HEWLETT® PACKARD

HP E2747/48A
Vector Waveform Generator

Product Overview

dc to 6 MHz

May 1998

Key Features

- **Digital transmitter architecture gives complete control over modulation parameters**
- **Open platform for generating new or unique modulation formats**
- **Generate messages, including protocol**
- **Real-time signal generation from data, or playback mode from memory with variable center frequency and sample rate**

Virtual transmitter improves your time-to-market for new or unique digital communication formats

One of the difficulties in designing and testing new or unique digital wireless systems is that there is no easy way to verify a receiver design, or to test new transmitter modulation schemes in real-world signal environments. Since no commercial hardware yet exists to generate or test signals with these unique modulation schemes and message formats, communications designers have had to resort to a number of cumbersome techniques, including developing custom hardware.

The HP E2747/48A family of baseband vector waveform generators can help with these new types of challenging signals. They let you generate a wide range of digitally modulated signals complete with message protocols. The HP E2747A is a preconfigured PC-format instrument. It contains up to three HP E2748A modules. The HP E2748A Vector Waveform Generator Module is a system builder's element which plugs into one of two supported carriers.

Both products use a flexible, generalized communication source block diagram which closely mimics a digitally modulated transmitter. They take advantage of powerful digital signal processing, and an HP-proprietary application specific integrated circuit (ASIC).

An open platform

Both the HP E2748A vector waveform generator module and the HP E2747A vector waveform generator which uses it, are designed as generalized digital transmitters, with complete user control over the various parameters of the block diagram stages. This open platform approach means that as your signals change, your test equipment can too

Both products include two means of interfacing to them: an easy-to-use, fill-in-the-blanks "soft panel" user interface, and a function library interface for programmatic control. For both user interfaces, the parameters you enter are the same parameters with which you design your system: symbol rate, number of symbol bits, filter coefficients, etc.

The soft panel user interface requires no programming. You can choose the modulation type and its associated parameters, configure the filter stage using the built-in wizard to help synthesize an FIR filter, input a code table and set up message fields.

You can exercise the greatest control by making program calls to the HP E2747/48A function library using Visual C++ and Visual BASIC. With this programmatic interface, you can generate unique signals with extreme flexibility.

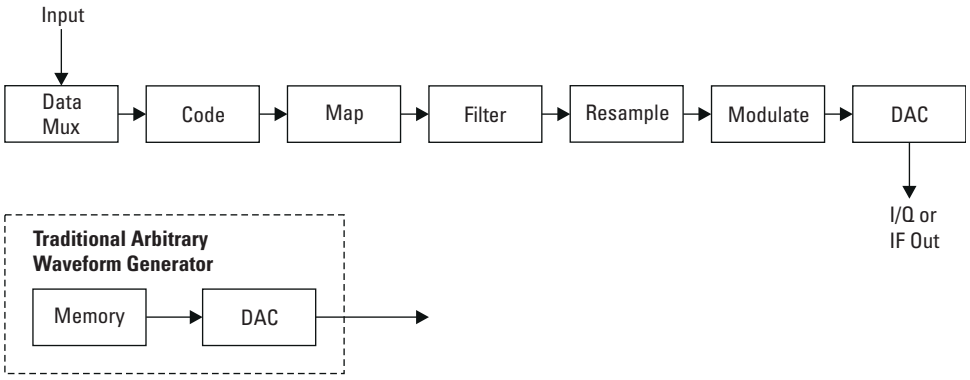


Figure 1. The block diagram of the new Vector Waveform Generator is similar to that of a digital transmitter. Unlike a traditional arbitrary waveform generator which simply replays waveform samples stored in memory, the HP E2747A/48A accepts data as input and actually creates the signal from its constituent parameters.

Generate real world messages — with protocols

Even for standard digitally modulated signal formats, generating arbitrary test messages, including protocol and framing bits, can be problematic. For emerging standards and proprietary modulation schemes, it can be almost impossible.

Currently, designers of new or unique modulation formats often use an arbitrary waveform generator (AWG) to generate test signals. Calculating the mathematical sequence needed to generate any specific message or protocol is difficult and time-consuming, especially when simulating non-ideal conditions such as noise or defective data or protocol.

Creating messages with the vector waveform generator's soft panel user interface is easy to do. Simply set up the message fields using the template provided.

