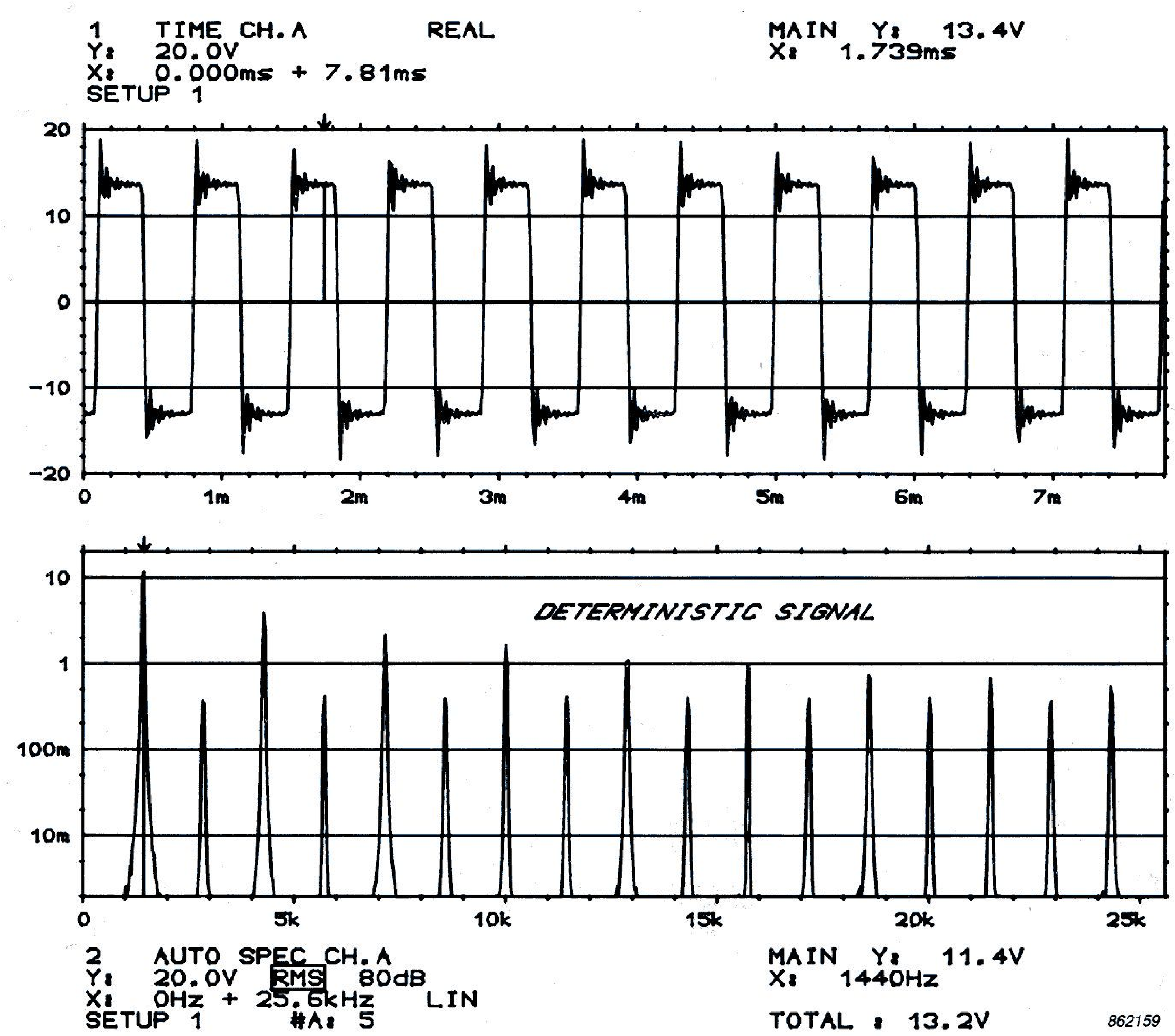
Brüel & Kjær application notes

Choose your units!

The Brüel & Kjær Dual-Channel Signal Analyzers Type 2032 and 2034 allow you to choose the appropriate units to suit your measurement signal, be it deterministic, random or transient. The frequency spectrum can be scaled in terms of:

- Root mean square (RMS)
- Mean square power (PWR)
- Power spectral density (PSD)
- Energy spectral density (ESD)

The noise bandwidth and record length imposed by the analyzer affect the scaling of the frequency spectra. The 2032 & 2034 automatically compensate for this error eliminating the need for rescaling.



