THURLBY THANDAR INSTRUMENTS

TGA1200 Series

Single and Multi-channel Universal ARB Generators

1, 2 or 4 independent or inter-linked channels

40MS/s or 100MS/s, up to 1M words per channel

Function generator and pulse generator capabilities

TGA1200 series universal ARB waveform generators

Universal generators

The TGA1200 series combine a true variable clock arbitrary generator with a high performance DDS function generator and pulse generator in a single instrument.

Wide model range

The TGA1200 series comprises 6 models:

TGA1241 - 40MS/s single channel waveform generator in 3U half rack size case.

TGA1242 - 40MS/s two channel waveform generator in 3U case.

TGA1244 - 40MS/s four channel waveform generator in 3U case.

TGA12101 - 100MS/s single channel waveform generator in 3U half rack size case.

TGA12102 - 100MS/s two channel waveform generator in 3U case.

TGA12104 - 100MS/s four channel waveform generator in 3U case.

On multi-channel units each channel can be operated fully independently, or multiple channels can be linked using simple or complex relationships.

A true arbitrary generator

The TGA1200 series are highly sophisticated 12-bit arbitrary generators capable of recreating virtually any waveform.

True variable clock architecture is used with clock speeds between 0.1Hz and 100MHz (40MHz on TGA124x units). This architecture avoids the clock jitter associated with DDS arbitrary generators and permits waveform linking, looping and sequencing.

Waveforms may be defined with up to 4096 vertical points and from 8 to 1M horizontal points (4 to 64K points on TGA124x units).

Arbitrary waveforms may be replayed at a specified waveform frequency, period or sample rate. An external clock sample clock can also be used on TGA1210x units.

On TGA124x units, up to 100 user-defined waveforms can be stored within the instrument's non-volatile memory.

On TGA1210x units waveform storage is on removeable Compact Flash memory cards and is therefore effectively unlimited.

Function generator

Each channel can operate as a full DDS function generator. High quality sine, cosine, haversine, havercosine and square waves are available between 1mHz and 16MHz (TGA124x) or 40MHz (TGA1210x).

Triangle, ramp and sine(x)/x waveforms are available from 0.1mHz up to 100kHz.

Pulse generator

Each channel can generate not just pulses but complex pulse trains.

A pattern of up to 10 pulses can be quickly defined with each pulse having its own amplitude, width and delay. The whole pulse train pattern can then be replayed at a user defined repetition rate.

Where variable rise time pulses are required, the full arbitrary function can be used.
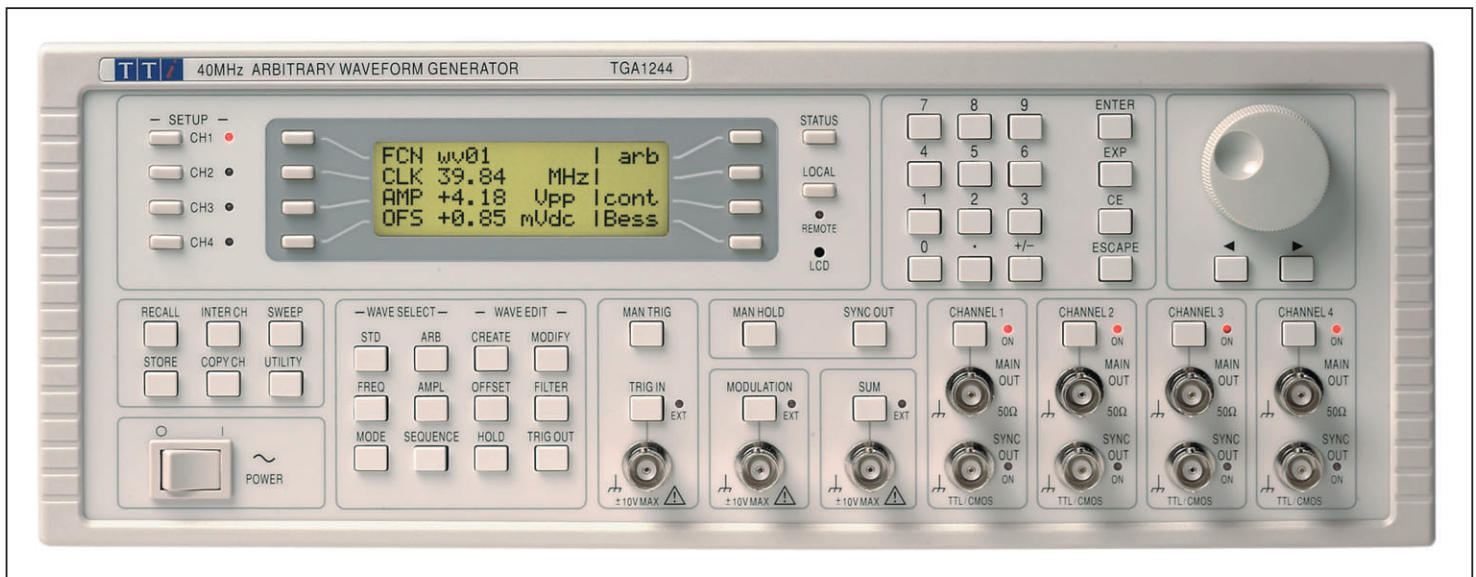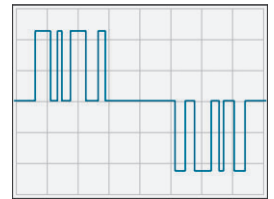
TGA1200 Series - Main Features

- ▶ 1, 2 or 4 waveform channels, independent or linked.
- ▶ 40MS/s or 100MS/s 12-bit arbitrary waveform capability using true variable clock architecture.
- ▶ 64K or 1M point waveform memory per channel.
- ▶ 16MHz or 40MHz function generators using DDS*.
- ▶ Multiple 'standard' waveforms including sine, square, triangle, haversine, ramp, pulse and sin(x)/x.
- ▶ Pulse train pattern generation for up to 10 pulses.
- ▶ Complex waveform sequencing and looping capability using up to 1024 waveform segments.
- ▶ Wide range sweep, AM, tone switching, signal summing.

