Thorough device test can rarely be done in situ. Consideration of repeatability, limit testing, and safety—quite apart from sheer feasibility—are some of the reasons for simulating input signals rather than trying to force the real environment to provide all desired situations at will.

Automotive, energy and navigation are example segments of the electronic control device market where these arguments are particularly important.

Typical measurement concerns in these segments are: the relative position or speeds of shafts, power line phase, and the computation of position from signal phase information. In the past, the problem has been to generate a number of synchronous signals with programmable phase difference. This product note explains how this can be solved by master/slaving a number of HP3324A synthesized function generators.

General description

One HP3324A is equipped with Option 004 (master auto-cal) and the rest with Option 003 (slave auto-cal). This allows the phase between channels to be set up accurately on automatic or manual command without external phase measurement. A VHF switch (HP59307A) is required for automatic operation if more than two channels are needed. A second switch is necessary for more than five channels.

Features and benefits

- No oscilloscope, phase meter or counter needed for calibration. Auto-cal accuracy is +/-1 to +/-7 degree, depending on waveform and amplitude mix. Refer to HP3324A data sheet.
- Manual or programmed operation.
- Extendable to virtually any number of channels.
- Output waveforms need not be the same, and are selectable from: sine (up to 21 MHz), square or triangle (up to 11 MHz), and ramp (up to 11 kHz). Minimum frequency is 1 mHz.
- Frequency resolution 9 digits. Stability 5 ppm, can be improved to 0.05 ppm by fitting master 3324A with Option 001.
- Independent amplitude 1 mVpp to 10 Vpp into 50 ohm. Option 002 provides 4 mVpp to 40 Vpp into 500 ohm.

Application example: control circuit for energy supply network.

To test the design of a control circuit, three signals are needed to represent the voltages of a 3-phase supply. Additionally, a signal representing current lead or lag tests the response to power factor changes. As only one current phase need be simulated at a time, four 3324A’s are adequate in this application.

Setting up for the first time

After racking or stacking the synthesizers, "daisy chain" the rear panel Reference connectors, and interconnect the Phase Cal connectors as shown in the following diagram:
Master 3324A with Option 004
(and Option 001 if high stability needed)

--- > Oven out (Opt)
|  Phase Cal In
|----> Ext.ref.in
|   ---< Ext.ref.out

1st Slave 3324A with Option 003
|  Phase Cal In<--< from A1
|  Phase Cal Out>---> to B1
|   ---< Ext.ref.in
|   ---< Ext.ref.out

2nd Slave 3324A with Option 003
|  Phase Cal In<--< from A2
|  Phase Cal Out>---> to B2
|   ---< Ext.ref.in
|   ---< Ext.ref.out

---< Ext.ref.out

Now use the following procedure to equalize the path lengths of the master Phase Cal Output to the various slave Phase Cal Inputs:

1. Set the following parameters of all 3324As to zero:
   Phase,
   Assign Phase 0,
   Calibration Delay, } Select Util menu and roll.
   Signal Delay.
}
2. Set same frequency, waveform and amplitude on all 3324As.
3. Press 1st slave’s Shift and Phase Cal keys.
4. When auto phase cal complete, measure the time interval between corresponding points on the master and 1st slave outputs. Measure from the master signals FORWARDS to the slave signal, even if this means nearly a full cycle (this simplifies handling the other slaves).
5. Enter this value in ps in the 1st slave’s Calibration Delay (Util menu).
6. Do auto phase cal again, verify phase is OK.
7. Repeat steps 3 to 5 for the other slaves in turn.

Using the setup
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Try to use the same path lengths from the 3324A outputs to the device under test. If this is not feasible, use a similar procedure to that above, measuring the signals at the DUT, and entering the delay into the appropriate slave’s Signal Delay (Util menu).

From here on, correct phase relationship is simply a matter of setting each slave to the required phase. Subsequently, whenever frequency, waveform or amplitude are changed an auto-cal should be performed on each slave.