Time record and frequency spectrum for a stationary, deterministic signal. The frequency spectrum is scaled as the root mean square of the signal.

Deterministic signals

Stationary, deterministic signals are made up entirely of sine waves at discrete frequencies. The resolution of the frequency analysis is determined by the filter bandwidth used in the analysis. The filter bandwidth should enable the analyser to distinguish between the two most closely-spaced frequency components. This means that only one sinusoid must be in the filter passband at any one time. If this is the case, then the power transmitted by the filter is independent of the bandwidth. Therefore, the averaged frequency-spectrum of a deterministic signal should be scaled in terms of mean square power (PWR) or the root mean square (RMS).

The above figure shows the time record and frequency spectrum for a deterministic signal. The "TOTAL" field gives the total power or total RMS of the displayed function. Alternatively the delta cursor can be used, in which case the "ΔTOTAL" field gives the total power within the band selected by the delta cursor, and the "Δ/TOTAL" field gives the fraction of the total power within the band selected using the delta cursor.

Each type of time-weighting function produces a different number of frequency lines in the filter bandwidth. This affects the magnitude of the power transmitted through the filter. But the 2032 & 2034 automatically scale the power spectrum according to the type of time-weighting function used. This ensures that the value of the power spectrum found, using the main or delta cursor, is correct and independent of the time-weighting function.

Random signals

Random signals have a spectrum which is continuously distributed with frequency. Consequently there is a continuous frequency distribution within the filter passband. Accordingly, the power transmitted by the filter is dependent on the filter bandwidth, i.e. the resolution of the analyzer. For a relatively flat spectrum, it is possible to remove the influence of the filter bandwidth by dividing the transmitted power by the bandwidth. This normalizes the result to a mean square spectral density, often called the power spectral density (PSD) which is a measure of the power per unit bandwidth.

Figure 1 shows the time record and power density spectrum for a random signal. The effective noise bandwidth is determined by the type of time-weighting function used in the analy-

