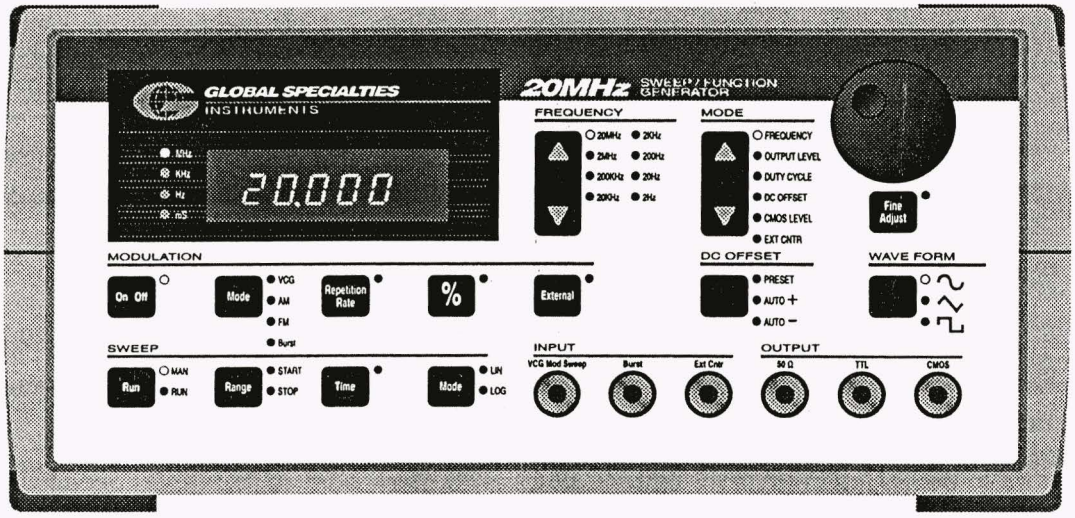
# PURE WAVE

Function Generator Series

# Operations Manual

**PW-2102 • PW-2105 • PW-2110 • PW-2120**




**GLOBAL SPECIALTIES**

INSTRUMENTS

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1486 HIGHLAND AVENUE
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# Specifications

## 1. *Frequency Characteristics*

| | |
|---|---|
| Waveforms | sine, triangle, square, +/- pulse, +/- ramp |
| Range | 0.2 Hz to 20 MHz in 8 ranges |
| Resolution | 5 digits |
| Frequency stability | +1 - 0.01% for ranges 20 Hz to 20 MHz, +1 - 0.1% for range 2 Hz (excluding VCG, FM modulation, manual sweep, stop sweep frequency setting and external counter modes) |
| Tuning range | coarse and fine 0.09 to 1.1 times of the selected range, fine 1/100th of coarse setting speed |
| Variable duty cycle | 15% to 85% continuously variable |
| Operating modes | normal, sweep, VCG, AM, FM, burst |

## 2. *Output Characteristics*

| | |
|---|---|
| Impedance | 50 Ω ±10% |
| Amplitude Level | 20 V p-p open circuit, 10 V p-p into 50 Ω variable |
| DC offset | Preset ±0.1 V<br>Auto + negative peak of waveform 0 V ±<br>Auto — 0.1V<br>Variable positive peak of waveform 0 V ±0.1V<br>±10 V open circuit, ±5 V into 50 Ω<br>Signal plus offset not to exceed 10V |

## 3. *Sine Wave*

| | |
|---|---|
| Distortion | <1% (at 1 kHz, duty cycle 50%) |
| Flatness | ±5% (.45 dB) at 10 Hz to 10 MHz,<br>±10% (1.0 dB) at 10 MHz to 20 MHz |

## 4. *Square Wave*

| | |
|---|---|
| Symmetry | ±3% (at 0.2 Hz to 100 kHz) |
| Rise time | <20 ns |

## 5. *Triangle Wave*

| | |
|---|---|
| Linearity | >98% (at 0.2 Hz to 100 kHz) |

## 6. *TTL Output*

| | |
|---|---|
| Level | 0.8 V to 2.4 V |
| Rise time | <20 ns |

## 7. *CMOS Output*

| | |
|---|---|
| Max. frequency | 2 MHz |
| Level | 0-4V to 0-14 V continuously variable |
| Rise time | <120 ns |

## 8. *VCG (Voltage Controlled Generator) Input*

| | |
|---|---|
| Input voltage | 0 to 10 V ±lV , 0-10 V causes a 1 to 100 frequency change |
| Impedance | 10 k ±5% |

### 9. *Sweep Operation*

| | |
|---|---|
| Mode | Linear or logarithmic |
| Width | 1 to 100 continuously variable |
| Rate | 20 ms to 30 s continuously variable. |
| Sweep output | 0-2V |
| Start/stop Frequencies | Adjustable |

### 10. *Amplitude Modulation Characteristics*

| | |
|---|---|
| Source | Internal or external |
| Modulation depth | 0 to 100 % |
| Internal modulation | 1 Hz to 15 kHz |
| External modulation | DC to 500 kHz |
| External sensitivity | 10 V p-p for 100% (for carrier signal less than ±5 V) |

### 11. *Frequency Modulation Characteristics*

| | |
|---|---|
| Source | Internal or external |
| Deviation | 0 to 5% |
| Internal modulation | 1 Hz to 15 kHz |
| External modulation | DC to 500 kHz |
| External sensitivity | 10 V p-p for 5% deviation |

### 12. *Burst Characteristics*

| | |
|---|---|
| Source | Internal or external |
| Burst width | Continuously variable from 1 ms to burst repetition time minus 1 ms |
| Repetition rate | 0.5 to 50 Hz internal, DC to 500 kHz external |
| External level | TTL levels |
| Burst frequency | Same as main generator frequency |
| Tone Burst | Always integer number of cycles, starting and finishing at zero |

### 13. *Frequency Counter*

| | |
|---|---|
| Accuracy | ±10 ppm ±1 count at 23°C ± 5°C |
| Display | 5 digit |

### 14. *External Input*

| | |
|---|---|
| Frequency | 5 Hz to 40 MHz |
| Resolution | 0.005% of the selected range automatically switched depending on input frequency |
| Sensitivity | 60 mV rms. mm |
| Impedance | 1 MΩ at 1 kHz, 5 pF at output level<5 V |

### 15. *Square Wave Divide by 10 or 100*

Auxiliary square wave outputs at 1/10th and 1/100th of the main frequency - TTL levels

### 16. *Power Source*

110/230 VAC @ 50/60 Hz

# Front Panel

The generator's front panel is shown in Figure 1.

