INTRODUCING

COMTRAN™

AC circuit analysis with waveform response and optimization for your HP/300, 217, 9836, 9816, 9920, 9845 and 9020 desktop computers!

COMTRAN™ is a general purpose linear circuit analysis and optimization program featuring both time-domain and frequency-domain analysis of circuits having R,L,C, and voltage-controlled current source components. Using these, closed-loop gain and stability can be studied for circuits using either ideal opamps, or real opamps with user-specified open-loop characteristics.

The frequency-domain module is the AC-Circuit Analysis Program (AC-CAP). Expanded and improved by the original authors of Hewlett-Packard's AC-CAP, this program now interfaces with an improved time-domain module, S-WAVE. Combined with a newly-created WAVEFORM ANALYSIS program, COMTRAN relieves the designer of much of the guess-work and manual calculations that were formerly required to achieve final designs. With improved data handling and user control, COMTRAN provides the basis for a comprehensive computer-aided design and measurement laboratory.

COMTRAN Analyzes:
Magnitude and Phase Response
Complex Impedance
Group Delay and Phase Delay
Waveform Response
Component Tolerance Effects
Sensitivity Analysis

COMTRAN Applications:
Communications
Audio and RF Circuits
Test and Measurement
Navigation and Guidance
Oceanography/Sonar
Acoustics

COMTRAN Designs:
Active Filter Designs
Passive Filter Designs
Operational Amplifier Designs

COMTRAN Benefits:
Reduces design time through easy operation
Eliminates cut-and-try design attempts
Improves reliability
Achieves state-of-the-art designs
Allows expansion of your product line
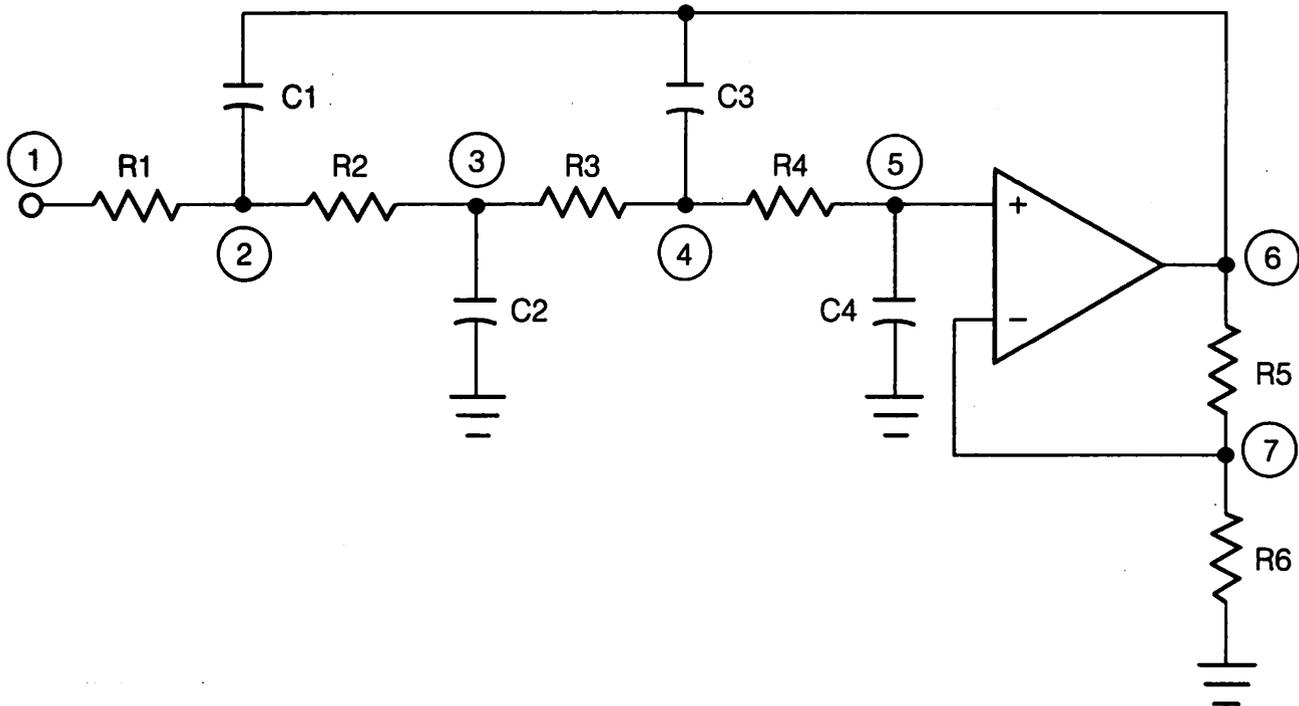
jensen transformers
INCORPORATED