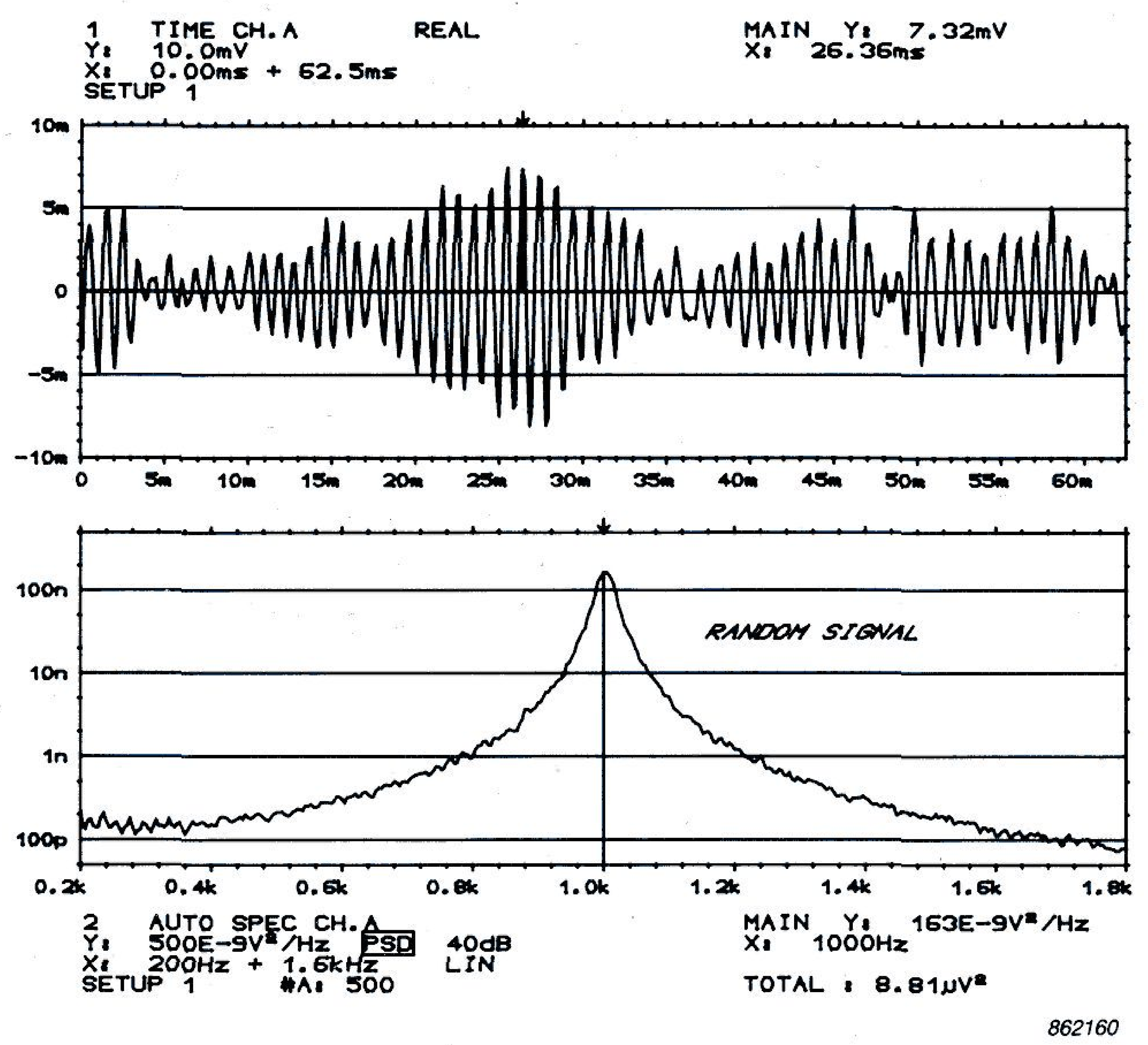


Fig. 1. Time record and frequency spectrum for a stationary, random process. The frequency spectrum is scaled as the power spectral density.