  * DDS = direct digital synthesis

- ▶ Inter-channel triggering, summing and phase control.
- ▶ Multiple generators can be easily phase locked.
- ▶ External ARB clock input (TGA1210x units only).
- ▶ Waveform creation/editing tools built-in; sophisticated external Windows based software included.
- ▶ Built-in trigger generator, gated and triggered burst modes.
- ▶ Tone switching facilitates precision DTMF generation.
- ▶ Unlimited waveform storage using CF memory cards (TGA1210x units only).
- ▶ GPIB (IEEE-488.2), RS-232 and USB interfaces (TGA124x units have GPIB and RS-232 only).

Waveform creation and editing

Waveform creation and editing features are incorporated within the instrument. These include waveform insert, point edit, line draw, amplitude adjust and invert.

A wide range of standard waveforms is available for insertion within an arbitrary waveform. Sections of existing arbitrary waveforms can also be inserted.

For more sophisticated waveform creation and editing, **Waveform Manager Plus** software for Windows is provided (see further on in this brochure for more detail).

Waveforms created on a PC can be downloaded to the instrument via the digital interfaces (or memory card where fitted).

Memory card storage

TGA1210x units incorporate a CompactFlash memory card giving effectively unlimited storage for waveforms and set-ups.

Waveform data can be transferred directly from a PC to the memory card using the USB card reader/writer supplied.

GPIB, RS-232, USB

The TGA1200 series incorporates both RS-232 and GPIB (IEEE-488) interfaces as standard. TGA1210x units also have a USB interface.

These can be used for loading arbitrary waveforms and for remote control of all the instrument functions.

Waveform sequencing

The variable clock architecture of the TGA1200 series enables waveforms to be sequenced. Up to 1024 arbitrary waveforms may be linked in a sequence (16 waveforms on TGA124x). Each waveform can have a loop count of up to 32,768 and the whole sequence can be run continuously or repeated more than a million times.
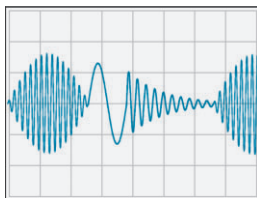
Simple waveform sequence

For multi-channel models, waveforms on different channels can be 'daisy chained' and looped.

By summing the channel outputs, multiple segments from multiple channels can be used to create highly complex waveforms.

Generating more voltage

For applications requiring more than 20V pk-pk emf, an external wideband amplifier is available. The WA301 can provide up to 30V pk-pk from 50 .

Wide range sweep

All waveforms can be swept over their full frequency range at a rate variable between milliseconds and minutes.

Sweep can be linear or logarithmic, single or continuous. Single sweeps can be triggered from the front panel, the trigger input, or the digital interfaces.
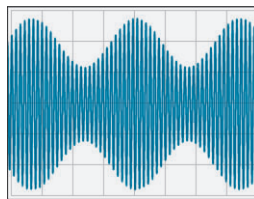
Multiple channels can be swept simultaneously.

Amplitude modulation

Amplitude Modulation and Suppressed Carrier Modulation are available for all waveforms.

Any channel can be used to modulate another channel.

Alternatively all channels can be modulated simultaneously via the modulation input.

Amplitude modulation

Built-in trigger generator

All waveforms are available as a triggered burst whereby each trigger edge will produce one burst of the carrier. Start and stop phase is fully variable.

Both Triggered and Gated modes can be operated from the internal trigger generator, from an adjacent channel, an external source or a key press or remote command.

The trigger generator signal is available as a separate output if required.

Tone switching

The TGA1200 series can provide triggered switching between up to 16 frequencies of standard or arbitrary waveforms.

Tone switching modes can be gated, triggered or FSK using any trigger source.

By summing two channels together it is possible to generate precise DTMF test signals.
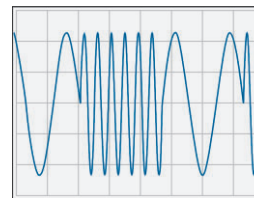
Simple tone switching

Fast and easy to use

All of the main information is clearly displayed on a backlit 80 character LCD. Eight 'soft' keys enable fast data editing.

Parameters can be entered directly from the numeric keypad or changed with the spin wheel.

On the 2 and 4 channel models, a Copy Channel key enables similar setups to be created across multiple channels with ease.
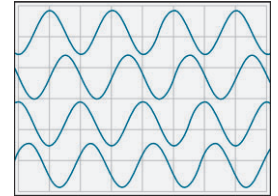
Multi-channel operation
(TGA1242/1244/12102/12104)

Multi-channel phase locking

Any number of channels can be phase locked with offsets defined to a resolution of $0.1°$ (or $360°$/waveform points for arbitrary waveforms).

