User Manual

Models 8550/8551

50 MHz Single Channel Modulated Function / Pulse Generators

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Tabor Electronics Ltd.

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FOR YOUR SAFETY

Before undertaking any troubleshooting, maintenance or exploratory procedure, read carefully the **WARNINGS** and **CAUTION** notices.

This equipment contains voltage hazardous to human life and safety, and is capable of inflicting personal injury.

If this instrument is to be powered from the AC line (mains) through an autotransformer, ensure the common connector is connected to the neutral (earth pole) of the power supply.

Before operating the unit, ensure the conductor (green wire) is connected to the ground (earth) conductor of the power outlet. Do not use a two-conductor extension cord or a three-prong/two-prong adapter. This will defeat the protective feature of the third conductor in the power cord.

Maintenance and calibration procedures sometimes call for operation of the unit with power applied and protective covers removed. Read the procedures and heed warnings to avoid "live" circuits points.

Before operation this instrument:

1. Ensure the instrument is configured to operate on the voltage at the power source. See Installation Section.

2. Ensure the proper fuse is in place for the power source to operate.

3. Ensure all other devices connected to or in proximity to this instrument are properly grounded or connected to the protective third-wire earth ground.

If the instrument:

- fails to operate satisfactorily
- shows visible damage
- has been stored under unfavorable conditions
- has sustained stress

Do not operate until performance is checked by qualified personnel.

DECLARATION OF CONFORMITY

We: Tabor Electronics Ltd.
9 Hatasia Street, Tel Hanan
ISRAEL 20302

declare, that the 50 MHz Pulse/Function Generators

Model 8550 and Model 8551

meet the intent of Directive 89/336/EEC for Electromagnetic Compatibility and complies with the requirements of the Low Voltage Directive 73/23/EEC. Compliance was demonstrated to the following
specifications as listed in the official Journal of the European Communities:

Safety:
EN 61010-1
IEC 1010-1 (1990) + Amendment 1 (1992)

EMC:
EN 50081-1 Emissions:
EN 55022 - Radiated, Class B
EN 55022 - Conducted, Class B
EN 50082-1 Immunity:
IEC 801-2 (1991) - Electrostatic Discharge
IEC 801-3 / ENV50140 (1993) - RF Radiated
IEC 801-4 (1991) - Fast Transients

Model 8550 and Model 8551 were tested in typical configuration.

Table of Contents

CHAPTER 1. GENERAL INFORMATION

CHAPTER 2. INSTALLATION

CHAPTER 3. OPERATION

CHAPTER 4. GPIB PROGRAMMING

List of Figures

List of Tables

General Information

Chapter 1

1-1. INTRODUCTION

This manual provides operation and maintenance information for both Model 8550 - Function Generator and Model 8551 - Pulse/Function Generator. Chapter 1 provides general description of the instruments. Chapters 2 and 3 contain installation and operation instructions. IEEE-488.2 (GPIB) programming is explained in Chapter 4. Maintenance and performance checks are provided in Chapter 5. Theory of operation is described in Chapter 6. Chapter 7 outlines calibration and troubleshooting procedure. Chapter 8 contain tables of replaceable parts and recommended spare parts. Chapter 9 contains schematic and component location diagrams.

NOTE

This manual is common to both Model 8550 and Model 8551. It describes all features and functions for both models. Therefore, some features which are described in this manual may not be available in your instrument. Features that are unique to the Model 8551 are described separately.

1-2. DESCRIPTION

Model 8550 is an extremely high-performance programmable function generator. It provides a variety of signal waveforms, to be used as test stimuli for different electronic devices. Microprocessor based, Model 8550 is easy to set up for manual use. It is also simple to program in GPIB system environment.

The instrument is built in an all-round metal case for improved RFI and EMI shielding. It is housed in a size to fit half-rack enclosures. Regardless of its small size, Model 8550 offers many features and functions, such as enhanced accuracy, eight different linear and logarithmic sweep modes, automatic phase lock loop, pulse and ramp waveforms with transition time control (Model 8551 only), counted burst, internal trigger generator, full implementation of the new IEEE-488.2 standard, and more. But, most of all, Model 8550 guarantees high quality waveforms through- out the specified frequency range, amplitude span, and operating temperature.

Model 8550 generates waveforms within a frequency range from 10mHz to 50MHz and an amplitude span from 10mV to 32Vp-p. Such broad coverage warrants a variety of complex applications. Rapid, repeatable testing every time is assured by a non-volatile memory. Up to 30 front panel set-ups can be stored and recalled for later use; ensuring exact duplication of previous tests. Its performance, programmability and economy make it equally at home in every laboratory.

For improved output accuracy, Model 8550 employs a built-in counter. This counter is incorporated in an internal loop which constantly monitors the output frequency. Even the slightest deviation from the programmed frequency is detected and corrected by the microprocessor circuit.

Model 8550 features self-calibration and self-diagnostic functions that can be operated anytime from the front panel or GPIB command. The self-calibration function compares the output signal parameters to built-in internal references and stores correcting factors in special tables. If calibration routine fails or can not be completed due to electrical faults, the generator produces a failure list that can be evaluated either from the front panel or through GPIB status reporting command.

Besides its normal continuous mode, Model 8550 offers a variety of interrupted and controlled modes. Output waveform may be gated, triggered, or may generate a counted burst of output waveforms. A built-in trigger generator, having a programmable period, can replace an external trigger stimulant.

The MANUAL trigger is just an additional convenience for front panel operation. The generator may also be placed in a number of externally controlled modes, such as VCO, FM, AM, and pulse width modulation
(PWM - Model 8551 only).

Model 8550 may be used as an independent sweep generator with its output swept over an exceptionally wide range of 10 decades. The instrument offers a choice of eight sweep modes, both linear and logarithmic to cover a large number of applications. A MARKER output provides an oscilloscope Z-axis modulation to intensify segments of sweep trace.

Alternately, Model 8550 may also be used as a stand-alone phase lock generator. The instrument locks automatically to an external signal and equates its output frequency and phase to that provided by the external reference. The operator may then generate a phase offset between the reference signal and the generator's output. Phase offset is adjusted within a range of ±18550°.

Model 8550 provides an output level from 20mV to 32Vp-p into open circuit or 10mV to 16Vp-p into 50□. DC offset plus amplitude are independently variable within two window levels: ±16V and ±1.6V (into open circuit). This special characteristics warrants production of extremely small signals at an elevated DC environment.

Model 8551 is a pulse/function generator and is also described in this manual. This instrument is identical in its basic functions to the Model 8550. In addition, this instrument offers Pulse and Ramp waveforms. Pulse width and ramp width are adjustable within a range of 10.0ns to 999ms.

Model 8551 provides control over the transition times for the leading and trailing edges; each can be adjusted independently within a common range. Pulse complement and inverted ramp functions are also available. This manual identifies those features and specifications that only apply to Model 8551.

1-3. INSTRUMENT & MANUAL IDENTIFICATION

The serial number of the instrument is located on the rear panel of the instrument. The two most significant digits identify instrument modifications. If this prefix differs from that listed on the title page of this manual, there are differences between this manual and your instrument.

Technical corrections to this manual (if any) are listed in the back of this manual on an enclosed MANUAL CHANGES sheet.

1-4. OPTIONS

Model 8550 offers a rack mounting option; designated as OPT 001. Opt 001 is field installable or may be ordered with new instruments from the factory.

1-5. SAFETY CONSIDERATIONS

Model 8550 has been manufactured according to international safety standards. The instrument meets EN 61010-1 and UL 1244 standards for safety of commercial electronic measuring and test equipment for instruments with an exposed metal chassis that is directly connected to earth via the power supply cable. Before the instrument is switched on, make sure that protective earth terminal is connected to a protective earth via the power cord. Do not remove instrument covers when operating or when power cord is connected to mains.

Any adjustment, maintenance and repair of the opened instrument under voltage should be avoided as much as possible, but when inevitable, should be carried out only by a skilled person who is aware of the hazard involved.

1-6. ACCESSORIES SUPPLIED

Model 8550 is supplied with ac power cord and with an instruction manual. Extra manual is available on request.

1-7. SPECIFICATIONS

Instrument specifications are listed in Tables 1-1. These specifications are the performance standards or limits against which the instrument is tested.

NOTE

All specifications in the following table apply under the following conditions: main signal output terminated into 50□, within ±5°C and 24 hours of last internal calibration, and after 30 minutes of warm-up time within a temperature range of 0 to 50°C.

Table 1-1. Model 8550/8551 Specifications

WAVEFORMS:	Sine, Triangle, Square, Positive Pulse, Negative Pulse, Ramp (Model 8551), DC (Model 8550)

FREQUENCY CHARACTERISTICS

Range:	10.00mHz to 50.00MHz.
Resolution:	4 digits
Accuracy:	
Continuous Mode:	±4% of reading, from 10mHz to 999.9mHz; ±0.1%, from 1.000Hz to 50.00MHz;
VCO, and Interrupted Modes:	±4% of reading, to 50.00MHz.
Jitter:	<0.1% ±50ps.

WAVEFORM CHARACTERISTICS

Sine Wave	
Total Harmonic Distortion:	<1%, from 10.00mHz to 100.0KHz.
Harmonic signals below the carrier level:	>40dB, 100KHz - 2.000MHz; >21dB, 2.000MHz - 50.00MHz.
Flatness:	±1%, 10.00mHz to 999.9KHz; ±2%, 1.000MHz to 9.999MHz; ±20%, 10.00MHz to 50.00MHz.
Triangle	
Linearity (10% to 90% of amplitude):	<1%, 10.00mHz to 5.000MHz; <3%, 5.000MHz to 20.00MHz; <8%, 20.00MHz to 50.00MHz;
Flatness:	±3%, 10.00mHz to 999.9KHz; ±5%, 1.000MHz to 9.999MHz; ±25%, 10.00MHz to 50.00MHz.
Square Wave, Pulse:	
Rise/Fall time:	<8ns, 10% to 90% of amplitude (6 ns typical).
Aberration:	<5%.
SYNC Pulse:	
Output Level:	0 to 1V, into 50Ω; 0 to 2V, open circuit.
Rise/Fall time:	<4ns, into 50Ω.
Aberrations:	<5%.

OUTPUT CHARACTERISTICS

Output Stand-by:	Output Normal or Disabled.
Impedance:	50Ω, ±1%.
Output Level:	20.0mV to 32.0Vp-p, into open circuit; 10.0mV to 16.0Vp-p, into 50Ω.
Resolution:	3 digits.
Accuracy (1 KHz):	±5% of reading, from 10.0mV to 16.0V.

Table 1-1. Model 8550/8551 Specifications (continued)

Level Windows:	±800mV, for amplitude from 10.0mV to 99.9mV; ±8V, for amplitude from 100mV to 16.0V.
Output Protection:	Protected against continuous short to case ground.
Offset	
Resolution:	3 digits
Range:	Offset and amplitude are independently adjustable within level windows of ±800mV and ±8.00V.
Within ±800mV	0 to ±795mV;
Within ±8V	0 to ±7.95V
Accuracy:	±(1% of setting + 1% of amplitude + 2mV), within ±800mV; ±(1% of setting + 1% of amplitude + 20mV), within ±8V.

DC CHARACTERISTICS (Model 8550 only)

Range:	Variable from -16.0V to +16.0V, into open circuit; -8.00V to +8.00V, into 50Ω.
Resolution:	3 digits with exponent.
Accuracy:	±(1% of reading + 100µV)

TRIGGERING CHARACTERISTICS

Trigger Input:	Via TRIG/REF BNC terminal.
Impedance:	10KΩ, ±5%.
Sensitivity:	500mVp-p.
Max Input Voltage:	±20V
Min Pulse width:	20ns.
Slope:	Positive going leading edge
Source:	Manual (front panel push button), internal, or external stimulant.
Modes	
Normal:	Continuous waveform is generated.
Triggered:	Each input cycle generates a single output cycle.
Internal Trigger:	An internal timer repeatedly generates a single output cycle
Gated:	External signal enables generator. First output cycle synchronous with the active slope of the triggering signal. Last cycle of output waveform always completed.
Burst:	Preset number of cycles (1-4000) stimulated by an internal, external, or manual trigger.
Internal Burst:	An internal timer repeatedly generates a burst of counted output cycles
Trigger Frequency:	
External:	To 50MHz.
Internal:	From 20µs to 999s;
Manual:	Simulates an external trigger signal.
Start Phase:	
Offset:	Adjustable, from -90° to +90°, to 500.0KHz; proportionally reduced from 500.1KHz to 50.00MHz..
Accuracy:	±4°, to 500.0KHz
Trigger Level:	variable, -10.0V to +10.0V.

LOGARITHMIC SWEEP CHARACTERISTICS

Modes:	Auto, Triggered, Gated and Burst. Output frequency repeatedly changes from start sweep to stop sweep settings. Available sweep directions are: up, down, up-down and down-up.
Width:	10 decades maximum.
Rate per Decade:	Continuously adjustable from 10mS to 999S, NOMINAL, per decade.
Steps per decade:	Depends on sweep time and range. Automatically adjusted for maximum steps per sweep time. Maximum steps are 200; minimum steps are 50.
Sweep Output:	1V/decade, below 5 decades; .5V/decade, above 5 decades.
Marker Output:	+5V with no marker; drops to 0V, NOMINAL, when marker frequency is reached and remains at this level until end of sweep.
Stop Sweep Resolution:	Same as Frequency resolution.

LINEAR SWEEP CHARACTERISTICS

Modes:	Same as in logarithmic sweep.
Width:	3 decades maximum.
Time:	Continuously adjustable from 10mS to 999S, NOMINAL.
Sweep Out:	0 to 5V, ±5%.
Sweep Steps:	Depends on sweep time and range. Automatically adjusted by the instrument to get the maximum steps per sweep time. Maximum steps are 1000; minimum steps are 2.
Marker Output:	Same as in logarithmic sweep. Stop Sweep
Resolution:	Same as Frequency resolution.

CONTROL CHARACTERISTICS

Modes:	VCO, AM, FM (Model 8550), PWM (Model 8551)
Input:	Via front panel CONTROL INPUT BNC connector.
Impedance:	10KΩ ±5%.
Max Input Voltage:	±10V.

VOLTAGE CONTROLLED OSCILLATOR (VCO)/FM CHARACTERISTICS

VCO Sensitivity:	0V to □4.7V, ±20% produces 1/1000 frequency change from main frequency when main frequency is set to 9999 counts.
FM Sensitivity:	0V to 0.5V ±70mV, modulates to 1% deviation from center frequency. Modulation Bandwidth: DC to 50KHz.

AM CHARACTERISTICS

Modulation Input:	DC coupled.
Modulation Bandwidth:	DC to 1MHz.
Modulation Range:	0 to 200%; reduced to 70% at 1MHz.
Sensitivity:	0V to 5Vp-p produces 100% modulations; 0V to 10Vp-p produces suppressed carrier amplitude modulation (SCAM).

Table 1-1. Model 8550/8551 Specifications (continued)

Envelop Distortion:	<1% for modulation depth <90%, carrier frequency <1.00MHz, and modulation frequency <50KHz; <3% for modulation depth <50%, carrier frequency <50.00MHz, and modulation frequency <50KHz

PHASE LOCK CHARACTERISTICS

Reference Input:	Via TRIG/REF BNC terminal.
Impedance:	10KΩ, ±5%.
Sensitivity:	500mVp-p.
Max Input Voltage:	±20V (dc+peak ac)
Min Pulse width:	10ns.
Operation:	Output locks automatically to the frequency and phase of an external signal.
Locking Range:	10Hz to over 60MHz.
Phase Offset	
Range:	Continuously adjustable from -180° to +180°, 10Hz to 19.99MHz.
Resolution:	1°
Accuracy:	±(3° +3% of reading), 10Hz to 100KHz.

PWM CHARACTERISTICS

Sensitivity:	0 to 5V, ±20% produces >10% pulse width change from pulse width setting.
Band Width:	DC to 70KHz.

PULSE/RAMP CHARACTERISTICS (Model 8551 only)

Pulse Modes:	Symmetrical Pulse, Positive Pulse, Negative Pulse and Complement.
Pulse Period	
Range:	20.00ns to 99.99s.
Resolution:	4 digits.
Accuracy and Jitter:	Same as for frequency.
Pulse Width	
Range:	10.0ns to 999ms
Setting Accuracy:	±(5%+2ns), 10.0ns to 99.9ns; ±(4%+2ns), 100ns to 999ms.
Duty Cycle Range:	1% to 80%, up to 99% using complement mode.
Resolution:	3 digits.
Ramp Modes:	Positive or Negative going ramps. Ramp Period
Range:	7.000µs to 99.99s.
Resolution:	4 digits
Ramp Width	
Range:	5.00µs to 999ms.
Setting Accuracy:	3%, 5.00µs to 999ms.
Resolution:	3 digits.
Duty Cycle Range:	1% to 80%.

LEAD/TRAIL TIME CONTROL (Model 8551 only)

Range:	8ns to 99.9ms (10% to 90% of amplitude), in 6 overlapping ranges. Leading and trailing edges may be independently programmed within a common range.
In-Range Span:	125:1.
Resolution:	3 digits of programmed value when both transitions are in the first 10:1 portion of their transition time range, decreasing to 2 digits at 100:1.
Accuracy:	±(7% + 2ns), to 99ns; ±(6% + 2ns), above 99ns.
Linearity:	3% for transitions >100ns.

GPIB INTERFACE (IEEE-488.2)

Interface Functions:	Complies with IEEE488.2, including queries and common commands. Programmable controls: All front panel controls except POWER switch.
Subsets:	SH1, AH1, T6, TE0, L4, LE0, SR1, RL1, PP2, DC1, DT1, C0.
Program Message Format:	Program Message Header, Program Data (floating point and/or suffix program data), Program Message Terminator. Characters lower or upper case.
Response Message Format:	Variable length response format consisting of Response Header, Response Data (NR1, NR2, or NR3 format), and Response Message Terminator.
Common Commands and Queries:	*CAL?, *CLS, *ESE, *ESE?, *ESR, *IDN?, *OPC, *OPC?, *RCL, *RST, *SAV, *SRE, *SRE?, *STB, *TRG, *TST?, *WAI.
Status Reporting:	*ESR?, *STB?, and RQS - read by Serial Poll.
String Termination:	Selectable NL, END (EOI) or combination of both.
Address Selection:	Front panel programming. Address stored in a non-volatile memory.

GENERAL

Display:	4 digits, 7 segment LED's 0.5" high.
Power:	115/230Vac (Optional 100V available), 50 to 400Hz, 100VA max.
Stored Set-ups:	Stores 30 complete sets of front panel set-ups.
Dimensions:	3.5" x 8.3" x 15.4" (H x W x L).
Rack Mount Dimensions:	3.5" x 19" (H x W).
Weight:	Approximately 12Lbs.
Operating Temperature:	0° to 50° C.
Specified Accuracy:	Within ±5° C and 24 hours of last internal calibration.
Storage Temperature:	-40° C to +70° C.
Humidity range:	80% R.H.
Safety Designed to:	MIL-T-28800D, EN61010, IEC1010-1, UL-1224.
EMC:	EN50081-1, EN55022, EN50082-1, IEC85501-2, IEC85501-3, IEC85501-4.
Vibration:	Operates at a vibration level of 0.013 in. from 5 to 55Hz (2g at 55Hz)
Shock:	Non-operating, 40g 9ms half-sine pulse.

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2-1. INTRODUCTION

This Chapter contains information and instructions necessary for the installation and shipping of the Model 8550 and Model 8551. Details are provided for initial inspection, voltage selection, primary power frequency, power connection, grounding safety requirements, installation information, and re-packing instructions for storage or shipment.

2-2. UNPACKING AND INITIAL INSPECTION

Unpacking and handling of the counter requires only the normal precautions and procedures applicable to the handling of sensitive electronic equipment. The contents of all shipping containers should be checked for included accessories and certified against the packing slip to ascertain that the shipment is complete.

2-3. PERFORMANCE CHECKS

The instrument was carefully inspected for mechanical and electrical performance before shipment from the factory. It should be free of physical defects and in perfect electrical order upon receipt. Check the instrument for damage in transit and perform the electrical procedures outlined in Chapter 5. If there is indication of damage or deficiency, see the warranty in this manual and notify your local Tabor field engineering representative or the factory.

CAUTION

It is recommended that the operator be fully familiar with the specifications and all Chapters of this manual. Failure to do so may compromise the warranty and the accuracy which Tabor has engineered into your instrument.

2-4. LINE VOLTAGE AND FUSES

The Model 8550 accepts a primary input voltage from one of the following sources: a. 103.5 to 126.5 Vac (115 Vac, NOMINAL) b. 207 to 253 Vac (230 Vac, NOMINAL) Tabor ships the Model 8550 set for the line voltage and with the proper fuse for the destination country. Figure 2-1 illustrates the location of the line voltage switch and fuse holeder.

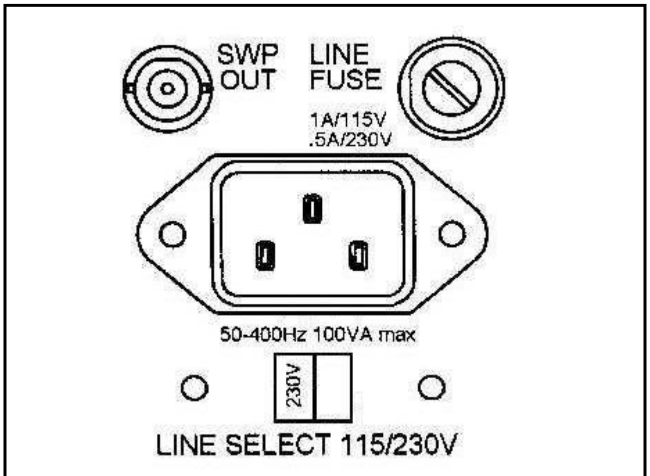

Figure 2-1. Line Voltage and Fuse Holder.

The instrument operates over the power mains frequency range of 50 to 400Hz. Always verify that the operating power mains voltage is the same as that specified on the rear panel voltage selector switch.

CAUTION

Failure to switch the instrument to match the operating line voltage will damage the instrument and may void the warranty.

The Model 8550 should be operated from a power source with its neutral at or near ground (earth potential). The instrument is not intended for operation from two phases of a multi- phase ac system or across the legs of a single-phase, three-wire ac power system. Crest factor (ratio of peak voltage to rms) should be typically within the range of 1.3 to 1.6 at 10% of the nominal rms mains voltage.

To change the line voltage, disconnect the power cord from the Model 8550, slide the Line Select switch (Figure 2-1) to the desired line voltage. Also be sure to change the fuse; see the following procedure.

To change the fuse, perform the following steps:

1. Disconnect the power cord from the instrument. Remove the fuse from the fuse holder.

2. Compare the ampere rating on the fuse to the ampere ratings given in Table 2-1. If the fuse is blown, replace it by sliding the new fuse back into the fuse holder. If the fuse is not blown and has the right rating, keep it. If the fuse has the wrong rating, replace the new fuse into the fuse holder.