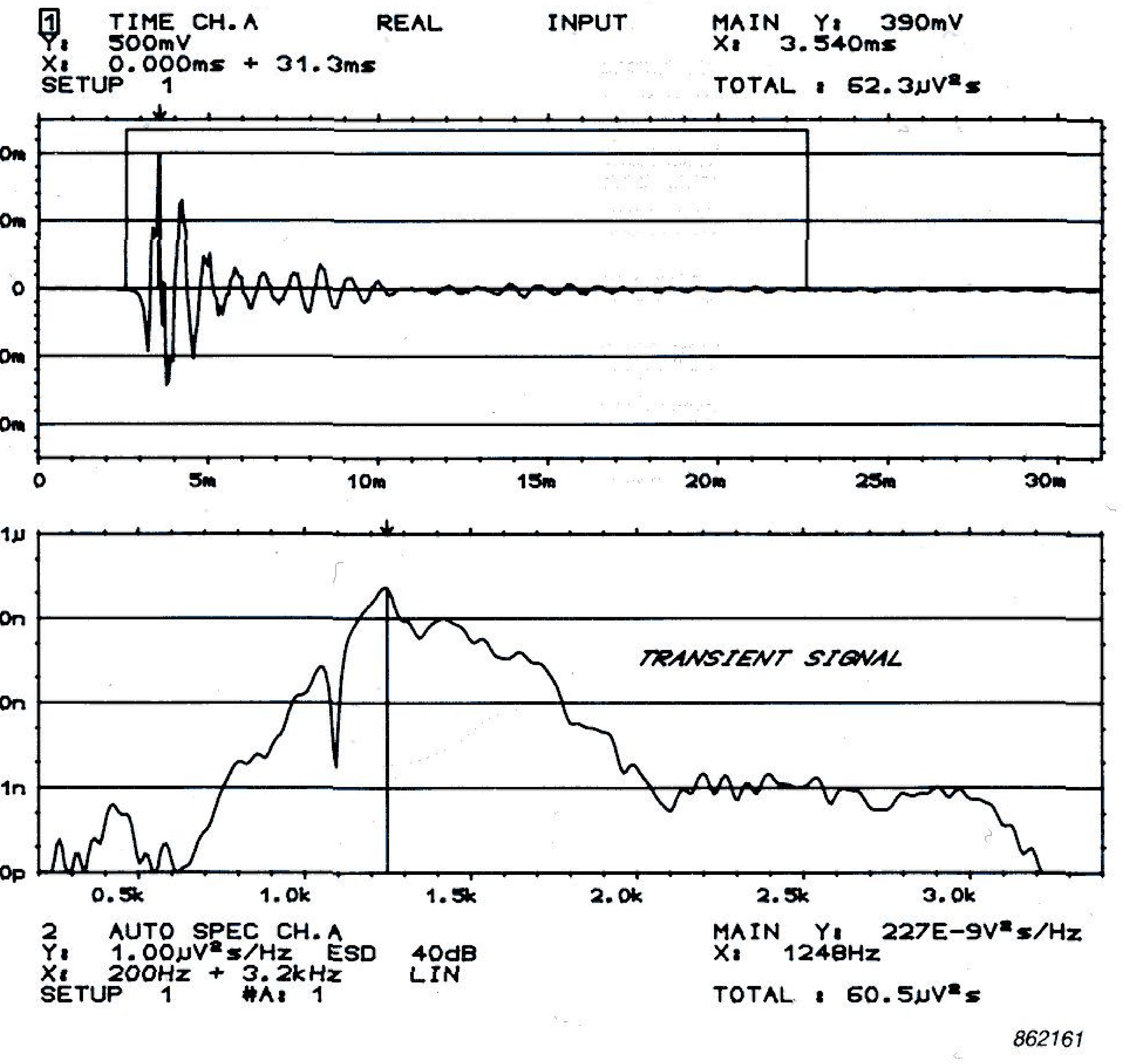


Fig. 2 .Time record and frequency spectrum for a transient signal. A transient time-weighting function is used in the analysis of the time record, and the frequency spectrum is scaled as the energy spectral density.

sis, and affects the magnitude of the power spectrum. The 2032 & 2034 automatically compensate for the noise bandwidth according to time-weighting function used. This ensures that the main and delta cursors read correctly.

Transient signals

A transient is a signal which starts and finishes at zero, as shown in Fig. 2. This signal contains a finite amount of energy and so cannot be characterized in terms of power, since the power is dependent on the record length: the longer the time window, the lower the average power. Transient signals also have a spectrum continuously distributed with frequency. Consequently, the transmitted power must be normalized with respect to the filter bandwidth and rescaled according to the record length. This results in an energy per unit bandwidth, often termed energy spectral density (ESD).

Figure 2 shows the time record and energy density spectrum for a transient signal. Transients must be analyzed using an equal time-weighting function across the signal. To achieve this, a rectangular weighting (no weighting) or a transient weighting function should be used, depending on the length of the transient. An exponential window can be used for transients which do not decay within the record length.

Type of Signal	Spectrum Unit (Scaling)	Units	
		Absolute	Relative
Deterministic	RMS (Root Mean Square)	u	e.g. dB re 1 u
	PWR (Power)	u^2	e.g. dB re 1 u^2
Random	PSD (Power Spectral Density)	u^2/Hz	e.g. dB re 1 u^2/Hz
Transient	ESD (Energy Spectral Density)	u^2s/Hz	e.g. dB re 1 u^2s/Hz

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Table 1. A summary of the scaling units used for different signal types.

Summary

An analysis of a signal using a Brüel & Kjær Type 2032 or 2034 results in a frequency spectrum which is scaled independently of the measurement time and frequency resolution of the analysis. The appropriate spectrum scaling units are summarized in Table 1 for the different types of signals.

Brüel & Kjær

WORLD HEADQUARTERS: DK-2850 Nærum · Denmark · Telephone: +45 2 80 05 00 · Telex: 37316 bruka dk

Australia (02) 450-2066 · Austria 02235/7550*0 · Belgium 02·242-97 45 · Brazil 246 8149 · Canada (514) 695-8225 · Finland (90) 80 17 044 · France (1) 64 57 20 10
Federal Republic of Germany (04106) 4055 · Great Britain (01) 954-2366 · Holland 03402-39994 · Hong Kong 5-487486 · Italy (02) 52 44 141
Japan 03-435-4813 · Republic of Korea 02-793-6886 · Norway 02-78 70 96 · Singapore 225 8533 · Spain (91) 268 10 00 · Sweden (08) 711 27 30 · Switzerland (042) 65 11 61
Taiwan (02) 713 9303 · USA (617) 481-7000 · Local representatives and service organisations world-wide

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