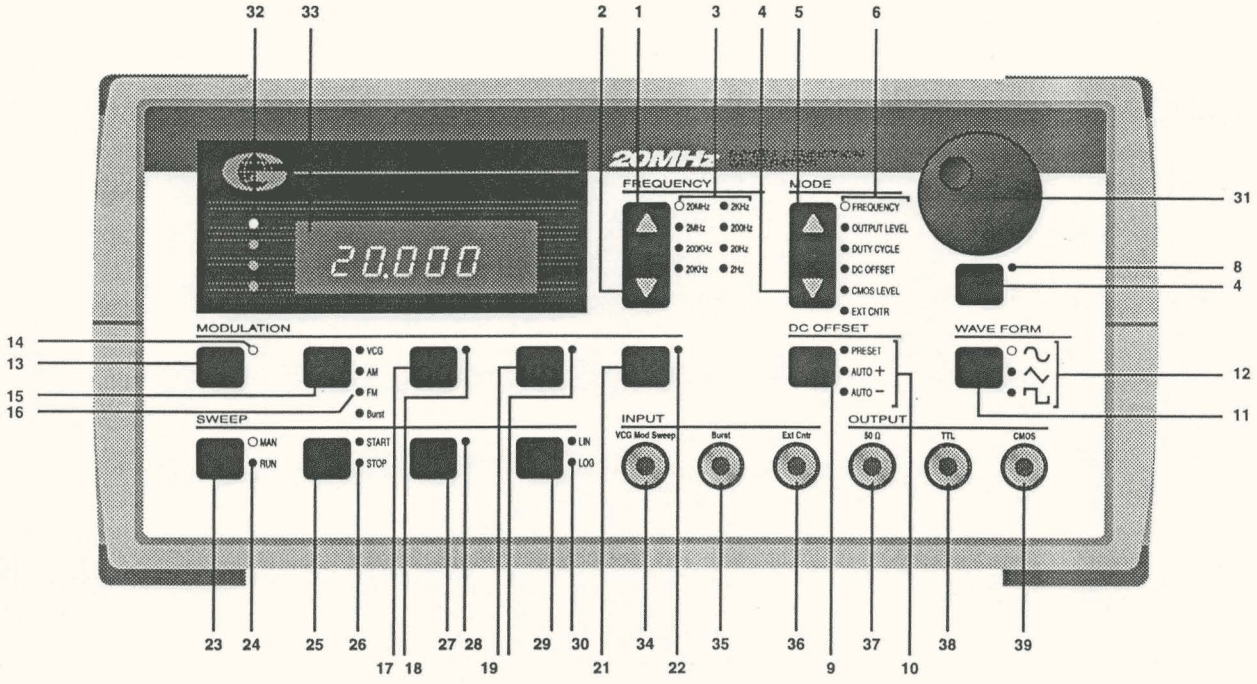


***Figure 1: Front Panel.***

### *1-3. Frequency Group*

1,2. FREQUENCY RANGE selection keys. The selected range is indicated by the LED indicators (3).

3. FREQUENCY RANGE LED indicators. 8 LED indicators determine maximum frequency of each range - **20 MHz, 2 MHz, 200 kHz, 20 kHz, 2 kHz, 200 Hz, 20 Hz, 2 Hz.**

### *4-6. Mode Group*

**4,5. MODE** selection keys. Selects one of six available operating modes.

**6. MODE** LED indicators. There are 6 LED indicators - **FREQUENCY, OUTPUT LEVEL, DUTY CYCLE, DC OFFSET, CMOS LEVEL, EXT CNTR.** The lighted LED indicates the parameter, which value is being displayed (33), and can be adjusted by rotation of the tuning knob (31).

**7. FINE ADJUST** key. Switches on/off fine adjustment of frequency, burst repetition rate, tone burst time and sweep time.

***Note:*** The FINE ADJUST key (7) has three additional functions — see Output Level Adjustment (page 9, item 4), Sweep Operation (page 18, item 19) and DC Offset Compensation (page 19).

**8. FINE ADJUST** LED indicator. When the LED indicator (8) is on, rotation of the tuning knob (31) causes fine adjustment of the above mentioned parameters, otherwise - coarse adjustment prevails.

*DC Offset Group*

9. **DC OFFSET** key. Selects one of three possible preset values of DC offset.
10. **DC OFFSET** LED indicators. There are 3 LED indicators - **PRESET, AUTO+,** and **AUTO-** that indicate the preset value selected by the DC OFFSET key (9). When the PRESET LED indicator is on, the DC offset is set to zero. When AUTO+ LED indicator is on, the DC offset is set to be equal to output level value, and when AUTO- LED indicator is on, the DC offset is set to be equal to minus the output level value.

*Waveform Group*

11. **WAVEFORM** key. Selects sine, triangle or square waveforms at the 50Ω output jack (37).
12. **WAVEFORM** LED indicators. There are 3 LED indicators - **SINE, TRIANGLE, SQUARE**, which indicate the selected waveform.

*Modulation Group*

13. **ON/OFF** key. Switches modulation on/off. Modulation is on when lit.
14. **ON/OFF** LED indicator. When the LED indicator (14) is on, modulation mode shown by the LED indicator (16) is on. Otherwise all LED indicators (16), (18), (20) and (22) are off and keys (15), (17), (19) and (21) will be disabled.
15. **MODULATION MODE** key. Selects one of four possible modulation modes. Modulation must be on to enable.
16. **MODULATION MODE** LED indicators. There are 4 LED indicators - **VCG, AM, FM, BURST**, which indicate the selected modulation mode.
17. **REPETITION RATE** key. Enables adjustment of the repetition rate of the internal signal in the burst gate in the burst modulation mode. Enables adjustment of the frequency of the internal modulating signal for AM/FM modulation modes.
18. **REPETITION RATE** LED indicator. When the LED indicator (18) is on and internal BURST mode is selected, the repetition period value in milliseconds is displayed (33) and can be adjusted by rotation of the tuning knob (31). When the LED indicator (18) is on and internal AM or FM mode is selected, the frequency of internal modulating signal is displayed (33) and can be adjusted by rotation of the tuning knob (31).
19. % key. Enables the percentage of internal AM/FM modulation or the duty cycle of internal burst gate adjustment - according to the selected modulation mode (AM, FM or BURST). Enabled only if the ON/OFF LED indicator (14) is on and the EXTERNAL LED indicator (22) is off.
20. % LED indicator. When the LED indicator (20) is on, and internal AM or FM or BURST mode is selected, the AM or FM modulation percentage or the duty cycle of burst modulation is displayed (33), and can be adjusted by rotating of the tuning knob (31).
21. **EXTERNAL** key. Selects whether modulation is from an internal source or from a signal applied to the VCG MOD input jack (34) (for AM or FM modulation), or from BURST input jack (35) (for burst modulation mode). Enabled only if the LED indicator (14) is on and the VCG LED indicator (16) is off.
22. **EXTERNAL** LED indicator. When the LED indicator (22) is on, the modulating source will be a signal applied to the VCG MOD input jack (34) (for VCG, AM or FM

modulation) or to the BURST input jack (35) (for burst modulation mode). Otherwise the modulating source will be an internal signal. If VCG modulation mode is selected, the LED indicator (22) is always on.

