KERNFORSCHUNGSZENTRUM

KARLSRUHE

August 1972

KFK 1660

Labor für Elektronik und Meßtechnik

CAMAC – Specification of Amplitude Analogue Signals Proposal of the ESONE Working Group on Analogue Signals for EUR 5100 (1973) and Comments

K. Tradowsky

GESELLSCHAFT FUR KERNFORSCHUNG M. B. H.

KARLSRUHE

GESELLSCHAFT FÜR KERNFORSCHUNG M.B.H.
KARLSRUHE

KERNFORSCHUNGSZENTRUM KARLSRUHE

August 1972 KFK 1660

Labor für Elektronik und Meßtechnik

CAMAC – Specification of Amplitude Analogue Signals
Proposal of the ESONE Working Group on Analogue Signals for EUR 5100 (1973)
and Comments

K. Tradowsky*

* Editor, Chairman of the ESONE Working Group on Analogue Signals

Gesellschaft für Kernforschung m.b.H., Karlsruhe

Abstract

The EURATOM Report EUR 4100e defines the essential features of the CAMAC system of instrumentation. This system is primarily for on-line use with digital controllers or computers. This report specifies amplitude analogue signals which are recommended for use by CAMAC compatible units and summarises the contents of EUR 5100 (1972) and its extension published as KFK 1641.

There are two classes of signals according to whether their rise times are shorter or longer than 30 ns (corresponding to a 3 db cutoff frequency of approximately 11 MHz). For signals with rise times longer than 30 ns the + 5 volt class (5PB) with 50 Ω output and a matched or unmatched termination is recommended. For signals with rise times shorter than 30 ns the – 1 volt class (1NB) with a terminated 50 Ω system is recommended.

In Part B comments of the ESONE Working Group are given for explanation.

Zusammenfassung

Der EURATOM-Bericht EUR 4100e legt die wesentlichen Merkmale des CAMAC-Systems für Instrumentierungen fest. Dieses System ist in erster Linie für den on-line Betrieb mit digitalen Steuerungen oder Rechnern bestimmt. Dieser Bericht enthält die Spezifikation der Amplituden-analogen Signale, die für CAMAC-kompatible Einheiten empfohlen werden, und faßt den Inhalt von EUR 5100 (1972) und dessen Erweiterung, die als KFK 1641 veröffentlicht wurde, zusammen.

Es gibt zwei Klassen von Signalen, danach eingeteilt, ob ihre Anstiegszeit kürzer oder länger als 30 ns ist (das entspricht einer 3-dB-Grenzfrequenz von ungefähr 11 MHz). Für Signale mit Anstiegszeiten länger als 30 ns wird die + 5 V Klasse (5PB) mit 50-Ω-Ausgang und einem angepaßten oder unangepaßten Abschluß empfohlen. Für Signale mit Anstiegszeiten kürzer als 30 ns wird die – 1 V Klasse (1NB) mit einem abgeschlossenen 50-Ω-System empfohlen.

In Teil B des Berichtes wird die Spezifikation von der ESONE Working Group kommentiert und erläutert.

Contents

Part A

CAMAC

A MODULAR INSTRUMENTATION SYSTEM FOR DATA HANDLING

Specification of Amplitude Analogue Signals

ABSTRACT

The EURATOM Report EUR 4100e defines the essential features of the CAMAC system of instrumentation. This system is primarily for on-line use with digital controllers or computers. This document specifies amplitude analogue signals which are recommended for use by CAMAC compatible units and summarises the contents of EUR 5100 (1972) and its extension published as KFK 1641.

There are two classes of signals according to whether their rise times are shorter or longer than 30 ns (corresponding to a 3 db cutoff frequency of approximately 11 MHz). For signals with rise times longer than 30 ns the + 5 volt class (5PB) with 50 Ω output and a matched or unmatched termination is recommended. For signals with rise times shorter than 30 ns the – 1 volt class (1NB) with a terminated 50 Ω system is recommended.

Draft Text
ESONE Working Group on Analogue Signals
Harwell July 1st, 1972

Contents

1. INTRODUCTION

The EURATOM Report EUR 4100e defines the essential features of the CAMAC system of instrumentation. This system is primarily for on-line use with digital controllers or computers.