10735 BURBANK BOULEVARD
N. HOLLYWOOD, CALIFORNIA 91601

(213) 876-0059

(Visitors by Appointment Only)

DESIGNING A SINGLE

This example demonstrates the power of COMTRAN'S optimization feature to aid in the design of a circuit topology using only one opamp, where two opamps would normally be employed.

Since there are nine circuit components which affect the filter response, but only four simultaneous equations which can be derived from the filter transfer function, there is no method other than optimization to obtain a set of realizable component values. This is the primary reason why higher order filters are almost always constructed from cascaded single- and two-pole filter sections.

Optimization

During optimization, selected component values are varied until the response of the network in the frequency domain matches the performance specifications within a prescribed error limit. The error limit function may include any of the following performance criteria: gain, phase, input impedance, and output impedance.

Starting component values for this circuit can be calculated from:

$$R1 = R2 = R3 = R4 = 10k\,OHM$$

$$C1 = C2 = C3 = C4 = \frac{1}{2 \times \pi \times F_c \times R} = \frac{1}{2 \times \pi \times 1000 \times 10000} = 15.9nF$$

Three optimization gain targets are sufficient to determine the desired Butterworth response:

1)   0 dB at 500   Hz
2) − 3 dB at   1 KHz
3) −24 dB at   2 KHz

OPAMP 4-POLE FILTER

After keying-in the initial circuit description or loading the data from a tape or disk file, optimization can be performed. Shown below are the optimized circuit values with graphic displays of frequency- and time-domain responses before and after optimization.
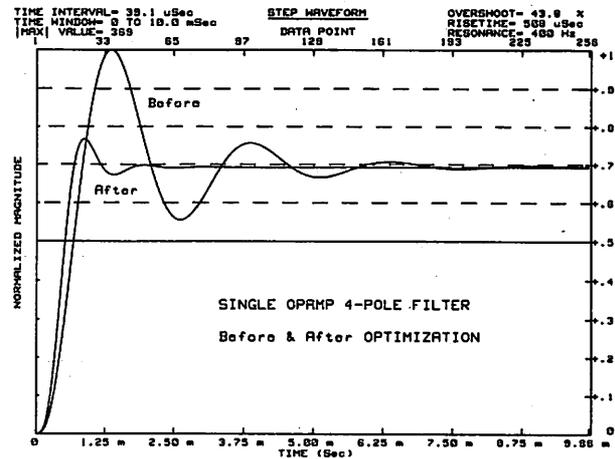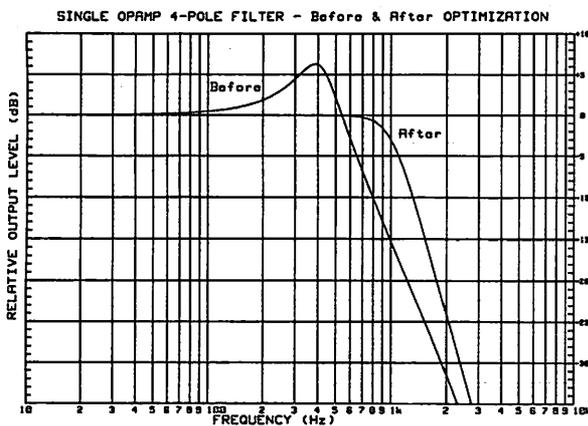
```
                                    Xmpl5b:H9
        4 pole Butterworth active lowpass filter, 1 k Hz cutoff frequency.  Optimized
        result of 11 iterations to 3 target frequencies.   Ideal opamp model used.
```