Start-up tools
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An UNSUPPORTED disk is available in order to assist implementation in an automated environment with the following software:
1. HP ITG (Interactive Test Generator) applications driver and instrument driver IDHP3324PS. These run only on HPBasic platforms, and are NOT supported.

2. An HPBasic routine for users to build into their own programs. A listing appears at the end of this document. This routine is NOT supported.

**HP3324A Auto-cal ITG applications driver**

To load the auto-cal driver, first load the file IDHP3324PS as many times as you have HP3324As. Each time you will be asked "stand alone or slave" and you should respond with "slave". Subsequently, change the driver name to "Master", "Slave1", "Slave2" etc. Now load file ADPC3324A, and enter switch address and driver names in the first panel as required.

The file ADPC3324A generates a small panel (see inset below) that allows the phase of the master (M) and any slave (Sn) 3324A to be changed, as well as the common frequency (F). Auto-cal is implemented with the CAL label (an exclamation mark indicates when this should be done)

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**HPBasic Auto-cal routine**

The routine PHASECAL implements the HP3324A’s built-in phase-cal feature for setups with up to five function generators connected as shown in the above diagram.

The routine simply switches each slave in turn to the master and triggers the
INTEGER A,B,C,D,E,F  ! this main program is only a dummy program
A=0                  ! to be replaced by other main programs
B=0
C=0
D=0
E=0
F=0

CALL Save_ib_address(A,B,C,D,E,F)
CALL Phase_cal
END

SUB Save_ib_address(INTEGER Switch,Master,Slave1,OPTIONAL INTEGER Slave2,Slave3,Slave4)
COM /Hpibdata/ INTEGER Switch_addr,Master_addr,Slave_addr(1:4)
INTEGER I
MAT Slave_addr= (0)       !  clear addresses
Switch_addr=Switch
Master_addr=Master
Slave_addr(1)=Slave1
IF NPAR>3 THEN Slave_addr(2)=Slave2
IF NPAR>4 THEN Slave_addr(3)=Slave3
IF NPAR>5 THEN Slave_addr(4)=Slave4
SUBEND

SUB Phase_cal
COM /Hpibdata/ INTEGER Switch_addr,Master_addr,Slave_addr(1:4)
INTEGER I,J
REAL Master_phase,Frequency
DIM Lf$[2]
Lf$=CHR$(13)&CHR$(10)             ! separator for switch commands
ON TIMEOUT 7,30 GOTO End          ! device select code 7 for HPIB card assumed !!!

IF Master_addr THEN
  OUTPUT Master_addr;"IPH"        ! read master phase
  ENTER Master_addr USING "K";Master_phase
  OUTPUT Master_addr;"PH 0DEIFR"  ! set phase during calibration to 0
  FOR I=1 TO 4
    IF Slave_addr(I)<>0 THEN
      IF Switch_addr THEN         ! connection of slave by switch
        OUTPUT Switch_addr;"A"&VAL$(I)&Lf$&"B"&VAL$(I)  !  change this
        ELSE                        ! manual connection of selected slave
          DISP "Please connect SLAVE"&VAL$(I)&" to MASTER instrument, confirm with any key"
          ON KBD ALL GOTO Confirmed
          GOTO 44                   ! wait for keypress
          Confirmed: OFF KBD
          DISP ""
        END IF
      END IF
      OUTPUT Slave_addr(I);"FR"&VAL$(Frequency)&"HZ"  ! set slave to same frequency as master
      J=SPOLL(Slave_addr(I))
      !  if calibration is failed, ( J AND 8 ) is <> 0, a failure routine could be done here ( to ensure failure, use ISE command of 3324A )
    END IF
  NEXT I
  OUTPUT Master_addr;"PH"&VAL$(Master_phase)&"DE"   ! restore phase of
master
55      BEEP 160,.05      ! finished
56      END IF
57   End:       !
58      OFF TIMEOUT
59  SUBEND