Representatives of European Research Laboratories, under the auspices of the ESONE Committee (Appendix 2), have agreed to recommend standard analogue signals for use with the CAMAC system.

This specification is published to ensure compatibility between CAMAC units which process analogue signals.

The signals are classified according to whether their rise times[1] are shorter or longer than 30 ns:

Class 5PB[2]:	$t_r > 30$ ns	$f_c < 11$ MHz
Class 1NB[2]:	$t_r < 30$ ns	$f_c > 11$ MHz

These signals must satisfy the mandatory statements appropriate to their class.

The technical features of any equipment must meet the outlined specifications only within the designed frequency range.

2. INTERPRETATION OF THIS DOCUMENT

This document is the reference text describing and specifying amplitude analogue signals for use by units which conform to the CAMAC specification EUR 4100e (1972). Authorised translations are available in French, German and Italian.

Statements which specify mandatory aspects of the standard are written in bold type and blocked in, as here, and are usually accompanied by the word "must".

The word "should" indicates a recommended or preferred practice which is to be followed unless there are sound reasons to the contrary.

The word "may" indicates good practice but leaves freedom of choice to the designer.

In order to claim compatibility with this specification a signal must comply with the mandatory statements in this document.

An amplitude analogue signal is one whose amplitude conveys significant information. This specification applies both to continuous and to pulse-like electrical signals. In the latter case, the amplitude may be significant during a portion of the waveform (e.g. as for peak pulse amplitude analysis) or throughout the duration of the waveform (e.g. as for pulse shape analysis).

---

1 A practical relationship between the upper 3 db cutoff frequency (f_c) and rise time (t_r) of a pulse-like signal, defined as the time interval between the 10 and 90 percentile points, is approximately given by $t_r \cdot f_c \approx 0.34$.

2 The classification is in accordance with IEC Publication 323. The code is voltage, polarity, output impedance (B: 50 Ω).

The standards defined below must be used for analogue signals which are input or output through connectors on the front panel of CAMAC compatible units, or at the back of CAMAC compatible units above the Dataway, unless there are strong technical reasons to the contrary.

There may, however, be special circumstances requiring some deviations from this specification to suit a specific equipment with which the CAMAC compatible unit is closely associated. In such cases, these deviations are tolerated until further CAMAC and/or IEC specifications are available for use.

3. SPECIFICATION OF AMPLITUDE ANALOGUE SIGNALS

The signals are classified according to whether their rise times are shorter or longer than 30 ns:

Class 5PB[2]:	$t_r > 30$ ns	$f_c < 11$ MHz
Class 1NB[2]:	$t_r < 30$ ns	$f_c > 11$ MHz

The specification given below is summarised in Table I.

3.1. Output Characteristics

3.1.1. Output Voltage Range

Class 5PB: The working range of an output EMF must be 0 V to 5 V.

Class 1NB: The working range of an output voltage across a 50 Ω load must be 0 V to 1 V.

3.1.2. Maximum Output Voltage

The absolute maximum range of an output must be – 7.5 V to + 7.5 V for both classes.

The absolute maximum range of an output voltage across a 50 Ω load must be – 3.75 V to + 3.75 V for both classes.

3.1.3. Output Current Range

Class 5PB: The output must be able to provide 5 mA.

The output should be able to provide 50 mA.

3.1.4. Output Polarity

Class 5PB: **An output must provide positive polarity.**

Provision should also be made for negative polarity.

Class 1NB: **An output must provide negative polarity.**

Provision may also be made for positive polarity.

3.1.5. Output Impedance

Class 5PB: **The output impedance must be 50 Ω ± 5 %.**

Class 1NB: The output impedance should be 50 Ω ± 10 %.

The output impedance of a current or a voltage source may also be used.

3.1.6. Output Protection

An output must be able to withstand connection to 0 V without damage under all working conditions for both classes.

3.2. Input Characteristics

3.2.1. Input Impedance

Class 5PB: **An unterminated input must have a high impedance of which the resistive component is greater than 5000 Ω.**

A terminated input must have an input impedance of 50 Ω ± 5 %.

