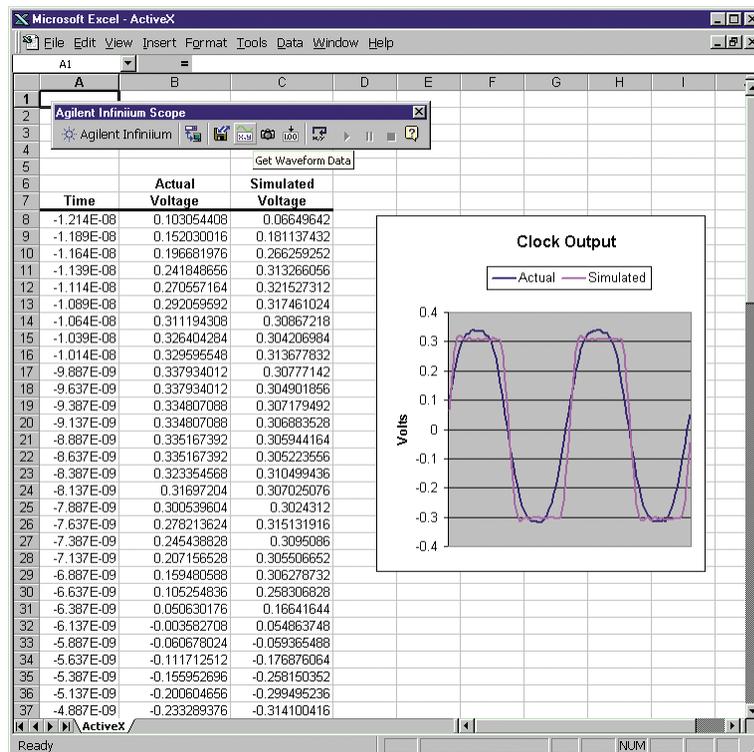Figure 1 shows Agilent's Infiniium IntuiLink® toolbar [1] installed in Excel. The toolbar

Figure 1. Agilent Infiniium toolbar installed in Excel using ActiveX controls.

buttons let users save or load scope setups, import waveform data, fetch measurements, or transfer a screen shot. In the figure the user has imported 100 data points from the scope and has placed them in an Excel graph, where they are being compared to the expected data generated by a simulation program. Tektronix and LeCroy offer similar ActiveX controls called TekVISA [2] and ActiveDSO [3], respectively. Agilent also provides IntuiLink controls for many of its other test and measurement products.

Instrument control

Beyond the toolbar operations, these controls let you program your scope from within Excel using Visual Basic for Applications (VBA). All scripting is performed in Excel using VBA, so it's natural to use it for instrument control too. You can run chunks of VBA code by invoking an Excel macro with a keyboard shortcut, but an easier way is to run the code in response to a graphical button press.

Data import with deep memory scopes

Figure 2 shows a button on the spreadsheet and the code block that has been created. You can see that 4 million data points are being fetched from the oscilloscope. This is too much data to place on the spreadsheet (Excel columns are limited to 64 K rows each), but we can analyze it nicely using a VBA array.