3. Connect the ac line cord to the power connector at the rear of the unit and the power source.

AC Voltage	Selection	Fuse
103.5 to 126.5	115	1 amp, slo-blo
207.0 to 253.0	230	0.5 amp, slo-blo

Table 2-1. Line Voltage and Fuse Selection.

2-5. GROUNDING REQUIREMENTS

To insure the safety of operating personnel, the U.S. O.S.H.A. (Occupational Safety and Health) requirement and good engineering practice mandate that the instrument panel and enclosure be "earth" grounded. All of Tabor instruments are provided with an Underwriters Laboratories (U.L. and V.D.E) listed three-conductor power cable, which when plugged into an appropriate power receptacle, grounds the instrument. The long offset pin on the male end of the power cable carries the ground wire to the long pin of the Euro connector (DIN standard) receptacle on the rear panel of the instrument.

To preserve the safety protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green lead on the adapter to an "earth" ground.

CAUTION

To avoid operator shock hazard do not exceed the power mains voltage frequency rating which limits the leakage current between case and power mains. Never expose the instrument to rain, excessive moisture, or condensation.

2-6. INSTALLATION AND MOUNTING

The instrument is fully solid state and dissipates only a small amount of power. No special cooling is required. However, the instrument should not be operated where the ambient temperature exceeds 40° C, when the relative humidity exceeds 8550% or condensation appears anywhere on the instrument. Avoid operating the instrument close to strong magnetic fields which may be found near high power equipment such as motors, pumps, solenoids, or high power cables. Use care when rack mounting to locate the instrument away from sources of excessive heat or magnetic fields. Always leave 4 cm (1.5 inches) of ventilation space on all sides of the instrument.

2-7. BENCH OPERATION

The Model 8550/8551 is shipped with plastic feet, tilt stand in place and ready for use as a bench or portable instrument. See outline drawing Figure 2-1 for dimensions.

2-8. RACK MOUNTING

The instrument may be rack mounted in a standard 19 inch rack. The instrument may be rack mounted in Rack Mount Kit option 001.

2-9. PORTABLE USE

The instrument may be used in applications requiring portability. A tilt stand consisting of two retractable legs is provided with each unit.

2-10. SHORT TERM STORAGE

If the instrument is to be stored for a short period of time (less than three months), place cardboard over the panel and cover the instrument with suitable protective covering such as a plastic bag or strong craft paper. Place power cable and other accessories with the instrument. Store the covered voltmeter in a clean dry area that is not subject to extreme temperature variations or conditions which may cause moisture to condense on the instrument.

2-11. LONG TERM STORAGE OR RE-PACKAGING FOR SHIPMENT

If the instrument is to be stored for a long period or shipped, proceed as directed below. If you have any questions contact your local Tabor field engineering representative or the Tabor Service Department at the factory.

If the original Tabor supplied packaging is to be used proceed as follows:

1. If the original wrappings, packing material, and container have been saved, re-pack the instrument and accessories originally shipped to you. If the original container is not available, one may be purchased through the Tabor Service Department at the factory.

2. Be sure the carton is well sealed with strong tape or metal straps.

3. Mark the carton with the model number and serial number with indelible marking. If it is to be shipped, show sending address and return address on two sides of the box; cover all previous shipping labels.

If the original container is not available, proceed as follows:

1. Before packing the unit, place all accessories into a plastic bag and seal the bag.

2. For extended storage or long distance shipping only, use U.S. government packing method II C and tape a two-unit bag of desiccant (per MIL-D-3464) on the rear cover.

3. Place a 13 cm (5 inch) by 30 cm (12 inch) piece of sturdy cardboard over the front panel for protection.

4. Place the counter into a plastic bag and seal the bag.

5. Wrap the bagged instrument and accessories in one inch thick flexible cellular plastic film cushioning material (per PPP-C-795) and place in a barrier bag (per MIL-B-131). Extract the air from bag and heat seal.

6. Place bagged instrument and accessories into an oversized card-board box (per PPP-B-636 type CF, class WR, variety SW, grade V3C). Fill additional spaces with rubberized hair or cellular plastic cushioning material. Close box in accordance with container specifications. Seal with sturdy water resistant tape or metal straps.

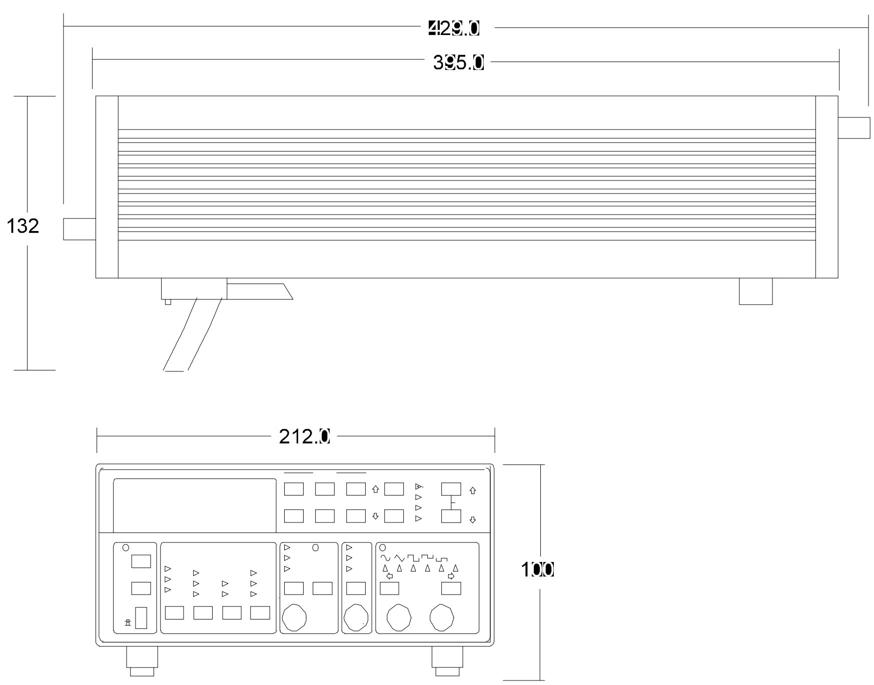

Figure 2-2. Model 8550/8551 - Outline Dimensions.

7. Mark container "DELICATE INSTRUMENT", "FRAGILE", etc. Mark instrument model and serial number and date of packaging. Affix shipping labels as required or mark according to MIL-STD-129.

NOTE

If the instrument is to be shipped to Tabor for calibration or re- pair, attach a tag to the instrument identifying the owner. Note the problem, the symptoms, and service or repair desired. Record the model and serial number of the instrument. Show the work authorization order as well as the date and method of shipment. ALWAYS OBTAIN A RETURN AUTHORIZATION NUMBER FROM THE FACTORY BEFORE SHIPPING THE INSTRUMENT TO Tabor.

2-12. SAFETY

Be fully acquainted and knowledgeable with all aspects of this instruction manual before using the instrument to assure operator safety and protection against personnel shock hazard.

3-1. INTRODUCTION

Model 8550/8551 operation is divided into two general categories: basic bench operation, and IEEE-488 operation. Basic bench operation, which is covered in this Chapter, explains how to use the model 8550 for generating the required waveform characteristics. IEEE programming can also be used to greatly enhance the capability of the instrument in applications such as automatic test equipment. This aspect is covered in details in Chapter 4.

3-2. FRONT PANEL FAMILIARIZATION

The front panel is generally divided into three Chapters: controls, connectors, display and indicators. The following paragraphs describe the purpose of each of these items in details.

3-2-1. Controls

All front panel controls except POWER are momentary contact switches. Most controls include an annunciator light for indication of the selected parameter and operating mode. Some controls do not have an annunciator light. Exercising these controls generates an immediate response on the display.

Front panel controls may be divided into functional groups: Operating mode, State, Main Parameters, Trigger Mode, Control, Output and Modifiers.

3-2-1-1. Operating Mode

Two push-buttons in the operating mode group provide selection between four operating modes. Selection of one of the operating modes is done by depressing one of these buttons. The selected mode is indicated by an LED.

3-2-1-2. State

Three push-buttons are included in the status group. The function of each of these buttons is described in the following.

POWER - The POWER switch controls the AC power to the instrument. Pressing and releasing the switch once turns the power on. Pressing and releasing the switch a second time turns the power off.

2nd/EXE - Several push-buttons were assigned a second function which are only accessible after the [2nd] button was depressed. These functions are marked below the buttons in blue script. Some second functions require that the [EXE] push-button be pressed again before the function is executed.

LCL/P.SET/DCL - The LCL/P.SET push-button when depressed, and the instrument is in its remote mode (but not in remote lockout condition LLO), restores the instrument to its local operating mode. When the generator is in its local operating mode, depressing this push-button restores only the currently displayed parameter to its factory pre-set value, other parameters are not affected by pressing this button. Front panel P.SET values are listed in Table 3-1. A third function is also assigned to this switch. Depressing this push-button after the [2nd] button consequently modifies front panel set-up to its factory default. The function of DCL is described in details in paragraph 3.5.

3-2-1-3. Main Parameters - Model 8550

There are four MAIN PARAMETERS push-buttons which are used to modify the displayed reading. Each time a button is depressed a different parameter is displayed. The selected parameter is indicated by an LED. Each row of LEDs is associated with a specific operating mode. The parameters in the following may be displayed and modified. Table 3-2 lists the limits for each of the above parameters.

1. FUNCTION

FREQ - Frequency of the selected output waveform. Frequency is defined for repetitive signals only. When the function generator is set to operate in triggered mode, the programmed frequency value has no effect on the output. In gated mode, the frequency defines the repetition rate within the gating signal. In sweep mode, the programmed value defines the sweep start point. The programmed frequency retains its value at both SYNC and the main output connectors. The frequency parameter may be programmed within the range of 10.00mHz to 50.00MHz. Preset value is set to 1.000KHz.

AMPL - Amplitude of the selected waveform at the main output connector. The output signal is driven from a 50Ω source therefore, the value of the amplitude parameter is specified and accurately controlled only when the output is terminated with 50Ω. If the signal from the output connector is connected to an high impedance circuit, the actual amplitude level at the output connector is doubled. Amplitude control has no effect on the amplitude level at the SYNC output connector. The amplitude parameter may be programmed within the range of 10.0mV to 16.0V. Preset value is set to 1.00V.

OFST - DC offset of the selected waveform at the main output connector. Similarly to the amplitude, the offset parameter is specified and accurately controlled only when the output is terminated with 50Ω. Offset control has no effect on the SYNC output connector. The offset parameter may be programmed within the range of 0.00mV to ±7.95V. Preset value is set to 0mV.

2. SWEEP

STOP - Defines the sweep stop frequency. When the function generator is set to operate with one of its sweep modes, the waveform at the output connector sweeps from frequency set by the FREQ setting to that set by the STOP frequency. In several sweep modes sweep stop may change its function to sweep start. The programmed frequency retains its value at both SYNC and the main output connectors. If the instrument is set to operate in logarithmic sweep mode, the sweep stop parameter may be programmed within the range of 10.00mHz to 50.00MHz. In linear sweep mode the sweep stop parameter may only programmed within three decades from the start frequency setting. Preset value is set to 9.000KHz.

TIME - In linear sweep mode, sweep time determines the time that it takes for completing one sweep cycle. Sweep time is different for logarithmic sweep mode where the specified value is that required for sweeping one decade. The generator may be set to sweep over 10 decades. In that case, the sweep time should be multiplied by ten. Decade size ranges from 1000 to 9999 counts (or 100:1 if settings other than full and minimum scales are required). If only part of the decade is being swept, the sweep time is reduced proportionally. The sweep time parameter may be programmed within the range of 10ms to 999s. Preset value is set to 1.00s.

MARK - Specifies the frequency of which the sweep marker changes its voltage level at the marker output connector. The marker output is only active when the function generator is set to operate with one of its built-in sweep modes. The sweep marker parameter may be programmed within the same range as the frequency stop parameter. Preset value is set in both linear and logarithmic modes to 5.000KHz.

3. PHASE OFFSET

PLL - The Model 8550 output may be locked to an external signal. The operator may then introduce a phase offset between the leading edge of the external signal and the leading edge of the signal at the output connector. The phase offset is programmed with the PLL parameter. The phase offset parameter may be programmed within the range of ±180°. Preset value is set to 0°.

TRIG - The TRIG parameter inserts a phase offset between the triggering signal and the generated output signal. The trigger phase offset has no effect on external signals having a high slew rate, such as square waves. The trigger phase offset parameter may be programmed within the range of ±90°. Preset value is set to 0°.

4. TRIGGER

PER - A built-in generator provides an internal triggering stimulant in such cases where an external signal is not available. The displayed value specifies the interval between consecutive triggering sequences. The trigger period parameter may be programmed within the range of 20μs to 999s. Preset value is set to 1.00s.

BUR - Model 8550 has the capability of generating a burst of waveforms, at its output connector, having an exact number of complete cycles. The counted burst function operates on all output waveforms except on DC output. The burst of counted number of output cycles can be programmed within the range of 1 to 4000 output cycles. Preset value is set to 2 cycle.

LEVEL - The LEVEL parameter sets the trigger voltage level at the TRIG INPUT connector. The output signal will trigger the function generator at the point set by LEVEL parameter. The trigger level parameter may be programmed within the range of -10.0V to +10.0V. Preset value is set to 1.6V.

3-2-1-3A. Main Parameters - Model 8551

There are four MAIN PARAMETERS push-buttons which are used to modify the displayed reading. Each time a button is depressed a different parameter is displayed. The selected parameter is indicated by an LED. Each row of LEDs is associated with a specific operating mode. The parameters in the following may be displayed and modified. Table 3-2 lists the limits for each of the above parameters.

1. FUNCTION

FREQ - Frequency of the selected output waveform. Frequency is defined for repetitive signals only. When the function generator is set to operate in triggered mode, the programmed frequency value has no effect on the output. In gated mode, the frequency defines the repetition rate within the gating signal. In sweep mode, the programmed value defines the sweep start point. The programmed frequency retains its value at both SYNC and the main output connectors. The frequency parameter may be programmed within the range of 10.00mHz to 50.00MHz. Preset value is set to 1.000KHz.

AMPL - Amplitude of the selected waveform at the main output connector. The output signal is driven from a 50 source therefore, the value of the amplitude parameter is specified and accurately controlled only when the output is terminated with 50. If the signal from the output connector is connected to an high impedance circuit, the actual amplitude level at the output connector is doubled. Amplitude control has no effect on the amplitude level at the SYNC output connector. The amplitude parameter may be programmed within the range of 10.0mV to 16.0V. Preset value is set to 1.00V.

OFST - DC offset of the selected waveform at the main output connector. Similarly to the amplitude, the offset parameter is specified and accurately controlled only when the output is terminated with 50. Offset control has no effect on the SYNC output connector. The offset parameter may be programmed within the range of 0.00mV to ±7.95V. Preset value is set to 0mV.

P.OFST - The Model 8551 output may be locked to an external signal. The operator may then introduce a phase offset between the leading edge of the external signal and the leading edge of the signal at the output connector. The phase offset is programmed with the P.OFST parameter. The phase offset parameter may be programmed within the range of ±180°. Preset value is set to 0°.

2. PULSE

PER - Similar to the FREQ parameter, the PER sets the period of the selected output waveform. Period is defined for repetitive signals only. When the pulse/function generator is set to operate in triggered mode, the programmed period value has no effect on the output. In gated mode, the period defines the repetition rate within the gating signal. The programmed period retains its value at both SYNC and the main output connectors. The period parameter may be programmed within the range of 20.00ns to 99.99s. Preset value is set to 1.000ms.

WIDTH - The pulse width parameter defines the time interval between two consecutive transitions; positive to negative transition in normal output mode or negative to positive transition in pulse complement mode. The width parameter is common to the pulse and the ramp waveforms. It is convenient to interpret the displayed and specified value as that obtained with the fastest edges. However, In linear transition mode, the displayed and specified value is that obtained at the turning point of the pulse edges. The pulse width parameter may be programmed within the range of 10.0ns to 999ms. The ramp width parameter may be programmed within the range of 5.00**s** to 999ms. Preset value is set for both the pulse width and the ramp width to 100**s**.
DUTY - The DUTY parameter specifies the duty cycle of either the pulse output or the ramp output, when the Model 8551 is set to operate in its fixed duty cycle mode. The duty cycle parameter may be programmed within the range of 1% to 8550%. Preset value is set 50%.

3. TRANSITION

LEAD - The LEAD parameter specifies the time interval between the 10% to 90% amplitude points on the leading edge. The leading edge value may only be selected when the pulse/function generator is set to operate in its linear transition mode; otherwise, the leading edge transition time is set to its fastest position. The leading edge transition time parameter may be programmed within the range of 8ns to 99.9ms. Preset value is set 10.0µs.

TRAIL - The TRAIL parameter specifies the time interval between the 10% to 90% amplitude points on the trailing edge. The trailing edge value may only be selected when the pulse/function generator is set to operate in its linear transition mode; otherwise, the trailing edge transition time is set to its fastest position. The trailing edge transition time parameter may be programmed within the range of 8ns to 99.9ms. Preset value is set 10.0□s.

4. TRIGGER

PER - A built-in generator provides an internal triggering stimulant in such cases where an external signal is not available. The displayed value specifies the interval between consecutive triggering sequences. The trigger period parameter may be programmed within the range of 20µs to 999s. Preset value is set to 1.00s.

BUR - Model 8551 has the capability of generating a burst of waveforms, at its output connector, having an exact number of complete cycles. The counted burst function operates on all output waveforms except on DC output. The burst of counted number of output cycles can be programmed within the range of 1 to 4000 output cycles. Preset value is set to 2 cycles.

LEVEL - The LEVEL parameter sets the trigger voltage level at the TRIG INPUT connector. The output signal will trigger the function generator at the point set by LEVEL parameter. The trigger level parameter may be programmed within the range of □10.0V to +10.0V. Preset value is set to 1.6V.

PHASE - The PHASE parameter inserts a phase offset between the triggering signal and the generated output signal. The trigger phase offset has no effect on external signals having a high slew rate, such as square waves. The trigger phase offset parameter may be programmed within the range of ±90°. Preset value is set to 0°.

3-2-1-4. Trigger Mode

Two push-buttons are grouped in the TRIGGER MODE Chapter. Selection of one of the trigger modes is done by depressing one of these buttons. The selected mode is indicated by an LED. Model 8550 may be triggered from either one of the following sources:

1. External signal which may be applied to the TRIG/REF IN connector
2. An internal - asynchronous trigger generator
3. GPIB commands (like GET or *TRG)
4. Front panel [MANual] push-button

The [MANual] trigger is active when the instrument set to operate in one of its external trigger modes. This push-button when depressed serves as a replacement for an external trigger source.

3-2-1-5. Control

There is one push-button in the MOD group. This button is used to select an external modulation control for the function generator. The selected control mode is indicated by an LED.

3-4-1-6. Output

There are two push-buttons in the OUTPUT group. These buttons are used for selecting an output waveforms for the output connector. The selected function is indicated by an LED.

Note

The Model 8550 powers up with its output in stand by state. You have to press one of the two push-buttons in the OUTPUT group to remove the Model 8550 from stand by.

3-4-1-7. Modifier

The MODIFIER push-buttons simulate digital potentiometers. The MODIFIER push-buttons operate in conjunction with the MAIN PARAMETER group. There are four sets of modifying buttons. Three sets are dedicated for changing the displayed read-out. The two push-buttons which are marked RANGE are used to change the range of the displayed parameter.

3-2-2 Connectors

The connectors are used for connecting the Model 8550 to the unit under test, to a control device, and to an external triggering stimulant.

1. TRIG/REF INPUT - The TRIG/REF INPUT connector is used for applying an external triggering source to the function generator. The same connector is used in conjunction with the phase lock operating mode; the reference signal is applied to this connector.

2. MOD INPUT - The MOD INPUT connector is used for applying external controlling signals to the

Table 3-1. Default States After Software Reset

FUNCTION	DESCRIPTION	DEFAULT STATE
Function Parameters		
FREQ	Frequency	1.000KHz
AMPL	Amplitude	1.00V
OFST	Offset	0mV
Sweep Parameters		
STOP	Sweep Stop Frequency	9.000KHz
TIME	Sweep Time	1.00s
MARK	Sweep Marker Frequency	5.000KHz
Phase Parameters		
PLL (Model 8550)	Phase Lock Offset	0º
P.OFST (Model 8551)	Phase Lock Offset	0º
TRIG (Model 8550)	Start Trigger Phase Offset	0º
Trigger Parameters		
PER	Internal Trigger Period	1.00s
BUR	Counted Burst	2 cycles
LEVEL	Trigger Level	1.6V
PHAS (Model 8551)	Start Trigger Phase Offset	0º
Pulse/Ramp Parameters		
PER (Model 8551)	Period	1.000ms
WIDTH (Model 8551)	Pulse/Ramp Width	10.0s
DUTY (Model 8551)	Duty Cycle	50%
Operating Mode	Main Operating Mode Selection	Normal Function Generator
State	GPIB Status	Local state
Display	Displayed Parameter	Frequency
Trigger Mode	VCO stimulant	Internal, Continuous Mode
Control	Carrier Modulation Control	Off
Output	Output Waveform	Sinewave
ST. BY	Output Stand By	On (no output)

function generator. Model 8550 accepts VCO, amplitude and frequency modulating signals, while Model 8551 accepts additional pulse width modulating signal.

3. SYNC OUT - The SYNC OUT connector outputs fixed amplitude pulses from a 50Ω source. The leading edge of the SYNC output is synchronous with the leading edge at the main output connector.

4. OUT - The OUT connector is used as the main output for the function generator. Output is driven from a 50Ω source. Special care should be taken when these outputs are connected to the device under test because these outputs are capable of delivering up to 32Vp-p. For safety reasons, after power on or after software reset, the OUT connector is disconnected from the output circuit. To resume normal operation press one of the two buttons above the OUT connector.

3-2-3. Display And Indicators

1. DISPLAY - The function of the numeric display is to indicate the value of the various parameters. The display consists of a 4 digit mantissa and a single digit exponent. The exponent uses a leading minus indicating negative values. The sign on the exponent changes to + for zero or positive values.

The display is also used to indicate other information such as messages.

2. INDICATORS - 35 indicators are located on the front panel (Model 8551). These indicators are used as pointers to a selected parameter, operating modes, trigger modes etc.

3-3. REAR PANEL FAMILIARIZATION

3-3-1. Connectors And Switches

1. AC RECEPTACLE - Power is applied through the supplied power cord to the 3-terminal AC receptacle. Note that the selected ac mains voltage is marked on the line voltage selector switch.

2. LINE SWITCH - The LINE VOLTAGE SELECTOR switch selects one of the primary voltage which are marked on both sides of the switch.

3. LINE FUSE - The line fuse provides protection for the AC power line input. For information on replacing this fuse, refer to Chapter 5.

4. IEEE-488 CONNECTOR - This connector is used for connecting the instrument to the IEEE-488 bus.

5. SWEEP OUT CONNECTOR - This connector is used for connecting the instrument the X input on the oscilloscope. Its output level is either fixed - in linear sweep mode, or proportional to the sweep time per decade - in logarithmic sweep mode.