Messages can contain up to 16 fields, each of varying length. Each message field can accept data from four sources: onboard RAM, the onboard pseudo-random noise source, a user-loadable register, or an external file. In addition, using the vector waveform generator under programmatic control, you can feed a real-time data stream from a program source as input to the message fields.

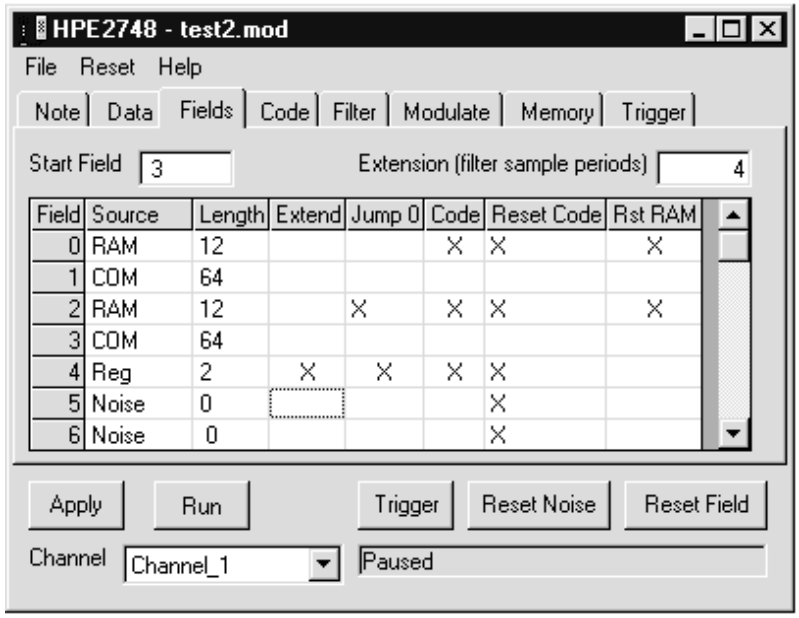
Use any combination of these data sources together to build a custom message with protocol — even for proprietary message formats.

Real-time message generation

Rather than precomputing the output samples and then storing them in memory for playback as with traditional arbitrary waveform generators, the HP E2747/48A generates its output samples by reading the data source selected, applying the signal description, and then digitally computing the signal samples in real-time. This means that you can provide coded or uncoded digital data, and the vector waveform generator applies the modulation and filtering. Since the signal source uses hardware to do this, it can operate at high, and arbitrary, symbol rates.

Even signals stored as samples in memory at one sample rate can be replayed automatically at another rate. The vector waveform generator automatically computes

Generate live messages including protocol. The vector waveform generator steps through each message field, beginning with the field designated in the Start Field box and retrieves data from the indicated data source. You can use the jump0 flag to reset the sequence to field zero and repeat a set of steps in a loop. The code flag sends the data from the source through the coder block. Otherwise, the coder block is bypassed, and the data is presented as symbol codes.



and resamples the output to the desired sample rate and center frequency. For instance, if you develop an amplitude versus sample time waveform profile using one of a variety of simulation tools, you can play it back at a different sample rate simply by changing one parameter — sample rate. There's no need to go back and recompute the simulation file.

Combine this sophisticated hardware with the data FIFO manager built into the vector waveform generation software, and the result is the ability to build and output a data sequence in real time. Now you can transmit an actual message with useful test information such as preamble, sync words, power control etc.—even for your own proprietary formats.

Because the vector waveform generator inputs data rather than pre-calculated samples and calculates the samples in real time itself, it can produce long duration, high-sample rate outputs, such as those needed by certain types of FSK. Combine this with the optimized analog reconstruction filters, and the result is a high quality signal output.