*Sweep Group*

23. **RUN** key. Switches sweep modes between Normal Sweep, Manual Sweep, and Sweep off.
24. **RUN/MAN** LED indicators. Indicate the sweep mode, selected by the RUN key. If the RUN and MAN LED indicators (24) are both off, the sweep mode is off. If the RUN LED indicator (24) is on - the generator sweeps between the start and stop frequencies. If the MAN LED indicator (24) is on, some intermediate frequency will be continuously present at the output with its value fixed on the specific value the moment the RUN key is pressed. The frequency value will be displayed (33) and can be adjusted in the range between the start and stop frequencies by rotation of the tuning knob (31).
25. **SWEEP RANGE** key. Enables the adjustment of the sweep start and/or stop frequencies. This switch also switches sweep or modulation on and off.
26. **START/STOP** LED indicators. Indicates whether sweep start or stop is enabled. Start or stop frequencies can be adjusted by rotating tuning knob (31).
27. **TIME** key. Enables sweep time adjustment.
28. **TIME** LED indicator. When the LED indicator (28) is on, the value of sweep time is displayed in milliseconds and can be adjusted by rotating the tuning knob (31).
29. **SWEEP MODE** key. Selects linear or logarithmic sweep operation.
30. **LIN/LOG** LED indicators. Indicates sweep mode of operation.
31. **TUNING KNOB**. Adjusts the parameter selected by one of the following keys listed below:

    - MODE (4, 5)
    - REPETITION RATE (17)
    - % (19)
    - SWEEP RANGE (25)
    - TIME (27)

    Clockwise rotation of the tuning knob changes the selected parameter from its minimum to maximum value, and vice versa for counter-clockwise rotation. Units of measure, excluding volts, are indicated by the UNITS of MEASURE LED indicators (32).
32. **UNITS of MEASURE** LED indicators. There are 4 LEDs, which indicate the units of measure corresponding to the operation mode selected.
33. **DISPLAY.** Displays the appropriate numerical value corresponding to the parameter selected by one of the keys listed below: MODE (4,5), REPETITION RATE (17), % (19), SWEEP RANGE (25), TIME (27). When frequency is displayed, the value is updated every 0.5s.

*Input Group*

34. **VCG (VOLTAGE CONTROLLED GENERATOR) MOD** input jack. Becomes the Modulation signal source, or the VCG input once selected by the Mode key (15). The VCG allows external control of the generator output frequency by a voltage applied to this jack.
35. **BURST** input jack. Input for the external gating signal for the burst operation.
36. **EXT CNTR** input jack. Input for external frequency measurements.

*Output Group*

37. **50Ω** output jack. Function generator output.
38. **TTL** output jack. TTL-level square wave output with adjusted duty cycle in the FM, VCG or Sweep Modulation modes.
39. **CMOS** output jack. Square wave output with adjusted CMOS level and duty cycle, with FM, VCG or sweep modulation (if selected) for frequencies less than 2 MHz.

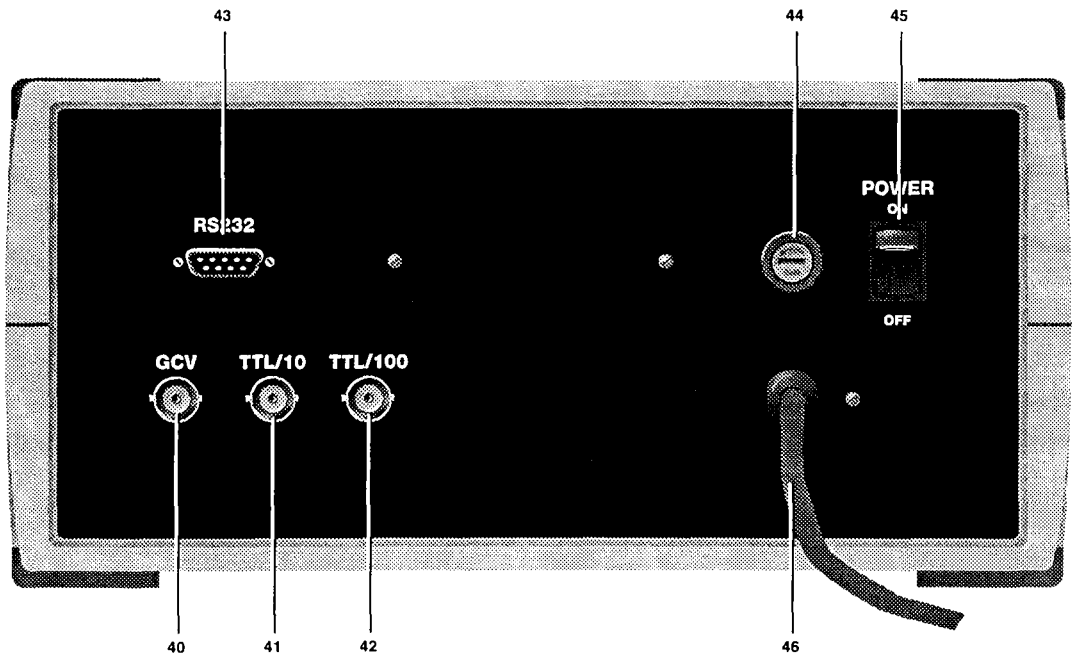


*Figure 2: Back Panel*

40. **GCV** output jack. Generator Control Voltage output. Output voltage proportional to the generator frequency. When the sweep mode is selected, a sweep voltage output is available at this jack for connection to an oscilloscope.
41. **TTL/10** output jack. TTL level square wave output at 1/10th of tuned frequency.
42. **TTL/100** output jack. TTL level square wave output at 1/100th of tuned frequency.
43. **RS-232** interface.
44. **Fuse.**
45. **Power** switch.
46. **Power** cord.

# Operating Instructions

### *Frequency Selection*

1. Select FREQUENCY by depressing the MODE keys (4,5). Once selected, the main output frequency will be displayed along with the appropriate units of measure.
2. Select the desired maximum frequency range by depressing the FREQUENCY RANGE keys (1,2). Table 1 lists the features of each frequency range.

| Range name | range nominal minimum frequency MIN | range nominal maximum frequency MAX | range real minimum frequency $F_{min}$, approx. | range real maximum frequency $F_{max}$, approx. | Units | measuring time | measurement resolution at MIN**** | measurement resolution at MAX**** |
|---|---|---|---|---|---|---|---|---|
| 2 Hz | 0.2 | 2.0000 | 0.1800 | 2.2000 | Hz | 5..0.5 s* | $4*10^{-6}$ Hz | $4*10^{-4}$ Hz |
| 20 Hz | 2 | 20.000 | 01.800 | 22.000 | Hz | 5..0.5 s** | $4*10^{-5}$ Hz | $4*10^{-3}$ Hz |
| 200 Hz | 20 | 200.00 | 018.00 | 220.000 | Hz | 0.5..0.05 s** | $4*10^{-4}$ Hz | $4*10^{-2}$ Hz |
| 2 kHz | 0.2 | 2.0000 | 0.1800 | 2.2000 | KHz | 0.5..0.05 s*** | $4*10^{-5}$kHz | $4*10^{-4}$ kHz |
| 20 kHz | 2 | 20.000 | 01.800 | 22.000 | KHz | 1 s | $10^{-3}$ kHz | $10^{-3}$ kHz |
| 200 kHz | 20 | 200.00 | 018.00 | 220.000 | KHz | 0.1 s | $10^{-2}$ kHz | $10^{-2}$ kHz |
| 2 MHz | 200 | 2000.0 | 0180.0 | 2.2000 | KHz | 0.5 s | $6.4*10^{-1}$ kHz | $6.4*10^{-2}$ kHz |
| 20 MHz | 2000 | 20000 | 01800 | 22000 | KHz | 0.05 s | $6.4*10^{-1}$ kHz | $6.4*10^{-1}$ kHz |

***Table 1 - Main Features of Generated Frequency Ranges.***

* For the 2 Hz range, measurement time is equal to 1 period of the measured frequency.