Class 1NB: **The input impedance must be 50 Ω with a tolerance of ± 5 % for $t_r \geqslant 3$ ns.**

The tolerance must not exceed ± 10 % for 3 ns $> t_r \geqslant 1$ ns.

3.2.2. Input Voltage Range

The working range of the input voltage must be consistent with the output voltage range specification of 3.1.1.

3.2.3. Input Polarity

Class 5PB: **An input must accept positive polarity.**

Provision should also be made to accept negative polarity.

Class 1NB: **An input must accept negative polarity.**

Provision should also be made to accept positive polarity.

3.2.4. Input Protection

Class 5PB: **An unterminated input must withstand any voltage in the range – 15 V to + 15 V.**
A terminated input must withstand any voltage in the range – 4 V to + 4 V.

Class 1NB: **An input must withstand any voltage in the range – 4 V to + 4 V.**

4. CONNECTORS AND CABLES

4.1. Coaxial Connector

For coaxial connectors, the LEMO 00250 (50 Ω impedance) connector or any other type of connector whose mating conditions are compatible with it must be used.

4.2. Coaxial Cable Impedance

The characteristic impedance of coaxial cables used for these amplitude analogue signals must be 50 Ω ± 5 %.

TABLE I

AMPLITUDE ANALOGUE SIGNALS FOR CAMAC

Class 5 PB:	$t_r > 30$ ns	$f_c < 11$ MHz
Class 1 NB:	$t_r < 30$ ns	$f_c > 11$ MHz

CHARACTERISTICS	CLASS	OUTPUTS	INPUTS	
			Terminated	Unterminated
Working Voltage Range	5PB	0 V to + 5 V*	0 V to + 2.5 V*	0 V to + 5 V*
	1NB	0 V to – 1 V† across a 50 Ω load	0 V to – 1 V†	——
Impedance	5PB	50 Ω ± 5 %	50 Ω ± 5 %	> 5000 Ω
$t_r \geqslant 3$ ns	1NB	50 Ω ± 10 % ‡	50 Ω ± 5 %	——
3 ns $> t_r \geqslant 1$ ns	1NB	50 Ω ± 10 % ‡	50 Ω ± 10 %	——
Absolute Maximum Voltage Range	5PB	– 7.5 V to + 7.5 V	– 4 V to + 4 V	– 15 V to + 15 V
		– 3.75 V to + 3.75 V across a 50 Ω load	– 4 V to + 4 V	– 15 V to + 15 V
	1NB	– 7.5 V to + 7.5 V	– 4 V to + 4 V	——
		– 3.75 V to + 3.75 V across a 50 Ω load	– 4 V to + 4 V	——

* Provision for negative polarity should also be made.

† Provision for positive polarity may also be made.

‡ The output impedance of a current or a voltage source may also be used.

Appendix 1

RELATED SPECIFICATIONS

CAMAC: A Modular Instrumentation System for Data Handling. Revised Description and Specification.

Euratom Report EUR 4100e (1972), Commission of the European Communities, Luxembourg, 1972

(technically identical with: TID–25875)

CAMAC: Organisation of Multi-Crate Systems. Specification of the Branch Highway and CAMAC Crate Controller Type A.

Euratom Report EUR 4600e, Commission of the European Communities, Luxembourg, 1972

(technically identical with: TID–25876)

CAMAC: A Modular Instrumentation System for Data Handling. Specification of Amplitude Analogue Signals.

Euratom Report EUR 5100e (1972) (to be published in 1972)

Standard Instrument Modules

Report TID–20893 (Revision 3), United States Atomic Energy Commission, 1969

Appendix 2

THE ESONE COMMITTEE

The Committee comprises representatives from laboratories, institutes and organisations that have an interest in the compatibility of electronic equipment.

The Committee has a permanent Secretariat. When the Committee is not in session its business is handled by an Executive Group consisting of the secretary and one representative from each of C.E.R.N., Euratom, C.E.A. France, U.K. Nuclear Laboratories, Deutsche Studiengruppe für Nukleare Elektronik, and C.N.E.N. Italy. These representatives are nominated by their respective organisations. The Chairman of the Executive Group is also the Chairman of the ESONE Committee and is chosen annually from the nominated representatives.