6. MARKER OUTPUT CONNECTOR - This connector is used for connecting the function generator to the Z input on the oscilloscope. This output is only active when sweep mode is on.

3-4. POWER-UP PROCEDURE

The basic procedure of powering up the Model 8550 is described below.

1. Connect the female end of the power cord to the AC mains receptacle on the rear panel. Connect the other end of the power cord to a grounded AC outlet.

WARNING

Be sure the power line voltage agrees with the indicated value on the rear panel of the instrument. Failure to heed this warning may result in instrument damage.

The instrument is equipped with a 3-wire power cord designed to be used with grounded outlets. When the proper connections are made, the instrument chassis is connected to the power line ground. **Failure to use a properly grounded outlet may result in personal shock hazard.**

2. Turn on the mains power by pressing and releasing the POWER switch on the front panel.

3. The instrument then begins operation by performing a display and indicator test which takes approximately one second. All front panel indicators turn on and the display appears as follows:

8.8.8.8.|8

4. To verify that all display segments are operating, compare the instrument's display with the above during the test.

5. After all the indicators are tested, the instrument performs ROM and RAM tests. Successful execution of these tests is followed by a one second read-out of the installed software revision, similar to the example below:

So1.0

6. Following the software revision level, the instrument proceeds with displaying the previously selected GPIB primary address. The GPIB address is set by front panel programming and is stored in the non-volatile memory. For example, with the generator programmed to address 18, the display shows:

GP18

7. Following these display messages, the instrument commences its normal operating mode and generates waveforms. Note that the instrument is equipped with a non-volatile memory. This memory automatically monitors front panel traffic and retains its latest set-up for events such as accidental power loss. In case of power loss the instrument resumes operation with its previously programmed front panel set-up.

NOTE

One who does not wish to observe the power-up procedure every time that the generator is turned on, can easily remove the sequence of displayed messages. Depressing [2nd] and then [Operating Mode □] in sequence writes a special code to the non-volatile memory. The next time the generator will be powered-up, the instrument will skip the power-up procedure and will immediately commence with displaying the front panel set-up. repeating the sequence of [2nd] and [Operating Mode ↑] restores normal power up procedure. Note that there are no front panel markings that indicate power-up sequence removal. Therefore, unless the instrument is being used by one person only, and to remove confusion, it is recommended that power-up sequence remains unchanged.

3-5. SOFTWARE RESET

An operator who is not yet fully familiar with front panel operation of the function generator, may find himself locked into a “dead-end” situation where nothing operates the way it should. The fastest way of restoring the generator to a known state is by resetting its software. This may be done by pressing the [2nd] push-button and then pressing the [DCL] push-button (second function to the [LCL/P.SET] push-button). The instrument then resets to its factory selected defaults. Table 3-1 summarizes these defaults.

3-5-1. Parameter Preset

As discussed in paragraph 3-5, software reset restores all front panel parameters to their factory selected values. It may, however, be required to preset one or two parameters and leave the rest intact. In that case the instrument provides additional capabilities with its [P.SET] (preset) function. Depressing [LCL/P.SET] push-button modifies the displayed parameter to its default value. Default values are summarized in Table 3-1.

NOTE

Software reset has no effect on the stored front panel set-ups. Software reset also has no effect on the programmed GPIB address.

3-6. DISPLAY MESSAGES

Model 8550 has several display messages pertaining to its operation. The generator also displays an error indication when a front panel programming error is detected. These messages and error indications are discussed in the following. Note that the instrument has a number of additional display messages associated with IEEE-488.2 programming. These messages are discussed in Chapter 4 of this manual.

3-7. DETECTING PROGRAMMING ERRORS

Model 8550 is a product of many years of experience and complete understanding of human engineering requirements. A great deal of time was devoted during its design stage to simplify front panel programming procedures, thereby minimizing the potential of programming errors. It is impossible however for an inexperienced operator to completely avoid programming errors. For such cases, the function generator employs a built-in error detection mechanism which warns against programming errors.

There are several error indications that may occur due to incorrect front panel programming procedures. The indications are either visible (error messages) or audible (beeping sound). The audible alarm sounds while attempting an incorrect front-panel programming sequence. For instance, an attempt to program an offset which exceeds the level window limits is a cause for such an alarm. The alarm sound as long as the conditions remain false. Other error conditions which may cause an audible alarm are discussed in different parts of this manual.

Front panel programming errors are normally indicated by an audible alarm. GPIB errors are detected automatically and are screened for a service request poll. These indications are described in the following paragraphs.

3-8. FRONT PANEL ERROR INDICATION

In general, whenever a front panel or GPIB programming attempts to place the 8550 in an error condition, the Model 8550 responds by front panel error indication or by addressing the IEEE-488.2 service request register.

Errors are categorized in four main groups:

1. General errors
2. Limit errors
3. Pulse/Ramp setup errors
4. IEEE errors
5. Auto-Calibration errors

3-8-1. General Errors

Errors in this group are caused by improper usage of the instrument. Such errors occur while attempting to place the instrument in an illegal mode. For example, depressing simultaneously two push-buttons (except [AUTOCAL]) has no valid definition or by depressing the MANUAL push-button while the instrument is in its continuous operating mode. In such cases, the instrument sounds an audible alarm, ignores this error, and continues with its normal operation.

3-8-2. Limit Errors

Errors in this group are caused by an attempt to program values outside the legal limits of the instrument. The instrument automatically rejects any attempt to program such parameters, sounds an audible alarm, and then resumes normal operation. Table 3-2 summarizes all front panel entry limits.

3-8-3. Pulse/Ramp Set-up Errors (Model 8551 only)

The pulse/ramp setup errors are inter-parameter inconsistencies errors, such as pulse width greater than the selected period. The pulse generator tests the programmed parameter every time that a modifier push-button is depressed. Programming the Model 8550 with pulse/ramp errors is possible and executable however, when such errors are detected, the ERROR light starts blinking; indicating that the signal at the output connector may emerge with other parameters then those programmed. The light error blinks until the error conditions are removed. Pulse/ramp error summary is given in Paragraph 4-14-4.

Pulse/Ramp errors may occur under one or more of the following conditions:

1. The programmed pulse/ramp WIDTH parameter is greater than the selected period.

2. Model 8551 is placed in linear transition time and one of the programmed transitions is greater than the selected pulse width.

3. Model 8551 is placed in internal triggered mode and the programmed pulse/ramp width is greater than the selected internal trigger period.

4. The programmed ramp width is outside the limit of 5.00µs.

5. The programmed pulse width is outside the specified limits.

3-8-4. IEEE-488.2 Errors

In general, whenever a GPIB programming attempts to put the model 8550 into an error condition, the function generator responds in two ways. First by displaying a front panel message and then, if programmed so, by raising an SRQ flag in its Status Byte Register. Using the serial poll command, the controller may then address the generator and request its status byte.

The generator incorporates a number of display messages which are associated with errors involving GPIB interface programming. These messages are discussed in detail in Chapter 4 of this manual.

There is one message however, which should be explained at this point because it may interfere with front panel operation. A remote enable or a device dependent command sent to the instrument through the bus turns the REMOTE light on. In this case, all front panel push-buttons except [LCL] are disabled. Press one of these push-buttons causes the function generator to respond with the following message:

LcL

This message indicates that the instrument expects that the [LCL] push-button be first depressed otherwise front panel operation is ignored. After the [LCL] button is depressed, the REMOTE light turns off and the instrument is ready to accept further front panel programming sequences.

3-8-5. Auto-Calibration Errors

Model 8550 provides an auto-calibration function which may be used by the operator. In the event that the calibration routine fails to successfully complete, the generator generates a calibration failure list and starts displaying the following message:

FAIL d

Where d represents blinking digits in the range of 1 to 9. A function LED indicator - in the MAIN PARAMETERS, blinks simultaneously; indicating the area where the generator failed to calibrate. Operating the auto-calibration function and interpreting the generated failure list are described later in this manual. The auto-calibration failure list is also available as a GPIB failure status query.

3-9. SELECTING 2nd FUNCTIONS

A few front panel push-buttons were assigned a secondary function. These functions are marked below the button in blue color and are accessible through the [2nd] push-button.

There are ten front panel buttons which were assigned a secondary function. These functions are:

DCL	**STORE**
RECALL	**SWP MODE** (Model 8550)

GPIB ADR **LIN/FIXED** (Model 8551)
RCL MODE **INT TRG STANDBY**
COMPL (Model 8551) **FAIL LIST**

The operation of these secondary functions is described later in this chapter. Pressing the [2nd] push-button generates the following display read-out:

2nd ?

The question mark (?) appears blinking; indicating that the instrument is ready for a consequent press of another push-button which was assigned a secondary function. Depressing [2nd] once more cancels this function. Second functions: DCL, SWP MODE, LIN/FIXED/ INT TRG, ST-BY, and COMPL function are executed immediately; STORE, RECALL, GPIB ADR, RCL MODE, and FAIL LIST will be executed only after depressing the [EXE] push-button.

3-10. AUTO-CALIBRATION

Model 8550 provides an auto-calibration function that may be operated at any time, either from the front panel or through a GPIB command. Operating the auto-calibration is very simple and can be done by anyone; no special skills are required. Although this function can give the user relative confidence that the instrument is operational and within specification, it is still recommended that the function generator will be checked periodically by certified calibration laboratories. Suggested calibration period by certified calibration laboratories is given in Chapter 5 of this manual. The auto-calibration takes only few seconds to complete. It therefore could be used often without serious delay to its normal operation. However, the auto-calibration function **must be** operated when one or more of the following conditions occur:

1. After 30 minutes of warm-up time;

2. After 24 hours of last internal auto-calibration;

3. If ambient temperature changes by more than 5□C, and;

4. After replacing components or sub-assemblies.

To operate the auto-calibration function proceed with the following steps:

1. Depress the POWER switch once to turn power on, and leave the instrument on at least 30 minutes until the internal circuits reach thermal equilibrium.

PARAMETER	LOW LIMIT	HIGH LIMIT	REMARKS
FRQ (frequency)	10.00mHz	50.00MHz	
AMP (amplitude)	10.	16.0V	Into 50Ω
OFS (offset)	0.0mV	±795mV	Within a ±800mV level window
OFS (offset)	0mV	±7.95V	Within a ±8.00V level window
PLL (phase offset)	0º	±180º	
PER (period)	99.99s	20.00ns	Model 8551 only
WID (pulse/ramp width)	999ms	10.0ns	Model 8551 only
DTY ((duty Cycle)	1%	80%	Model 8551 only
LEE (leading edge)	99.9ms	8ns	Model 8551 only
TRE (trailing edge)	99.9ms	8ns	Model 8551 only
RPT (internal trigger period)	999s	20µs	
BUR (counted burst)	1	4000	
TLV (trigger level)	0.0mV	±10.0V	
TPH (trigger phase offset)	0º	±90º	
DCO (dc output level)	0.0mV	8.00V	Model 8550 only
STP (log sweep stop)	10.00mHz	50.00MHz	Model 8550 only
SSN (lin sweep stop)	10 display counts	5000 display counts	Model 8550 only
SWT (sweep time)	10ms	999s	Model 8550 only
MRK (log marker freq)	10.00mHz	50.00MHz	Model 8550 only
MKN (lin marker freq)	10 display counts	5000 display counts	Model 8550 only
*SAV (store)	00	30	
*RCL (recall)	00	30	

Table 3-2. Front Panel Parameter Entry Limits

2. Depress the two [AUTOCAL] push-buttons simultaneously, and observe that the generator displays the following:

CAL ?

The "?" appears blinking; indicating that the instrument has not yet commenced with its calibration routine. Depress any front panel push-button to quit the auto-calibration sequence and return to normal operation. Depressing [EXE] initiates the calibration routine. The blinking question mark is then replaced by a moving bar. The bar circles as long as the calibration routine is in process.

Following successful execution of its internal calibration, the instrument resumes normal operation. If self calibration fails, the generator proceeds with displaying a failure list. Recalling and terminating the failure list display is described in the succeeding paragraph. Analyzing and interpreting the failure list is described in Chapter 5.

3-11. REVIEWING THE AUTO-CALIBRATION FAILURE LIST

As discussed above, if the auto-calibration fails to successfully complete, the instrument automatically generates a failure list. The operator can review this list either immediately after the auto-calibration process or anytime later provided, however, that a sub- sequent calibration process did not remove one the previously generated errors.

If the auto-calibration completes without detecting a calibration error, no failure list is generated and the function generator resumes normal operation. If a calibration error is detected, the generator starts displaying a message as described in paragraph 3-8-5.

To terminate this display message and to exit from the failure evaluation process depress any front panel push-button. To evaluate the complete failure list depress the [FAIL LIST ↑] or the [FAIL LIST ↓] push-buttons. The blinking LED and the associated displayed digit indicates where the instrument has some difficulties to calibrate itself.

To recall the last saved failure list depress the [2nd] and the [FAIL LIST ↓] push-buttons in sequence and observe that the instrument displays the message as described in paragraph 3-8-5. Commence with the evaluation using the same procedure as was described above.

3-12. MODIFYING PARAMETERS

There are various parameters, such as frequency and amplitude, which control the shape of the wave-form at the output connector. Modification of a specific parameter is simply done by pressing the push-button below the requested parameter until the light behind the required parameter illuminates. At this time the numeric readout displayed a value plus an exponent. For example, a FREQ readout of 10.00 (exp)+3 tells us that the output waveform is programmed to have a frequency of 10.00 KHz. Limits for each parameter are given in Table 3-2. The parameter can be modified using the [MODIFIER] and the [RANGE] push-buttons.

The parameters which can be modified are marked on the front panel as follows:

Function parameters:

FREQ (Frequency)
AMPL (Amplitude)
OFST (Offset)
PHASE (PLL offset - Model 8551)

Sweep parameters (Model 8550 only):

STOP (Sweep stop frequency)
TIME (Sweep time)
MARK (Marker frequency)

Pulse parameters (Model 8551 only):

PER (Period)
WIDTH (Pulse width)
DUTY (Duty cycle)

Phase offset Parameters:

PLL (PLL offset - Model 8550)
TRIG (Trigger phase offset)

Transition times parameters (Model 8551 only):

LEAD Leading edge
TRAIL Trailing edge

Trigger parameters:

PER (Int. trigger period)
BUR (Burst count)
LEVEL (Trigger level)
PHASE (Trig phase - Model 8550)

In addition, some parameters are accessible through the [2nd] button. These parameters are:

3-10 *Operating Instructions*

STORE	(Store address)
RECALL	(Recall address)
SWP MODE	(Sweep mode/direction)
GPIB ADR	(GPIB address)

3-12-1. Using the Modifier

The modifier group consists of three sets of push-buttons - each having its top button marked with an arrow pointing up (↑) and its bottom key marked with an arrow pointing down (↓). These modifier push-button control the displayed readout within a selected range.

The [x1 ↑] or [x1 ↓] push-buttons when depressed and released once increment or decrement the least significant digit on the numeric display. Depressing these buttons for more than one second modifies this digit constantly until the button is released or until the parameter limit is encountered. Incrementing the [x1] above 9 carries 1 to the second digit.

The [x10 ↑] or [x10 ↓] push-buttons control the second digit. Their operation is similar to the [x1] operation. Incriminating the [x10] above 9 carries 1 to the second digit.

The [x100 ↑] or [x100 ↓] push-buttons control the third and the fourth (most significant) digit.

3-12-2. Modifying the Range

The [RANGE] buttons control the range of the dis-played parameter. Depressing and releasing the [RANGE ↑] or the [RANGE ↓] buttons increases or decreases respectively the displayed range. Depressing these buttons when the generator is already at its highest or lowest range produces no further change.

3-12-3. Parameter Limits

In general, parameters were assigned definite boundaries. The instrument was design in such a way that front panel programming, under no circumstances, may lead to an error situation by exceeding the specified limits. GPIB parameter programming errors are discussed in Chapter 4. Front panel programming permits modification of parameters within the limits which are given in Table 3-2. Note that the modifier buttons [x1], [x10] and [x100] can only modify a parameter within one range. These buttons in con- junction with the [RANGE] push-button may cover the entire specified range.

3-13. SELECTING AN OPERATING MODE - MODEL 8550

Model 8550 may operate as a function generator, as a sweep generator (linear or logarithmic), and as a phase locking generator. Selecting one of the operating modes is done by depressing one of the OPERATING MODE [↑ or ↓] push-buttons until the light behind the desired mode illuminates.

Description of the various modes which can be used Model 8550 is given in the following.

3-13-1. Normal Function Generator Operating Mode - Model 8550

Function generator operating mode is the normal operating conditions where the output waveform is symmetrical about its horizontal and vertical axis. The normal operating mode also permits a vertical offset of its output waveform. The generator is placed in its normal operating mode when the light behind FUNC illuminates. Triggered operation and externally controlled modes such as VCO, FM, and AM may operate in conjunction with the normal function generator operating mode.

3-13-2. Linear/Logarithmic Sweep Operating Mode - Model 8550

Placing the model 8550 in linear or logarithmic sweep operating mode transforms the instrument into an independent sweep generator. The function generator has eight built-in sweep modes of which four of them are linear sweep modes and four are logarithmic. Select between linear or logarithmic sweep mode by depressing the OPERATING MODE [□ or □] push- buttons until the light behind the desired mode illuminates. The various sweep modes may operate in conjunction with the triggered modes.

3-13-2-1. Selecting Sweep Direction

When Model 8550 is placed in sweep mode (linear or logarithmic), the selected waveform at the output connector repeatedly changes its frequency in a direction set by the sweep start (FREQ) parameter to frequency set by the sweep stop (STOP) parameter. The time for completing one sweep cycle is deter- mined by the sweep time (TIME) parameter. There are four different directions that the output waveform may sweep to. The difference between the various modes is more significant when using the triggered sweep mode as described in the following:

SWEEP UP - The function generator, when triggered, sweeps from value set by FREQ to value set by STOP. Sweep time is determined by TIME. At the end of the sweep, the output waveform remains at the stop frequency. Following another trigger, the output jumps quickly to its start frequency and the above cycle is repeated. In normal mode the generator repeats its sweep cycle continuously.

SWEEP DN - The sweep down mode is similar to the sweep up mode except that the output waveform, when triggered, sweeps from frequency set by the sweep stop (STOP) parameter to frequency set by the sweep start (FREQ) parameter. Sweep time is determined by the TIME parameter. At the end of the sweep, the output waveform remains at the start frequency. Following another trigger, the output jumps quickly to its stop frequency and the above cycle is repeated. In normal mode the generator repeats its sweep cycle continuously.

SWEEP UP-DN - The function generator, when triggered, sweeps from value set by the FREQ parameter to value set by the STOP parameter and back to the FREQ value. Sweep time is doubled than the displayed TIME parameter. At the end of the sweep, the output waveform remains at the start frequency. Following another trigger, the above cycle is repeated. In normal mode the generator repeats its sweep cycle continuously.

SWEEP DN-UP - The sweep down mode is similar to the sweep up mode except that the output waveform, when triggered, sweeps from value set by the STOP parameter to value set by the FREQ parameter and back to the STOP value. Sweep time is doubled than the displayed TIME parameter. At the end of the sweep, the output waveform remains at the stop frequency. Following another trigger, the above cycle is repeated. In normal mode the generator repeats its sweep cycle continuously.

Selecting one of the above sweep directions is described in the following. The same procedure is used for both linear and logarithmic sweep scales.

1. Depress the [2nd] push-button and observe that the display is modified to indicate the following:

2nd ?
(? appears flashing)

2. Depress the [SWP MODE] push-button in the MAIN group and observe that one of the following read-outs is displayed:

UP, dn, U-d or d-U

This reading indicates the selected sweep mode. To modify the selected sweep mode to your desired modes depress the [x1 □] modifier push-button until the selected mode is displayed.

3. Depress the [EXE] push-button. The output waveform now sweeps with the selected sweep mode.

3-13-3. Phase Locking Generator Operating Mode - Model 8550

Model 8550 employs an automatic locking circuit which enables phase and frequency locking to an external reference. Model 8550 locks on the external reference signal regardless of its programmed frequency setting. After the generator has locked on the signal, the user may generate a phase offset between the external signal and the signal at the output connector. Offset range is ±180°. The generator is placed in its phase locking operating mode when the light behind PLL illuminates. The phase locking operating mode can not be operated in conjunction with the triggered modes. To operate the instrument in its PLL operating mode proceed as follows:

1. Depress the [POWER] switch once to turn the power on.
2. Depress the operating mode push-buttons until the light behind PLL illuminates.
3. Modify trigger level parameter (TRIG LEVEL) to the required thrash-hold level.
4. Connect a BNC cable from the reference source to the front panel REF INPUT connector. Use a "T" connector and connect the reference signal to channel A on an oscilloscope.
5. Connect a BNC cable from 8550 output to channel B on the oscilloscope.
6. Set oscilloscope and observe that the two signals have the same frequency and are locked on the same phase.

3-13-3-1. Generating Phase Offsets

As discussed in paragraph 3-12-3, the generator is capable of generating phase offsets between the external reference signal and the main output connector. To generate phase offset proceed as follows:

1. Repeat the operating instruction as in the previous paragraph.

2. Depress the [PHASE OFFSET] push-button until the light behind PLL illuminates.
3. Use the [MODIFIER] push-buttons to modify the present setting of the phase offset. Observe that the oscilloscope and note that a phase offset is generated.
4. Depress the [P.SET] to restore phase offset to factory default phase offset value (0°).

3-13-3-2. Using Model 8550 as a Frequency Counter

Model 8550 employs a built-in frequency counter circuit which is used in different parts of the instrument for various purposes. This internal counter is utilized when the instrument is placed in its PLL operating mode for automatic detection of the frequency of the external reference. The frequency counter reading is made available to the user and can measure external frequencies from 10Hz to over 60MHz. Frequency reading is given with fixed resolution of 4 digits. Decimal point and exponent are displayed automatically. To use Model 8550 as a frequency counter proceed as follows:

1. Depress the [POWER] switch once to turn the power on.
2. Depress the operating mode push-buttons until the light behind PLL illuminates.
3. Modify trigger level parameter (TRIG LEVEL) to the required thrash-hold level.
4. Remove any BNC cable from front panel connectors.
5. Depress the [FUNC] push-button in the MAIN PARAMETERS group until the light behind FREQ illuminates; observe the programmed frequency setting.
5. Connect a BNC cable from the reference source to the front panel REF INPUT connector.
6. Observe that the displayed reading is modified to read the frequency of the external frequency and that the decimal point blinks at a constant rate; indicating that the display reads the frequency of the external signal.
7. Remove the BNC cable from the REF input connector and observe that the decimal point stopped blinking and that the display resumes its normal programmed frequency parameter.

3-13A. SELECTING AN OPERATING MODE - MODEL 8551

Model 8551 may operate as a normal function generator, as a variable pulse width pulse generator, as a fixed duty cycle pulse generator, and as a phase locking generator. Similar to Model 8550, selecting an operating modes is done by depressing one of the OPERATING MODE [□ or □] push-buttons until the light behind the desired mode illuminates.

Description of the various modes which can be used on Model 8551 is given in the following.