In this case we are calculating the signal's average voltage over two subsets of the data: the pre-trigger portion and the post-trigger portion. By default the scope positions the trigger point in the middle of the acquisition record, so the pre- and post-trigger portions are equal in length. This sort of analysis is valuable when the trigger condition corresponds to a change in the character of the signal, for example when a serial communications signal changes from its frame sync state to its data payload state.
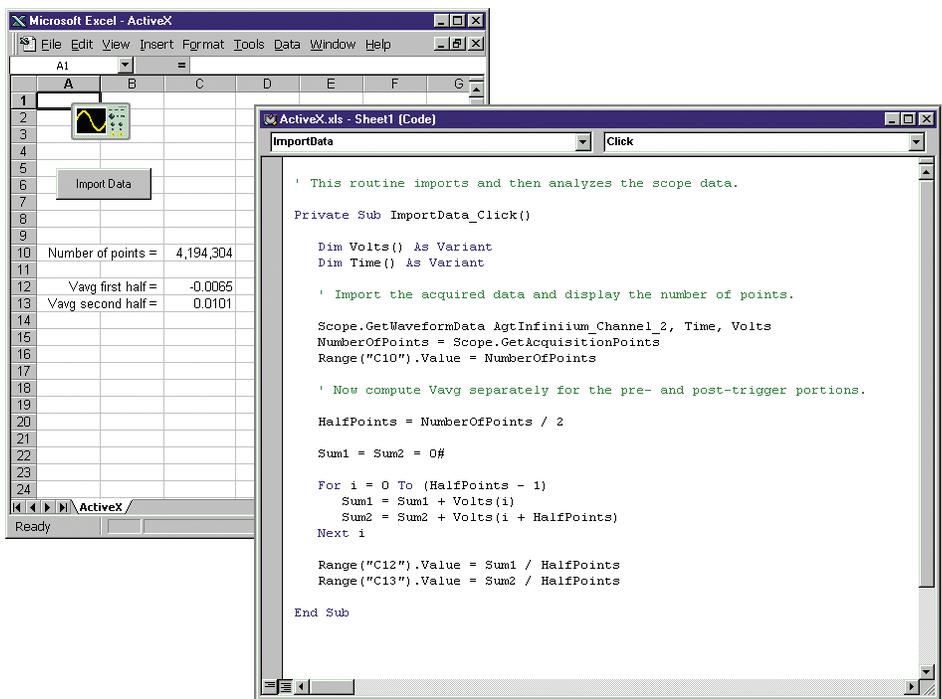


```
' This routine imports and then analyzes the scope data.

Private Sub ImportData_Click()

    Dim Volts() As Variant
    Dim Time() As Variant

    ' Import the acquired data and display the number of points.

    Scope.GetWaveformData AgtInfiniium_Channel_2, Time, Volts
    NumberOfPoints = Scope.GetAcquisitionPoints
    Range("C10").Value = NumberOfPoints

    ' Now compute Vavg separately for the pre- and post-trigger portions.

    HalfPoints = NumberOfPoints / 2

    Sum1 = Sum2 = O#

    For i = O To (HalfPoints - 1)
        Sum1 = Sum1 + Volts(i)
        Sum2 = Sum2 + Volts(i + HalfPoints)
    Next i

    Range("C12").Value = Sum1 / HalfPoints
    Range("C13").Value = Sum2 / HalfPoints

End Sub
```

Figure 2. A graphical button on a spreadsheet and the code block created. ActiveX allows the user to program an oscilloscope from within Excel.

The code in Figure 2 imported the waveform data using the IntuiLink function **GetWaveformData**. This is a driver function that encapsulates several GPIB (IEEE 488.2) oscilloscope commands. ActiveX controls also let native GPIB commands be used.

In Figure 3, two 4 M waveforms have been imported using the scope's **DATA?** query. In this case, the native commands provide an efficiency gain because the floating point voltage and time values don't need to be computed and only one byte per point is transferred. (**GetWaveformData** uses two bytes per point, which is more accurate but also slower.)

Once the two waveform arrays have been filled, the code computes the *correlation* [4] for a variety of delay values. Correlation is useful for assessing the similarity of two signals. The zero-delay correlation of two n-point sampled signals u and v is defined as:

$$C = \sum_{i=1}^{n} u_i v_i$$

More generally, we can shift (delay or advance) one signal by k points and compute its correlation with the other signal. If we want to compare correlations for a variety of k values, it is easiest to pick a fixed window of one signal and correlate it against different regions of the other signal. The window size determines the largest value of k that can be evaluated because there are only a finite number of samples of each signal available.

Mathematically, this is expressed as follows:

$$C(k) = \sum_{i=i_1}^{i_2} u_i v_{i-k} , \;\; -k_{max} \leq k \leq k_{max}$$

$$i_1 = 1 + k_{max}$$
$$i_2 = n - k_{max}$$

The window size is thus $n\text{-}2k_{max}$, which represents the number of products in each of the $2k_{max}+1$ sums. Clearly there is a tradeoff between the window size and
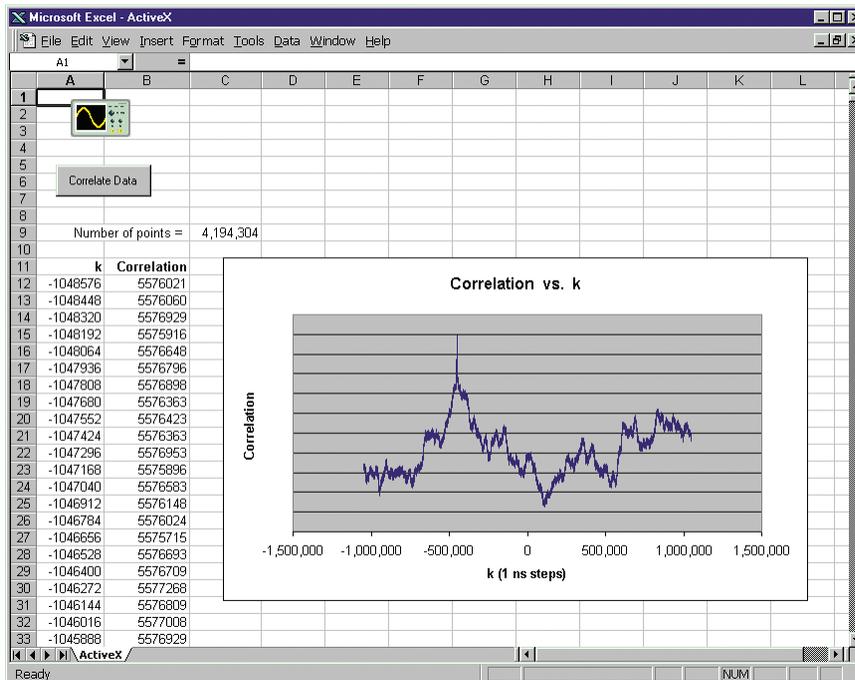
k_{max}. A larger window makes the calculation of each individual correlation more robust, but it means the correlation can be assessed over a smaller range of k values. A smaller window makes the correlation more vulnerable to local similarities, but it lets a larger range of k values be evaluated. Deep memory increases n and reduces the compromise, letting k_{max} be larger while retaining a reasonable window size.
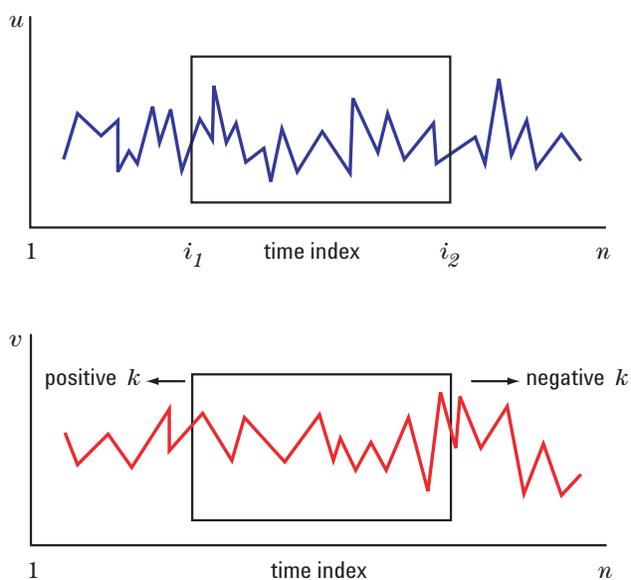
Figure 3. The large data sets that deep-memory scopes provide result in robust correlation analysis and accomodate a large range of index offsets.

The graph in Figure 4 has been computed with k_{max} = 1,000,000. At a 1 GHz sample rate, this means we are assessing time shifts over a full +/- 1 ms range, with a very robust window of 2 M points, or half the acquisition record. Every 128th value of $C(k)$ is plotted in Excel.

The acquired waveforms in this case represent two signals in their quiescent states. The signals are ostensibly independent, but the peak in the correlation graph suggests the waveforms are fairly similar when they are shifted by around k = 500,000 points. Perhaps they are both being influenced by a third signal that is coupling in at different points in the two paths. Or possibly the system includes two correlated sequence generators that are affecting the measured signals. In any case, the deep data from the oscilloscope provides a good place to start the investigation.

Figure 4. Standard queries can import large data sets.

Data import with mixed signal scopes

The ActiveX control can import digital data from the Agilent mixed-signal scopes as well. Figure 5 shows an example where 2 M points of data are imported from the 16 digital channels of the 54832D oscilloscope. The data comes in as byte pairs, with each bit representing a given digital channel.

The analysis here consists of counting the number of 1 and 0 samples of each bit, and also noting the number of net state changes from sample to sample. The counts for each bit are shown in terms of the "One's Density" measure used in communications systems. The value for bit 6 indicates that it is behaving differently from the other bits, which may or may not be intended.