A list of member laboratories is given in this Appendix. Further information about current membership and nominated representatives on the Committee and Executive Group can be obtained from the Secretary*.

This document is issued with the approval of the Executive Group. Any questions relating to the interpretation of this document should be submitted to the Secretary. Any points that cannot be cleared by him will be referred to the Executive Group for resolution.

Users of this document who wish to be informed of any future revisions should inform the Secretary.

* Address of the Secretary: Dr. W. Becker, Euratom C.C.R., I–21020 Ispra (VA), Italy
Telephone: Italy (39), Varese (332), 780131 Extension 245.
Telex Number: 38042.

Membership of the ESONE Committee

International	European Organization for Nuclear Research (CERN)	Genève, Switzerland
	Centro Comune di Ricerca (Euratom CCR)	Ispra, Italy
	Bureau Central de Mesures Nucléaires (Euratom BCMN)	Geel, Belgium
	Institut Max von Laue – Paul Langevin	Grenoble, France
Austria	Studiengesellschaft für Atomenergie (SGAE)	Wien
Belgium	Centre d'Etude de l'Energie Nucléaire (CEN)	Mol
Denmark	Forsögsanläg Risö	Roskilde
France	Centre d'Etudes Nucléaires de Saclay (CENS)	Gif-sur-Yvette
	Centre d'Etudes Nucléaires de Grenoble (CENG)	Grenoble
	Laboratoire de l'Accélérateur Linéaire, Faculté des Sciences	Orsay
Germany	Deutsche Studiengruppe für Nukleare Elektronik (SGNE), c/o Physikalisches Institut der Universität	Marburg
	Deutsches Elektronen-Synchrotron (DESY)	Hamburg
	Hahn-Meitner-Institut für Kernforschung Berlin GmbH (HMI)	Berlin (West)
	Kernforschungsanlage Jülich (KFA)	Jülich
	Gesellschaft für Kernforschung (GFK)	Karlsruhe
	Institut für Kernphysik der Universität	Frankfurt
Greece	Nuclear Research Center "Democritus"	Athens
Hungary	Hungarian Academy of Sciences, Central Research Institute for Physics	Budapest

Italy	Comitato Nazionale Energia Nucleare (CNEN)	Roma
	Comitato Nazionale Energia Nucleare, Laboratori Nazionali	Frascati
	Comitato Nazionale Energia Nucleare, Centro Studi Nucleari	Casaccia
	Centro Studi Nucleari Enrico Fermi (CESNEF)	Milano
	Centro Informazioni Studi Esperienze (CISE)	Milano
	Istituto di Fisica dell'Università	Bari
Netherlands	Reactor Centrum Nederland (RCN)	Petten
	Instituut voor Kernphysisch Onderzoek (IKO)	Amsterdam
Poland	Instytut Badań Jądrowych	Swierk/Otwocka
Sweden	Aktiebolaget Atomenergi Studsvik	Nyköping
Switzerland	Institut für Angewandte Physik der Universität	Basel
United Kingdom	Atomic Energy Research Establishment (AERE)	Harwell
	Rutherford High Energy Laboratory (RHEL)	Chilton
	Daresbury Nuclear Physics Laboratory (DNPL)	Daresbury
	United Kingdom Atomic Energy Authority, Culham Laboratory	Abingdon
	Department of Nuclear Physics, University of Oxford	Oxford
Yugoslavia	Boris Kidrič Institute of Nuclear Sciences	Vinča, Beograd

Affiliated Laboratory

Canada	TRIUMF Project University of British Columbia	Vancouver

Part B

Comments

of the ESONE Working Group on Analogue Signals to the

Proposal for the Specification of Amplitude Analogue Signals (EUR 5100 [1973])

O. Fromhein

K. Tradowsky, Chairman

Contents

1. Introduction

In the Euratom Report EUR 4100 amplitude analogue signals are not specified. This problem was first discussed at the ESONE General Assembly 1968 in Rome. At that time the main interest of the conference was to publish EUR 4100 as soon as possible. Therefore it was impossible to specify amplitude analogue signals because of lack of time. In order to intensify this discussion and to come to a proposal for the General Assembly an Analogue Signals Working Group was established and K. Tradowsky, Head of the Laboratory of Electronics and Measurements from the Nuclear Research Center Karlsruhe, was elected as Chairman (1968, Rome).