| COMPONENT	VALUE	PERCENT TOLERANCE	OPTIMIZE ? (YES=1, NO=0)	NODE CONNECTIONS FROM	TO	(+)	(−)
RESISTOR 1	9.10893317984 kohm	1	1	1	2		
RESISTOR 2	13.8315489095 kohm	1	1	2	3		
RESISTOR 3	13.2879666415 kohm	1	1	3	4		
RESISTOR 4	6.07636820764 kohm	1	1	4	5		
RESISTOR 5	7.87525737888 kohm	1	1	6	7		
RESISTOR 6	10 kohm	0	0	7	0		
RESISTOR 7	10 ohm	0	0	6	0		
CAPACITOR 1	17.6377797335 nF	2.5	1	2	6		
CAPACITOR 2	26.8125108352 nF	2.5	1	3	0		
CAPACITOR 3	15.3802945857 nF	2.5	1	4	6		
CAPACITOR 4	8.66766387709 nF	2.5	1	5	0		
SOURCE 1	Value 1 kmho	0	0	0	6	5	7

INPUT IS NODE 1   OUTPUT IS NODE 7   GROUND IS NODE 0

SINGLE OPAMP 4-POLE FILTER - Before & After OPTIMIZATION

TIME INTERVAL= 39.1 uSec   STEP WAVEFORM   OVERSHOOT= 43.0 %
TIME WINDOW= 0 TO 10.0 mSec   DATA POINT   RISETIME= 568 uSec
|MAX| VALUE= 369   RESONANCE= 480 Hz

SINGLE OPAMP 4-POLE FILTER

Before & After OPTIMIZATION

STUDYING TOLERANCE EFFECTS

The selection of TOLERANCE MODE allows you to determine how a random selection of component values within the tolerance ranges specified alters the magnitude, phase, delay, or impedance response of the circuit. The resulting minimum and maximum envelopes approximate the range of expected performance variations of the finished product.

SINGLE OPAMP 4-POLE FILTER - 1% TOLERANCE - ERROR LIMITS
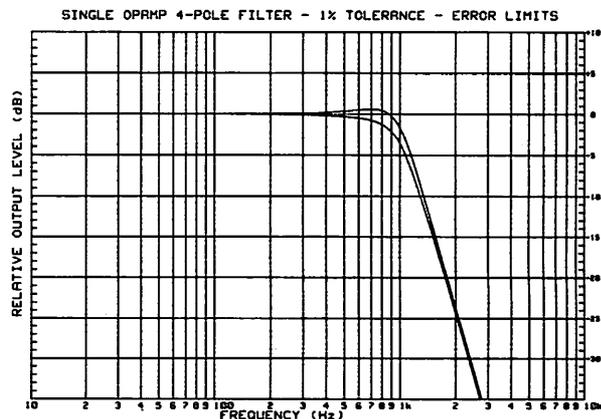
SUMMARY OF FEATURES

Accurate Circuit Results

COMTRAN™ yields accurate results for all types of circuits, including a 3 order of magnitude improvement in numerical precision for group delay.

High-Speed Binary Algorithms

Proprietary binary algorithms make AC-CAP 50 times faster than the original HP Circuit Analysis and S-WAVE 4 times faster than HP Waveform Analysis.

TYPICAL CALCULATION SPEEDS:
AC-CAP: <1.00 second per frequency with 30-node circuit
S-WAVE: <1.25 seconds for 256 real-precision time-domain data points

Comprehensive Optimization

Magnitude response, phase response, input impedance, and output impedances can be optimized according to user-specified weighting values. Optimization can be performed on up to 25 components at up to 30 frequencies.

Friendly Operation

Most commands can be executed by single-key commands. Entry of the circuit description is interactive with single keystroke entries for most data. You may interrupt any operation at any time and begin another without having to restart the program. Default responses offered for all entries.

Interactive Graphics

High-speed graphics allow multiple plots, labeling, and printing of calculated results. A cursor mode allows interactive numeric readout of curve values.

Product Support and Documentation

A comprehensive, easy-to-read user manual is provided. A special function key overlay identifies program commands. Software support is available, including periodic software updates.