For applications requiring more than four channels, multiple generators can be phase locked.

TGA1210x models can be phase locked to an external clock and offer phase continuous frequency changes.

N.B.
All models including the TGA1241 and TGA12101 have the facility for phase synchronising to another similar generator.

Multi-channel summing

Waveform Summing sums the waveform from any channel into the next channel.

Alternatively any number of channels can be summed with an external signal.

This permits complex modulations to be created such as noise superimposition.
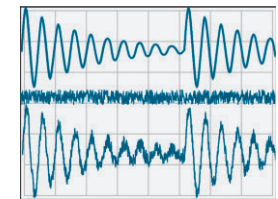
Arbitrary waveform summed with noise

Inter-channel triggering and modulation

Because any channel can be triggered by the previous or next channel, waveforms on different channels can be 'daisy chained' and looped. By summing the channel outputs, many segments from different channels can be used to generate the final waveform.

A channel can be used to AM modulate or SCM modulate another channel.

Digital modulation

Inter-channel modulation and summing allows the simulation of various telecom digital modulation systems.
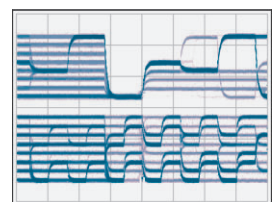
IQ Modulation signals (Quadrature Amplitude Modulation)

Advanced waveform creation, editing and management software

- ▶ *Full waveform building tools including standard waveforms, mathematical expressions, and freehand drawing.*
- ▶ *Operates under Windows 95, 98, Millennium, NT, 2000 and XP.*
- ▶ *Supports vertical resolutions up to 16 bits (65536 points).*
- ▶ *Supports horizontal resolutions to over one million points.*
- ▶ *Provides waveform import and export via clipboard functions.*
- ▶ *Directly supports waveform upload from some Tektronix DSOs.*
- ▶ *Supports download and upload via RS-232, GPIB and USB.*

WAVEFORM BUILDING TOOLS

TOOLKIT

Waveforms can be built in any number of sections using any combination of the following: Standard waveforms, mathematical expressions, drawn waveforms, uploaded waveforms, imported waveforms (using clipboard), existing stored waveforms.

Note: Waveform section limits can be defined via moveable cursors which can be dragged or positioned numerically.

STANDARD WAVEFORMS

The following waveforms are available directly from the Waveforms dialogue box: Sine, square, triangle, pulse, ramp, sinc [sin(x)/x], gaussian, exponent, noise.

Note: The mathematical expression for any standard waveform can be examined by opening the expression editor window.

EXPRESSION EDITOR FUNCTIONS

The following mathematical operators are available within the expression editor: Add, subtract, multiply, divide, x^n, sin, cos, arcsin, arccos, abs, log_{10}, log_e, e^n, square root, floor, ceiling, random, pulse, in conjunction with constants and waveforms.

Note: The expressions used for each section of a waveform are retained and can be displayed in a drop-down window.

EXPRESSION LIBRARIES

The mathematical expressions used for waveform creation can be stored in libraries. A default library is created for each project which includes a number of useful examples including waveshapes and modulations.

WAVEFORM DRAWING FUNCTIONS

Waveforms can be created or edited using freehand drawing and/or point to point line drawing.

SMOOTH

Waveforms can be smoothed using a running average filter. Start and end points can be specified as well as the number of points to average.

WAVEFORM EDITING/CONVERSION

TOOLKIT

All of the waveform building tools previously mentioned can be used to edit existing waveforms. In addition waveforms can be manipulated directly using the following functions:

RESIZE WAVEFORM

Allows a waveform to be resized horizontally to any length between 4 and 1M horizontal points.

Note: The vertical resolution of a waveform is automatically adjusted when it is downloaded to the generator. Thus an 8-bit waveform from a DSO will be expanded to 12-bits if it is downloaded to a 12-bit generator (and vice versa).

WAVEFORM MATHEMATICS

The Waveforms Maths function allows waveforms to be combined and manipulated independently of the expression editor. Waveforms can be scaled, offset, added, subtracted or multiplied using dialogue boxes.

Note: Waveforms can also be combined and manipulated within the expression editor giving access to the full range of mathematical functions.

INPUT/OUTPUT FUNCTIONS

FILE FORMATS

Waveforms can be read from and saved as any of the following formats: WFM(binary), NRM (normalised data in ASCII), WAV (WaveCAD), ASC (WaveCAD), DSF (Tektronix DSO).

WAVEFORM DOWNLOAD/UPLOAD

Waveforms can be downloaded/uploaded to/from TTi arbitrary generators (or certain Tektronix DSOs) using either an RS232 or GPIB (IEEE-488) interface or, for the TGA1210x, a USB interface.

CLIPBOARD FUNCTIONS

Waveforms can be imported to the program and exported from the program using the Windows Clipboard.

Waveform import uses the "Text" clipboard format (i.e. numeric lists). This enables waveforms to be imported from spreadsheets such as Excel and from mathematical programs such as MathCad. Values are automatically normalised and re-scaled.

Waveform export creates multiple clipboard formats of Text (normalised numeric values between ±1), Bitmap (as per on-screen display) and Picture (metafile retaining waveform vector properties).

Note: Pictures or bitmaps can be pasted into programs such as Word for documentation purposes.