The Working Group discussed the problems of analogue signals in every detail with view at future aspects and held the following meetings:

Karlsruhe on 1st and 2nd July, 1969

Participants:

Fischer, P.-M.	GFK, Karlsruhe
Friese, T.	HMI, Berlin
Konrad, H.	GFK, Karlsruhe
Lecomte, J.	CEN, Grenoble
Neuburger, E.	GFK, Karlsruhe
Patzelt, R.	SGAE, Wien
Richards, J. M.	AERE, Harwell
Sattler, E.	EURATOM, Geel
Schär, F.	Universität Basel
Tradowsky, K., Chairman	GFK, Karlsruhe

Received comments for the topics from:

Costrell, L.	NBS, Washington, D.C.

Frankfurt on 5th and 6th May, 1970

Participants:

Barthel, H.	Universität Frankfurt
Friese, T.	HMI, Berlin
Halling, H.	SGAE, Wien
Kessel, W.	Universität Frankfurt
Iselin, F.	CERN, Genève
Richards, J. M.	AERE, Harwell
Sattler, E.	EURATOM, Geel
Schär, F.	Universität Basel
Tradowsky, K., Chairman	GFK, Karlsruhe

Received comments for the topics from:

Costrell, L.	NBS, Washington, D.C.
Lang, A.	CERN, Genève
Lecomte, J.	CEN, Grenoble
Manfredi, P. F.	CESNEF, Milano
Playford, V. J.	AERE, Harwell
Sarquiz, M.	CEN, Saclay

Karlsruhe on 21st and 22nd February, 1972

Participants:

Barthel, H.	GFK, Karlsruhe
Fischer, P.-M.	GFK, Karlsruhe
Friese, T.	HMI, Berlin
Fromhein, O.	GFK, Karlsruhe
Guillon, H.	CEN, Saclay
Hagelberg, R.	CERN, Genève
Kurz, R.	KFA, Jülich
Manfredi, P. F.	CESNEF, Milano
Sattler, E.	EURATOM, Geel
Tradowsky, K., Chairman	GFK, Karlsruhe
Urban, H.-J.	Universität Freiburg

Received comments for the topics from:

Proposal of the AEC NIM Working Group on Analog Signals	
Iselin, F.	CERN, Genève

Harwell on 28th – 30th June, 1972

Participants:

Barthel, H.	GFK, Karlsruhe
Bisby, H.	AERE, Harwell
Friese, T.	HMI, Berlin
Fromhein, O.	GFK, Karlsruhe
Kurz, R.	KFA, Jülich
Sattler, E.	EURATOM, Geel
Tradowsky, K., Chairman	GFK, Karlsruhe

Received comments for the topics from:

Manfredi, P. F.	CESNEF, Milano
Porat, D. (Chairman of the AEC NIM Working Group on Analog Signals)	SLAC, Stanford, Cal.
Thielmann, R.	Universität Marburg

The first proposal of the Working Group was discussed at the Geneva General Assembly 1970. The main essence of the proposal was a system with an EMF of -5 V with a 50 Ω output termination. For longer rise times it was considered to use a high impedance input, and for shorter rise times a 50 Ω input termination was thought to be applicable, which means -2.5 V across 50 Ω. Furthermore a -1 V range was provided for very high frequency signals with a 50 Ω input termination.

The discussion of the Working Group showed very clearly that it was impossible to find a compromise between all existing analogue signal levels and polarities. A large number of standards is specified in the IEC Publication 323 (1970) [1], but the discussion of the Working Group showed that there are no technical reasons for so many voltage levels.