COMPUTER REQUIREMENTS

| COMPUTER	MEDIA	MEMORY	OPERATING SYSTEM
HP/9845	Tape or 8" disk	187K byte	BASIC
HP/9836	5-1/4" or 3-1/2" disk	750K byte	BASIC 2.1, 3.01 or 4.0
HP/200 HP/300	3-1/2" disk	750K byte	BASIC 2.1, 3.01 or 4.0
HP/9020	5-1/4" disk	1.25M byte	BASIC

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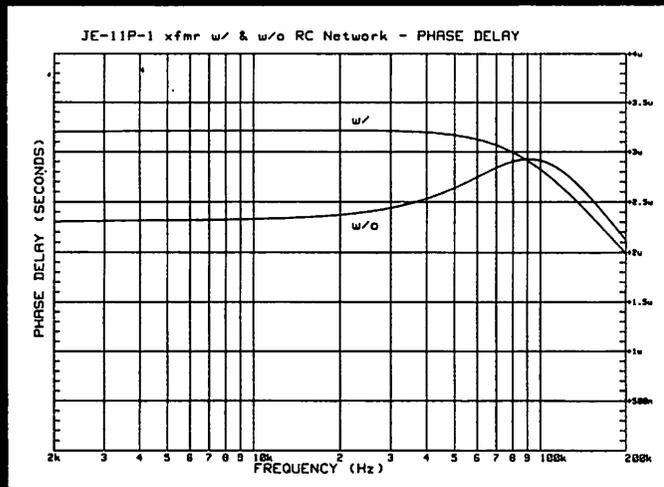
FREQUENCY-DOMAIN PLOTS