3-13A-1. Normal Function Generator Operating Mode - Model 8551

Function generator operating mode is the normal operating conditions where the output waveform is symmetrical about its horizontal and vertical axis. The normal operating mode also permits a vertical offset of its output waveform. The generator is placed in its normal operating mode when the light behind FUNC illuminates. Triggered operation and externally controlled modes such as VCO and AM may operate in conjunction with the normal function generator operating mode.

3-13A-2. Pulse Generator With Variable Pulse Width Operating Mode - Model 8551

Model 8551 offers additional capability to the basic normal function generator by allowing modification of parameters which are associated with the pulse output. When the pulse generator operating mode is selected, one can modify the pulse width, the pulse period, and independently adjust the rise and the fall times. Variable ramp width function is also made available.

The generator is placed in its pulse generator operating mode when the light behind PULSE illuminates. Triggered operation and externally controlled modes such as PWM, VCO, and AM may operate in conjunction with the pulse generator operating mode. Access to the DUTY parameter is automatically inhibited by the generator.

3-13A-3. Pulse Generator With Fixed Duty Cycle Operating Mode - Model 8551

Some applications require that the ratio between the pulse width to the pulse period remain constant regardless of the programmed period. The pulse generator with fixed duty cycle operating mode is a special case of the normal pulse generator which provides control over the duty cycle rather than the pulse width. In this mode, the user should only program the required duty cycle. Then, while changing the period, the instrument automatically adjusts the duty cycle ratio at the output connector.

The duty cycle may be selected within the range of 1% to 8550%, however, this range may be extended to almost 99% by using the pulse complement function.

The generator is placed in its fixed duty cycle operating mode when the light behind F.DTY illuminates. Triggered operation and externally controlled modes such as PWM, VCO, and AM may operate in conjunction with the pulse generator operating mode. Access to the WIDTH parameter is automatically inhibited by the generator.

3-13A-4. Phase Locking Generator Operating Mode - Model 8551

Model 8551 employs an automatic locking circuit which enables phase and frequency locking to an external reference. Model 8551 locks on the external reference signal regardless of its programmed frequency setting. After the generator has locked on the signal, the user may generate a phase offset between the external signal and the signal at the output connector. Offset range is ±180°.

The generator is placed in its phase locking operating mode when the light behind PLL illuminates. The phase locking operating mode cannot be operated in conjunction with the triggered modes. To operate the instrument in its PLL operating mode proceed as follows:

1. Depress the [POWER] switch once to turn the power on.

2. Depress the operating mode push-buttons until the light behind PLL illuminates.

3. Modify trigger level parameter (TRIG LEVEL) to the required thrash-hold level.

4. Connect a BNC cable from the reference source to the front panel REF INPUT connector. Use a “T” connector and connect the reference signal to channel A on an oscilloscope.

5. Connect a BNC cable from 8551 output to channel
B on the oscilloscope.

6. Set oscilloscope and observe that the two signals have the same frequency and are locked on the same phase.

3-13A-4-1. Generating Phase Offsets

As discussed in paragraph 3-12A-4, the generator is capable of generating phase offsets between the external reference signal and the main output connector. To generate phase offset proceed as follows:

1. Repeat the operating instruction as in the previous paragraph.

2. Depress the [FUNCTION] push-button until the light behind PHASE illuminates.

3. Use the [MODIFIER] push-buttons to modify the present setting of the phase offset. Observe that the oscilloscope and note that a phase offset is generated.

4. Depress the [P.SET] to restore phase offset to factory default phase offset value (0°).

3-13A-4-2. Using Model 8551 as a Counter/Timer

Model 8551 employs a built-in counter/timer circuit which is used in different parts of the instrument for various purposes. This internal counter/timer is utilized when the instrument is placed in its PLL operating mode for automatic detection of the frequency of the external reference.

The counter/timer reading is made available to the user and can measure external frequencies from 10Hz to over 60MHz and external periods from .1s to 16ns. Frequency and period readings are given with fixed resolution of 4 digits. Decimal point and exponent are displayed automatically.

To use Model 8551 as a frequency counter proceed as follows:

1. Depress the [POWER] switch once to turn the power on.

2. Depress the operating mode push-buttons until the light behind PLL illuminates.

3. Modify trigger level parameter (TRIG LEVEL) to the required threshold level.

4. Remove any BNC cable from front panel connectors.

5. Depress the [FUNC] push-button in the MAIN PARAMETERS group until the light behind FREQ illuminates; observe the programmed frequency setting.

5. Connect a BNC cable from the reference source to the front panel REF INPUT connector.

6. Observe that the displayed reading is modified to read the frequency of the external signal and that the decimal point blinks at a constant rate; indicating that the generator is its timer mode of operation.

7. Remove the BNC cable from the REF input connector and observe that the decimal point stopped blinking and that the display resumes its normal programmed frequency parameter.

To use Model 8551 as a timer proceed as follows:

1. Depress the [POWER] switch once to turn the power on.

2. Depress the operating mode push-buttons until the light behind PLL illuminates.

3. Modify trigger level parameter (TRIG LEVEL) to the required thrash-hold level.

4. Remove any BNC cable from front panel connectors.

5. Depress the [PULSE] push-button in the MAIN PARAMETERS group until the light behind PER illuminates; observe the programmed period setting.

6. Connect a BNC cable from the reference source to the front panel REF INPUT connector.

7. Observe that the displayed reading is modified to read the period of the external signal and that the decimal point blinks at a constant rate; indicating that the generator is its timer mode of operation.

8. Remove the BNC cable from the REF input connector and observe that the decimal point stopped blinking and that the display resumes its normal programmed period parameter.

3-14. SELECTING A MODULATION MODE

Model 8550 provides three modulation modes: FM, AM, and VCO. Model 8551 offers PWM, AM, and VCO. Placing the instrument in one of these modulation modes is done by depressing the push-buttons in the MOD Chapter until the light nest to the required modulation mode. The controlling signal is applied to the front panel INPUT BNC connector.

3-14-1. Frequency Modulation (FM) Mode (Model 8550 only)

The generator, when placed in this mode, operates as a free running voltage controlled oscillator. The applied sinewave at the MOD INPUT connector determines modulation characteristics. Model 8550 is placed in its FM mode when the light behind FM illuminates.

To frequency modulate the instrument first select the FM control mode, and then apply the modulating signal to the front panel INPUT connector. Observe external signal limits to avoid damage to the input circuit.

3-14-2. Amplitude Modulation (AM) Mode

The instrument, when placed in this mode, releases its amplitude control to an external control. A signal with an appropriate characteristics modulates the amplitude at the main output connector. Any of the available output waveforms may be modulated by the AM input modulating signal. Model 8550 is placed in its AM mode when the light behind AM illuminates.

To amplitude modulate the generator first select the AM control mode, and then apply the modulating signal to the front panel INPUT connector. Frequency and amplitude limits of the modulating signal should be observed to avoid damage to the input circuit.

3-14-3. Voltage Controlled Oscillator (VCO) Mode

Placing the function generator in VCO (voltage controlled oscillator) operating mode removes the frequency control from its output connector. The frequency of the selected waveform is then proportional to an amplitude level of a signal which may be applied to the VCO IN connector. The instrument is placed in its VCO mode when the light behind VCO illuminates.

To operate the generator as a voltage controlled amplifier first select the VCO mode, then apply the control voltage to the front panel INPUT connector. Input limits should be observed to avoid damage to the input circuit. Note that, although the FM mode is not available on the Model 8551, if required, the VCO input may be used to frequency modulate the generator.

3-14-4. Pulse Width Modulation (PWM) Mode (model 8551 only)

Placing the Model 8551 in PWM (pulse width modulation) operating mode removes the pulse width control from its output connector. The pulse width at the output connector is then proportional to an amplitude level of a signal which is applied to the front panel control input. The instrument is placed in its PWM mode when the light behind PWM illuminates.

To pulse width modulate the generator first select the PWM mode, then apply the control signal to the front panel INPUT connector. Input limits should be observed to avoid damage to the input circuit.

3-15. SELECTING AN OUTPUT WAVEFORM

Selecting one of the available output waveforms is done by depressing one of the two push-buttons in the OUTPUT Chapter until the light behind the required waveform illuminates. Model 8550 makes available six different waveforms through the OUTPUT connector. These waveforms are:

Operating Instructions **3-15**

SINE WAVE **POSITIVE SQUARE WAVE**
TRIANGLE **NEGATIVE SQUARE WAVE**
DC **SQUARE WAVE**

Model 8551 offers eight additional waveforms (DC output function is omitted):

PULSE
PULSE COMPLEMENT
POSITIVE PULSE
POSITIVE PULSE COMPLEMENT
NEGATIVE PULSE
NEGATIVE PULSE COMPLEMENT
RAMP
INVERTED RAMP

Note that pulse complements are selected using the 2nd function selection procedure. For more information on operating 2nd functions refer to paragraph 3-9.

3-16. DISABLING THE OUTPUT

The Model 8550/8551 features a stand-by mode which disconnects the signal from the output connectors. The stand-by function is especially useful in automatic test systems where the output is constantly connected to the device under test and where modification of waveform parameters may endanger this device. Note that after power up or software reset, the output is disabled.

To resume normal operation simply depress one of the push-button in the OUTPUT Chapter. The light behind the previously selected waveform illuminates; indicating that the output signal in now connected to the output connector.

To place the instrument in its stand-by mode depress in sequence the [2nd] and the [ST-BY] push-buttons. The selected waveform light turns off; indicating that the output signal is disconnected from the output connector.

3-17. TRIGGERING THE FUNCTION GENERATOR

Model 8550/8551 when set to one of its trigger modes accepts stimulation from a variety of sources. The Operator has the option of selecting either an external source, an internal source, or a manual source. Each triggering method is used in a different way and for different applications. The triggering options are de- scribed in the following.

3-17-1. Triggering The Function Generator With An External Stimulant

Selecting one of the external triggering modes is simply a matter of depressing push-buttons in the TRIGGER Chapter until the light behind the desired mode illuminates. When no light in the TRIGGER MODE Chapter is on, the function generator operates in its normal continuous mode.

The Model 8550/8551 triggers on the leading edge of the applied external signal. The internal trigger level is programmable within the range of ±10V. The instrument may operate in one of the following external triggering modes: Triggered, Gated, or in Counted burst mode. Each mode is described in the following.

3-17-1-1. Triggered Mode

When set to operate in triggered mode, each positive going transition at the TRIG/REF INPUT connector generates a single waveform at the OUTPUT connector. The waveform at the output connector is automatically synchronized with the external transition. To trigger the generator from an external source proceed as follows:

1. Depress the [POWER] switch once to turn the power on.

2. Select the required output waveform and set up the parameters to the required characteristics.

3. Modify trigger level parameter (TRIG LEVEL) to the required thrash-hold level.

4. Depress the TRIGGER MODE push-button until the light behind TRIG'D illuminates.

5. Connect a BNC cable from the external stimulant to the front panel TRIG/REF INPUT connector. Make sure to observe external signal limits to avoid damage to the input circuit.

6. When done with the triggered operation remove the BNC cable from the input connector and select the normal continuous mode.

3-17-1-2. Gated Mode

When set to operate in gated mode, the first positive going transition at the TRIG/REF INPUT connector enables the generator output. The consecutive negative going transition disables the generator output. First output waveform is synchronized with the first external transition. Last waveform is always completed.

NOTE

The TRIG/REF INPUT connector is sensitive to dc levels. If this input is left open and the trigger level was set to a negative voltage, the generator may self gate.

To gate the generator from an external source proceed as follows:

1. Depress the [POWER] switch once to turn the power on.

2. Select the required output waveform and set up the parameters to the required characteristics.

3. Modify trigger level parameter (TRIG LEVEL) to the required thrash-hold level.

4. Depress the TRIGGER MODE push-button until the light behind GATED illuminates.

5. Connect a BNC cable from the external stimulant to the front panel TRIG/REF INPUT connector. Make sure to observe external signal limits to avoid damage to the input circuit.

6. When done with the gated operation remove the BNC cable from the input connector and select the normal continuous mode.

3-17-1-3. Counted Burst Mode

When set to operate in counted burst mode, each positive going transition at the TRIG/REF INPUT connector generates a train of waveforms at the OUTPUT connector. The number of generated wave-forms are programmable within the range of 1 to 4000. The first waveform at the output connector is automatically synchronized with the external transition.

To generate a counted burst using an external source proceed as follows:

1. Depress the [POWER] switch once to turn the power on.

2. Select the required output waveform and set up the parameters to the required characteristics.

3. Modify trigger level parameter (TRIG LEVEL) to the required thrash-hold level.

4. Depress the TRIG push-button in the MAIN PARAMETERS group until the light behind BUR illuminates. Modify the burst parameter to the required count.

5. Depress the TRIGGER MODE push-button until the light behind BURST illuminates.

6. Connect a BNC cable from the external stimulant to the front panel TRIG/REF INPUT connector. Make sure to observe external signal limits to avoid damage to the input circuit.

7. When done with the counted burst operation remove the BNC cable from the input connector and select the normal continuous mode.

3-17-2. Triggering The Function Generator With An Internal Stimulant

When an external source is not available, the operator has the option of using the built-in trigger stimulant. The internal trigger generator is a free running generator, asynchronous to the main output generator, with a programmable period. Signal applied to the TRIG/REF INPUT will have no effect on the generator when it is placed in internal trigger mode. The internal trigger may be used in conjunction with the triggered and the counted burst modes; it can not, however, be used in gated mode. Operating the internal trigger generator in triggered and counted burst modes is described in the following.

3-17-2-1. Triggered Mode

When set to operate in internal triggered mode, the output connector generates one waveform at programmable intervals. Note that the programmed internal period should not exceed one half of the output waveform duration otherwise an error will result (Model 8551 will indicate such errors with an ERROR LED). To trigger the generator from the internal trigger generator proceed as follows:

1. Depress the [POWER] switch once to turn the power on.

2. Select the required output waveform and set up the output parameters to the required characteristics.

3. Modify internal trigger period (PER) to the required interval.

4. Depress the TRIGGER MODE push-button until the light behind TRIG'D illuminates.

5. Depress [2nd] and then the [MAN] push-buttons and observe that the I.TRG light illuminates; indicating that the internal trigger stimulant is now active.

3-17-2-2. Counted Burst Mode

When set to operate in internal counted burst mode, the output connector generates a train of counted waveforms at programmable intervals. Note that the programmed internal period should not exceed the period of the complete burst duration otherwise an error will result (Model 8551 will indicate such errors with an ERROR LED). To generate a counted burst using the internal period generator proceed exactly as described in paragraph 3-17-2-1, except select the BURST mode.

3-17-3. Triggering The Function Generator With A Manual Stimulant

The MAN button simulates an external signal. If the generator is placed in GATED mode, an output signal will be available as long as the MAN push-button is depressed. When the generator is set to TRIG'D (triggered) mode, each time the MAN button is depressed a single output waveform is generated. When the Model 8550/8551 is set to generate a counted burst, each time the MAN push-button is depressed the output generates a train of counted waveforms at programmable intervals. The MAN push-button has no effect in normal mode of operation or when the instrument is set to internal trigger mode.

3-18. USING THE OFFSET

The function generator employs two level windows; allowing amplitude and offset to be independently selected within these levels. When setting up the offset parameter, one must keep in mind that the offset is attenuated with the signal. The user has no control over the selected internal amplitude range. This may cause some confusion since not knowing this fact may produce an offset error at an amplitude-offset combination that seems to be reasonable. It is therefore suggested to first set up the amplitude parameter and only then to set the required offset level. An attempt to modify the offset parameter beyond the capability of the instrument will generate an error indication. Offsets and amplitudes are in- dependently selectable within the level windows given in Table 3-3.

3-19. USING FRONT PANEL SET-UPS

Setting-up all parameters in a versatile instrument such as the Model 8550/8551 takes some time. The set-up time is longer when a number of tests are performed and more than one set-up is required. The function generator incorporates a non-volatile memory that preserves stored information for a long time. The size of the non-volatile memory permits storage of up to 30 complete front panel set-ups. Front panel set-ups can be recalled one at a time. The generator also employs a special recall mode that permits automatic scrolling through the stored set-ups for sequential tests. The operator may select to scroll in an ascending or descending order. Description how to save and recall set-ups and how to use the recall mode is given in the following.

3-19-1. Storing Set-ups

First modify front panel parameters as necessary to perform the required test. Parameter modification procedure is discussed in paragraph 3-12. When all parameters are programmed and verified for accuracy, proceed with storing this set-up as follows:

1. Depress the [2nd] and [STORE] push-button in sequence and observe that the display is modified to indicate the following:

S xx ?
"?" appears blinking

"S" means that the instrument is placed in memory store mode. "xx" indicates the number of the present storage cell. Numbers may range from 00 to 30. Depressing any other push-button removes the generator from the memory store mode and leaves front panel settings unchanged.

2. To program individual memory cells for a specific front panel set-up depress the MODIFIER [x1 ↑] or [x1 ↓] until the desired memory number is displayed. Depressing [EXE] locks in the entire front panel set-up for later usage. The instrument then resumes normal operation.

3. Repeat the above procedure for as many set-ups that are required. Stored front panel set-ups are limited to 30.

3-19-2. Recalling Set-ups

The Model 8550/8551 employs a non-volatile memory (RAM). The computer circuit continuously monitors

Table 3-3. Offset-Amplitude Programming Limits

Level Window	Amplitude Range	Offset Range
±8.00V	100mV to 16.0V	0V to ±7.95V
±800mV	10mV to 99.9mV	0V to ±795mV

front panel traffic and saves it in a special location within the RAM. This location is separated from the stored front panel set-ups. After turning AC MAINS off or in case of an accidental power failure, the generator updates front panel indicators with the last set-up before power shut-down. To recall a stored front panel set-up proceed as follows:

1. Depress the [2nd] and [RECALL] push-button in sequence and observe that the display is modified to indicate the following:

C xx ?
"?" appears blinking

"C" means that the instrument is placed in memory recall mode. "xx" indicates the number of the present storage cell. Numbers may range from 00 to 30. Depressing any other push-button removes the generator from the memory recall mode and leaves front panel settings unchanged.

2. Recalling a specific front panel set-up is done by depressing the MODIFIER [x1 □] or [x1 □] until the desired cell number is displayed. Depressing [EXE] updates front panel set-up with the parameters which were stored in the selected memory cell.

3. Repeat the above procedure for as many set-ups that are required. Recalled front panel set-ups are limited to 30.

3-19-2-1. Using The Recall Mode

Model 8550/8551 employs a special recall mode which permits ascended or descended scroll through a number of set-ups by pressing either the MODIFIER [x1 □] or [x1 □] push-buttons respectively. This mode is especially useful for repetitive procedures such as calibration and performance tests.

To set the function generator for operation in its recall mode proceed as follows:

1. Depress the [2nd] push-button and observe that the display is modified to indicate the following:

2nd ?

? appears flashing

2. Depress the [RCL MODE] push-button and observe that the display is modified to indicate the following:

C 00 ?

The instrument is now set to operate in its recall mode. The display is first updated with the parameters which were stored in memory cell 00.

3. Use the MODIFIER [x1 □] or [x1 □] to scroll through the memory bank.

4. Depress any other front panel push-button to exit this function and to return to normal display operation.

3-20. CHANGING THE GPIB ADDRESS

GPIB address is modified using front panel programming. The GPIB address is stored in the non-volatile memory, therefore, conventional address switches are not provided. Detailed instructions how to change the GPIB address are given in Paragraph 4-7.

3-21. CHANGING EMULATION MODE TO HP

Models 8550 and 8551 can be made fully compatible with HP Model 8116A device-dependent commands set. HP 8116A is a 50MHz function generator that provides similar functions to those offered in Models 8550 and 8551. The three instruments do not offer the same functions and feature, however, in places where they are the same, the GPIB commands that are used for programming these instruments are the same. This emulation mode saves extremely valuable programming time when replacing Model 8116A by Model 8550 or Model 8551.

The complete set of commands that are used with HP 8116A are listed in Table 4-8. Information on how to change Models 8550 and 8551 settings from normal GPIB programming to HP programming mode is given in paragraph 4-16.

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GPIB Operation Chapter 4

4-1. INTRODUCTION

The GPIB (general purpose interface bus) is an instrumentation data bus with standards originally adopted by the IEEE (Institute of Electrical and Electronic Engineering) in 1975 and given the IEEE-488 designation. In November 1987 the IEEE-488 document was revised, primarily for editorial classification and addendum, and the new document was identified as IEEE-488-1978.

This document has been the standard for general-purpose instrumentation bus (GPIB) which has been adopted by worldwide instrumentation manufacturers. In June 1987 the IEEE approved a new standard for programmable instruments and devices IEEE Standard 488.2-1987 Codes, Formats, Proto- cols, and Common Commands. The original document, IEEE-488-1978, was re-titled IEEE-488.1.

The IEEE-488.2 standard was designed to make the interface system easier to use by requiring that all devices provide certain capabilities such as talk and listen, respond to device clear commands, and be capable of service requests. Other functions such as parallel poll are left optional with the instrument manufacturer. The Model 8550 complies with all of the mandatory IEEE-488.1 and IEEE-488.2 requirements. Some of the issues which IEEE-488.2 Addresses are:

1. A required minimum set of IEEE-488.1 capabilities.

2. Reliable transfer of messages between a talker and listener and precise syntax in those messages.

3. A set of commands which would be useful in all instruments.

4. Common serial poll status reporting.

5. Synchronization programming with instrument functions.

This Chapter contains general bus information as well as detailed programming information and is divided as follows:

1. General introductory information pertaining to the IEEE-488 bus may be found primarily in paragraphs 4-2 through 4-5.

2. Information necessary to connect the Model 8550 to the bus and to change the bus address is contained in paragraphs 4-6 and 4-7.

3. Programming of the instrument with general bus command is covered in paragraph 4-8.

4. Device-dependent command programming is described in detail in paragraph 4-10. The commands outlined in this Chapter can be considered to be the most important since they control virtually all instrument functions.

5. Additional information pertaining to device status reporting and error messages can be found in paragraphs 4-13 and 4-15.

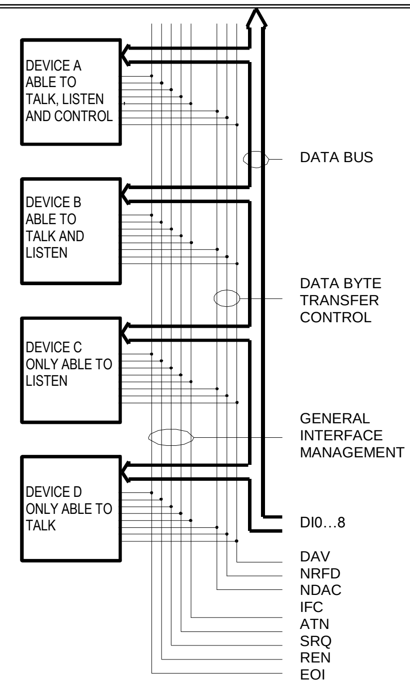
4-2. BUS DESCRIPTION

The IEEE-488 bus was designed as a parallel data transfer medium to optimize data transfer without using as excessive number of bus lines. In keeping with this goal, the bus has only eight data lines which are used for both data and most commands. Five bus management lines and three handshake lines round out the complement of signal lines. Since the bus is of parallel design, all devices connected to the bus have the same information available simultaneously. Exactly what is done with the information by each device depends on many factors, including device capabilities.