** For the 20 Hz and 200 Hz ranges, measuring time is equal to 10 periods of the measured frequency.

*** For the 2 kHz range, measurement time is equal to 100 periods of measured frequency.

**** Displayed resolution is limited by the 5 digit display.

3. Switch fine adjustment on or off by the FINE ADJUST key (7).
4. Rotate the tuning knob for coarse adjustment to the approximate desired output frequency value. Coarse adjustment adjusts the output in steps of 1/202th of ($F_{max}$ -$F_{min}$).
5. Turn on the FINE ADJUST key (7).
6. Rotate the tuning knob for fine adjustment of the output frequency to the specific desired value. Fine adjustment provides 1/100 of coarse setting speed.
7. The function generator output is available in several places:
   TTL output jack (38).
   50 Ω output jack (37)
   CMOS output jack (39) (at frequencies less than 2Mhz)
   TTL/10 & TTL/100 (for signals at 1/10th and 1/100th of main frequency)
8. Frequency stability is provided by automatic frequency regulation.
   ***Note:*** The display value is updated every 0.5 s. However, if the **measurement time** (see Table 1) exceeds 0.5 s, the value is updated once every measuring period.

### *Output Level Adjustment*

1. Select the DC OFFSET PRESET key (9) for zeroing the DC component.
2. Select OUTPUT LEVEL via the MODE key (4,5). The output level in volts is displayed (33), while the UNITS of MEASURE indicators (32) are off.
3. Rotate the tuning knob to adjust for the desired output amplitude. The output level can be varied from 0.1 V to 1 V in 0.01 V steps (-20 dB), and from 1 V to 10 V in 0.1 V steps (0 dB). The output may also be set to 0V. The -20 dB and 0 dB pads are indicated in the first position of the display (33) by "_" or "¯" symbol respectively.
   **IMPORTANT:** Changes in amplitude can affect the DC offset because amplitudes below 1.1 V warrant a -20 dB attenuation, which limits the offset to -1V to 1V. Therefore, if previous to an amplitude change, the amplitude was 1.1 V and the DC offset was 6 V and then the amplitude was changed to 1 V, the offset would be changed to 0.6 V. Changing the amplitude back to 1.1 V would bring the offset back to 6 V. In order to avoid the unwanted DC offset change, switch the attenuation pad as indicated in step 4.
4. When the amplitude is forced to exceed 1 V the message, "0db" is displayed (33) and the FINE ADJUST key (7) must be pressed to confirm the change in the attenuation pad as well as the corresponding change in the DC offset. Respectively, when the amplitude is forced to decrease below 1.1 V, the message "-20db" appears, and the FINE ADJUST key (7) must be pressed in order to change amplitude to 1 V.
5. The signal at the desired amplitude is available at the 50 Ω output jack (37). Adjusting the output level will not affect the TTL and CMOS output jacks (38), (39), (41) and (42).

### *Waveform Selection*

1. Select the desired waveform (SINE, TRIANGLE or SQUARE) by using the WAVEFORM key (11). The appropriate LED indicator will light and the desired signal will be present at the 50 Ω output jack (37).
2. Waveform selection will not affect the TTL and CMOS output jacks (38), (39), (41) and (42).
3. Ramp and pulse waveforms can be obtained by adjusting the duty cycle (see below).

### *Adjusting the Duty Cycle and Obtaining Pulse and Ramp Waveforms*

#### *Sine*

1. Select the sine waveform.
2. Select DUTY CYCLE via the MODE keys (4,5). The duty cycle (as ratio of "high" time to whole period in percentage terms) is displayed (33), with the % LED (32) illuminated.
3. Rotate the tuning knob to adjust the duty cycle appropriate for the desired waveshape. The duty cycle can be varied from 15% to 85% in 0.35% steps.
4. The desired waveshape will now be available at the 50Ω output jack (37). The square or pulse signal at adjusted duty cycle is present at the TTL (38) and CMOS (39) output jacks. Adjustment of the duty cycle does not affect the TTL/10 (41) and TTL/100 (42) output jacks, which always provide a square wave with a 50% duty cycle.

***Triangle***

5. Select triangle waveform.
6. Adjust the duty cycle with the tuning knob to obtain the desired ramp waveform, otherwise a triangle wave will be present with a 50% duty cycle.
7. The desired waveshape is available at the 50 Ω output jack (37), at the TTL (38) and CMOS (39) output jacks. Adjustment of the duty cycle does not affect the TTL/10 (41) and TTL/100 (42) output jacks, which always provide a square wave with a 50% duty cycle.

***Square***

8. Select square waveform.
9. Adjust the duty cycle via the tuning knob. For a duty cycle equal to 50%, a square wave is obtained, otherwise a pulse signal is obtained.
10. The square or pulse signal at the adjusted duty cycle is available at the 50 Ω output jack (37), as well as at the TTL (38), and CMOS (39) output jacks.
11. Varying the duty cycle has no effect on the output frequency.

***DC Offset Adjustment***

There are two ways to set the DC offset - preset to one of three values by the DC OFFSET key (9) or continuous adjustment by the tuning knob (see below).

1. Select DC OFFSET via the MODE keys (4,5). The DC offset in volts is displayed (33), however, the Unit of MEASURE LED indicators (32) will be off.
2. Rotate the tuning knob to add a positive or negative DC component to the output as desired. The DC offset can be varied independently from the output level control, ranging from -10 V to 10 V in 0.1 V steps or from -1 V to 1 V in 0.01 V steps depending on the attenuation pad (0 dB or -20 dB). The attenuation pad is determined by the amplitude value and is indicated in the first position of the display (33) by the "_"or "—" symbol respectively (see Output Level Adjustment (page 9)).
3. The signal at the required DC offset will now be available at the 50 Ω output jack (37). Adjustment of the DC offset does not affect the TTL and CMOS output jacks (38), (39), (41) and (42).

**Note:** The output signal cannot exceed ±10 V, and therefore excessive offsets will be cut off.

***CMOS Level Adjustment***

1. Select CMOS LEVEL via the MODE keys (4,5). CMOS levels in volts are displayed (33) and all UNIT of MEASURE LED indicators (32) will be off.
2. Rotate the tuning knob to the desired CMOS output level. A positive CMOS level with respect to ground can be varied from 4 to 14 V in 0.1 V steps.
3. The adjusted signal will now be available at the CMOS output (39). Adjustment of the CMOS level does not affect the 50 Ω output jack (37) and TTL output jacks (38), (41) and (42).

***External Counter***

1. Select EXT CNTR via the MODE keys (4,5). If no signal is applied to the EXT CNTR input jack (36), five "dashes" will appear on the display "——", indicating no frequency measurement has been obtained.
2. The tuning knob is disabled in this mode.