In the frequency domain, six responses can be calculated and plotted at any node of the circuit. Both nominal response and tolerance limits can be analyzed. Plots can be overlaid on an interactive basis. With the use of the HP-9872A color plotter, all graphs can be generated on plain paper or K&E log graph paper for engineering reports.
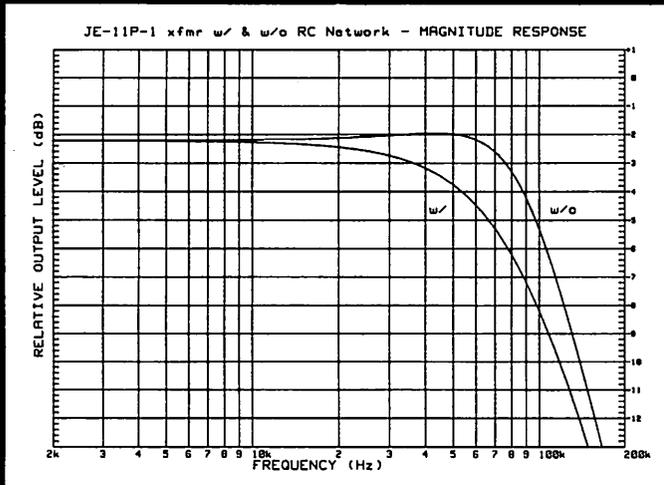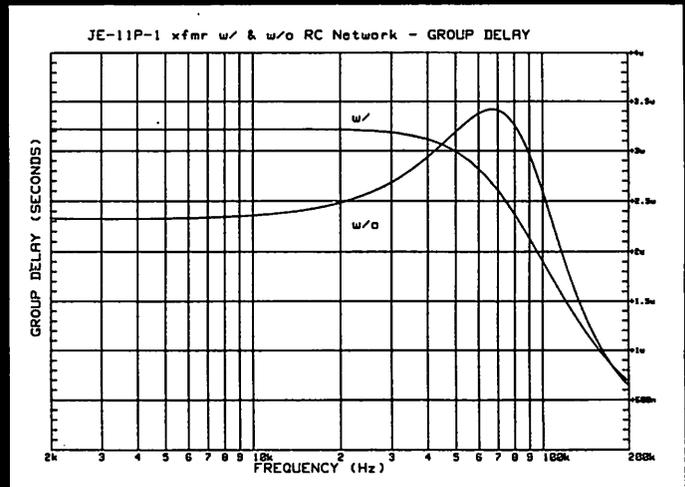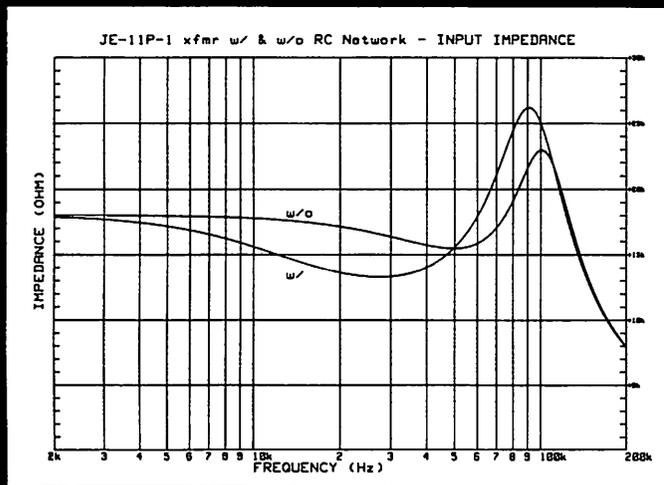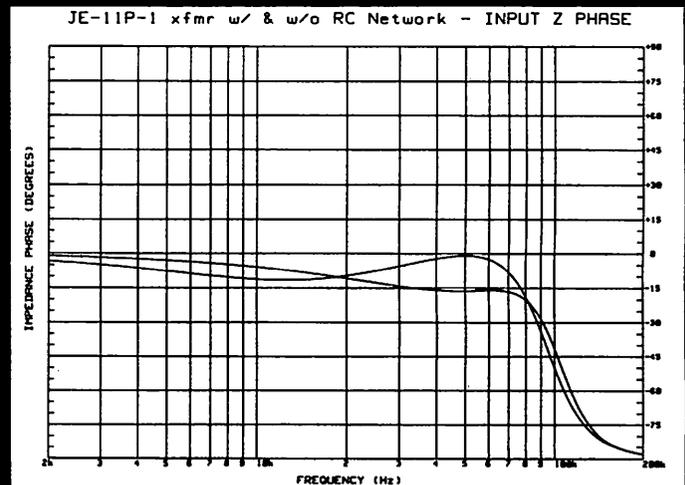