Sophisticated filter synthesis

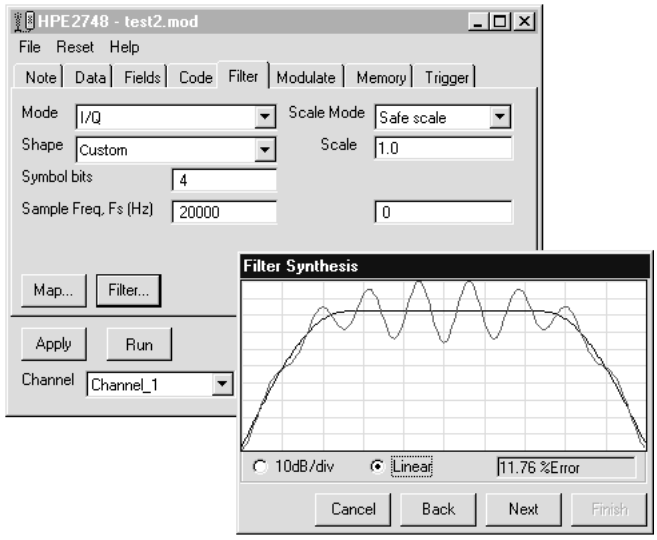
Generating a test signal with the proper filtering for today's digitally modulated signals can be difficult. The HP E2747/48A vector waveform generator provides sophisticated filter synthesis capability to help you with this demanding task.

Choose from several filter types: including Gaussian and flat top, as well as custom filters. Custom filters allow you to cascade together predefined standard filters (raised cosine, root raised cosine, or Gaussian), filters specified with a time-domain impulse response, and filters specified with a frequency domain response. You may use one or all of these three types of filters cascaded together for maximum flexibility.

There's flexibility in how you describe your filter, too. The predefined standard filters allow you to vary the bandwidth and alpha (if applicable). For the time-domain impulse response and the frequency domain response, you can provide the data in either real or complex format, and specify a symmetric or asymmetric response.

Finally, for all filters, you can vary the amount of pass band fidelity vs. stop band rejection you want to have. Your filter design is then shown to you graphically. The end result is unprecedented flexibility in defining the filtering for the signal you want to generate.

Designers can modify and try out various filter designs in minutes using the Filter Synthesis Wizard. Vary the filter parameters, cascade filters using both impulse and frequency responses, adjust the amount of stop band rejection, and more to get the optimal design.



Prototype transmitters

During the initial stages of transmitter design, development engineers may want to vary certain transmitter specifications such as filter frequency response, sample rate, modulation format, framing, coding, and others. The HP E2747/48A vector waveform generator allows users to vary all of these parameters and to generate test signals without the expense of prototype hardware.

Test receivers

Using the vector waveform generator can also improve the effectiveness of the receiver development team. With the test signal provided by the Vector Waveform Generator, receiver designers can begin testing their designs more completely, long before having prototype transmitter hardware. And, they can add impairments to the transmitted signal to test how well their design performs with realistic signals.

Simulate spectral environments with multiple in-band signals

With the increasing number of wireless digital communication services and products offered every day, it is important for manufacturers to know that their equipment will work in a crowded spectrum. To help you meet these demanding system testing requirements, the HP E2747/48A optionally offers multiple output channels for injecting multiple in-band or out-of-band signals. Simulate adjacent channels, other channel co-users, or multipath. For each output channel (up to three in the HP E2747A, more with the HP E2748A in a VXI system) you have independent control of bandwidth, carrier frequency, amplitude, and modulation — all the signal parameters, in fact.

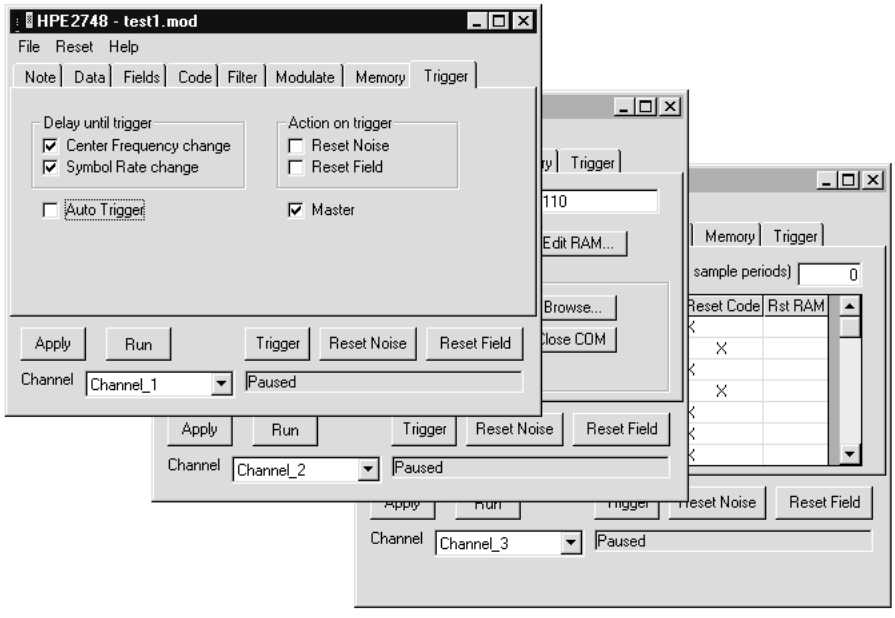
Upconversion options for signal sourcing at RF