A typical bus configuration for remote controlled operation is shown in Figure 4-1. The typical system will have one controller and one or more instruments to which commands are given and from which data is received. There are three categories that describe device operation. These include: controller; talker; listener.

The controller controls other devices on the bus. A talker sends data, while a listener receives data. an instrument, may be a talker only, a listener only, or both a talker and listener.

Figure 4-1. IEEE Bus Configuration



Any given system can have only one controller (control may be passed to an appropriate device through a special command). Any number of talkers or listeners may be present up to the hardware constraints of the bus. The bus is limited to 15 devices, but this number may be reduced if higher than normal data transfer rates are required or if long interconnect cables are used.

Several devices may be commanded to listen at once, but only one device may be a talker at any given time. Otherwise, communications would be scrambled much like an individual is trying to select a single conversation out of a large crowd.

Before a device can talk or listen, it must be appropriately addressed. Devices are selected on the basis of their primary address. The addressed device is sent a talk or listen command derived from its primary address. Normally, each device on the bus has a unique primary address so that each may be addressed individually. The bus also has another addressing mode called secondary addressing, but not all devices use this addressing mode.

Once the device is addressed to talk or listen, appropriate bus transactions may be initiated. For example, if an instrument is addressed to talk, it will usually place its data on the bus one byte at a time. The listening device will then read this information, and the appropriate software is then be used to channel the information to the desired location.

4-3. IEEE-488 BUS LINES

The signal lines on the IEEE-488 bus are grouped into three general categories. The data lines handle bus information, while the handshake and bus management lines assure that proper data transfer and bus operation takes place. Each of the bus lines is
“active low” so that approximately zero volts is a logic “one”. The following paragraphs describe the purpose of these lines, which are shown in Figure 4-1.

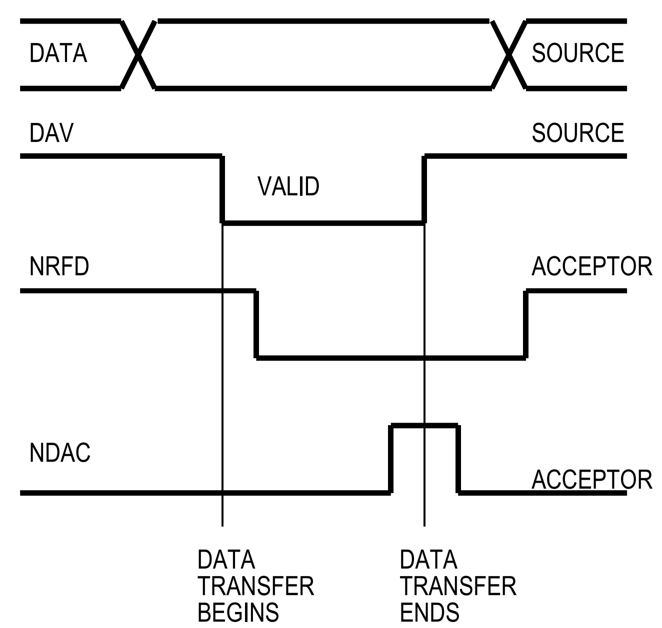
4-3-1. Bus Management Lines

The bus management group is made up of five signal lines that provide orderly transfer of data. These lines are used to send the uniline commands described in paragraph 4-8-1.

1. ATN (Attention) - the ATN line is one of the more important management lines. The state of the ATN line determines whether controller information on the data bus is to be considered data or a multiline command as described in paragraph 4-8-2.

2. IFC (Interface Clear) - Setting the IFC line true (low) causes the bus to go to a known state.

Figure 4-2. IEEE Handshake Sequence



3. REN (Remote Enable) - Setting the REM line low sends the REM command. This sets up instruments on the bus for remote operation.

4. EOI (End Or Identify) - The EOI line is used to send the EOI command that usually terminates a multi-byte transfer sequence.

5. SRQ (Service Request) - the SRQ line is set low by a device when it requires service from the controller.

4-3-2. Handshake Lines

The bus uses three handshake lines that operate in an interlocked sequence. This method assures reliable data transfer regardless of the transfer rate. Generally, data transfer will occur at a rate determined by the slowest active device on the bus.

One of the handshake lines is controlled by the data source, while the remaining two lines are controlled by accepting devices. The three bus handshake lines are:

1. DAV (Data Valid) - The source controls the state of the DAV line.

2. NRFD (Not Ready For Data) - the acceptor controls the state of the NRFD line.

3. NDAC (Not Data Accepted) - the acceptor also controls the NDAC line.

The complete handshake sequence for one data byte is shown in Figure 4-2. Once data is on the bus, the source checks to see that NRFD is high, indicating that all devices on the bus are ready for data. At the same time NDAC should be low from the previous byte transfer. If these conditions are not met, the source must then wait until the NRFD and NDAC lines have the correct status. If the source is controller, NRFD and NDAC must remain stable for at least 100 ns after ATN is set low. Because of the possibility of bus hang up, some controllers have time-out routines to display error messages if the handshake sequence stops for any reason.

Once the NRFD and NDAC lines are properly set, the source sets the DAV line low, indicating that data on the bus is now valid. the NRFD line then goes low; the NDAC line goes high once all devices on the bus have accepted the data. Each device will release the NDAC line at its own rate, but the NDAC line will not go high until the slowest device has accepted the data byte.

After the NDAC line goes high, the source then sets the DAV line high to indicate that the data on the bus is no longer valid. At this point, the NDAC line returns to its low state. Finally, the NRFD line is released by each of the devices at their own rates, until the NRFD line finally goes high when the slowest device is ready, and the bus is set to repeat the sequence with the next data byte.

The sequence just described is used to transfer both data and multiline command. The state of the ATN line determines whether the data bus contains data or commands.

4-3-3. Data Lines

The IEEE-488.2 bus uses the eight data lines that allow data to be transmitted and received in a bit-parallel, byte-serial manner. These eight lines use the convention DI01 through DI08 instead of the more common D0 through D7 binary terminology. The data lines are bi-directional and, as with the remaining bus signal lines, low is true.

4-4. INTERFACE FUNCTION CODES

The interface function codes are part of the IEEE-488.2 standards. These codes define an instrument's ability to support various interface functions and should not be confused with programming commands found elsewhere in this manual.

Table 4-1 lists the codes for the Model 8550. The numeric value following each one or two letter code define Model 8550 capability as follows:

SH - (Source Handshake Function) - The ability for the Model 8550 to initiate the transfer of message/data on the data bus provided by the SH function.

AH - (Acceptor Handshake Function) - The ability for the Model 8550 to guarantee proper reception of message/data on the data bus provided by the AH function.

T - (Talker Function) - The ability of the Model 8550 to send device-dependent data over the bus (to another device) is provided by the T function. Model
8550 talker capabilities exist only after the instrument has been addressed to talk.

L - (Listen Function) - The ability of the Model 8550 to receive device-dependent data over the bus (from anther device) is provided by the L function. Listener function capability of the Model 8550 exist only after it has been addressed to listen.

RS - (Service Request Function) - The ability of the Model 8550 to request service from the controller is provided by the RS function.

RL - (Remote-Local Function) - The ability of the Model 8550 to be placed in remote or local modes is provided by the RL function.

Table 4-1. Model 8550 Interface Function Codes

CODE	INTERFACE FUNCTION
SH1	Source Handshake Function
AH1	Acceptor Handshake Capabilities
T6	Talker (basic talker, serial poll, unaddressed to talk on LAG)
L4	Listener (basic listener, unaddressed to listen on TAG)
SR1	Service request capability
RL1	Remote/Local capability
PP2	Parallel Poll capability
DC1	Device Clear capability
DT1	Device Trigger capability
C0	No controller capability
E1	Open collector bus drivers
TE0	No Extended Talker capabilities
LE0	No Extended Listener capabilities

PP - (parallel Poll Function) - The ability of the Model 8550 to respond to a parallel poll request from the controller is provided by the PP function.

DC - (Device Clear Function) - The ability for the Model 8550 to be cleared (initialized) is provided by the DC function.

DT - (Device Trigger Function) - The ability of the Model 8550 to have its output triggered is provided by the DT function.

C - (controller Function) - The Model 8550 does not have a controller function.

TE - (Extended Talker Capabilities) - The Model 8550 does not have extended talker capabilities.

LE - (Extended Listener Function) - The Model 8550 does not have extended listener function.

4-5. SOFTWARE CONSIDERATIONS

The most sophisticated computer in the world would be useless without the necessary software. This basic requirement is also true of the IEEE-488.2 bus, which requires the use of handler routines as described in this paragraph. Before a controller can be used with the IEEE-488.2 interface, the user must make certain that appropriate handler software is present within the controller. With the IBM PC computer, for example, the GPIB interface card must be used with an additional software which contains the necessary handler software.

Other small computers that can be used as controllers have limited IEEE command capability. The capabilities of some computers depends on the particular interface being used. Often, little software "tricks" are required to achieve the desired results.

From the preceding discussion, the message is clear: make sure the proper software is being used with the instrument. Often, the user may incorrectly suspect that a hardware problem is causing fault, when it was the software that was causing the problem all along.

4-6. HARDWARE CONSIDERATIONS

Before the instrument can be used with the IEEE-488 bus, it must be connected to the bus with a suitable connector. Also, the primary address must be properly programmed as described in this Chapter.

4-6-1. Typical Controlled Systems

The IEEE-488.2 bus is a parallel interface system. As a result, adding more devices is simply a matter of using more cables to make the desired connections. Because of this flexibility, system complexity can range from simple to extremely complex.

The simplest possible controlled system comprises a controller and one Model 8550. The controller is used to send commands to the instrument, which sends data back to the controller.

The system becomes more complex when additional instruments are added. Depending on programming, all data may be routed through the controller, or it may be transmitted directly from one instrument to another.

4-6-2. Connections

The instrument is connected to the bus through an IEEE-488.2 connector. This connector is designed to be stacked to allow a number of parallel connections on one instrument.

NOTE

To avoid possible mechanical damage, it is recommended that no more than three connectors be stacked on any one instrument. Otherwise, the resulting strain may cause internal damage to the connectors.

The IEEE-488.2 bus is limited to a maximum of 15 devices, including the controller. Also, the maximum cable length is 20 meters. Failure to observe these limits will probably result in erratic bus operation.

Custom cables may be constructed using the information in Table 4-2. Table 4-2 also lists the contact assignments for the various bus lines.

Table 4-2. IEEE-488 Contact Designations

Contact Number	IEEE-488 Designation	Type
1	DIO1	Data
2	DIO2	Data
3	DIO3	Data
4	DIO4	Data
5	EOI	Management
6	DAV	Handshake
7	NRFD	Handshake
8	NDAC	Handshake
9	IFC	Management
10	SRQ	Management
11	ATN	Management
12	SHIELD	Ground
13	DIO5	Data
14	DIO6	Data
15	DIO7	Data
16	DIO8	Data
17	REN	Management
18-24	Gnd	Ground

Contacts 18 through 24 are return lines for the indicated signal lines, and the cable shield is connected to contact 12. Each ground line is connected to digital common in the Model
8550.

CAUTION

The voltage between IEEE common and ground must not exceed 0 V or damage may result to your instrument.

4-7. CHANGING GPIB ADDRESS

The primary address of your instrument may be programmed to any value between 0 and 30 as long as the selected address is different from other devices addresses in the system. This may be accomplished using a front panel programming sequence. Note that the primary address of the instrument must agree with the address specified in the controller's program.

NOTE

The programmed primary address is briefly displayed during the power-up cycle of the Model 8550. It is stored in the non-volatile memory of the instrument and is retained even when power is turned off.

To check the present address, or to enter a new one, proceed as follows:

1. Depress the [2nd] push-button once then depress the [GPIB ADR] push-button. The display will be modified to display the following:

GPxx

Where x may be any number from 0 to 30.

2. Use the MODIFIER [x1 ↑] or the [x1 ↓] push-buttons for selecting a new GPIB primary address.

3. To store the newly selected primary address depress [EXE]. The instrument then resumes normal operation.

4-8. BUS COMMANDS

While the hardware aspect of the bus is essential, the interface would be essentially worthless without appropriate commands to control the communications between the various instruments on the bus. This paragraph briefly describes the purpose of the bus commands, which are grouped into the following three categories:

1. Uniline commands: Sent by setting the associated bus line low (true).

2. Multiline commands: General bus commands which are sent over the data lines with the ATN line low (true).

3. Device-dependent commands: Special commands that depend on device configuration; sent over the data lines with ATN high (false).

4. Common commands and queries: A special set of commands that all devices must use and does not depend on device configuration; sent over the data lines in the same format as the device dependent commands.

4-8-1. Uniline Commands

Uniline commands are sent by setting the associated bus line to low. The ATN, IFC, and REN commands are asserted only by the system controller. The SRQ command is sent by an external device. The EOI command may be sent by either the controller or an external device depending on the direction of data transfer. The following is descriptions of each command.

REN - (Remote Enable) - The remote enable command is sent to the Model 8550 by the controller to set the instrument up for remote operation.

Table 4-3. IEEE-488 Bus Command Summary

COMMAND TYPE	COMMAND	STATE OF ATN LINE(*)	COMMENTS
Uniline	REN	X	Set up for remote operation
	EOI	X	Sent by setting EOI low
	IFC	X	Clears Interface
	ATN	Low	Defines data bus contents
	SRQ	X	Controlled by external device
Multiline Universal	LLO	Low	Locks out front panel controls
	DCL	Low	Returns device to default conditions
	SPE	Low	Enable serial polling
	SPD	Low	Disables serial polling Addressed
	SDC	Low	Returns unit to default condition
	GTL	Low	Returns to local control
	GET	Low	Triggers device for reading
Unaddress	UNL	Low	Removes all listeners from bus
	UNT	Low	Removes all talkers from bus
Device- Dependent(**)		High	Programs Model 8550 for various modes.

(*) X = Don't Care, (**) See paragraph 4-9 for complete description

Generally, this should be done before attempting to program the instrument over the bus. The Model 8550 will indicate that it is in the remote mode by illuminating its front panel REM indicator. To place the Model 8550 in the remote mode, the controller must perform the following steps:

1. Set the REN line true.
2. Address the Model 8550 to listen.

NOTE

Setting REN true without addressing will not cause the REM indicator to turn on; however, once REN is true, the REM light will turn on the next time an address command is received.

EOI (End Or Identify) - The EOI command is used to positively identify the last byte in a multi-byte transfer sequence. This allows variable length data words to be transmitted easily.

IFC (Interface Clear) - The IFC command is sent to clear the bus and set hand shake lines to a known state. Although device configurations differ, the IFC command usually places instruments in the talk and listen idle states.

ATN (Attention) - The controller sends ATN while transmitting addresses or multiline commands. Device-dependent commands are sent with the ATN line high (false).

SRQ (Service Request) - The SRQ command is asserted by an external device when it requires service from the controller. If more than one device is present, a serial polling sequence, as described in paragraph 4-8-2, must be used to determine which has requested service.

4-8-2. Universal Multiline Commands

Universal commands are multiline commands that require no addressing. All instrumentation equipped to implement the command will do so simultaneously when the command is transmitted over the bus. As with all multiline commands, the universal commands are sent over the data lines with ATN set low:

LLO (Local Lockout) - The LLO command is sent by the controller to remove the Model 8550 from the local operating mode. Once the unit receives the LLO command, all its front panel controls (except Power) will be inoperative.

NOTE

The REN bus line must be true before the instrument will respond to an LLO command.

To lock out the front panel controls of the Model 8550, the controller must perform the following steps:

1. Set ATN true.
2. Send the LLO command to the instrument.

DCL (Device Clear) - The DCL command may be used to clear the Model 8550, setting it to a known state. Note that all devices on the bus equipped to respond to a DCL will do so simultaneously. When the Model 8550 receives a DCL command, it will return to the default conditions listed in Table 4-4. Factory pre-selected parameters are listed in Table 3-1. To send a DCL command the controller must perform the following steps:

1. Set ATN true.
2. Place the DCL command on the bus.

SPE (Serial Poll Enable) - The serial polling sequence is used to obtain the Model 8550 status byte. Usually, the serial polling sequence is used to determine which of several devices has requested service over the SRQ line. However, the serial polling sequence may be used at any time to obtain the status byte from the Model 8550. For more information on status byte format, refer to paragraph 4-14. The serial polling sequence is conducted as follows:

1. The controller sets the ATN line true.
2. The SPE (Serial Poll Enable) command is placed on the bus by the controller.
3. The Model 8550 is addressed to talk.
4. The controller sets ATN false.
5. The Model 8550 then places its status byte on the bus to be read by the controller.
6. The controller then sets the ATN line low and places SPD (Serial Poll Disable) on the bus to end the serial polling sequence.

Steps 3 trough 5 may be repeated for other instruments on the bus by using the correct talk address for each instrument. ATN must be true when the talk address is transmitted and false when the status byte is read.

SPD (Serial Poll Disable) - The SPD command is sent by the controller to remove all instrumentation on the bus from the serial poll mode.

Table 4-4. Default Conditions. (Status After SDC, DCL, or *RST)

Mode	Default	Status
Operating Mode - Model 8550	F0	Normal
Sweep Direction	S1	Start to stop
Trigger Modes	M1	Normal continuous mode
Control Modes	CT0	Off
Output Waveforms	W1	Sinewave output
Output Disable/Enable Mode	D0	Output enabled
Pulse/Ramp Output Mode	C0	Complement OFF (Model 8551)
Edge Control	L0	Fastest edge transition (Model 8551)
Response Message Format	X0	Response header OFF
Response Message Terminator	Z0	New line(LF), END(EOI) terminator
Event Status Enable Mask	*ESE0	No mask
SRQ Enable Register Mask	*SRE0	No mask

4-8-3. Addressed Commands

Addressed commands are multiline commands that must be preceded by a listen command derived from the device's primary address before the instrument will respond. Only the addressed device will respond to each of these commands:

SDC (Selective Device Clear) - The SDC command performs essentially the same function as the DCL command except that only the addressed device will respond. This command is useful for clearing only a selected instrument instead of all devices simultaneously. Model 8550 will return to the default conditions listed in Tables 3-1 and 4-4 when responding to an SDC command. To transmit the SDC command, the controller must perform the following steps:

1. Set ATN true.
2. Address the Model 8550 to listen.
3. Place the SDC command on the data bus.

GTL (Go To Local) - The GTL command is used to remove the instrument from the remote mode of operation. Also, front panel control operation will usually be restored if the LLO command was previously sent. To send the GTL command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 8550 to listen.
3. Place the GTL command on the bus.

NOTE

The GTL command does not remove the local lockout state. With the local lockout condition previously set, the GTL command will enable front panel control operation until the next time a listener address command is received. This places the Model 8550 in the local lockout state again.

GET (Group Execute Trigger) - The GET command is used to trigger or arm devices to perform a specific task depends on device configuration. Although GET is considered to be an addressed command, many devices respond to GET without being addressed. Using the GET command is only one of several methods that can be used to initiate a trigger. More detailed information on triggering can be found in Chapter 3 of this manual. To send GET command over the bus, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 8550 to listen.
3. Place the GET command on the data bus.

GET can also be sent without addressing by omitting step 2.

4-8-4. Unaddressed Commands

The two unaddressed commands are used by the controller to simultaneously remove all talkers and listeners from the bus. ATN is low when these multiline commands are asserted.

UNL (Unlisten) - All listeners are removed from the bus at once when the UNL commands is placed on the bus.

UNT (Untalk) - The controller sends the UNT command to clear the bus of any talkers.

4-8-5. Device-dependent Commands

The meaning of the device-dependent commands is determined by instrument configuration. Generally, these commands are sent as one or more ASCII characters that tell the device to perform a specific function. For example, M2 is sent to the Model 8550 to place the instrument in the external trigger mode. The IEEE-488.2 bus treats device-dependent commands as data in providing that ATN is high (false) when the commands are transmitted.

4-8-6. Common Commands and Queries

Since most instruments and devices in an ATE system use similar commands which perform identical functions, the IEEE-488.2 document has specified a common set of commands and queries which all device must use. This avoids the problem in which devices from various manufacturers used a different set of commands to enable functions and report status. The IEEE-488.2 treats the common commands and queries as device dependent commands. For example, *TRG is sent over the bus to trigger the instrument. Some common commands and queries, however, are optional; most of them are mandatory. The following set of command groups ensure that all devices communicate uniformly:

1. System Data - These commands are used to store or retrieve information such as device identification, descriptions and options. It is possible to determine the manufacturer, model, and serial number of the device under remote control.

2. Internal Operation - These commands include such instrument operations as resetting, self-calibrating, and self-diagnostics of a GPIB device. The device may respond to a calibration query to indicate that the calibration was carried out successfully and report any calibration errors that may have occurred. The reset command sets the device-dependent func- tions to a known state and must not affect the state of the IEEE-488 interface, the Service Request Enable register, or Standard Event Status Enable register.

3. Status and Event - These commands control the status structure of the GPIB device and provide a means to read and enable events. Included in these commands are Clear, Event Status Enable, Power-on Status, and Service Request Enable.

4. Synchronization - The operation of the devices within the system are synchronized with these commands. Included is a Wait to Continue command which forces the devices to complete all previous commands and queries. The Operation Complete command tells the device to set bit 0 in the Standard Event Status register when it completes all pending operations.

5. Device Trigger - These commands enable a device to be triggered and specify how it responds to the trigger message. The Define Device Trigger command stores a sequence of commands which the device will follow when the Group Execute Trigger (GET) is received.

6. Stored Settings - These commands are used to save the state of the device under control, to be used at a later time. The Save command stores the present state of the device in the device's memory. If there is more than one location in which this data can be stored, the command is followed by a number which designates the storage register to use. The Recall command restores the state of the device, as stored in its memory from the previous Save command. As with the Save command, the Recall command must be followed by a number to specify the register from which the stored settings are to be recalled.

4-9. DEVICE LISTENING FORMATS

This paragraph discusses the formatting of <Program Message> elements received by a device from its system interface. Allowable IEEE-488.2 <Program Message> is composed of sequence of <Program Message> units, each unit representing a program command. Each program command is composed of a sequence of functional syntactic elements. Legal IEEE-488.2 program commands are created from functional elements sequences.

Some commands of universal instrument system application have been defined by the IEEE-488.2. They are the common commands; these commands and queries are specific path selections through the functional syntax diagram as specified in the IEEE-488.2 standard. The remaining commands are device-specific and are generated by the device designer using the functional syntax diagram and the needs of the device. The functional elements include separators, terminators, headers, and data types. These elements are discussed in the following.

4-9-1. Functional Element Summary

<Program Message> Represents a sequence of zero or more <Program Message Unit> elements separated by <Program Message Unit Terminator> elements.

<Program Message Unit> Represents a single command or programming data received by the device.