DISPLAY AREA AND PRINTING

Multiple waveform windows can be open simultaneously. Each window is fully scaleable. Variable zoom is provided with panning from a "navigator" sub-window.

Waveform section limits can be defined via moveable cursors which can be dragged or positioned numerically.

Waveforms can be printed with automatic annotation and scaling.

MANAGEMENT AND UTILITIES

PROJECTS

To maintain good housekeeping, waveforms can be organised into "projects" with separate directory structures. Each project maintains its own library of expressions. Waveforms and expressions can be imported and exported from other projects.

INSTRUMENT SETUP

The instrument setup screen enables options for the waveform generator to be set from the program. Examples of settable options are output amplitude, clock frequency and trigger source.

HELP

Full on-screen Help is available with a hyper linked contents table.

Variable-clock ARB architecture

Direct replay for jitter-free waveforms

All TGA1200 series units generate arbitrary waveforms using a variable clock architecture rather than DDS.

This ensures that every point in the waveform is replayed exactly as it was defined, the rate of replay being set by the clock frequency.

By contrast, a DDS arbitrary generator uses a fixed clock frequency and varies the replay rate by duplicating or omitting waveform points. Unless there is an integer relationship between the desired replay rate, clock frequency and waveform length, each "cycle" of the waveform will differ from the previous one, resulting in jitter.

Sequencing for increased waveform length

Variable clock architecture also allows sequencing and looping. The 64K words of waveform memory per channel provided in TGA124X units can be used to create arbitrary waveforms with many more than 65536 points.

Many real-world waveforms include repetitive elements. By using a segment of the memory to recreate each repeating element, the waveform can be constructed by a "sequence" in which the individual elements are replayed in a defined order and with a defined number of repetitions (loop count). In this way waveforms can be created with a much greater number of points than the waveform memory size.

DDS arbitrary generators can not do this and the effective waveform length is limited to the actual waveform memory size.

TGA12100 - the next step forward

TTi designed the new TGA1210X generators based upon extensive experience of actual user requirements. So in addition to raising the maximum clock speed from 40MHz to 100MHz, a number of other important features have been added that meet the needs of particular groups of customers.

1M word waveform memory

Some users require very long arbitrary waveforms. TGA1210X units incorporate 1,048,576 words of waveform memory per channel. Thus even long and complex waveforms which have no repetitive elements can be accommodated.

CompactFlash memory card storage provides effectively unlimited storage for waveforms. Greater sequencing capability (up to 1024 segments) gives even more flexibility in waveform reconstruction.

External ARB clock input

Some applications require that the arbitrary waveform is clocked in direct synchronism with an external signal.

TGA1210X units incorporate an external ARB clock input that can be used to clock any number of channels at any rate from DC up to 50MHz.

It should be noted that DDS arbitrary generators have no such capability.

System clock architecture

All TGA1200 units incorporate a separate clock generator for each channel allowing completely independent operation.

On the TGA1242 and TGA1244, channel synchronisation is achieved by defining one channel as the Master channel and driving the other channel(s) from its clock.

The TGA12102 and TGA12104 provide a further option by incorporating an additional independent system clock generator. The system clock creates an internal version of the external ARB clock signal and can generate frequencies between 0.1Hz and 50MHz.

When the system clock (or external ARB clock) is used to drive multiple channels, phase skew is significantly reduced and frequency changes can be made without any discontinuities.

The system clock output is also available on the rear panel to drive external circuitry or the external ARB input of another generator when more than four channels are required.

Auxiliary sinewave output

The output of the master clock generator is also available as a fixed level sinewave. When not being used as the master for channel synchronisation, this can be used as another independent variable frequency generator over the range 0.1Hz to 50MHz, providing the equivalent of three or five channel outputs.

Specifications apply at 18°C to 28°C after 30 minutes warm up, at maximum output into 50Ω.

ARBITRARY WAVEFORMS

Waveform Parameters

	TGA124x	TGA1210x
Waveform Memory:	64k points/ch	1M points/ch
Waveform Length:	4 to 65,536 points	8 to 1,048,576 points
Vertical Resolution:	12 bits (4096 levels)	
Sample Clock Rate:	0.1Hz to 40MHz	0.1Hz to 100MHz [1]
Clock Resolution:	4 digits	8 digits
Clock Accuracy:	<10 ppm for 1 year (± 1 digit of setting)	
Clock Temp. Stability:	Typically <1 ppm/°C	
Waveform Storage:	256K Words Non-volatile RAM	CF Memory Cards (32MB to 1GB size)
Max. Waveforms:	100	500 per card

Note 1: TGA1210x generators can also use an external sample clock, DC to 50MHz.

Waveform Creation and Editing

	All Models
Internal:	Basic arbitrary waveform creation and editing tools are built into the instrument. Arbitrary waveforms can be built-up using insertion of standard waveforms between points, point by point value setting, and straight line drawing between points.
External:	All TGA1200 series units are supplied with Waveform Manager Plus software for Windows which provides full waveform creation, editing and management. Waveforms are transferred using the digital interfaces or memory card.

Sequence

A number of waveforms can be linked and played as a sequence. Each waveform can have a loop count of up to 32,768. A sequence of waveforms can be looped up to 1,048,575 times or run continuously.

	TGA124x	TGA1210x
Max. Waveforms in a Sequence:	16	1024

Output Filter

The output filter type is selectable. This can be used to optimise a particular waveshape.