3. Apply the signal to be measured to the EXT CNTR input jack (36).
4. The frequency range corresponding to the measured frequency will be automatically selected to fulfill the correlation:

$$F_{low} < F_{inp} < F_{high},$$

where $F_{inp}$ is input frequency, $F_{low}$ and $F_{high}$ are the lowest and the highest permissible frequency for selected range according to Table 2.

| range name | range lowest permissable frequency y, $F_{low}$ | range highest permissible frequency , $F_{high}$ | range lowest measureable frequency *, $F_{ml}$ | range highest measureable frequency* , $F_{mh}$ | measuring time | resolution at MIN (see table 1) | resolution at MAX (see table 1) |
|---|---|---|---|---|---|---|---|
| 2 Hz | 0.1526 Hz | 2.2 Hz | 0.1526 Hz | 6.5535 Hz | 5..0.5 s | $4*10^{-6}$ Hz | $4*10^{-4}$ Hz |
| 20 Hz | 1.8 Hz | 22.0 Hz | 1.526 Hz | 65.535 Hz | 5..0.5 s | $4*10^{-5}$ hz | $4*10^{-3}$ Hz |
| 200 Hz | 18 Hz | 220 Hz | 15.26 Hz | 655.35 Hz | 0,5..0,0 5 s | $4*10^{-4}$ Hz | $4*10^{-2}$ Hz |
| 2 kHz | 0.18 kHz | 2.2 kHz | 0.1526 kHz | 6.5535 kHz | 0,5..0,0 5 s | $4*10^{-5}$ kHz | $4*10^{-4}$ kHz |
| 20 kHz | 1.8 kHz | 22.0 kHz | 0.001 kHz | 65.535 kHz | 1 s | $10^{-3}$ kHz | $10^{-3}$ kHz |
| 200 kHz | 18 kHz | 220 kHz | 0.01 kHz | 655.35 kHz | 0.1 s | $10^{-2}$ kHz | $10^{-2}$ kHz |
| 2MHz | 180 kHz | 2.2 MHz | 0.1 kHz | 4194.3 kHz | 0.5 s | $6.4*10^{-2}$ kHz | $6.4*10^{-2}$ kHz |
| 20 MHz | 1.8 MHz | 41.943 MHz | 1.0 kHz | 41943 kHz | 0.05 s | $6.4*10^{-1}$ kHz | $6.4*10^{-1}$ kHz |

***Table 2. Main features of ranges for external frequency counter.***

* The lowest and highest range of measurable frequencies, $F_{ml}$ and $F_{mh}$ is limited by the counter capacity.

If the input frequency is lower than 0.1526 Hz, five "underscores" message "_____" are displayed. This indicates that the measured frequency is lower than range lowest measurable frequency. If the input frequency is higher than 41.943 MHz, five "overscores" "‾‾‾‾‾" will be displayed. This indicates that the measured frequency is higher than highest measurable frequency. If the input frequency exceeds $F_{high}$ or $F_{low}$, the next higher or the next lower frequency range respectively would be automatically selected, and at that moment five "dashes" message "-----" may be displayed during <1 s after range switching, while the first measuring period passed.

5. The next lower or higher frequency range may be selected via the FREQUENCY RANGE keys (1,2).
6. Disconnect the input signal from the EXT CNTR jack. Seven seconds (maximum) after the input signal is disconnected, five "dashes" "-----" will appear on the display (33).
7. Selecting EXTERNAL COUNTER does not stop signal generation at any output, and does not any affect output signal parameters, however automatic output frequency regulation is not provided in this mode.

### *Modulation Modes: Voltage Controlled Frequency Operation*

1. Select the desired starting frequency range.
2. Select FREQUENCY via the MODE keys (4,5).
3. To achieve the maximum possible frequency variation, set the starting frequency value to be near the minimum of the range (see Table 1).
4. Switch modulation on via the MODULATION ON/OFF key (13).
5. Select VCG by the MODULATION MODE key (15).
6. Apply a positive DC voltage to the VCG MOD input jack (34) to increase the frequency. A voltage from 0 to 10 V ±1 V will cause the resulting frequency to increase by a factor from 1 to 100.
7. If FREQUENCY is selected via the MODE keys (4,5), the resulting output frequency is displayed (33) along with the appropriate units of measure. Rotating the tuning knob does not affect the value of the frequency in the VCG mode.
8. If the resulting frequency exceeds Fhigh of the selected range (see Table 2), the following range will be automatically selected in order to display the measured frequency at the proper resolution.

| range name | absolute maximum frequency limit, $F_{lim}$ |
|---|---|
| 2 Hz | 20 Hz |
| 20 Hz | 200 Hz |
| 200 Hz | 2 kHz |
| 2 kHz | 20 kHz |
| 20 kHz | 200 kHz |
| 200 kHz | 2 MHz |
| 2MHz | 20 MHz |
| 20 MHz | 20 MHz |

***Table 3. Absolute maximum frequency limits of ranges.***

9. To select another start frequency range, switch modulation off using the ON/OFF key (13), select the desired range via the FREQUENCY RANGE keys (1,2), and then switch modulation on using the MODULATION ON/OFF key (13).
10. To adjust the start frequency, switch the modulation off via the MODULATION ON/OFF key (13), adjust the frequency, and then switch modulation on again via the ON/OFF key (13).
11. There is no need to switch the modulation off in order to adjust the output level, duty cycle, DC offset or CMOS level - simply select the desired parameter with the MODE keys (4,5) and adjust it via the tuning knob.
12. Adjustment of modulation depth via the generator controls is not available for the VCG modulation mode.
13. Automatic frequency regulation is not provided in the VCG modulation mode.
14. The signal at the voltage-controlled frequency is available at the 50Ω (37), TTL (38), and CMOS (39) output jacks.
15. The VCG operation can be used to obtain an external controlled sweep signal. For this purpose, apply a positive-going ramp signal to the VCG MOD input jack (34).

As the ramp voltage increases, the frequency will increase as well. The sweep rate can be adjusted by varying the frequency of the ramp signal.

**IMPORTANT: Do not apply signals with levels higher than 10 V or lower than 0 V to the VCG MOD input jack (34). It will not cause any frequency shift and can damage the generator.**

### *AM Operation*

The 50 Ω output can be amplitude-modulated, either by an internal signal (1 Hz to 15 kHz) or by an external signal (DC to 500 kHz, less than 10 V p-p), applied to the VCG MOD input jack (34).

1. Switch modulation on via the ON/OFF key (13).
2. Select AM via the MODULATION MODE key (15).
3. Select internal modulation via the EXTERNAL key (21). The EXTERNAL LED indicator (22) must be off.
4. If the FREQUENCY parameter is selected via the MODE keys (4,5), the carrier frequency will be displayed (33). Rotating the tuning knob will adjust the frequency value.
5. Depress the % key (19). The percentage of modulation (ratio of double amplitude of the modulating signal to amplitude of carrier signal in percentage terms) will be displayed (33) while the % LED (32) is illuminated.

$$m\% = (2A_m/A_0)*100\% = m*100\%,$$

Where:
m% - percent of modulation,
m - modulation factor,
$A_m$ - amplitude of modulating signal,
$A_0$ - amplitude of carrier signal.