<Command Message Unit> Represents a single command or programming data received by the device.

<Query Message Unit> Represents a single query sent from the controller to the device.

<Program Data> Represents any of the six different program data types.

<Program Message Unit separator> Separates the <Program Message Unit> elements from one another in a <Program Message>.

<Program Data Separator> Separates sequential <Program data> elements that are related to the same header.

<Program Header Separator> Separates the header from any associated <Program Data>.

<Program Message Terminator> Terminates a <Program Message>.

<Command Program Header> Specifies function operation. Used with any associated <Program Data elements>.

<Query Program Header> Similar to <Command Program Header> except a query indicator (?) shows that a response is expected from the device.

<Character Program Data> A data type suitable for sending short mnemonic data, generally where a numeric data type is not suitable.

<Decimal Numeric Program Data> A data type suitable for sending decimal integers or decimal fractions with or without exponents.

<Suffix Program Data> An optional field following <Decimal Numeric Program Data> used to indicate associated multipliers and units.

<NonDecimal Numeric Program Data> A data type suitable for sending integer numeric representation in base 16, 8, or 2. Useful for data that is more easily interpreted when directly expressed in a non-decimal format.

<String Program Data> A data type suitable for sending 7-bit ASCII character strings where the content needs to be “Hidden” (by delimiters)

<Arbitrary Block Program Data> A data type suitable for sending blocks of arbitrary 8-bit information.

<Expression Program data> A data type suitable for sending data that is elevated as one or more non-expression data elements before further parsing.

4-9-2. Separator Functional Element Summary The various elements within the <Program Message> are separated by ASCII characters that were specially assigned for this purpose. These separators are discussed in the following paragraphs.

4-9-2-1. Program Message Unit Separator

The <Program Message Unit Separator> separates sequential <Program Message Unit> elements from one another within a <Program Message>. The <Program Message Unit Separator> is defined as:

;

It is allowed to use leading <white space> elements before the <Program Message Separator>. <White Space> is defined as a single ASCII-encoded byte in the range of 00-09, 0B-20. This range includes the ASCII control characters and the space, but excludes the new line.

4-9-2-2. Program Data Separator

The <Program Data Separator> separates sequential <Program Data> elements from one another after a <Command Program Header> or <Query Program Header>. It is used when a <Command Program Header> or <Query Program Header> has multiple parameters. The <Program Data Separator> is defined as:

,

Preceding and succeeding <White Space> elements are permitted.

4-9-2-3. Program Header Separator

The <Program Header Separator> separates the <Command Program Header> or <Query Program Header> from the <Program Data> elements. The <Program Header Separator> is defined as white space:

<White Space>

Refer to paragraph 4-9-2-1 for the definition of <White Space> elements.

4-9-3. Program Message Terminator

A <Program Message Terminator> terminates a sequence of one or more definite length <Program Message Unit> elements. There are three possible <Program Message Terminator> elements:

1. NL (new line);
2. NL END (EOI); and
3. END (EOI)

NL is defined as a single ASCII-encoded byte 0A (10 decimal). Leading <White Space> elements are permitted. The instrument interprets any and all of the three terminators as semantically equivalent. No alternative encoding are allowed. Note that IEEE-P981 amendment forbids the use of CR as a <Program Message Terminator> element. This is because some controller treat CR as the end of transmission and leave the LF character in the unit, thereby creating an error in the controller.

4-9-4. Command Program Header

The <Command Program Header> represents the operation to be performed in a device. The header may be optionally followed by associated parameters encoded as <Program Data> elements. There are three defined <Command Program Header> elements: <Simple Command Program Header>, <Compound Command Program Header>, and <Common Command Program Header.

<Simple Command Program Header> is defined as:

<Program Mnemonic>

For example, FRQ. Leading <White Space> elements are permitted. Upper/lower case alpha characters are treated with the same semantic equivalence. <Compound Command Program Header> is not used in model 8550 and will not be discussed here. A <Common Command Program Header> is defined as:

***<Program Mnemonic>**

For example, *TRG. Leading <White Space> elements are permitted. Upper/ lower case alpha characters are treated with the same semantic equivalence.

4-9-5. Query Program Header

The <Query Program Header> represents the operation to be performed in a device. A <Query Program Header> causes the device to generate a response. This element may be optionally followed by associated parameters encoded as <Program Data> elements. There are three defined <Query Program Header> elements: <Simple Query Program Header>, <Compound Query Program Header>, and
<Common Query Program Header. A <Simple Query Program Header> is defined as:

<Program Mnemonic>?

For example, FRQ?. Leading <White Space> elements are permitted. Upper/lower case alpha characters are treated with the same semantic equivalence. <Compound Query Program Header> is not used in model 8550 and will not be discussed here. A <Common Query Program Header> is defined as:

***<Program Mnemonic>?**

For example, *CAL?. Leading <White Space> elements are permitted. Upper/lower case alpha characters are treated with the same semantic equivalence.

4-9-6. Program Data

A <Program Data> functional element is used to convey a variety of parameter information related to the <Program Header>.

4-9-6-1. Character Program Data

The <Character Program Data> functional element is not implemented in Model 8550. Therefore it shall not be discussed in this manual.

4-9-6-2. Decimal Numeric Program Data

The <Decimal Numeric Program Data> is a flexible version of the three numeric representations as defined in ANSI X3.42-1975 - NR1, NR2, and NR3. A <Decimal Numeric Program Data> elements are defined as:

1. **NR1** elements consists of a set of implicit point representations of numeric values. i.e. (+/-)12345.
2. **NR2** elements are the representations of explicit point numeric values. i.e. (+/-)12.345.
3. **NR3** elements are representations of scaled explicit radix point numeric values together with an exponent notation. i.e. (+/-)123.456E(+/-)3.

4-9-6-3. Suffix Program Data

A <Suffix Program Data> element permits the use of a suffix following the <Decimal Numeric Program Data> (NRf). The suffix expression associated units and (optional) multipliers that modify how the NRf is interpreted by the device. The presence of a <Suffix Program Data> after an NRf is always optional. No particular <Command Program Header> or <Query Program Header> is a device shall require the use of a <Suffix Program Data> element.

4-9-6-4. Non-Decimal Numeric Program Data

The <Non-Decimal Program Data> functional element is not implemented in Model 8550. Therefore it shall not be discussed in this manual.

4-9-6-5. Arbitrary Block Program Data

The <Arbitrary Block Program Data> functional element is not implemented in Model 8550. Therefore it shall not be discussed in this manual.

4-9-6-6. Expression Program Data

The <Expression Program Data> functional element is not implemented in Model 8550. Therefore it shall not be discussed in this manual.

4-10. DEVICE-DEPENDENT COMMAND PROGRAMMING

IEEE-488.2 device-dependent commands are sent to the Model 8550 to control various operating conditions such as display modify, operating mode, output and parameter interrogate. Each command is made up of a program, command or query header followed by program data, program suffix, and terminated by program message terminator. The IEEE bus treats device-dependent commands as data in, providing that ATN is high when the commands are transmitted. For example the output amplitude is programmed by sending the following <Program Message Unit>: AMP 10.5V.

A number of <Program Message Unit> elements may be grouped together in one <Program Message> provided that each <Program Message Unit> is separated by a <Program Message Unit Separator>.
<Program message Unit> elements within a <Program Message> are executed **exactly** in the same order they are received from the controller. The Model 8550 ignores all non-printable ASCII characters (00 HEX through 20 HEX) except the "CR" (carriage return). A command string is terminated by a <Program Message Terminator> which tells the instrument to execute the <Program Message>.

If an illegal <Program Header> or <Program Data> is present within a <Program Message>, the instrument will:

1. Ignore the illegal part or the <Program Message> (but will execute the rest of the <Program Message>).
2. Display an appropriate front panel error message.
3. Set certain bits in its status registers.
4. Generate an SRQ if programmed to do so. Device-dependent programming aspects are covered in paragraph 4-8-5 and 4-10.

NOTE

Before programming the instrument over the bus, It is recommended that the instrument be set to its default values by sending an SDC or DCL over the bus. See paragraph 4-8-3 for information on using the SDC command.

In order to send a device-dependent or a common command, the controller must perform the following sequence:

1. Set ATN true.
2. Address the Model 8550 to listen.
3. Set ATN false.
4. Send the command string over the data bus one byte at a time.

NOTE

REN must be true when attempting to program the Model 8550.

Device-dependent commands that affect Models 8550 and 8551 are listed in Table 4-5. Common commands and queries are listed in Table 4-6. All the commands listed in the Tables 4-5 and 4-6 are covered in detail in the following.

4-10-1. Operating Mode (F)

The operating mode command controls the mode that the model 8550 operates. Operator may select between four different operating modes: normal op- erating mode, linear sweep mode, logarithmic sweep mode, and phase locking generator mode. Model 8551 has different operating modes: normal operating mode, variable duty cycle pulse generator mode, fixed duty cycle pulse generator mode, and phase locking generator mode.

The model 8550 operating mode may be programmed by sending one of the following commands:

F0 = Normal operating mode
F1 = Linear sweep mode
F2 = Logarithmic sweep mode
F3 = Phase locking generator mode

Table 4-5. Device-Dependent Command Summary

Mode	Program Header and Data	Description
OPERATING MODE		
(Model 8550)	F0	Normal
	F1	Linear Sweep
	F2	Logarithmic Sweep
	F3	PLL
OPERATING MODE		
(Model 8551)	F0	Normal
	F1	Pulse
	F2	Fixed Duty Cycle
	F3	PLL
SWEEP DIRECTION		
(MODEL 8550)	S1	Start to Stop (up)
	S2	Stop to start (down)
	S3	Start to stop to start (up-down)
	S4	Stop to start to stop (down-up)
TRIGGER MODES		
	M1	Normal continuous mode
	M2	External Trigger
	M3	External Gate
	M4	External Burst
	M5	Internal Trigger
	M6	Internal Burst
CONTROL MODES		
	CT0	Off
	CT1	FM (Model 8550)
	CT2	AM
	CT3	PWM (Model 8551)
	CT4	VCO
OUTPUT WAVEFORMS		
	W0	DC (Model 8550)
	W1	Sinewave
	W2	Triangle
	W3	Squarewave
	W4	Fixed base-line positive squarewave
	W5	Fixed base-line negative squarewave
	W6	Ramp (Model 8551)
OUTPUT MODE		
	D0	Normal output
	D1	Disabled output
(Model 8551)	C0	Pulse/Ramp complement OFF
(Model 8551)	C1	Pulse/Ramp complement ON
EDGE CONTROL		
(Model 8551)	L0	Fastest edge transition
	L1	Linear edge transition

Table 4-5. Device-Dependent Command Summary (continued)

Mode	Program Header and Data	Description	Suffix* Data
PROGRAM PARAMETERS			
	FRQ	Program output frequency	MHZ, HZ, KHZ, MAHZ
	AMP	Program output amplitude	MV, V
	OFS	Program output offset	MV, V
	PLL	Program phase lock offset	DEG
(Model 8551 only)	PER	Program pulse period	NS, US, MS, S
(Model 8551 only)	WID	Program pulse width	NS, US, MS, S
(Model 8551 only)	DTY	Program fixed duty cycle	PCT
(Model 8551 only)	LEE	Program leading edge transition time	NS, US, MS, S
(Model 8551 only)	TRE	Program trailing edge transition time	NS, US, MS, S
	RPT	Program internal trig. generator per.	NS, US, MS, S
	BUR	Program counted burst	
	TLV	Program trigger level	V
	TPH	Program trigger phase offset	DEG
(Model 8550 only)	DCO	Program dc output level	MV, V
(Model 8550 only)	STP	Program logarithmic sweep stop	MHZ, HZ, KHZ, MAHZ
(Model 8550 only)	SWT	Program sweep time	NS, US, MS, S
(Model 8550 only)	MRK	Program logarithmic sweep marker	MHZ, HZ, KHZ, MAHZ
(Model 8550 only)	SSN	Program linear sweep stop	MHZ, HZ, KHZ, MAHZ
(Model 8550 only)	MKN	Program linear sweep marker	MHZ, HZ, KHZ, MAHZ
REVIEW PARAMETER			
	VFRQ	Display output frequency VAMP	Display output amplitude
	VOFS	Display output offset VPLL	Display phase lock offset
(Model 8551 only)	VPER	Display pulse period	
(Model 8551 only)	VWID	Display pulse width	
(Model 8551 only)	VDTY	Display fixed duty cycle	
(Model 8551 only)	VLEE	Display leading edge transition time	
(Model 8551 only)	VTRE	Display trailing edge transition time	
	VRPT	Display internal trigger generator period	
	VBUR	Display counted burst	
	VTLV	Display trigger level	
	VTPH	Display trigger phase offset	
(Model 8550 only)	VDCO	Display dc output level	
Model 8550 only)	VSTP	Display logarithmic sweep stop	
(Model 8550 only)	VSWT	Display sweep time	
(Model 8550 only)	VMRK	Display logarithmic sweep marker	
(Model 8550 only)	VSSN	Display linear sweep stop	
(Model 8550 only)	VMKN	Display linear sweep marker	

* Suffix Data is optional.

Table 4-5. Device-Dependent Command Summary (continued)

Mode	Program Header and Data	Description
RESPONSE DATA QUERY		
	FRQ?	Interrogate output frequency
	AMP?	Interrogate output amplitude
	OFS?	Interrogate output offset
	PLL?	Interrogate phase lock offset
(Model 8551)	PER?	Interrogate pulse period
(Model 8551)	WID?	Interrogate pulse width
(Model 8551)	DTY?	Interrogate fixed duty cycle
(Model 8551)	LEE?	Interrogate leading edge transition time
(Model 8551)	TRE?	Interrogate trailing edge transition time
	RPT?	Interrogate internal trig. generator period
	BUR?	Interrogate counted burst
	TLV?	Interrogate trigger level
	TPH?	Interrogate trigger phase offset
(Model 8550)	DCO?	Interrogate dc output level
(Model 8550)	STP?	Interrogate logarithmic sweep stop
(Model 8550)	SWT?	Interrogate sweep time
(Model 8550)	MRK?	Interrogate logarithmic sweep marker
(Model 8550)	SSN?	Interrogate linear sweep stop
(Model 8550)	MKN?	Interrogate linear sweep marker
(Model 8550)	ERR?	Interrogate pulse/ramp error status
	STT?	Interrogate machine status
	FSA?	Interrogate cal. failure status byte A
	FSB?	Interrogate cal. failure status byte B
	FSC?	Interrogate cal. failure status byte C
RESPONSE MESSAGE FORMAT		
	X0	Response header OFF
	X1	Response header ON
	Z0	New line (LF), END (EOI) terminator
	Z1	New line (LF) terminator
	Z2	END (EOI) terminator
	Z3	No terminator
COMMON COMMANDS		
	*CLS	Clear status command
	*ESE	Standard event status enable command
	*OPC	Operation complete command
	*RCL	Recall front panel set-up command
	*RST	Reset command
	*SAV	Save front panel set-up command
	*SRE	Service request enable command
	*TRG	Trigger command
	*WAI	Wait-to-continue command

Table 4-5. Device-Dependent Command Summary (continued)

Mode	Program Header and Data	Description
COMMON QUERIES		
	*CAL?	Calibration query
	*ESE?	Standard event status enable query
	*ESR?	Standard event status register query
	*IDN?	Identification query
	*OPC?	Operation complete query
	*SRE?	Service request enable query
	*STB?	Read status byte query
	*TST?	Self-test query
STANDARD EVENT STATUS ENABLE REGISTER MASK		
	*ESE0	No mask
	*ESE1	ESB bit set on operation complete
	*ESE2	Not used
	*ESE4	ESB bit set on query error
	*ESE8	ESB bit set on device dependent error
	*ESE16	ESB bit set on execution error
	*ESE32	ESB bit set on command error
	*ESE64	ESB bit set on user request
	*ESE128	ESB bit set on power on
CALIBRATION FAILURE STATUS BYTE A MASK		
	FSA0 through FSA16383	Mask not available
CALIBRATION FAILURE STATUS BYTE B and C MASK		
	FSB0 through FSB255	Mask not available
	FSC0 through FSC16383	Mask not available
SERVICE REQUEST ENABLE REGISTER MASK		
	*SRE0	No mask
(Model 8551 only)	*SRE1	RQS/MSS bit set on ERR bit
	*SRE2	RQS/MSS bit set on FSC bit (fail status byte C)
	*SRE4	RQS/MSS bit set on FSB bit (fail status byte B)
	*SRE8	RQS/MSS bit set on FSA bit (fail status byte A)
	*SRE16	RQS/MSS bit set on MAV bit (message available)
	*SRE32	RQS/MSS bit set on ESB bit (standard event status register)
	*SRE128	Not used

The model 8551 operating mode may be programmed by sending one of the following commands:

F0 = Normal operating mode
F1 = Variable duty cycle pulse generator mode
F2 = Fixed duty cycle pulse generator mode
F3 = Phase locking generator mode

4-10-2. Sweep Direction (S)

Model 8550 while being used in one of its sweep modes provides a selection from four different sweep directions. The sweep direction command controls the direction of which the output will sweep. The sweep direction may be programmed by sending one of the following commands:

S0 = Sweep from start frequency to stop Frequency - up
S1 = Sweep from stop frequency to start Frequency - down
S2 = Sweep from start frequency to stop Frequency to start frequency - up-down
S3 = Sweep from stop frequency to start Frequency to stop frequency - down-up

4-10-3. Trigger Modes (M)

The trigger mode command gives the user control over the output stimulant of the Model 8550. There are a number of acceptable external sources for stimulating the output of the function generator. The instrument may also be set to operate in continuous mode or with having an internal trigger source. The generator may be programmed to accept either an external stimulant or an internal stimulant. Program the Model 8550 to one of the trigger modes by sending one of the following commands:

M1 = Normal continuous mode
M2 = External trigger
M3 = External gate
M4 = External burst
M5 = Internal trigger
M6 = Internal burst

4-10-4. Control Modes (CT)

Model 8550 provides three control modes: FM, AM, and VCO. Model 8551 offers PWM, Am, and VCO. The control mode command gives the user control over the control mode of the function generator. Program the Model 8550 to one of the control modes by sending one of the following commands:

CT0 = Normal operating mode **CT1** = FM mode (model 8550 only)
CT2 = AM mode
CT3 = PWM mode (model 8551 only)
CT4 = VCO mode

4-10-5. Output Waveforms (W)

The output waveform command give the user control over the output waveform. The seven parameters which are associated with the waveform commands, set the instrument to output sinewave, triangle, squarewave, positive pulse, negative pulse, DC (model 8550 only), and ramp (model 8551 only). The output waveform may be programmed by sending one of the following commands:

W0 = DC output (model 8550 only)
W1 = Sinewave
W2 = Triangle
W3 = Square wave
W4 = Fixed base-line positive square wave
W5 = Fixed base-line negative square wave
W5 = Ramp output (model 8551 only)

4-10-6. Output Mode (D, C)

The output mode command places the function generator in stand by mode. In model 8551 this command places the output in pulse complement mode and in inverted ramp mode. The output mode may be programmed by sending one of the following commands

D0 = Normal output
D1 = Disabled output
C0 = Pulse/Ramp complement OFF (mode 8551 only)
C1 = Pulse/Ramp Complement ON (model 8551 only)

4-10-7. Edge Control (L)

Model 8551, when set to operate as a pulse generator, may be placed in linear transition times mode. Rise or fall times may be independently controlled for each edge or be set to fixed (fast) transitions. The edge control command places the pulse generator in linear transition times mode. Model 8551 may be programmed by sending one of the following commands

L0 = Fastest edge transitions
L1 = Linear edge transitions

4-10-8. Parameter Programming

The parameter programming command sets the function generator to the various levels which are required for the unit under test. There are 19 different parameters which may be modified using this command. The command message unit is comprised of three parts: the <command program header>, the <decimal numeric program data>, the <suffix program data> (optional), and the <program message terminator>.

The <command program header> mnemonic is independent of control location on the front panel but relates to front panel nomenclature. For example, FRQ mnemonic is related to front panel Frequency marking.

The <decimal numeric program data> is a flexible version of numeric representation denoted by NRf. Operator may choose to program <decimal numeric program data> using NR1, NR2, or NR3 formats. Examples of the various <decimal numeric program data> is given in the following.

NR1 elements consists of a set of implicit point representations of numeric values. i.e. (±)12345.

NR2 elements are the representations of explicit point numeric values. i.e. (±)12.345.

NR3 elements are representations of scaled explicit radix point numeric values together with an exponent notation. i.e. (±)123.456E(+/-)3.

The <suffix program data> element permits the use of suffix following the NRf. The suffix expresses associated units and (optional) multipliers that modify how the NRf is interpreted by the device.

For an example, to program the model 8550 for a frequency output of 10.7 MHz, the following <program message unit> options may be used:

FRQ 10.700000; or
FRQ 10.7MAHZ; or
FRQ 10.7E+6; or
FRQ 10.7E6HZ; etc.

<Command program header> and <suffix program data> and (optional) multipliers summary is given in the following

FRQ ...MHZ, HZ, KHZ, MAHZ = Program frequency parameter
AMP ...MV, V = Program amplitude parameter
OFS ...MV, V = Program offset parameter
PLL ...DEG = Program phase lock offset parameter
PER ...NS, US, MS, S = Program pulse period parameter (model 8551 only)
WID ...NS, US, MS, S = Program pulse width parameter (model 8551 only)
DTY ...PCT = Program fixed duty cycle parameter (model 8551 only)
LEE ...NS, US, MS, S = Program leading edge transition time parameter (model 8551 only)
TRE ...NS, US, MS, S = Program trailing edge transition time parameter (model 8551 only)
RPT ...NS, US, MS, S = Program internal trigger generator period parameter
BUR ... = Program counted burst parameter
TLV ...MV, V = Program trigger level parameter
TPH ...DEG = Program trigger phase offset parameter
DCO ...MV, V = Program dc output level parameter (model 8550 only)
STP ...MHZ, HZ, KHZ, MAHZ = Program logarithmic sweep stop parameter (model 8550 only)
SWT ...NS, US, MS, S = Program sweep time parameter (model 8550 only)
MRK ...MHZ, HZ, KHZ, MAHZ = Program logarithmic sweep marker parameter (model 8550 only)
SSN ...MHZ, HZ, KHZ, MAHZ = Program linear sweep stop parameter (model 8550 only)
MKN ...MHZ, HZ, KHZ, MAHZ = Program linear sweep marker parameter (model 8550 only)

The programming limits for each of the above parameters are listed in Table 3-2. After DCL or SDC, the instrument defaults to its factory selected values. Factory defaults are listed in Table 3-1 and 4-4.

4-10-9. Display Parameter (V)

The display parameter command controls what the Model 8550 places on the display. The display parameter mode may be programmed by sending one of the following commands. The numbers in parenthesis represent the value of V in the Machine Status String - STT.