The graph of the state changes shows that over this acquisition, the most common number of nonzero changed bits was 8. (The 0 case is to be expected and indicates that we have sampled the data stream fast enough.) The peak at 8 suggests there may be a counter rollover of some sort in the system. This type of analysis is valuable with high-speed CMOS devices, where changes in state correspond to large current transfers that can interfere with adjacent circuits. Knowing when and how often the largest number of bits change may therefore provide insights into signal coupling issues in a design.
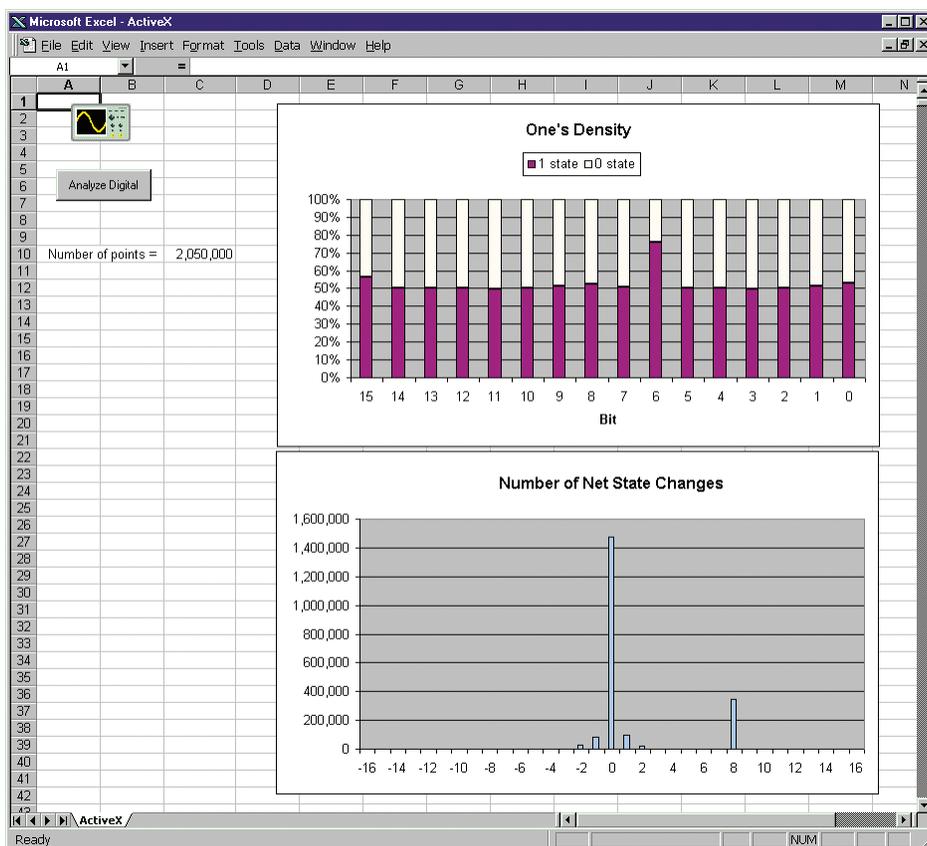

Figure 5. Data imported to a mixed signal oscilloscope for analysis. The one's density measure shows bit 6 is behaving differently from other bits. State change graph indicates a peak at bit 8.

Conclusion

The previous examples are but some of the many types of analysis that are possible once the data is inside of Excel. Excel has numerous math facilities of its own, and when these are combined with the flexibility of user-supplied VBA code, the results can be quite impressive.

As previously mentioned, Excel isn't the only application capable of hosting ActiveX instrument controls. If you are an experienced programmer, you may prefer an even richer environment like C++. New driver schemes associated with Microsoft's .NET initiative are also broadening the options for instrument control. But the ActiveX/Excel combination is a good one for oscilloscope users who need to do deep memory analysis. It's flexible and easy to use, and the price is right, too. Excel is likely already in your toolkit of PC applications, and the instrument manufacturers provide their ActiveX controls free of charge.

References

[1] http://www.agilent.com/find/IntuiLink
[2] http://www.tek.com/Measurement/Support/scopes/tds7000/tekvisa.html
[3] http://www.lecroy.com/Software/ActiveDSO
[4] William H. Press, Brian P. Flannery, Saul A. Teukolsky and William T. Vetterling, *Numerical Recipes in C*, Second Edition, Cambridge University Press, 1993

Related Literature

Publication Title	Publication Type	Publication Number
Agilent Technologies Digital and Mixed Signal Oscilloscopes	Selection Guide	5988-8460EN
Finding Hidden Problems Using Agilent's Deep Memory Oscilloscope: How IBM Solved a Mystery	Customer Success Story	5988-5655EN
Mixed Signal Measurement Solution: Which One Fits Your Measurement Needs?	Application Note 1424	5988-8156EN
Capturing Infrequent and Random Events Using Deep Memory Oscilloscopes	Application Note 1431	5988-8240EN
Spectral Analysis Using a Deep Memory Oscilloscope Fast Fourier Transform (FFT)	Application Note 1383-1	5988-4368EN
Debugging a PCI Bus With a Mixed Signal Oscilloscope	Application Note 1417	5988-7745EN
Mixed Analog and Digital Signal Debug and Analysis Using a Mixed Signal Oscilloscope	Application Note 1418	5988-7746EN

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