The standard HP E2747/48A generates carrier frequencies from dc up to 6 MHz. For RF analysis, two upconversion options are available for your convenience.

Single channel upconversion to frequencies between 250 kHz and 3000 MHz is available via the HP E2747A Option 003 which uses the HP E4432B ESG-Series Signal Generator as the upconverter. Order Option 004 for single or multichannel upconversion between 2 MHz to 2.65 GHz with the HP 89431A with option AY8 RF source. The software for the HP E2747/48A is specially designed for compatibility with the HP 89431A and can control the upconverter via the RS-232 port.

Of course, you can also use the generator's outputs to drive other RF signal generators with I & Q or composite IF inputs.

Synchronize the multiple channels together with variable delays to simulate multi-path, or let their clock and symbol rates vary independently for realistic adjacent channel testing.



A breakthrough in signal source technology

The HP E2747A vector waveform generator and the HP E2748A module which comprises it, use a new hardware architecture based around an HP-proprietary ASIC designed for flexibility and generality of signal type. (See Figure 2.)

The data multiplexer (MUX) is used to select the source of data for various fields within the transmitted data sequence. This capability is what allows you to create real-world messages with protocol bits and information.

This stream of digital words is fed into the coder, which produces a sequence of symbol codes. Common examples are differential coding, or error correction codes.

The symbol codes then pass into the map block of the architecture, which converts them to a sequence of signal samples. Some of the mappings which are possible include: symbol codes to real samples, symbol codes to complex samples, and dual channel (I/Q) symbols to I/Q samples, etc. You may also specify an additional fixed angle of rotation between symbols, such as is needed for pi/4 DQPSK or VSB.

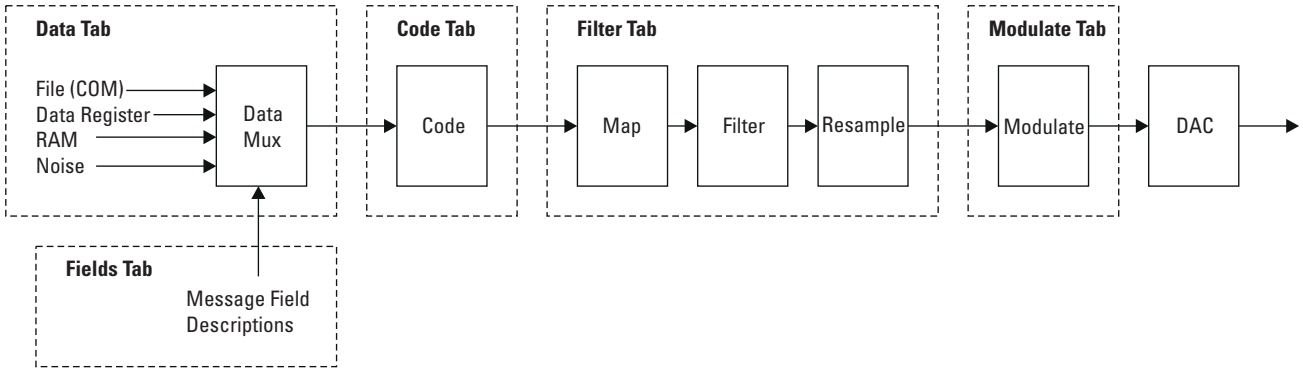
The signal samples then pass through the filter function, which applies an arbitrary filter of your choice. The filter is designed to handle real, complex, or interleaved I/Q signals. Complex filter coefficients are allowed, providing you with the capability of creating asymmetric frequency responses useful in simulating some signal transmission impairments or predistortion. You can even generate offset modulation by creating filters with a different amount of delay in the I and Q (real and imaginary) outputs.