	TGA124x	TGA1210x
Filter Choice:	16MHz Elliptic, 10MHz Elliptic, 10MHz Bessel or None	40MHz Elliptic, 20MHz Bessel or None

STANDARD WAVEFORMS

Sine, square, triangle, DC, positive ramp, negative ramp, sin(x)/x, pulse, pulse train, cosine, haversine and havercosine.

All Waveforms

	TGA124x	TGA1210x
Frequency Accuracy:	<10 ppm for 1 year	
Temp. Stability:	Typically <1 ppm/°C	
Output Level:	2.5mV to 10Vpp into 50Ω (5mV to 20Vpp e.m.f.)	

Sine, Cosine, Haversine, Havercosine

	TGA124x	TGA1210x
Frequency Range:	0·1mHz to 16 MHz	0·1mHz to 40 MHz
Freq. Resolution:	0·1mHz or 7 digits	0·1mHz or 10 digits
Harmonic Distortion:	<0.1% THD to 100kHz; <−65dBc to 20kHz, <−50dBc to 300kHz, <-35dBc to 10MHz <-30dBc to 16MHz	<0.15% THD to 100kHz; <-60dBc to 20kHz, <-50dBc to 1MHz, <-40dBc to 10MHz, <-30dBc to 40MHz.
Nonharmonic Spurii:	<−65dBc to 1MHz, <−65dBc + 6dB/octave 1MHz to 16MHz	<-60dBc to 1MHz, <-60dBc + 6dB/octave 1MHz to 40MHz.

Square

	TGA124x	TGA1210x
Frequency Range:	1mHz to 16 MHz	1mHz to 50 MHz
Freq. Resolution:	1mHz or 4 digits	1mHz or 8 digits
Freq. Accuracy:	± 1 digit of setting	
Rise and Fall Times:	<25ns	<8ns

Pulse and Pulse Train

	TGA124x	TGA1210x
Period Range:	100ns to 100s	40ns to 100s
Period Resolution:	4 digits	8 digits
Period Accuracy:	± 1 digit of setting	
Delay Range:	-99·99s to + 99·99s	
Delay Resolution:	0·002% of period (25ns minimum)	0.001% of period (10ns minimum)
Width Range:	25ns to + 99·99s	10ns to + 99·99s
Width Resolution:	0·002% of period (25ns minimum)	0.001% of period (10ns minimum)
Rise and Fall Times:	<25ns	<8ns

Note that the pulse width and absolute value of the delay may not exceed the pulse period at any time.

Pulse trains of up to 10 pulses may be specified, each pulse having independently defined width, delay and level. The baseline voltage is separately defined and the sequence repetition rate is set by the pulse train period.

Triangle

	TGA124x	TGA1210x
Frequency Range:	0.1mHz to 100kHz	0.1mHz to 500kHz
Freq. Resolution:	0.1mHz or 7 digits	0.1mHz or 10 digits
Linearity Error:	<0.1% to 30 kHz	

Ramps and Sin(x)/x

	TGA124x	TGA1210x
Frequency Range:	0.1mHz to 100kHz	0.1mHz to 500kHz
Freq. Resolution:	0.1mHz or 7 digits	0.1mHz or 10 digits
Linearity Error:	<0.1% to 30 kHz	

Noise Function (TGA1210x only):

Digital noise generated by a 35-bit linear feedback register clocked at 100MHz. User's external filter defines bandwidth and response.

OPERATING MODES

Continuous

Waveform runs continuously.

Triggered Burst

Each active edge of the trigger signal will produce one burst of the waveform.

	TGA124x	TGA1210x
Carrier Waveforms:	All standard and arbitrary waveforms	
Max. Carrier Frequency:	1MHz or the maximum for the selected waveform if lower. 40Msamples/s for ARB and Sequence.	2.5MHz or the maximum for the selected waveform if lower. 100Msamples/s for ARB and Sequence.
Number of Cycles:	1 to 1,048,575	
Trigger Repetition:	0.005Hz to 100kHz internal, dc to 1MHz external.	
Trigger Signal Source:	Internal from keyboard, previous channel, next channel or trigger generator. External from TRIG IN or remote interface.	
Trigger Start/Stop Phase:	± 360° settable with 0.1° resolution, subject to waveform frequency and type.	

Gated

Waveform will run while the Gate signal is true and stop while false.

	TGA124x	TGA1210x
Carrier Waveforms:	All standard and arbitrary waveforms	
Max. Carrier Frequency:	1MHz or the maximum for the selected waveform if lower. 40Msamples/s for ARB and Sequence.	2.5MHz or the maximum for the selected waveform if lower. 100Msamples/s for ARB and Sequence.
Number of Cycles:	1 to 1,048,575	
Trigger Repetition:	0.005Hz to 100kHz internal, dc to 1MHz external.	
Gate Signal Source:	Internal from keyboard, previous channel, next channel or trigger generator. External from TRIG IN or remote interface.	
Gate Start/Stop Phase:	± 360° settable with 0.1° resolution, subject to waveform frequency and type.	

Sweep

Frequency sweep capability is provided for both standard and arbitrary waveforms. Arbitrary waveforms are expanded or condensed to exactly 4096 points and DDS techniques are used to perform the sweep.