6. Rotate the tuning knob to set the percentage of modulation. The percentage of modulation can by varied from 0 to 100% in 1% steps.
7. Depress the REPETITION RATE key (17). The REPETITION RATE LED indicator (17) will be on and the frequency of internal modulating signal will be displayed (33).
8. Rotate the tuning knob to set the appropriate modulation frequency, which can be varied from 1 Hz to 15000 Hz in steps of 1 Hz to 150 Hz in 1 Hz steps, and from 150 Hz to 15 kHz steps is determined by the formula:

$$F_{mod} = 30000/N,$$

where $F_{mod}$ - modulating frequency in Hz,
N - cod, which is varied from 200 (150 Hz) to 2 (15000 Hz) with step of 1.

9. Select external modulation by the EXTERNAL key (21).
10. Connect a suitable modulating signal to the VCG MOD input jack (34).
11. Adjust the amplitude and frequency of the external signal as desired. Modulating the signal with amplitude exceeding half of the carrier signal amplitude will cause over-modulation.
12. **Do not apply signals exceeding ±5 V or frequencies higher than 500 kHz to the VCG MOD input jack (34). This could damage the generator or distort the resulting signal.**

13. Both internal and external modulating signals affect the resulting signal in accordance to the correlation:

$$A(t)= A_0(1+m*\cos(2\pi*F*t)),$$

Where:
A(t) - instant amplitude of the resulting signal,
$A_0$- carrier signal amplitude
m - modulation factor, $m=2\ A_m / A_0$,
F - modulating signal frequency (1 Hz to 15 kHz for internal, DC to 500 kHz for external),
t - time.

14. The resulting signal will be cut if the following correlation is not fulfilled:

$$ABS(A_0+2\ A_m)+ABS(DC\ offset)>10\ V,$$

Where:
ABS - absolute value,
$A_0$- amplitude of carrier signal,
$A_m$ - amplitude of modulating signal,
DC offset - DC offset level.

15. There is no need to switch the AM modulation off to adjust the carrier frequency, output level, duty cycle, DC offset or CMOS level - simply select the desired parameter via the MODE keys (4,5) and adjust it by rotating the tuning knob. The output level adjustment does not affect the percent of modulation in the internal modulation mode.
16. Automatic frequency regulation is provided in AM modulation mode.
17. An Amplitude Modulated (AM) signal is available at the 50 Ω output jack (37) while in AM modulation mode.

***FM Operation***

The 50 Ω output can be frequency-modulated by an internal signal (1 Hz to 15 kHz) or an external signal (DC to 500 kHz, less than 10 V p-p) applied to the VCG Mod input jack (34).

1. Select the desired frequency range.
2. Select FREQUENCY via the MODE keys (4,5).
3. Set the carrier frequency via the tuning knob.
4. Switch modulation on via the MODULATION ON/OFF key (13).
5. Select FM by the MODULATION MODE key (15).
6. Select internal modulation via the EXTERNAL key (21). Internal modulation will be enabled when the indicator (22) is off.
7. If the FREQUENCY parameter is selected via the MODE keys (4,5), a frequency value close to carrier frequency will be displayed. Rotating the tuning knob will not affect the frequency value in this mode.
8. Depress the % key (19). The percent of deviation will be displayed (33), while illuminating the % LED indicator (32). The output is achieved by the following formula:

$$m\% = (0.01*A_m)*100\% = m*100\%,$$

Where:
m% - percent of deviation,
m - modulation factor,
$A_m$ - amplitude of modulating signal in volts

9. Rotate the tuning knob to adjust the percent of deviation, which can be varied from 0 to 5% in 0.05% steps.
10. Depress the REPETITION RATE key (17). The REPETITION PATE LED indicator (17) will illuminate and the frequency of the internal modulating signal will be displayed (33)
11. Rotate the tuning knob to set the modulating frequency, which is in the range 1 – 15 kHz. The modulation frequency can be set in 1Hz steps from 1Hz to 150Hz. In the range 150Hz to 15kHz the available steps are set by the formula f=30000/N where N can vary from 2 for 15kHz (30000/2) to 200 for 15kHz (300000/200).
12. Select external modulation via the EXTERNAL key (21)
13. Connect a suitable modulating signal to the VCG MOD input jack (34).
14. Adjust the amplitude and frequency of the external signal as desired.
15. **Do not apply signals exceeding ±5 V or frequencies higher than 500 kHz to the VCG MOD input jack (34), as this can cause damage to the generator or signal distortion.**
16. Both the internal and external modulating signals affect the carrier signal in accordance to the relation:

$$F(t) = F_0 (1+m*\cos ( 2\pi*Fm*t),$$

Where:
F(t) - instantaneous frequency of the resulting signal,
$F_0$ - carrier frequency,
m - modulation factor, m= 0.0l*A ml
$A_m$ - modulating signal amplitude in volts,
$F_m$ - modulating signal frequency (1 Hz to 15 kHz for internal, DC to 500 kHz for external),
t - time.

17. To select another frequency range, switch modulation off via the ON/OFF key (13), select the desired range via the FREQUENCY RANGE keys (1,2), and then switch modulation on via the MOD ON/OFF key (13).
18. To adjust the carrier frequency, switch modulation off using the ON/OFF key (13), adjust the frequency, and then switch modulation on using the ON/OFF key (13).
19. There is no need to switch modulation off to the adjust output level, duty cycle, DC offset or CMOS level — just select the desired operation via the MODE keys (4,5) and adjust it by turning the tuning knob.
20. Automatic frequency regulation is not provided in FM modulation mode.
21. The FM signal is present at 50 Ω (37), TTL (38) and CMOS (39) output jacks.

### *Burst Operation*

In the Burst mode, the generator output is switched on and off (gated), either by an internally generated signal or by an externally applied signal. Both the repetition rate and the tone burst duty cycle are variable. The tone burst always contains an integer number of periods of carrier frequency, starting and finishing at zero.