MAGNITUDE RESPONSE
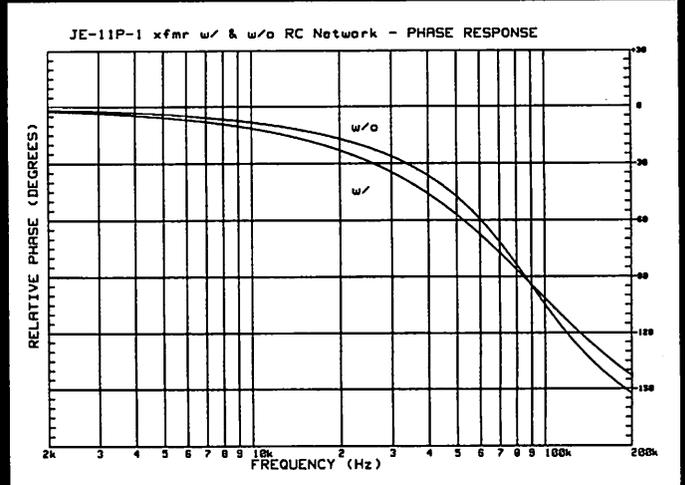
PHASE RESPONSE

PHASE DELAY

GROUP DELAY

IMPEDANCE MAGNITUDE
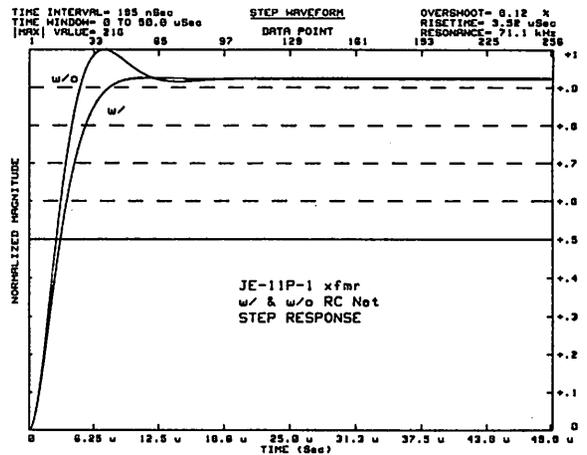

IMPEDANCE PHASE

TIME-DOMAIN PLOTS

COMTRAN's time-domain module "S-WAVE" is a general-purpose math and plotting package for manipulating digitized waveforms and frequency response spectra. S-WAVE can accept either measured laboratory data, or data calculated by the frequency-domain module. Operations include Fast Fourier Transform, Inverse Fourier Transform, Integration, Differentiation, Convolution, Deconvolution, Cross-Power, and numerous others. These calculations allow S-WAVE to display the time-domain response of the circuit model to any type of stimulus waveform.
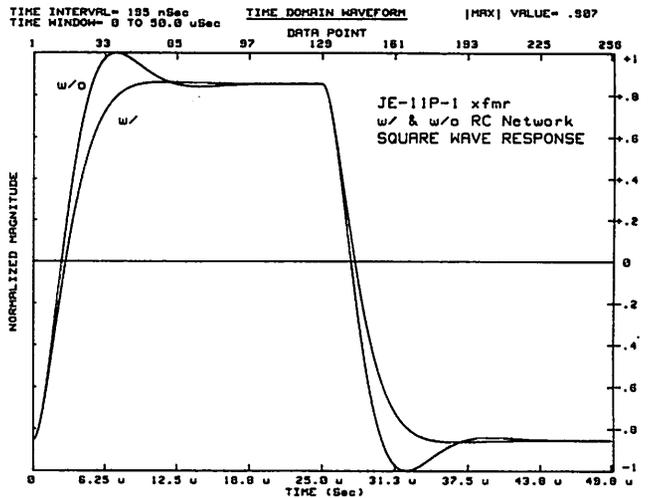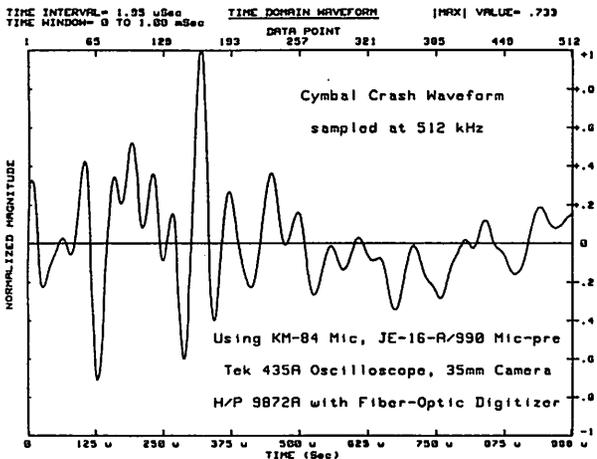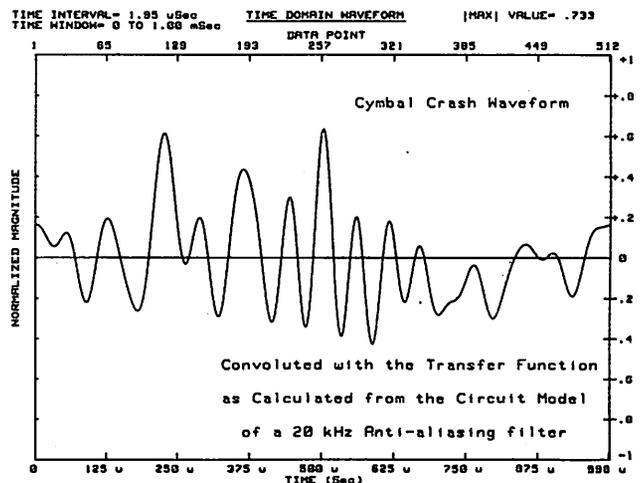