	TGA124x	TGA1210x
Carrier Waveforms:	All standard and arbitrary except pulse, pulse train and sequence.	
Sweep Mode:	Linear or logarithmic, triggered or continuous.	
Sweep Direction:	Up, down, up/down or down/up.	
Sweep Range:	From 1mHz to 16 MHz in one range.	From 1mHz to 40 MHz in one range.
Sweep Time:	30ms to 999s	1ms to 999s
Marker:	Variable during sweep.	
Sweep Trigger Source:	The sweep may be free run or triggered from the following: Manually from keyboard. Externally from TRIG IN input or remote interface.	
Sweep Hold:	Sweep can be held / restarted by the HOLD key.	

Multi Channel Sweep (multi-channel units only)

Any number of channels may be swept simultaneously. Amplitude, Offset and Waveform can be set independently for each channel. For TGA124x units the sweep parameters will be the same for all channels. For TGA1210x units the sweep parameters can be set independently for each channel.

Tone Switching

Capability provided for both standard and arbitrary waveforms. Arbitrary waveforms are expanded or condensed to exactly 4096 points and DDS techniques are used to allow instantaneous frequency switching.

	TGA124x	TGA1210x
Carrier Waveforms:	All except pulse, pulse train and sequence.	
Frequency List:	Up to 16 frequencies from 1mHz to 10MHz.	Up to 16 frequencies from 1mHz to 40MHz.
Trigger Repetition Rate:	0.005Hz to 100kHz internal. dc to 1MHz external. Usable repetition rate and waveform frequency depend on the tone switching mode.	
Trigger Source:	Internal from keyboard, previous channel, next channel or trigger generator. External from TRIG IN or remote interface.	
Tone Switching Modes:	Gated, Triggered or FSK (see below).	

Tone Switching Modes:

Gated: The tone is output while the trigger signal is true and stopped, at the end of the current waveform cycle, while the trigger signal is false. The next tone is output when the trigger signal is true again.

Triggered: The tone is output when the trigger signal goes true and the next tone is output, at the end of the current waveform cycle, when the trigger signal goes true again.

FSK: The tone is output when the trigger signal goes true and the next tone is output, immediately, when the trigger signal goes true again. Using 2 channels with their outputs summed together it is possible to generate DTMF test signals.

Trigger Generator

Internal source 0.005 Hz to 100kHz square wave adjustable in 10us steps. 3 digit resolution. Available for external use from any SYNC OUT socket.

OUTPUTS

Main Output - One for each channel

	TGA124x	TGA1210x
Output Impedance:	50Ω	
Amplitude Range:	5mV to 20Vpp open circuit (2.5mV to 10Vpp into 50Ω). Amplitude can be specified open circuit (hi Z) or into an assumed load of 50Ω or 600Ω in Vpk-pk, Vrms or dBm.	
Amplitude Accuracy:	2% ±1mV at 1kHz into 50Ω.	
Amplitude Flatness:	±0.2dB to 200 kHz; ±1dB to 10 MHz; ±2.5dB to 16 MHz.	±0.2dB to 1 MHz; ±0.4dB to 40 MHz;
DC Offset Range:	±10V from 50Ω. Offset plus signal peak limited to ±10V.	
DC Offset Accuracy:	Typically 3% ±10mV, unattenuated.	
Resolution:	3 digits or 1mV for both Amplitude and DC Offset.	

Auxiliary Sine Output

TGA124x	TGA12101	TGA12102/104
N/A	N/A	Nominal 1Vp-p sinewave, frequency set by system clock, frequency 0.1Hz to 50MHz.

ARB Clock Out
See ARB clock In/Out within INPUTS section.

Sync Out - One for each channel
Multifunction output user definable or automatically selected to be any of the following:

	TGA124x	TGA1210x
Waveform Sync: (all waveforms)	Square wave with 50% duty cycle at the main waveform frequency, or pulse coincident with the first few points of an arbitrary waveform.	
Position Markers: (Arbitrary only)	Any point(s) on the waveform may have associated marker bit(s) set high or low.	
Burst Done:	Produces a pulse coincident with the last cycle of a burst.	
Sequence Sync:	Produces a pulse coincident with the end of a waveform sequence.	
Trigger:	Selects the current trigger signal. Useful for synchronizing burst or gated signals.	
Sweep Sync:	Outputs a pulse at the start of sweep to synchronize an oscilloscope or recorder.	
Sweep Marker:	N/A	Additional pulse for use as sweep marker.
Phase Lock Out:	Used to phase lock two generators. Produces a positive edge at the 0° phase point.	
Signal Level:	Logic levels of <0.8V and >3V for all outputs.	Logic levels of <0.8V and >3V for all outputs except Sweep Sync.
Signal Level: (Sweep Sync. only)	N/A	3 level waveform - as above but plus narrow +1V pulse at marker.

Cursor/Marker Out (TGA124x units only)
Adjustable output pulse for use as a marker in sweep mode or as a cursor in arbitrary waveform editing mode. Can be used to modulate the Z axis of an oscilloscope or be displayed on a second 'scope channel.

	TGA124x	TGA1210x
Signal Level:	Adjustable from nominally 2V to 14V, normal or inverted; adjustable width as a cursor.	N/A
Output Impedance:	600Ω typical	N/A

INPUTS

Trig In

	TGA124x	TGA1210x
Frequency Range:	DC to 1MHz.	
Signal Range:	Threshold nominally TTL level; maximum input ±10V.	Threshold adjustable over ±5V range; maximum input ±10V.
Min. Pulse Width:	50ns, for Trigger/Gate; 50us for Sweep mode.	
Polarity:	Selectable as high/rising edge or low/falling edge.	
Input Impedance:	Typically 10 kΩ.	