VFRQ = Display output frequency parameter (01)
VAMP = Display output amplitude parameter (02)
VOFS = Display output offset parameter (03)
VPLL = Display phase lock offset parameter (04)
VPER = Display pulse period parameter - model 8551 only (05)
VWID = Display pulse width parameter - model 8551 only (06)
VDTY = Display fixed duty cycle parameter - model 8551 only (07)
VLEE = Display leading edge transition time parameter - model 8551 only (08)
VTRE = Display trailing edge transition time parameter - model 8551 only (09)
VRPT = Display internal trigger generator period parameter
VBUR = Display counted burst parameter
VTLV = Display trigger level parameter

VTPH = Display trigger phase offset parameter
VDCO = Display dc output level parameter (model 8550 only)
VSTP = Display logarithmic sweep stop parameter (model 8550 only)
VSWT = Display sweep time parameter (model 8550 only)
VMRK = Display logarithmic sweep marker parameter (model 8550 only)
VSSN = Display linear sweep stop parameter (model 8550 only)
VMKN = Display linear sweep marker parameter (model 8550 only)

4-10-10. Common Commands

As discussed in previous paragraphs most instruments and devices in an ATE system use similar commands which perform identical functions to avoids the problem in which devices from various manufacturers used a different set of commands to enable functions and report status. Some common commands and queries, however, are optional; most of them are mandatory. Common commands and queries are listed in Table 4-6. The following set of common commands are utilized in the model 8550 (optional common commands that are not included in the model 8550 command set will not be discussed here).

***CLS** (Clear Status Command) - clears status data structures, and forces the device to the Operation Complete Command/Query Idle State. If the Clear Status command immediately follows a <Program Message Terminator>, the Output Queue and the MAV bit will be cleared.

***ESE** (Standard Event Status Enable Command) - followed by a number in the range of 0 to 255, sets the Standard Event Status Enable Register bits. The binary equivalent of the number represents the values of the individual bits set into the Standard Event Status Enable register.

***OPC** (Operation complete Command) - causes the device to generate the operation complete message in the Standard Event Status Register when all pending selected device operations have been finished.

***RCL** (Recall Command) - restores the state of the device to a state previously stored in the device's memory. If the device has more than one memory register, the command must be followed by a number to specify which register is to be used. The functions restored by the *RCL command are the same as those affected by the *RST command. Model 8550 may recall settings in registers designated with numbers from 00 to 30.

***RST** (Reset) - Sets device-dependent functions to a known state, purges all *OPC commands and

Table 4-6. Common Commands and Queries Summary

Mode	Program Header and Data	Suffix* Data	Description
COMMON COMMANDS	*CLS		Clear status command
	*ESEn		Standard event status enable command
	*OPC		Operation complete command
	*RCLn		Recall front panel set-up command
	*RST		Reset command
	*SAVn		Save front panel set-up command
	*SREn		Service request enable command
	*TRG		Trigger command
	*WAI		Wait-to-continue command
COMMON QUERIES	*CAL?		Calibration query
	*ESE?		Standard event status enable query
	*ESR?		Standard event status register query
	*IDN?		Identification query
	*OPC?		Operation complete query
	*SRE?		Service request enable query
	*STB?		Read status byte query
	*TST?		Self-test query

queries, and aborts all pending operations. The output queue, Service Request Enable Register, Standard Event Status Enable Register, and power-on flag are not affected. Device defaults are listed in Table 4-4

***SAV** (Save Command) - allows the user to store the present state of a device in local memory. If the device has more than memory location, the command must be followed by a number to designate the storage register to be used. Model 8550 may store settings in registers designated with numbers from 00 to 30.

***SRE** (Service Request Enable Command) - followed by a number, sets the Service Request Enable register which determines what bit in the status byte will cause a service request from the device. The binary equivalent of the number represents the values of the individual bits of the Service Request Enable Register.

***TRG** (Trigger Command) - has exactly the same effect as a GET when received, parsed, and executed by the device.

***WAI** (Wait to Continue Command) - causes a device to wait until all previous commands and queries are completed before executing any which follow the *WAI command.

4-10-10-1. Set-ups (*SAV, *RCL)

The setups commands select the memory location where front panel setup is to be stored (*SAV) or from where recalled (*RCL). To store or recall a setup use one of the following commands:

***SAVnn**
***RCLnn**

Where nn may range from 00 to 30. nn is the selected memory cell of which the setup is to be stored or from where the setup is to be recalled.

4-11. DEVICE TALKING FORMATS

This paragraph discusses the formatting of <Response Message> elements sent from a device via its system interface. Allowable IEEE-488.2 response message is composed of a sequence of <Response Message> units, each unit representing a response to a query. Each <Response Message> is composed of a sequence of functional syntactic elements. Legal IEEE-488.2 <Response Message> is created from functional elements sequences. A <Response Message is interpreted by a controller running an application pro- gram, and as such, needs to convey its information precisely for consistent operation with a wide range of controllers. A <Response Message>, therefore, has a more restrictive format than a <Program Message>.

Some queries of universal instrument system application have been defined by the IEEE-488.2. They are the common queries; these queries are specific path selections through the functional syntax diagram as specified in the IEEE-488.2 standard. The remaining queries are device-specific and are generated by the device designer using the functional syntax diagram and the needs of the device. The functional elements include separators, terminators, headers, and data types. These elements are discussed in the following.

4-11-1. Functional Element Summary

<Response Message> Represents a sequence of one or more <Response Message Unit> elements separated by <Response Message Unit Terminator> elements.

<Response Message Unit> Represents a single message unit sent from the device.

<Response Data> Represents any of the eleven different <Response Data> types.

<Response Message Unit Separator> Separates <Response Message Unit> elements from one another in a <Response Message>.

<Response Data Separator> Separates sequential <Response Data> elements that are related to the same header or to each other.

<Response Header Separator> Separates the header from the associated <Response Data>.

<Response Message Terminator> Terminates a <Response Message>.

<Response Header> Specifies the function of the associated <Response Data> element(s). Alpha characters mnemonically indicate the function.

<Character Response Data> A data type suitable for sending short mnemonic character strings. Generally used when a numeric data type is not suitable.

<Decimal Numeric Response Data> A data type response suitable for sending decimal integers or decimal fractions with or without exponents.

<NonDecimal Numeric Response Data> A data type suitable for sending integer numeric representation in base 16, 8, or 2. Useful for data that is more easily interpreted when directly expressed in a non-decimal format.

<String Response Data> A data type suitable for sending 7-bit ASCII character strings where the content needs to be “Hidden” (by delimiters). This element is generally used to send data for direct display on a device.

<Definite Length Arbitrary Block Response Data> A data type suitable for sending blocks of arbitrary 8-bit information when the length is known beforehand.

<Indefinite Length Arbitrary Block Response Data> A data type suitable for sending blocks of arbitrary 8-bit information when the length is not known beforehand or when computing the length beforehand is undesirable.

<Arbitrary ASCII Response data> A data type suitable for sending arbitrary ASCII data bytes when alternate data types are unworkable.

4-11-2. Separator Functional Element Summary The various elements within the <Response Message> are separated by ASCII characters that were specially assigned for this purpose. These separators are discussed in the following paragraphs.

4-11-2-1. Response Message Unit Separator

The <Response Message Unit Separator> separates sequential <Response Message Unit> elements from one another when multiple <Response Message Unit> elements are sent in a <Response Message>. The <Response Message Unit Separator> is defined as:

;

4-11-2-2. Response Data Separator

The <Response Data Separator> separates sequential <Response Data> elements from one another when multiple data elements are sent. The <Response Data Separator> is defined as:

,

4-11-2-3. Response Header Separator

The <Response Header Separator> separates the <Response Header> from the <Response Data>. The <Response Header Separator> is defined as:

<Space>

4-11-3. Response Message Terminator

The <Response Message Terminator> element's function is to terminate a sequence of one or more <Response Message Unit> elements. There are three possible <Response Message Terminator> elements:

1. NL (new line);
2. NL END (EOI); and
3. END (EOI)

NL is defined as a single ASCII-encoded byte 0A (10 decimal). Leading <White Space> elements are not permitted. The instrument interprets any and all of the three terminators as semantically equivalent. No alternative encoding are allowed. Note that IEEE-P981 amendment forbids the use of CR as a <Response Message Terminator> element. This is be- cause some controller treat CR as the end of transmission and leave the LF character in the unit, thereby creating an error in the controller.

4-11-4. Response Header

The <Response Header> is available for use by the device designer for device-specific responses. It may be used, for example, to create responses in directly resendable <Program Message Unit> format or to identify response data to the controller. There are three defined <Response Header> elements: <Simple Response Header>, <Compound Response Header>, and <Common Response Header. A <Simple Response Header> is defined as:

<Response Mnemonic>

For example, FRQ. Leading <White Space> elements are not permitted. Upper/lower case alpha characters are treated with the same semantic equivalence. <Compound Response Header> is not used in model 8550 and will not be discussed here. A <Common Response Header> is defined as:

***<Response Mnemonic>**

For example, *SRE. Leading <White Space> elements are not permitted. Upper/ lower case alpha characters are treated with the same semantic equivalence.

4-11-5. Response Data

A <Response Data> functional element is used to convey a variety of response information related to the <Response Header>. The element type is determined by the eliciting query. <Non-Decimal Response Data>, <String Response Data>, and <Arbitrary Block Response Data> functional elements are not implemented in Model 8550. Therefore it shall not be discussed in this manual.

4-11-5-1. Character Response Data

The <Character Response Data> functional element is used to convey information best expressed mnemonically as a short alpha or alphanumeric string. It is useful when numeric parameters are inappropriate, for example, model number and manufacturer identification.

4-11-5-2. Decimal Numeric Response Data

The <Decimal Numeric Response Data> is a flexible version of the three numeric representations as defined in ANSI X3.42-1975 - NR1, NR2, and NR3. A <Decimal Numeric Response Data> elements are defined as:

1. NR1 elements consists of a set of implicit point representations of numeric values. i.e. (±)12345.
2. NR2 elements are the representations of explicit point numeric values. i.e. (±)12.345.
3. NR3 elements are representations of scaled explicit radix point numeric values together with an exponent notation. i.e. (±)123.456E(±)3.

4-12. READING FROM THE MODEL 8550

The reading sequence is used to obtain, from Model 8550, various <Response Message Units> such as frequency, amplitude, offset or operating modes. The
<Response Message Unit> elements are placed in an output queue. The output queue may be read by device-defined queries. Such device-defined queries cause the item read to be removed from the output queue. Model 8550 executes the <Program Message> elements in the order received. The output is cleared when any of the following occur:

1. Reading all the items in the output queue.
2. Upon receipt of a new <Program Message>.
3. Upon receipt of the *CLS, DCL or SDC commands.
4. Upon Power on.

IEEE-488.2 specifies that a device cannot send <Response Message> elements unless commanded to do so. This is specified as an "Unterminated Action". The "Unterminated Action" is executed when the controller attempts to read a <Response Message> from the device without first having sent a complete Query Message, including the <Program Message Terminator>, to the device. In the event of "Unterminated Action" model 8550 performs the following steps:

1. Sets the Query Error bit in the Standard Event Status Register.
2. Clears the output queue.
3. Sets **brq** False.

If a read sequence is interrupted by a new <Program Message> before it finishes sending a <Response Message>, model 8550 executes an "Interrupted Action". GPIB bus response is similar to the "Unterminated Action".

The reading sequence is conducted as follows:

1. The controller sets the ATN line true.
2. The Model 8550 is addressed to talk.
3. The controller sets ATN false.
4. The instrument sends the information string over the bus one byte at a time.
5. The controller recognizes that the string is terminated.
6. The controller sets the ATN line true.
7. The UNT (untalk) command is placed on the bus by the controller.

4-12-1. Interrogate Parameter Data Query

The interrogate parameter data query allows access to information concerning present operating conditions of the instrument. When the interrogate parameter data query is given, the Model 8550 will transmit appropriate data string information the next time the instrument is addressed to talk. Model 8550 Interrogate Parameter Data Query include:

FRQ? = Interrogate output frequency parameter
AMP? = Interrogate output amplitude parameter
OFS? = Interrogate output offset parameter
PLL? = Interrogate phase lock offset parameter
PER? Interrogate pulse period parameter (model 8551 only)
WID? Interrogate pulse width parameter (model 8551 only)
DTY? Interrogate duty cycle dat string (model 8551 only)
LEE? Interrogate leading edge transition time parameter (model 8551 only)
TRE? Interrogate trailing edge transition time parameter (model 8551 only)
RPT? Interrogate internal trigger generator period parameter
BUR? Interrogate counted burst parameter
TLV? Interrogate trigger level parameter
TPH? Interrogate trigger phase offset parameter
DCO? = Interrogate dc output level parameter (model 8550 only)
STP? = Interrogate logarithmic sweep parameter (model 8550 only)
SWT? = Interrogate sweep time parameter (model 8550 only)
MRK? = Interrogate logarithmic sweep marker parameter (model 8550 only)
SSN? = Interrogate linear sweep stop parameter (model 8550 only)
MKN? Interrogate linear sweep marker parameter (model 8550 only)
EER? Interrogate pulse/ramp error (model 8551 only)
STT? Interrogate machine status

FSA? Interrogate calibration failure status byte A
FSB? Interrogate calibration failure status byte B
FSC? Interrogate calibration failure status byte C

For example, model 8550 is asked to return frequency, amplitude, and offset parameters in a single <Response Message>

Command: FRQ?;AMP?

Response:FRQ 1.000E+3;AMP 1.00E+0

Table 4-7 shows the general <Response Message> format for each of the above commands. Default values are shown. These defaults are generated after an SDC or DCL commands.

4-12-2. Common Queries

As discussed in previous paragraphs most instruments and devices in an ATE system use similar commands which perform identical functions to avoids the problem in which devices from various manufacturers used a different set of commands to enable functions and report status. Some common commands and queries, however, are optional; most of them are mandatory. The following set of common queries are utilized in the model 8550 (optional common queries that are not included in the model 8550 command set will not be discussed here).

***CAL?** (Calibration Query) - causes a device to perform an internal self-calibration and generate a response that indicated whether or not the device completed the self-calibration without error. The calibration errors are stored in an internal 8-bit register which is not accessible by device-dependent or com- mon queries. Each bit in this register represents an error in a different block within the model 8550.

The generator responds to this query with a number in the range of 0 to 32767. The binary equivalent of the number represents the detected error in the calibration process. For example, if a value of 32 indicates a calibration failure in the pulse width circuit. Similarly, A value of 24 indicates a calibration error in the PLL and trigger circuits. A value of 0 in the response indicates that the calibration was carried out successfully. Note that complete information on calibration errors are available in the Calibration Failure Status Registers. These auxiliary status registers are discussed in-details later in this Chapter. The calibration query does not require any local operator interaction to function. Upon completion of *CAL?, the device returns to the state just prior to the calibration cycle. The various bits in the calibration error register are listed in the following.

Table 4-7. Response Message Format Summary

Command	**Response Format (*)**
FRQ?	FRQ 1.000E+3(terminator)
AMP?	AMP 1.00E+0(terminator)
OFS?	OFS 0.00E+0(terminator)
PLL?	PLL 00E+0(terminator)
PER?	PER 1.000E-3(terminator)
WID?	WID 10.00E-3(terminator)
DTY?	DTY 50E+0(terminator)
LEE?	LEE 10.0E-6(terminator)
TRE?	TRE 10.0E-6(terminator)
RPT?	RPT 1.00E+0(terminator)
BUR?	BUR 2E+0(terminator)
TLV?	TLV 1.6E+0(terminator)
TPH?	TPH 00E+0(terminator)
DCO?	DCO 0.00E+0(terminator)
STP?	STP 9.000E+3(terminator)
SWT?	SWT 1.00E+0(terminator)
MRK?	MRK 5.000E+0(terminator)
SSN?	SSN 9.000E+3(terminator)
MKN?	MKN 5.000E+0(terminator)
ERR?	ERR 00000000(terminator)
FSA?	FSA 00000000(terminator)
FSB?	FSB 00000000(terminator)
FSC?	FSC 00000000(terminator)

(*) NL END is normal terminator. Terminator may change (see paragraph 4-12-4).

Bit 0 - Frequency calibration error.
Bit 1 - Amplitude calibration error.
Bit 2 - Offset calibration error.
Bit 3 - PLL calibration error.
Bit 4 - Trigger calibration error.
Bit 5 - Pulse width calibration error.
Bit 6 - Rise/Fall time calibration error.
Bit 7 - Not used

***IDN?** (Identification Query) - Causes the generator to respond with its identity. The returned data is organized into four fields, separated by commas. The unit must respond with its manufacturer and model number in the first two fields and may also report its serial number and options in field three and four. If the later information is not available, the device must return an ASCII 0 for each. For example, model 8551 response to *IDN? is TABOR,8551,0,REV1.1.

***OPC?** (Operation Complete Query) - causes the device to generate the operation complete message in the Standard Event Status Register when all pending selected device operations have been finished.

***SRE?** (Service Request Enable Query) - enables the user to read the contents of the Service Request Enable register. The device returns a number in the range of 0 to 63 or 128 to 191, since bit 6 (RSQ) cannot be set. The binary equivalent of the number represents the value of the bits of the Service Request Enable Register.

***STB?** (Read Status Byte Query) - Reads the status byte containing the master summary status (MSS) bit. The device responds with an integer in the range of 0 to 255, whose binary equivalent represents the value of the bits of the status byte.

***TST?** (Self-Test Query) - Tells the device to perform an internal self-test and report back to the controller if any errors are detected. The generator responds to this query with a number. A value of 1 in the response indicates that the self-test routine has detected an error. A value of 0 in the response indicates that the self-test was carried out successfully.

4-12-3. Response Header (X)

The <Response Header> from the <Response Message> string may be suppressed using this command. When the <Response Header> is suppressed the output data string is 3 byte shorter. The <Response Header> may be suppressed using the following commands:

X0 = Response header OFF
X1 = Response header ON

4-12-4. Response Message Terminator (Z)

To allow a wide variety of controllers to be used, the terminator can be changed by sending the appropriate command over the bus. The default value is New Line (LF), End (EOI) sequence (mode Z0). The terminator sequence will assume this default value after receiving a DCL or SDC.

The EOI (END) line on the bus is usually set low by the device during the last byte of its data transfer sequence. In this way, the last byte is properly identified, allowing variable length data words to be transmitted. The Model 8550 will normally send EOI during the last byte of its data string or status word. The <Response Message Terminator> in model
8550 may be programmed by sending one of the following commands:

Z0 = New Line (LF), END (EOI) terminator
Z1 = New Line (LF) terminator
Z2 = END (EOI) terminator
Z3 = No terminator

NOTES

1. Most controllers use the LF character to terminate their input sequence. Using the NO TERMINATOR mode (Z3) may cause the controller to hang up unless special programming is used.

2. Some controllers may require that EOI be present at the end of the string.

4-13. DEVICE STATUS REPORTING

Device status reporting defined by IEEE-488.2 builds upon and extends the original specifications of the status byte of the IEEE-488.1 document. A complete model is defined for all status reporting. Figure 4-3 illustrates the IEEE-488.2 status reporting model showing the IEEE-488.1 status byte, which can be read by either a serial poll or Status Byte Query. Summary of related common commands and queries is given in the following.

***STB?** - Returns an NR1, which is the value of the IEEE-488.1 status byte and the MSS (Muster Summary Status) summary message.

***OPC** - Sets the Operation Complete event bit in the Standard Event Status Register when all selected pending device operation have been completed.

***OPC?** - Places a “1" in the output queue when all selected pending operations are completed which in turn cause the MAV (Message Available) summary message to be generated.

***CLS** - Clears all Event Registers summarized in the status byte.

***ESR?** - Returns an NR1, which is the value of the Standard Event Status Enable Register.

***SRE NRf** - Sets the bits of the Service Request Enable Register.

***SRE?** - Returns an NR1, which is the value of the Service Request Enable Register.

4-14. STATUS BYTE REGISTER (STB)

The Status Byte Register contains the device’s STB and RQS (or MSS) messages. IEEE-488.1 defines the method of reporting the STB and RQS, but leaves the setting and clearing protocols and semantics for the STB message undefined. The standard further defines specific device STB summary-messages.

A Muster Summary Status (MSS) message is also provided which is output as bit 6 with the STB

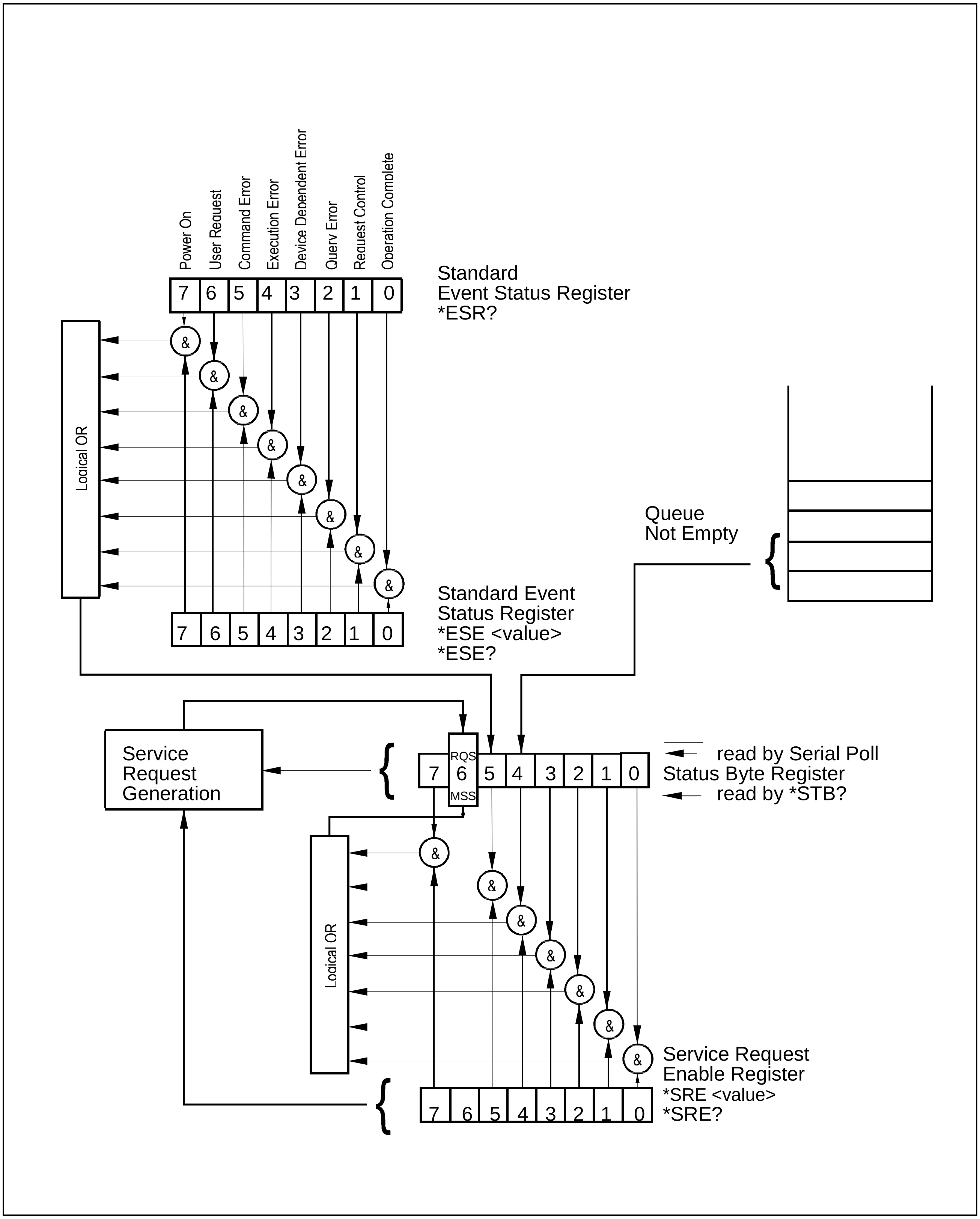


Figure 4-3. IEEE-488.2 Status Reporting Model

response to a *STB? common query. The Status Byte Register is altered only when the state of the overlaying Status Data Structure is altered. The description of the various bits within the Status Byte Register is given in the following.