At this point, the signal sequence is resampled to produce a 15 MSa/s sample rate. This high data rate is matched to the analog reconstruction filter cutoff of 6 MHz for optimum distortion performance. Note that this resampling is automatic, and you may choose any arbitrary filter sample frequency. Multi-channel systems allow for differing sample rates for each channel.

After resampling, the modulator takes the complex sample sequence and shifts the frequency by mixing it with a complex digital local oscillator. Or, you can use the I and Q inputs to control the magnitude and frequency of the carrier. With these tools, you can create any combination of AM, QAM, FM and PM formats, both analog and digital.

The DAC performs the final operation to create I and Q analog outputs. An analog reconstruction filter ensures that the generator outputs a single Nyquist interval of your desired spectrum.

Figure 2. Block diagram of the HP E2747A/E2748A vector waveform generator. The "Tabs" refer to the software front panel. Each tab configures the corresponding block(s) of the digital transmitter.



Summary Product Specifications

Hardware form factor

HP E2747A: PC-format instrument. Preconfigured, and pre-loaded with the application software.

HP E2748A: Module assembly to be used in separate carrier for system builder applications

Hardware specifications

The following apply to both the HP E2747A and the HP E2748A:

Carrier frequency: dc- 6 MHz

Signal bandwidth: 6 MHz, in playback mode.

2 MHz, typical, for real-time signal computation

Actual bandwidth limit depends on the filter and coding parameters selected by the user

Output resistance: 50 Ohms nominal

Level accuracy: ±0.5dB at 10 KHz

Flatness (relative to 10 KHz): ±0 .75dB

Full scale output: ±2V

DC Offset: ±50mV

Harmonic distortion: -55 dBc, or -70 dB below full scale, whichever is greater

Spurious distortion: -70 dB below full scale

DAC resolution: 14-bits

DAC clock:
Frequency accuracy
(15 MHz, 0°C to 40°C): ±30 ppm w/o phase lock

Lockable to external 10 MHz reference to remove absolute frequency error

Software functionality

User interface — Parameters set by:

Soft front panel: Graphical "fill-in-the-blanks" template

Function library: Accessible via Microsoft Visual BASIC or Microsoft Visual C++ (not included)

Data source

Data for each message field may be read from any of the following sources: RAM, file, internal noise source, data register. Additionally, under programmatic control using the library function calls, data may be read from an external program for real-time data generation.

Message fields

Number of fields per message: up to 16

Field length: 1 to 2,097,151; & infinity

Coder

Maximum coder table size: 2^{17} codes

Filter, mapping, & resample

Filter modes: Real; I&Q; Complex;

Filter response shape: Gaussian (±0.15 F_s); Gaussian (±0.075 F_s); Flat (±0.25 F_s); Custom

Custom filter

Wizard to synthesize custom filter allows you to cascade any or all of the following:

1. Standard filter types: Gaussian, raised cosine, root raised cosine with adjustable bandwidth and alpha (Gaussian, bandwidth only)
2. Filter time domain impulse response: real or complex; symmetric or asymmetric
3. Filter frequency domain response: real or complex; symmetric or asymmetric

Mapping Set # of symbol bits
Edit symbol code map
Set Q channel delay (relative to I)
Add symbol rotation

Resampling Sample frequency
# of filter samples per symbol period

Modulator block

Built-in modulation

A library of pre-programmed signal setups is provided. Included are: NADC; IS-95 (CDMA) Forward Traffic Channel, Reverse Traffic Channel; GSM; multi-level FSK; Automatic Link Establishment (ALE); common analog modulation

Modulation mode: I & Q with settable I & Q attenuation;

FM—with settable full scale FM deviation

Trigger: Manual; Auto (on transition from pause to run)

Actions on trigger: Center frequency change; Symbol rate change; Reset internal noise source; Reset message to designated start-up field

Related HP literature

HP E2747A & HP E2748A Technical Specifications, Publication No. 5966-4765E

HP E2747A & HP E2748A Configuration Guide, Publication No. 5967-5509E

HP SCMVX008 Technical Specification, Publication No. 5966-0904E

HP ESG Series RF Digital and Analog Signal Generators, Publication No. 5965-9088E

HP Test System and VXI Products Catalog, Publication No. 5966-2815EN

Test System and VXI Products Data Book, Publication No. 5965-5497E

Simulating Real World Signal Environments for Receiver Testing, Publication No. 5966-4776E

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