Modulation In

	TGA124x	TGA1210x
Frequency Range:	DC to 100kHz.	DC to 100kHz.
VCA Signal Range:	Approximately 1V pk-pk for 100% level change at maximum output.	
SCM Signal Range:	Approximately ± 1Vpk for maximum output.	
Input Impedance:	Typically 1 kΩ.	

Sum In

	TGA124x	TGA12101	TGA12102/4
Frequency Range:	DC to 8MHz.	DC to 30MHz.	DC to 16MHz
Signal Range:	Approximately 2 Vpk-pk input for 20Vpk-pk output.		
Input Impedance:	Typically 1 kΩ.		

Hold
Holds an arbitrary waveform at its current position. A TTL low level or switch closure causes the waveform to stop at the current position and wait until a TTL high level or switch opening which allows the waveform to continue. The front panel MAN HOLD key or remote command may also be used to control the Hold function. While held the front panel MAN TRIG key or remote command may be used to return the waveform to the start. The Hold input may be enabled independently for each channel. Input impedance is 10kΩ.

Ref Clock In/Out

	TGA124x	TGA1210x
Set to Input:	Input for an external 10MHz reference clock. TTL/CMOS threshold level.	
Set to Output:	Buffered version of the internal 10MHz clock. Output levels nominally 1V and 4V from 50Ω.	
Set to Phase Lock:	Used together with SYNC OUT on a master and TRIG IN on a slave to synchronise (phase lock) two separate generators.	

ARB Clock In/Out
TGA1210x generators can use an external signal as the arbitrary waveform clock. The TGA12102 and TGA12104 also include an internal system clock generator (in addition to the individual channel clock generators). The output of this system clock can be made available to drive external circuitry or the input of another generator.

	TGA124x	TGA12101	TGA12102/4
Set to Input:	N/A	Input for an external Arb clock. TTL/CMOS threshold level.	
Set to Output:	N/A	N/A	Outputs System Clock, logic level <0.8V to >3V
Frequency Range:	N/A	DC to 50MHz.	
Max. Input Voltage:	N/A	+5V, -1V.	

MULTI-CHANNEL OPERATION

Channel Relationships:
The channels of a multi-channel unit can be operated entirely independently, as if they were separate generators. The "copy" key allows the settings of any channel to be instantly copied to another when required.
Alternatively, inter-channel relationships of modulation, summing, triggering, or phase locking can be set up.

System Clock: (TGA12102/12104 only)
The TGA12102/12104 units incorporate an additional frequency generator which can be used as a clock source for multi-channel arbitrary waveforms and as an auxiliary output.

	TGA124x	TGA12101	TGA12102/104
Frequency Range:	N/A	N/A	DC to 50MHz.
Frequency Resolution:	N/A	N/A	0·1Hz

The output of the system clock is available as a 1 volt pk-pk sinewave at the Auxiliary Sine Out socket, and as a logic level squarewave at the Ext. ARB In/Out socket.
When not being used as a clock source for multi-channel arbitrary waveforms, the system clock provides an independent fixed amplitude sine or square output which is additional to the two or four main channel outputs.

Inter-channel Modulation:
The waveform from any channel may be used to Amplitude Modulate (AM) or Suppressed Carrier Modulate (SCM) the next channel. Alternatively any number of channels may be Modulated (AM or SCM) with the signal at the MODULATION input socket.

	TGA1242/1244/12102/12104
Carrier frequency:	Entire range for selected waveform.
Carrier waveforms:	All standard and arbitrary waveforms.
Modulation Types:	AM: Double sideband with carrier. SCM: Double sideband suppressed carrier.
Modulation source:	Internal from the previous channel. External from Modulation input socket. The external modulation signal may be applied to any number of channels simultaneously.
Frequency Range:	DC to >100 kHz.
Internal AM Depth:	0% to 105%.
Internal AM Resolution:	1%.
Carrier Suppression (SCM):	> 40dB.
External Modulation Signal Range:	VCA: Approximately 1V pk-pk for 100% level change at maximum output. SCM: Approximately ± 1Vpk for max. output.

Multi Channel Sweep
Any number of channels may be swept simultaneously. Amplitude, Offset and Waveform can be set independently for each channel.
For TGA124x units the sweep parameters will be the same for all channels.
For TGA1210x units the sweep parameters can be set independently for each channel.

Inter-channel Analogue Summing:

Waveform Summing sums the waveform from any channel into the next channel.

Alternatively any number of channels may be summed with the signal at the SUM input socket.

	TGA1242/1244	TGA12102/104
Carrier frequency:	Entire range for selected waveform.	
Carrier waveforms:	All standard and arbitrary waveforms.	
Sum source:	Internal from the previous channel. External from SUM IN socket.	
Frequency Range:	DC to >8MHz.	DC to >16MHz.
External Signal Range:	Approx. 5Vpk-pk input for 20Vpk-pk output.	Approx. 2Vpk-pk input for 20Vpk-pk output.
Input Impedance:	Typically 1 k .	