SQUARE WAVE RESPONSE
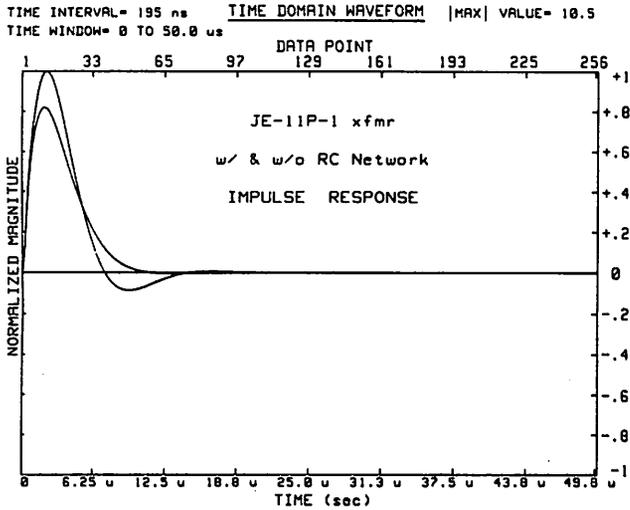
IMPULSE RESPONSE

STEP RESPONSE

INPUT WAVEFORM

OUTPUT WAVEFORM

COMTRAN is a PACKAGE of THREE MODULES for:
CIRCUIT ANALYSIS, OPTIMIZATION, and MEASUREMENT

(1) AC-CAP: HIGH SPEED
AC CIRCUIT ANALYSIS with

- 50 TIMES SPEED
- OPTIMIZATION
- GROUP DELAY
- DELAY CORRECTION for RELATIVE PHASE
- NEGATIVE COMPONENTS
- NEGATIVE IMPEDANCE
- TRANSIENT ANALYSIS
- TOLERANCE ANALYSIS
- GRADIENT SENSITIVITY

50 times FASTER than HP AC CIRCUIT ANALYSIS with BINARY math. Includes ALL features of original HP CIRCUIT ANALYSIS by the original author and 12 other experts, 7000 man-hours.

IMPROVED ALGORITHMS for speed and accuracy (5 yrs in use).

BINARY graphics for FAST lettering & graticule lines (9845),

OPTIMIZATION for circuit synthesis by iterative analysis.

98 NODES (300, 217, 9836, 9816, 9920, 9020, 9845/318K), 36 NODES (9845/187K).

DATA FILE COMPATIBLE with HP AC CIRCUIT ANALYSIS.

TIME DOMAIN graphs (requires companion program S-WAVE).

GROUP DELAY with selectable FREQ SHIFT, and PHASE DELAY graphs.

DELAY CORRECTION for RELATIVE PHASE, & DELAY graphs.

TOLERANCE ANALYSIS plots minimum and maximum results.

COMPONENT TYPES
- Resistors – positive or negative
- Capacitors – positive or negative
- Inductors – positive or negative
- Voltage controlled current sources
- Opamps, A_{vol}, GBW, R_{in}, R_{out}, Delay
- Transformers, 1:1, R_{pri}, R_{sec}, C_{pri}, C_{sec}, L_{pri}, L_{leak}, R_{loss}

OPTIMIZATION
- Up to 30 frequency targets
- Up to 25 variable components
- Up to 4 parameters weighted
  - Magnitude – Abs/Rel • Phase – Abs/Rel
  - Input Impedance • Output Impedance

FREQUENCY DOMAIN GRAPHS
- Magnitude
- Phase
- Relative Phase
- Phase Delay
- Group Delay
- Impedance Magnitude
- Impedance Phase

TIME DOMAIN GRAPHS
- Impulse Response • Step Response
- Square Wave Response
- Output Waveform given any stimulus (user defined)

Operates all HP PLOTTERS and DUMP GRAPHICS printers.

Circuit editing, add, delete, change value or nodes.

BROCHURE available with GRAPHICS and OPTIMIZATION examples.

DEMO version available for evaluation.

(2) S-WAVE: HIGH SPEED
FFT WAVEFORM ANALYSIS

- 4 TIMES SPEED
- 8192 DATA POINTS
- 32K POINTS with XTRA MEM
- IMPULSE RESPONSE
- STEP RESPONSE
- SQUARE WAVE RESPONSE
- OUTPUT WAVEFORM with USER DEFINED STIMULUS

4 times FASTER than HP WAVEFORM ANALYSIS, with BINARY math. Includes ALL features of HP WAVEFORM ANALYSIS and much more.

