Calibration of digital recorders to EN 601083-1

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1. INTRODUCTION

This paper describes a system set up to provide calibrations of the digital recorders used in high voltage measurements. A high voltage impulse can be up to several megavolts peak and a few microseconds long. A high voltage divider is used to reduce the voltage to a measurable level. The output of the divider is read by a digital recorder.

The calibrations are in accordance with the requirements of EN 601083-1 and cover

- Timebase
- Risetime
- Impulse scale factor
- Static and dynamic non-linearity
- Internal noise level
- Ripple tests
- Static scale factor

The measurements described were made on a Nicolet Power Pro 610 instrument but the principles are applicable to any instrument.

2. MEASUREMENTS

2.1 Timebase measurements

The standard specifies that the accuracy of the digitiser should be < 0.1% and that the integral non-linearity of the timebase shall be less than 2% of the time interval to be measured.

However, the specified uncertainty in typical instruments is much better than this and may be specified as, for example, < 0.001%. It was decided to calibrate the instrument to the more restrictive requirement of its specification.

A stable sinusoidal wave of measured frequency (to within the uncertainties appropriate for the instrument being calibrated) is recorded on the digitiser. Measurements were carried out using the minimum time increment of 13 ns and 1000 points. A frequency of 0.301 MHz gave approximately 100 zero crossings. Software is used to analyse the applied waveform to determine accurately the zero crossing points, correcting for any non-linearities in the amplitude of the applied waveform. A linear least squares fit is made to determine the error in crossing-time versus the true crossing-time (as defined by the frequency source).
This method showed that the timebase was within ±0.0008% of nominal over a 130 μs period.

An alternative method, looking over a much longer timescale of 1.3 s, and using the cursors on the instrument indicated that the timebase was within ±0.00009% of nominal.

2.2 Risetime Measurements

The risetime was measured using a step pulse with a transition duration of < 1 ns. The terms risetime and falltime are used interchangeably since the direction of the transition is not important.
The measurements were carried out using Reed Relay Pulse Generator (RRPG) developed at NPL. The circuit is shown in Figure 1. and the specification is shown below

Risetime/falltime into 1 MΩ: 0.628 ± 0.035 ns

Voltage range into 1 MΩ: 0.1 - 50 V

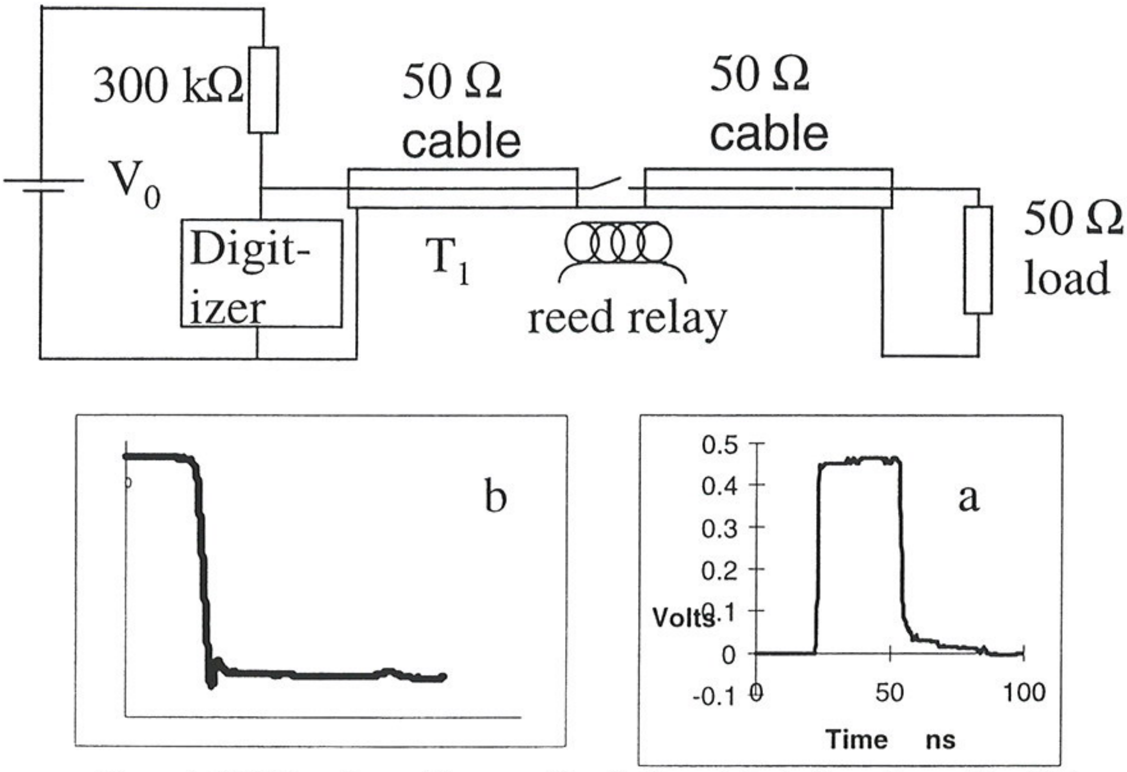

Figure 1. RRPG configured for use with a digitiser. A typicalwaveform at the 50Ω load is shown at (a). The waveform at the digitiser is shown at (b).

The line operates as follows:

- 50 Ω line T_1 is initially charged to some potential $V_c \approx 0.77\ V_0$ for a digitiser with 1 MΩ input impedance;
- when the relay is closed a pulse of amplitude $V_c/2$ propagates in both directions;
- the pulse travelling to the left takes time T_1 to reach the high impedance load of the digitiser and the 300 kΩ charging resistor. (The latter resistor is used to ensure a high impedance or open circuit relative to the 50 Ω line);
- the pulse is reflected by the "open circuit", producing a transition from V_c to zero volts, resulting in a pulse of length $2T_1$ travelling to the right into the 50Ω load;
- the pulse travelling to the right is terminated in the 50Ω load giving a voltage of $V_c/2$.

The risetime of the RRPG pulse, travelling to the right into the 50 Ω load is determined by the quality of the switch, cable and load and therefore places an upper limit on the risetime of the pulse at the switch.
The falltime of the pulse, travelling left through the cable T_1 into the high impedance load or near open circuit load is determined by the former, together with the reflection at the open circuit, the length of cable T_1, the quality of the switch and the quality of the open circuit.

The falltime was measured for a range of voltages (positive and negative) from 1 V to 39 V; no significant dependence on polarity or voltage was observed.

The risetime of of the digitiser was measured as (20 ± 6) ns. This translates to a bandwidth of 17.5 MHz (assuming a risetime.bandwidth product of .35) slightly lower than the 25 MHz specified by the manufacturer, but within the requirements of the standard.