Inter-channel Phase locking:

Two or more channels may be phase locked together. Each locked channel may be assigned a phase angle relative to the other locked channels. With one channel assigned as the Master and other channels as Slaves, a frequency change on the master will be repeated on each slave thus allowing multiphase waveforms at the same frequency to be easily generated.

The signals from the REF IN/OUT socket and the SYNC OUT socket can be used to phase lock two instruments where more than 4 channels are required.

Different condition apply to Standard waveforms generated using DDS techniques (sine, cosine, haversine, havercosine, triangle, ramps and sinex/x), and those generated using variable clock arbitrary waveform techniques which include square, pulse and pulse train.

Arbitrary waveforms and waveform sequences may be phase locked to the Master channel, but certain constraints apply to waveform lengths and clock frequency ratios.

On the TGA12102/12104, arbitrary waveforms and waveform sequences can alternatively be clocked from a separate internal clock generator (System clock), or from an external clock input (external ARB clock).

When using these clock sources, the restrictions that apply when using the Master channel as the clock source are eliminated. In addition, frequency changes require no settling time to re-establish phase locking, and thus phase continuous frequency changing or sweeping is possible.

	TGA1242/1244	TGA12102/104
Phase Resolution: (DDS waveforms)	0.1 degree.	
Phase Resolution: (Non DDS waveforms)	0.1 degree or 360 degrees/number of points.	
Clock Source:	Master Channel.	Master Channel, System Clock or Ext. ARB clock
Phase Error:	<±10ns.	<±5ns (internal clock) <+/-2ns (external ARB or system clock).

N.B. DDS waveforms are Sine, Cosine, Haversine, Havercosine, Triangle, Ramps and Sin(x)/x. Non DDS waveforms are Pulse, Pulse Train, and all Arbitrary waveforms.

Inter-channel Triggering:

Any channel can be triggered by the previous or next channel.

The previous/next connections can be used to 'daisy chain' a trigger signal from a 'start' channel, through a number of channels in the 'chain' to an 'end' channel. Each channel receives the trigger out signal from the previous (or next) channel, and drives its selected trigger out to the next (or previous) channel. The 'end' channel trigger out can be set up to drive the 'start' channel, closing the loop.

In this way, complex and versatile interchannel trigger schemes may be set up. Each channel can have its trigger out and its output waveform set up independently. Trigger out may be selected from Waveform End, Position Markers, Sequence Sync or Burst Done.

Products illustrated within this brochure

Front Cover: TGA12104, TGA1242, TGA12101. Inside Page: TGA1244

Designed and built in Europe by:

TTi

Thurlby Thandar Instruments Ltd.
Glebe Road, Huntingdon. Cambs. PE29 7DR U.K.
Tel: +44 (0)1480 412451 Fax: +44 (0)1480 450409
Web: www.tti-test.com Email: sales@tti-test.com

INTERFACES

Full remote control and waveform transfer is available through the digital interfaces.

	TGA124x	TGA1210x
IEEE488:	Conforms with IEEE488.1 and IEEE488.2	
RS232:	Variable Baud rate, 9600 Baud maximum.	Variable Baud rate, 38400 Baud maximum.
USB:	N/A	Conforms with USB1.1

GENERAL

	TGA124x	TGA1210x
Display:	20 character x 4 row alphanumeric LCD.	
Data Entry:	Keyboard selection of mode, wave etc., value entry direct by numeric keys or by rotary control.	
Memory Card:	N/A	Removable card slot conforming to the Compact Flash standard. Sizes 32MB to 1GB.
Waveform Storage: (non volatile)	Up to 100 waveforms within 256K words.	Up to 500 waveforms per CF card.
Stored Settings:	Up to 9 full set-ups.	Up to 500 full set-ups per CF card.

MECHANICAL, POWER, COMPLIANCE

TGA:	1241	12101	1242	12102	1244	12104
Width	212mm (½ rack)		350mm			
Height:	130mm (3U)		130mm (3U)			
Length:	335mm		335mm			
Weight:	4.1 kg	4.2kg	7.1kg	5.9kg	7.2kg	6.0kg
Power:	A	B	A	C	A	C
A = 230V, 115V or 100V ±14%, 50/60Hz, adjustable internally B = 230V, 115V or 100V ±14%, 50/60/400Hz, adjustable internally C =100V to 230V ±14%, 50/60/400Hz, universal input						
Maximum VA:	40	60	75	150	100	150
Temperature:	Operating Range +5°C to 40°C, 20-80% RH Storage Range -20°C to + 60°C.					
Environmental:	Indoor use at altitudes to 2000m, Pollution Degree 2					
Safety:	Complies with EN61010-1.					
EMC:	Complies with EN61326.					

SUPPLIED ITEMS

TGA124x	TGA1210x
IEC Mains Lead, RS-232 Lead, Printed Manual (partly multi-language), Multi-language manual on CD, Waveform Manager Plus software.	IEC Mains Lead, RS-232 Lead, Printed Manual, Multi-language manual on CD, Waveform Manager Plus software, USB drivers for Windows on CD, Compact Flash memory card, Compact Flash card reader/writer (USB connection to PC).

Instrument Drivers

Labview and LabWindows CVI drivers are either supplied with the instrument or are available for download without charge from the TTi website.

Options:

19 inch rack mounting kit for one multi-channel generator.
19 inch rack mounting kit for one or two single channel generators.

Thurlby Thandar Instruments Ltd. operates a policy of continuous development and reserves the right to alter specifications without prior notice.