Bit 0 - Pulse/Ramp Error Status Summary. The state of this bit indicates whether or not a pulse/ramp programming error in the Pulse/Ramp Error Status Register (ERR) have occurred. The ERR summary message is true when a pulse/ramp programming error have been detected.

Bit 1 - Calibration Failure Status Summary C. The state of this bit indicates whether or not a calibration failure in the Calibration Failure Status Byte C (FSC) have occurred. The FSC summary-message is true when a calibration error was have been detected.

Bit 2 - Calibration Failure Status Summary B. The state of this bit indicates whether or not a calibration failure in the Calibration Failure Status Byte B (FSB) have occurred. The FSB summary-message is true when a calibration error was have been detected.

Bit 3 - Calibration Failure Status Summary A. The state of this bit indicates whether or not a calibration failure in the Calibration Failure Status Byte A (FSA) have occurred. The FSA summary-message is true when a calibration error was have been detected.

Bit 4 - **Message Available Queue Summary Message (MAV)**. The state of this bit indicates whether or not the output queue is empty. The MAV summary-message is true when the output queue is not empty. This message is used to synchronize information exchange with the controller. The controller can, for example, send a query command to the device and then wait for MAV to become true. If an application program begins a read operation of the output queue without first checking for MAV, **all system bus** activity is held up until the device responds.

Bit 5 - **Standard Event Status Bit (ESB) Summary Message**. The ESB summary message is an IEEE-488.2 defined message. Its state indicates whether or not one or more of the enabled ESB events have occurred since the last reading or clearing of the Standard Event Status Register.

Bit 6 - Master Summary Status (MSS)/Request Service (RQS) Bit. Its state indicate if the device has at least one condition to request service. The MSS bit is not part of the IEEE-488.1 status byte and will not be sent in response to a serial poll. The RQS bit, however, if set, will be sent in response to a serial poll.

Bit 7 - Not used.

4-14-1. Reading the Status Byte Register

The Status Byte Register can be read with either a serial poll or the *STB? common query. Both of these methods read the IEEE-488.1 STB message. The value sent for the bit 6 position is, however, dependent upon the method used.

4-14-1-1. Reading with a Serial Poll

When serial polled, the generator returns the 7-bit status byte plus the single bit RQS message. The status bye and RQS message are returned to the controller as a single data byte. The RQS message is sent on line D107 (bit 6). **RQS TRUE** means that bit 6 line is asserted (pulled to a low voltage) when the status byte is sent. The response represents the sum of the binary-weighted values of the Status Byte Register.

Reading the Status Byte Register with a serial poll sets the RQS message FALSE until a new reason for service has occurred. The STB portion of the Status Byte Register is read non-destructively. The value of the status byte is not altered by a serial poll. Once the model 8550 has generated an RQS, its status byte should be read to clear the SRQ line so the controller can detect an SRQ from another device. Otherwise the instrument will continuously assert the SRQ line.

4-14-1-2. Reading with the *STB?

The *STB? common query causes the generator to send the contents of the Status Byte Register and the MSS (Master Summary Status) summary message as a single <NR1 Numeric Response Message> element. The response represents the sum of the binary-weighted values of the Status Byte Register. The *STB? common query does not alter the status byte.

4-14-1-3. Clearing the Status Byte Register

The entire Status Byte Register can be cleared by removing the reasons for service from the Auxiliary Status Registers. Sending the *CLS common command to the device after a <Program Message Terminator> and before <Query Message Unit>

elements clears the Standard Event Status Register and clears the output queue of any unread messages. With the output queue empty, the MAV summary message is set to FALSE.

Methods of clearing the other auxiliary status registers are discussed in the following. The RQS message in the Status Byte Register will be FALSE. The use of the IEEE-488.1 DCL or SDC commands another method of clearing the Status Byte Register, however, in some cases it is not recommended to use this method since the entire front panel set-up is reset to factory default values.

4-14-1-4. Service Request Enable Register

The Service Request Enabling Register is an 8-bit register that enables corresponding summary messages in the Status Byte Register. Thus, the application programmer can select reasons for the model
8550 to issue a service request by altering the contents of the Service Request Enable Register.

The Service Request Enable Register is read with the ***SRE?** common query. The response to this query is an number that represents the sum of the binary-weighted value of the Service Request Enable Register. The value of the unused bit 6 is always zero.

The Service Request Enable Register is written using the ***SRE** common command followed by a <Decimal Numeric Program Data> element representing the bit values of the Register. A bit value one indicates an enabled condition. Consequently, a bit value of zero indicates a disabled condition. The Service Request Enable Register is cleared by sending *SRE0. The generator always ignores the value of bit 6. Summary of *SRE messages is given in the following.

***SRE0** - No mask.
***SRE1** - Service request on pulse/ramp error.
***SRE2** - Service request on FSC.
***SRE4** - Service request on FSB.
***SRE6** - Service request on FSA.
***SRE16** - Service request on MAV.
***SRE32** - Service request on ESB.
***SRE128** - Not used.

4-14-2. Standard Event Status Register (ESR)

The Standard Event Status Register is a special application of the status reporting. IEEE-488.2 document specifies the meaning of each bit of this register. The 8 bits of the SESR have been defined by the IEEE-488.2 as specific conditions which can be monitored and reported back to the user upon request.

The Standard Event Status Register is destructively read with the ***ESR?** common query. The Standard Event Status Register is cleared by a ***CLS** common command, on power-on, and when read by
*ESR?.

The arrangement of the various bits within the register is firm and is required by all GPIB instruments that implement the IEEE-488.2. Description of the various bits is given in the following.

Bit 0 - Operation Complete. Generated in response to the *OPC command. It indicates that the device has completed all selected and pending operations and is ready for a new command.

Bit 1 - Request Control. This bit operation is disabled on model 8550.

Bit 2 - Query Error. This bit indicates that an attempt is being made to read data from the output queue when no output is either present or pending.

Bit 3 - Device Dependent Error. This bit is set when an error in a device function occurs. For example, the following <Program Message> will cause DDE error: AMP10E+0;OFS10E+0. Both parameters are legal and within the specified limits, however, the function generator is unable to generate such an amplitude and offset combination. Following the Device Dependent Error the generator continues to process the input stream.

Bit 4 - Execution Error. This bit is generated if the <Program Data> element following the header is outside of the legal input range of the generator.

Bit 5 - Command Error. This bit indicates the generator received a command that was a syntax error, or a command that the device does not implement. A GET receive inside a <Program Message> will also cause a Command Error.

Bit 6 - User Request. This event bit indicates that one of a set of local controls, the MANUAL push-button in this case, has been activated. This event bit occurs regardless of the remote or local state of the device.

Bit 7 - Power On. This bit indicates that the device's power source was turned off, then on, since the last time that the register was read.

4-14-2-1. Standard Event Status Enable Register (ESE)

The Standard Event Status Enable Register allows one or more events in the Standard Event Status Register to be reflected in the ESB summary-message bit. The Standard Event Status Enable Register is an 8-bit register that enables corresponding summary messages in the Standard Event Status Register. Thus, the application programmer can select reasons for the model 8550 to issue a ESB summary-message bit by altering the contents of the ESE Register.

The Standard Event Status Enable Register is read with the ***ESE?** common query. The response to this query is an number that represents the sum of the binary-weighted value of the Standard Event Status Enable Register.

The Standard Event Status Enable Register is written using the ***ESE** common command followed by a <Decimal Numeric Program Data> element representing the bit values of the Register. A bit value one indicates an enabled condition. Consequently, a bit value of zero indicates a disabled condition. The Standard Event Status Enable Register is cleared by sending *ESE0. Summary of *ESE messages is given in the following.

***ESE0** - No mask.
***ESE1** - ESB on Operation Complete.
***ESE2** - ESB on Request Control.
***ESE4** - ESB on Query Error.
***ESE6** - ESB on Device Dependent Error.
***ESE16** - ESB on Execution Error.
***ESE32** - ESB on Command Error.
***ESE64** - ESB on User Request.
***ESE128** - ESB Power on.

4-14-3. Calibration Failure Status Registers A (FSA), B (FSB), and C (FSC)

The Calibration Failure Status Registers FSA, FSB, an FSC are a special application of the status reporting. Figure 4-4 illustrates the calibration failure status registers. The 16 bits of the FSA contain information about calibration failures in the frequency and the amplitude circuits. The 8 bits of the FSB contain information about calibration failures in the offset, phase lock loop, trigger phase offset, and burst circuits. The 16 bits of the FSC contain information about calibration failures in the pulse width generator and the rise/fall time control circuits.

The summary-messages from these registers are fed to the Status Byte register and can be monitored and reported back to the user upon request. The Calibration Failure Status Registers are destructively read with the **FSA, FSB,** and **FSC** queries. The response to this query is a number that represents the sum of the binary-weighted value of the Calibration Failure Status Register. The Calibration Failure Status Registers are cleared by a ***CLS** common command, and when read by FSA, FSB, and FSC. Power off does not clear these registers. Description of the

Figure 4-4. Calibration failure Status Registers Interpretation.

Not Used		**Amplitude Errors**					**Frequency Errors**									
		5	**4**	**3**	**2**	**1**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	**FSA**

Burst	**Trig. Ph**		**PhaseLock**			**Offset**		
1	**2**	**1**	**3**	**2**	**1**	**2**	**1**	
6	7	5	4	3	2	1	0	**FSB**

Not Used		**Rise/Fall Times Errors**						**Pulse Width Errors**								
		6	**5**	**4**	**3**	**2**	**1**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	**FSC**

various calibration failures is given in the troubleshooting Chapter of this manual.

There are no enable registers for the Calibration Failure Registers which are available for the programmer. Thus, whenever a calibration error occurs, the information is immediately fed to the Status Byte Register.

4-14-4. Pulse/Ramp Error Status Register (ERR) The Pulse/Ramp Error Status Register (ERR) is a special application of the status reporting. It is available only on model 8551. Figure 4-5 illustrates the pulse/ramp errors status register. The 8 bits of the ERR contain information about programming errors of inter-related pulse or ramp <Program Data> parameters such as pulse width and period. Description of the various pulse/ramp errors is given in the following.

The ERR summary-message is fed to the Status Byte Register and can be monitored and reported back to the application programmer upon request. The ERR is **non-destructively** read with the **ERR?** query.

The response to this query is a number that represents the sum of the binary-weighted value of the Pulse/Ramp Error Status Register. The ERR register is cleared only by removing the related error that cause one or more bits in this register to be set TRUE. Power off does not clear the ERR register.

There is no enable register for the Pulse/Ramp Error Status Register which is available for the programmer. Thus, whenever such an error occurs, the information is immediately fed to the Status Byte Register.

Description of the various bits in the Pulse/Ramp Error Status Register is given int the following. When the pulse generator is set to operate in its triggered mode of operation, the period time, in the following formulas is replaced by the period of the internal trigger generator.

Error 1 (Bit 0) - This bit indicates that an error relating to the pulse width and the period have occurred. This error bit is set true under the following conditions:

Pulse Width > 0.8 x Period

Error 2 (Bit 1) - This bit indicates that an error relating to the pulse width and the period have occurred. This error bit is set true under the following conditions:

Period - Pulse Width < 10 ns

Error 3 (Bit 2) - This bit indicates that an error relating to the pulse width and the leading edge transition time have occurred. This error bit is set true under the following conditions:

1.25 x Rise Time > Pulse Width

Error 4 (Bit 3) - This bit indicates that an error relating to the pulse width, the period, and the trailing edge transition time have occurred. This error bit is set true under the following conditions:

1.25 x Fall Time > Period - Pulse Width

NOTE

When the model 8551 is placed is External Trigger mode, errors 1, 2, and 4 can not occur.

Error 5 (Bit 4) - This bit indicates that an error relating to the period (Per) counted burst (N), the trailing edge transition time (Trail), and the internal trigger period (I. Per) have occurred. This error bit is set true under the following conditions:

N x Per + Trail > I. Per

Note that in the above formula, the value of N in triggered mode is set to 1; and the value of Trail in fast transition times is set to 0.

Error 6 (Bit 5) - This bit indicates that an error relating to the ramp duration have occurred. This error bit is set true under the following conditions:

Ramp Duration > 5 μs

Error 7 (Bit 6) - This bit indicates that an error relating to the pulse width have occurred. This error bit is set true under the following conditions:

Pulse Width < 10 ns

Figure 4-5. Ramp/Pulse Errors Status String (ERR) Interpretation.

	Pulse/Ramp Errors							
Error No.	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Bit No.	7	6	5	4	3	2	1	0

Error 8 (Bit 7) - This bit indicates that an error relating to the pulse width have occurred. This error bit is set true under the following conditions:

Pulse Width > 999 ms

4-13-5. Machine Status Register (STT)

The Machine Status Register (STT) is a special register which contain the present front panel setting. The STT is **non-destructively** read with the **STT?** query. The response to this query is a NR1 <Numeric Response Data> with the length of 11 digits. These digits are numeric representation of the various Machine Status options as illustrated in Figure 4-6.

4-15. FRONT PANEL ERROR MESSAGES

The process of programming the Model 8550 involves the proper use of syntax. Syntax is defined as the orderly or systematic arrangement of programming commands or languages. The Model 8550 must receive valid commands with proper syntax or it will:

1. Ignore the part of the <Program Message Unit> in which the invalid command appears.

2. Set appropriate bits in the Standard Event Status Register.

3. Generate an SRQ if programmed to do so.

4. Display an appropriate front panel message.

4-15-1. ILI (Illegal Instruction) Error

An ILI error results when the Model 8550 receives an invalid <Program Header> such as AMPL1.00. This command is invalid because the real command should read AMP1.00. When such an illegal <Program Header> is detected by the instrument, the following message will be displayed on the Model 8550 for about one second:

ILI

4-15-2. ILP (Illegal Parameter) Error

An ILP error occurs when the <Numeric Data> parameter associated with a legal <Program Header> command is not valid. For example, the command AMP100E+0 is not a valid option because the required amplitude is outside the legal limits of the model 8550. When such an illegal <Numeric Data> is detected, the following message will be displayed on the Model 8550 for about one second:

ILP

4-16. GPIB COMPATIBILITY WITH HP MODEL 8116A

Model 8551 can be made fully compatible with HP model 8116A device-dependent command set. This built-in option saves a lot of valuable programming time, when replacing model 8116A with model 8551. In other words, one can remove HP's model 8116A from an ATE-system rack and replace it with the Tabor 8550/8551, without the need to modify the existing test software. A list of device dependent command which is being used by the HP mode

8116A is given in the following. Listed are those commands that have equivalent functions in the Model 8550. For complete description of the various commands refer to Table 3-3 - Mode/Parameter Messages (listen function) - in the HP manual. To modify 8551 device-dependent command set to comply with model 8116A proceed with the following steps:

1. Depress the [2nd] push-button once then depress the [GPIB ADR] push-button. The display will be modified to display the following:

GPxx

Where x may be any number from 0 to 30.

2. Depress MODIFIER [x100 □] push-button once. The displayed reading will change as follows:

HPxx

Indicating that model 8551's device-dependent command set is made fully compatible with HP's model

8116A device-dependent command set. Depressing the MODIFIER [x100 □] or [x100 □] push-buttons toggles between GPIB and HPIB compatibility options. To modify the GPIB address proceed with the procedure given in paragraph 4-7.

3. To store the required compatibility option depress [EXE]. The instrument then resumes normal operation.

Figure 4-6. Machine Status String (STT) Interpretation *

<Program Header>	**V**	**M**	**CT**	**W**	**L/S**	**F**	**C**	**D**	**X**	**Z**
<Program Data>	01	1	0	1	0/1	0	0	0	0	0

* Status given after IEEE-488.1 DCL or SDC commands, or afetr IEEE-488.2 *RST common command.

Table 4-8. HP's Model 8116A - Mode/Parameter Messages

MESSAGE	MNEMONICS ASCII CODE	ASCII CODE DELIMITER	Description
Operating Modes			
	M1		Select normal
	M2		Select Trigger
	M3		Select gate
	M4		Not used in Model 8550/8551
	M5		Select internal sweep (Opt. 001)
	M6		Select external sweep (Opt. 001)
	M7		Select internal burst (Opt. 001)
	M8		Select external burst (Opt. 001)
Control Mode	CT0		Off
	CT1		Select FM (Model 8550 only)
	CT2		Select AM
	CT3		Select PWM (Model 8551 only)
	CT4		Select VCO
Haversine (-90°)	H0		Off
	H1		On
Trigger Slope	T0		Off (Not used in Model 8551)
	T1		Positive slope (Not used in 8551)
	T2		Negative slope (Not used in 8551)
Waveforms	W0		Off (dc) (Model 8550 only)
	W1		Select sine
	W2		Select triangle
	W3		Select Square
	W4		Select pulse
	W5		Select positive pulse
	W6		Select negative pulse
Parameters(*)	FRQ	MZ = Millihertz HZ = Hertz KHZ = Kilohertz MHZ = Megahertz	Set frequency
	DTY	%	Set duty cycle (Model 8551 only)
	WID	NS = Nanoseconds US = Microseconds MS = Milliseconds	Set width (Model 8551 only)
	AMP	MV = Millivolts V = Volts	Set amplitude
	OFS	MV = Millivolts V = Volts	Set offset
	HIL	V = Volts	Set high level

Table 4-8. HP's Model 8116A - Mode/Parameter Messages (continued)

MESSAGE	MNEMONICS ASCII CODE	ASCII CODE DELIMITER	Description
Parameters(*) (Opt. 001)	BUR	#	Set burst number
	RPT	NS = Nonoseconds US = Microseconds MS = Milliseconds	Set repetition rate for internal burst
	STA	MZ = Millihertz HZ = Hertz KHZ = Kilohertz MHZ = Megahertz	Set sweep start frequency (Model 8550)
	STP	MZ = Millihertz HZ = Hertz KHZ = Kilohertz MHZ = Megahertz	Set sweep stop frequency (Model 8550)
	MRK	MZ = Millihertz HZ = Hertz KHZ = Kilohertz MHZ = Megahertz	Set sweep marker frequency (8550)
	SWT	S = Seconds MS = Milliseconds	Set sweep time (Model 8550)
Limit	L0		Off
	L1		On
Complement	C0		Off (normal output, Model 8551 only)
	C1		On
Disable	D0		Off (output enable)
	D1		On
Autovernier Mode	A0		Off
	A1		On
Autovernier Start	MU		Most significant digit up SU Second significant digit up LU Least significant digit up MD Most significant digit down
	SD		Second significant digit down
	LD		Least significant digit down
Execute Self Test	EST		
Current Parameter Setting (Model 8550, AMP and OFS active)	CST	M1,CT0,T0,W1,H0,A0,L0,C0,D0,BUR 0002 #,RPT 1.00 S, STA 1.000KHZ,STP 9.000KHZ,SWT1.00 S,MRK5.000 KHZ, FRQ 1.000KHZ,PLL 0DEG,TPH 0DEG,AMP 1.00V,OFS 0MV	
(Model 8551, AMP and OFS active)	CST	M1,CT0,T0,W1,H0,A0,L0,C0,D0,BUR 0002 #,RPT 1.00 S, LEE 10.0US,TRE 10.0US,TPH 0DEG,PLL 0DEG, FRQ 1.000KHZ,DTY 50%,WID 100US,AMP 1.00V,OFS 0MV	
Current Parameter Setting (Model 8550, HIL and LOL active)	CST	M1,CT0,T0,W1,H0,A0,L0,C0,D0,BUR 0002 #,RPT 1.00S, STA 1.000KHZ,STP 9.000KHZ,SWT 1.00S,MRK 5.000KHZ, FRQ 1.000KHZ,PLL 0DEG,TPH 0DEG,HIL 0.50V,LOL -0.50V	
(Model 8551, HIL and LOL	CST	M1,CT0,T0,W1,H0,A0,L0,C0,D0,BUR 0002#,RPT 1.00S, active) LEE 10.0US,TRE 10.0US,TPH 0DEG,PLL 0DEG, FRQ 1.000KHZ,DTY 50%,WID 100US,HIL 0.50V,LOL -0.50V	

Table 4-8. HP's Model 8116A - Mode/Parameter Messages (continued)

MESSAGE	MNEMONICS ASCII CODE	ASCII CODE DELIMITER	Description
HP-IB Universal Commands			
	DC4		Device clear (DCL)
	EOT		Selected device clear (SDC)
	BS		Group execute trigger
Interrogate Parameter			
	IERR		Interrogate error
	IFRQ		Interrogate frequency
	IDTY		Interrogate duty cycle
	IWID		Interrogate width
	IHIL		Interrogate high level
	ILOL		Interrogate low level
	IAMP		Interrogate amplitude
	IOFS		Interrogate offset
	IBUR		Interrogate burst
	IRPT		Interrogate repetition rate
	ISTA		Interrogate start frequency
	ISTP		Interrogate stop frequency
	IMRK		Interrogate marker frequency
	ISWT		Interrogate sweep time
Edge Control			(Model 8551 only. Not part of HP8116A commands set)
	E0		Fastest edge transitions
	E1		Linear edge transitions
Error Reporting			
(Response to IERR)	NO ERROR		No error detected
	WAVEFORM ERROR		Not used in Model 8550/8551
	DUTY C. ERROR		Not used in Model 8550/8551
	WIDTH ERROR		Incompatible width and frequency setting
	TIMING ERROR		Incompatible burst and frequency setting
	HANDLING ERROR		Programming parameters with values outside their limits
	LEVEL ERROR		Programming amplitude levels with values outside their limits
	LIMIT ERROR		Same as LEVEL ERROR except HIL/ LOL window is active
HP-IB Status Byte			
(Response to SPOLL)	Bit 1		Timing error
	Bit 2		Programming Error
	Bit 3		Syntax Error
	Bit 4		System Failure (Not used in 8550/8551)
	Bit 5		Autovernier in process
	Bit 6		Sweep in process (Model 8550 only)
	Bit 7		Service request
	Bit 8		Buffer not empty (Not used in 8550/8551)

(*) Engineering notations can not be used in combination with delimiters. For example, the following command will result in an error message: FRQ 1.000E+3KHZ. Use either engineering notation or delimiters only. The following two examples are legal: FRQ 1.000E+6, or FRQ 1.000 MHZ.

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