1. Switch modulation on via the ON/OFF key (13).
2. Select BURST by depressing the MODULATION MODE key (15).
3. Select internal modulation via the EXTERNAL key (21), the EXTERNAL LED indicator (22) should be off.
4. If the FREQUENCY operation is selected via the MODE keys (4,5), the carrier frequency will be displayed. Rotation of the tuning knob will adjust this frequency value.
5. Press the REPETITION RATE key (17). This will display the repetition period in milliseconds along with the MS LED indicator (32).
6. Rotate the tuning knob to adjust the repetition period. The repetition period can be varied from 20 ms to 2000 ms. Coarse adjustment will vary the repetition period in 10 ms steps, and fine adjustment in 1 ms steps (when the FINE ADJUST key (7) is selected).
7. Press the % key (19). Now the duty cycle of the internal gating signal (as ratio of tone burst time to the repetition period in percentage terms) will be displayed (33) along with the % LED indicator (32).
8. Rotate the tuning knob to set the burst width (tone burst time). The burst width can be adjusted from 1 ms up to the repetition period minus 1ns; the appropriate tone burst duty cycle will be calculated and displayed.
9. Adjustment of the repetition rate does not affect the burst width value unless the repetition period is more than the tone burst time, but the tone burst duty cycle will be re-calculated after each adjustment. If the repetition period becomes equal to, or less than, the tone burst time, the tone burst time will be set equal to the repetition period minus 1 ms.
10. Select external modulation using the EXTERNAL key (21), thus illuminating the EXTERNAL LED indicator (22).
11. Connect a TTL gating signal (DC to 500 kHz) to the BURST input jack (35).
12. Adjust the frequency and duty cycle of external input signal as required.
13. **Do not apply signals with frequencies higher than 500 kHz to the BURST input jack (35). It can cause distortion of the resulting signal.**
14. The repetition rate and the burst tone duty cycle are not controlled for external burst operation.
15. There is no need to switch the burst operation off to adjust the carrier frequency, output level, duty cycle, offset or CMOS level. Simply select the desired parameter via the MODE keys (4,5) and adjust with the tuning knob.
16. Automatic frequency regulation *is* provided in burst mode.
17. The burst signal is present at the 50 Ω output jack (37), and the unmodulated signal at the carrier frequency is present at the TTL (38), and CMOS (39) output jacks. Signals at 1/10th and 1/100th of the carrier frequency are present at the TTL/10 (41) and TTL/100 (42) output jacks respectively.

*Sweep Operation*

1. Select the desired start frequency range.
2. Select START via the SWEEP RANGE key (25). The start frequency will now be displayed (33).
3. Adjust the tuning knob to set the start frequency value to be near MIN of the range (see Table 1). Automatic frequency regulation *is* provided for the start sweep frequency.
4. Select STOP parameter via the SWEEP RANGE key (25). Now the stop frequency will be displayed (33).
5. Adjust the tuning knob to set the stop frequency value using coarse and fine settings. The stop frequency can be set exceeding the start frequency by a factor from 1 to 100. Automatic frequency regulation *is not* provided for stop sweep frequency.
6. If the stop frequency exceeds $F_{high}$ of the selected range (see Table 2), then the next highest range will be automatically selected and indicated by the FREQUENCY LED indicators (3) in order to display the frequency at proper resolution.
7. Note that the stop frequency is limited by the absolute maximum limit for each range ($F_{lim}$ at Table 3). So, if the stop frequency reaches $1.1*F_{lim}$, don't try to further increase the stop frequency. This will automatically select the next highest range.
8. Select linear or logarithmic sweep operation via the SWEEP MODE key (29)
9. Press the RUN key (23) to enable sweep operation, which will be indicated by the illumination of the RUN LED indicator (24). Also, the START/STOP LED indicators (26) will go off and the FREQUENCY LED indicator (6) will go on. If the sweep time is less than 1s, the start frequency value will be continuously displayed (33), otherwise frequency values between the start and the stop frequencies will be displayed. Rotation of the tuning knob does not affect the frequency value.
10. Select the TIME parameter via the TIME key (27). The sweep time in milliseconds will be displayed (33) along with lit MS LED indicator (32).
11. Rotate the tuning knob to adjust the sweep time. The sweep time can be varied from 20ms to 30s without interrupting sweep operation. Coarse adjustment will vary the sweep time from 20ms to 2000ms in 10ms steps, and from 2000ms to 30000ms in 1ms steps during fine adjustment.
12. In the sweep mode, up to 256 intermediate frequency values, from start to stop frequencies, are consistently generated during sweep operations.
13. Selecting START/STOP via the SWEEP RANGE key (25) <u>will</u> disable sweep operation.
14. There is no need to switch sweep off to adjust output level, duty cycle, DC offset or CMOS level. Simply select the desired parameter, using the MODE keys (4,5), and adjust via the tuning knob. Switching the sweep mode between linear or logarithmic, as well as sweep time adjustment, *will not* stop sweep operation.
15. Select manual sweep mode by using the RUN key (23). To enable this operation the MAN LED indicator (24) must be on, and the FREQUENCY LED indicator (6) will light. Sweep operation will stop and some intermediate frequency will be present at the output with its value fixed at the moment the RUN key is pressed.
16. Start and stop frequencies can be varied by 1/256th of ($F_{stop}$ - $F_{start}$) by adjusting the tuning knob.
17. To disable sweep operation, press the RUN key (23).

18. Automatic frequency regulation *is* provided by the unit by briefly pausing at the start frequency of the first sweep that occurs after 5 seconds have elapsed since the last time the frequency was regulated. This is to say that if the sweep time is 1 second, automatic start frequency regulation will take place at the beginning of every fifth sweep. If the sweep time is 5 seconds or longer, then automatic frequency regulation takes place at the beginning of every sweep. The pause for regulation will not be for more than 3 measuring time periods for the selected frequency range (see table 1).
    18.1. At the beginning of the sweep time period, sweeping is automatically stopped. At this moment the start frequency is generated. If the sweep time is set to be less than 5 seconds, sweeping is stopped after an integer number of sweep periods, but not earlier than 5 seconds after sweeping begins.
    18.2. Automatic regulation of start frequency will be performed. It will take no more than 3 measuring time periods for selected frequency range (see Table 1).
    18.3. Sweeping begins again and goes up to the following break.
19. During sweep operations, automatic frequency regulation can be disabled or enabled by pressing the FINE ADJUST key (7). When sweeping begins, automatic frequency regulation is continuously enabled, which is indicated by the flashing RUN LED (24). Press the FINE ADJUST key (7) to disable automatic frequency regulation, which is indicated by a steady RUN LED indicator (24). Press the FINE ADJUST key (7) again to enable automatic frequency regulation, indicated by the flashing RUN LED (4).
20. Removal of residual DC offset due to component tolerances.

# DC Offset Compensation

***Note:*** *The following operation is only required at factory test or if repair of the unit leads to an out of tolerance condition.*

1. Switch modulation and sweep off.
2. Set output level value to zero.
3. Select DC OFFSET parameter by the MODE keys (4,5) and set its value to zero.
4. Connect voltmeter to the 50 Ω output jack (37). Parasitic offset value is displayed at voltmeter display. If its value is not equal to zero ±10 mV, perform steps 5-8
5. Press the FINE ADJUST key (7). The message **"Corr"** will be displayed (33).
6. Rotate the tuning knob (31) until the voltmeter reads 0+/- 10mV (available compensation is +270 to –280 mV)
7. Store the compensation value by pressing the FINE ADJUST key (7). The zero value of the DC offset will be displayed (33). Press any other key to abort the procedure

# Storage Characteristics

This generator is equipped with an internal EEPROM, where all settings and parameter values are stored. When you switch the generator on for the first time, the generator will go through its EEPROM initialization routine, and the message "reset" will be displayed. The following default mode and values will be set:

| | |
|---|---|
| Frequency range | 20 kHz |
| Mode | Frequency |
| Fine adjust | Off |
| Wave form | Sine |
| Main frequency | 10 kHz |
| Output level | 0.2V |
| Duty cycle | 50% |
| DC offset | 0V |
| CMOS Level | 4V |
| Modulation | Off |
| Modulation mode | VCG |
| Percent of AM modulation | 0% |
| Percent of FM deviation | 0% |
| Burst repetition rate | 20 ms |
| Tone burst duty cycle | 5% (corresponding to a burst width of 1ms) |
| Sweep | Off |
| Sweep mode | Linear |
| Sweep time | 100 ms |
| Sweep start frequency | 2 kHz |
| Sweep stop frequency | Approximately equal start frequency |
| Modulating frequency | 1000 Hz |
| DC offset compensation | 0mV |

During common operation, all settings are stored in the memory, and will remain stored until changed. The generator will default to its previous settings upon power-up.