ALL routines are in ONE FILE, so NO WAITING for tape or disc.

IMPROVED ALGORITHMS for speed and accuracy (5 yrs in use).

BINARY graphics for FAST lettering & graticule lines (9845),

GRAPHICS CURSOR traces curve with numerical readout.

8192 Time Domain DATA POINTS (300, 217, 9836, 9816, 9920, 9020 or 9845/318K).

2048 Time Domain DATA POINTS (9845/187K).

32768 Time Domain DATA POINTS with 750K bytes added memory.

This program is used to plot TIME DOMAIN graphs for AC-CAP.

HIGH SPEED CIRCUIT OPTIMIZATION
- Impulse Response • Step Response
- Output Waveform, any stimulus
- Square Wave Response

STANDARD FUNCTIONS:
- FFT • IFT • HANNING • POWER
- CORRELATION • CONVOLUTION
- MODULATION – corrected
- CROSS POWER – multiple entry
- EDIT DATA – enhanced
- PRINT DATA – enhanced
- PLOT DATA – CRT, Plotter
- INPUT DATA • Keypad Numerical
  - Mass Storage
  - Digitize – Plotter

ADDITIONAL FUNCTIONS:
- DECONVOLUTION – derives transfer function given input & output waveform
- COMPLEX MULTIPLICATION
- ARITHMETIC • +, −, ×, /
  - SCALE by CONSTANT or by 2nd DATA FILE
- ZOOM into CURSOR position
- TIME REVERSE
- TRIGGER TIME CORRECTION
- SET ZERO starting at N
- GENERATE SQUARE WAVE
  - TRUNCATED • LOW PASS FILTERED
- 90 degree QUADRATURE ROTATE
- INTEGRATION – Time
- DIFFERENTIATION – Time
- MAGNITUDE UNITY for ALL PASS
- PHASE ZERO for MAGNITUDE ONLY

"STIM" utility stores DATA FILE from your BASIC program code.

"SWplus" utility provides access for USER ADDED FUNCTIONS.

HPIB data input by companion program TIMEIN, See PLOTFT listing.

(3) PLOTFT with TIMEIN:
(PLOT-EFF-TEE with TIME-IN)

SEMI-LOG SCALEABLE FREQUENCY DOMAIN GRAPHICS from TIME DOMAIN DATA ACQUISITION via HPIB.

ALL of the GRAPHICS of AC-CAP including GROUP DELAY using 3325A, 3437A, 3582A, and YOUR INSTRUMENTATION.

NETWORK ANALYSIS or NOISE and VIBRATION ANALYSIS with SEMI-LOG SCALEABLE GRAPHICS for:
- MAGNITUDE
- PHASE
- RELATIVE PHASE
- PHASE DELAY
- GROUP DELAY with selectable FREQUENCY SHIFT
- IMPEDANCE MAGNITUDE
- IMPEDANCE PHASE

CRT GRAPHICS with DUMP GRAPHICS and HP PLOTTER hardcopy.

EDITABLE BASIC program DIGITIZES TIME DOMAIN DATA from:
- 3437A SYSTEM VOLTMETER 10 MHz sampling for 5 MHz data
- 3582A FFT SPECTRUM ANALYZER 25 kHz real time data
- 5180A/5182A WAVEFORM RECORDERS 10 MHz real time data
- 3561A/3562A DYNAMIC SIGNAL ANALYZERS 100 kHz real time data
- YOUR OWN INSTRUMENTATION added easily by YOUR CODE
- 3325A SYNTHESIZER for STIMULUS
- Also easily EDITED for YOUR CHOICE of GENERATOR

Requires companion program S-WAVE, FFT WAVEFORM ANALYSIS DECONVOLUTION derives TRANSFER FUNCTION DATA FILE from digitized INPUT and OUTPUT waveforms.

GRAPHIC COMBINING of LF & HF files for WIDE BANDWIDTH.

DATA FILE COMPATIBLE with AC-CAP TRANSFER FUNCTION DATA allows COMBINING MEASURED TF with CALCULATED TF of MODEL.

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