# Data Communications

All generators in the Pure Wave series provide asynchronous data communication through via RS-232C serial communications, at baud rate of 300 bits per second in accordance with the communication protocol described below. The following Protocol commands allow for complete remote generator operation.

Message format - "/" CPD..D "."

Where:

"/"= leader symbol,

C = command (answer) symbol

P = parameter symbol,

D = data symbols

"."= termination symbol.

Data symbols are numerical data in hexadecimal format. Each symbol corresponds to the hexadecimal digit according to Table 4.

| Hexadecimal digit | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Á | Â | Ñ | D | E | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Symbol | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | ; | ; | , | = | . | ? |

***Table 4.***

Generator commands are described in Table 5.

| Command symbol | Command meaning | Parameter symbol | Data symbols quantity | Answer symbol |
|---|---|---|---|---|
| A | Asks parameter value | 0 to "?" | No | A (E) |
| B | Orders to begin cycle transmitting of current frequency value* | No | No | O (E) |
| D | Sets parameter value | 0 to "?" | 2 to 5 | A (E) |
| G | Sets generator mode | 0 to 9 | 1 | M (E) |
| M | Asks current generator mode | 0 to 9 | No | M (E) |
| I | Orders to indicate parameter | 0 to ":" | No | J (E) |
| J | Asks which parameter is displayed now | No | No | J (E) |
| E | Initialization | No | No | O (E, F) |
| C | Cancels cycle transmitting of frequency value | no | No | O (E) |

***Table 5. Generator Commands.***

* - current measured frequency value (displayed on the display) is transmitted from generator every 0.5 s.

Answers from the generator are described in Table 6.

| Answer symbol | Answer meaning | Parameter symbol | Data symbols quantity | To command |
|---|---|---|---|---|
| A | Parameter value | 0 to "?" | 2 to 5 | A,D |
| B | Current frequency value | No | 5 | No |
| M | Current generator mode | 0 to 9 | 1 | G, M |
| J: | Indicated parameter | 0 to "." | No | I, J |
| O | OK (command has been completed) | No | No | B, E, C |
| E | Command has not been understood | No | No | All commands |
| H | Current frequency is higher than Fmh | No | No | No |
| L | Current frequency is lower than Fml | No | No | No |
| N | No frequency is measured | No | No | No |
| F: | EEPROM write error | No | No | E |

***Table 6: Answers from generator.***

Parameters for commands/answers A and D are described in Table 7.

| *Parameter symbol* | *Parameter meaning* | *Data symbols quantity* | *Data range* | *Data meaning* |
|---|---|---|---|---|
| 0 | Stop sweep frequency code | 2 | 0 to 210 | 1 to 100 times start frequency |
| 1 | Manual sweep code | 2 | 0 to 255 | 1 to 100 times start frequency |
| 2 | Output level | 2+ | 128 to 228 | 0 to 1 V or 0 to 10V depending on |
| | Attenuation feature | 1 | 0 or 1 | attenuation feature (1 or 0 respectively) |
| 3 | Duty cycle | 2 | 25 to 231 | 15 to 85% |
| 4 | DC offset | 2+ | 0 to 255 | -1 to 1V or -10 to 1-V |
| | Attenuation feature | 1+ | 0 or 1 | depending on attenuation feature |
| | DC offset compensation | 1 | 0 or 27 or 228 to 255 | (1 or 0 respectively) |
| 5 | Percent AM | 2 | 128 to 228 | 0 to 100% |
| 6 | Percent FM | 2 | 128 to 228 | 0 to 5% |
| 7 | CMOS level | 2 | 128 to 28 | 4 to 14V |
| 8 | Burst repetition time | 4 | 20 to 2000 | 20 to 2000 ms |
| 9 | Tone burst time | 4 | 1 to repetition time | 1ms to repetition time |
| : | Sweep time | 4 | 20 to 30000 | 20 to 30000 ms |
| ; | mainfrequency value | 4+ | 1600 to 40000 | 0.08 to 2 times frequency range |
| | Frequency range* | 1 | 0 to 7 | 0.2 Hz to 20 MHz |
| < | Start sweep frequency value | 4+ | 1600 to 40000 | 0.08 to 2 times frequency range |
| | Frequency range* | 1 | 0 to 7 | 0.2 Hz to 20 MHz |
| = | Main frequency cod | 4 | 32768 to 65535 | 32768 to 65535 |
| > | Start sweep frequency cod | 4 | 32768 to 65535 | 32768 to 65535 |
| ? | Modulating frequency cod | 4 | 35536 to 65534 | 1 hz to 15 kHz |

***Table 7. Parameters for commands/answers A, D***

| Parameter symbol | Parameter meaning | Data symbol | Data meaning |
|---|---|---|---|
| 0 | Range | 0 | 2 Hz |
| | | 1 | 20 Hz |
| | | 2 | 200 Hz |
| | | 3 | 2 kHz |
| | | 4 | 20 kHz |
| | | 5 | 200 kHz |
| | | 6 | 2 MHz |
| | | 7 | 20 MHz |
| 1 | DC preset | 1 | Auto- |
| | | 2 | Auto+ |
| | | 4 | Preset |
| 2 | Waveform | 1 | Square |
| | | 2 | Triangle |
| | | 4 | Sine |
| 3 | Modulation mode | 1 | VCG |
| | | 2 | AM |
| | | 4 | FM |
| | | 8 | Burst |
| 4 | Sweep mode | 1 | linear |
| | | 2 | logarithmic |
| 5 | Sweep | 0 | Off |
| | | 4 | Manual |
| | | 8 | Sweep |
| 6 | Modulation on/ off | 0 | Off |
| | | 2 | On |
| 7 | External modulation on/off | 0 | Off |
| | | 8 | On |
| 8 | Fine/coarse | 0 | Coarse |
| | | 8 | Fine |
| 9 | Automatic frequency regulation | 0 | Disable |
| | | 1 | Enable |

***Table 8. Parameters for commands/answers G, M.***

Parameters for commands/answers I and J are described in Table 9.

| **Parameter symbol** | **Parameter meaning** |
|---|---|
| 0 | External counter |
| 1 | CMOS level |
| 2 | DC offset |
| 3 | Duty cycle |
| 4 | Output level |
| 5 | Main frequency |
| 6 | Stop sweep frequency |
| 7 | Start sweep frequency |
| 8 | Percent modulation |
| 9 | Burst repetition rate |
| : | Sweep time |

***Table 9. Parameters for commands/answers I,***