The main point was to find a standard which covers as many technical advantages as possible. On the other hand it was important to achieve compatibility with NIM, for currently a lot of NIM units must be used in combination with CAMAC modules. In addition the new standard must lead to the same accuracy in pulse height analysis as it is achieved with the best nowadays equipment. It was also considered important to work within the recommendations of the IEC Publication 323 (1970) [1]. So the Working Group decided to use the 5 V range.

During the discussion about signals with rise times shorter than 30 ns it only seemed to be possible to use the negative polarity. This is due to technical reasons arising from the use of active components and the negative polarity of digital signals and the also negative polarity of many modules which do not provide the positive polarity. Therefore it was decided to use the negative polarity for these signals.

We had a very long discussion on the polarity of the signals with rise times longer than 30 ns, reaching the culmination at the Geneva Conference. The Working Group proposed to use the negative polarity for these signals, too, for no significant technical reasons have been found for either polarity. The positive sign is based on historical reasons only and would once have been meaningful and desirable because of the compatibility with NIM. However, all modern NIM equipment is designed to accept pulses with both polarities. Therefore compatibility with NIM is safeguarded even if negative polarity is chosen. Negative polarity corresponds to the polarity of the digital signals specified in EUR 4100 (1972) [2].

At the Geneva Conference the Working Group proposal was also discussed with the American colleagues (Representative: L. Costrell, Chairman of the US AEC NIM Committee). It was a somewhat unhappy discussion, for Mr. Costrell was argueing for the positive NIM polarity. It was impossible to convince him, that the compatibility with NIM is achieved with the negative polarity because the manufacturers have already provided the use of both polarities. The representatives of the European Laboratories accepted the change of the polarity, for they must always buy some equipment from the U. S.. The proposal was recommitted to the Working Group for further action. After the revision of the paper was done by the Working Group the Executive Group decided to omit the Chapter 4.3. "Very High Frequency Signals" to avoid any further controversy because of the polarity.

During the period between the conferences in Geneva and Paris (1971) the question about the future of the fast signal specification grew more and more serious, since further details were urgently needed for the design of high frequency units. At the conference in Paris the Chairman of the Working Group on Analogue Signals reported on this still unsolved problem and introduced a recommendation for the further procedure. The conference decided: The Euratom Report EUR 5100 (1972) [3] should be published as soon as possible. The polarity is positive, very high frequency signals should be left out as proposed by the Executive Group. The Working Group should prepare an extension of EUR 5100, dealing with shorter rise time signals. This should be done in strong cooperation with the US AEC NIM Working Group. After this a new Euratom Report EUR 5100 should be published describing both classes of signals.

The Extension of EUR 5100 (1972) and the EUR 5100 (1973) were discussed by the Working Group at two meetings in 1972. The Working Group decided to publish the Extension of EUR 5100 (1972) only as a KFK Report (KFK 1641 [4]) to make the procedure as easy as possible. The final text of the EUR 5100 (1973) is covering both classes of signals and will be published very soon, because the technical parts are already agreed upon. The only new part is a shift of rise times with the corresponding frequency ranges for those signals described in the Extension (KFK 1641), but we hope that this will be agreed upon. The explanations for the decisions are given below.

2. Comments to the Abstract

The Working Group decided to bring the main technical ideas into the abstract. This was done to give technical information to a reader of one of the international abstracts publications, (e.g. INIS, Nuclear Science Abstracts, Electrical and Electronics Abstracts) where the abstract will be cited if given.

3. Comments to 1. Introduction

The Working Group decided to omit the word "Nuclear" in "European Nuclear Research Laboratories", for there are now Laboratories in the ESONE Committee not only working in the Nuclear Research field.

4. Comments to 2. Interpretation of this Document

According to an American proposal the Working Group agreed to add the words "blocked in" in the explanatory part in order to be consequent with the procedure of blocking the must-statements.

5. Comments to 3. Specification of Amplitude Analogue Signals

The need for the interaction of information handling systems between CAMAC units led to the necessity of specifying amplitude analogue signals which convey the significant information in a well defined form. Whatever characteristic of a signal is chosen to transmit some information, we can restrict our consideration to the following very general communication system.

This system will include a transmitter, this may be a transducer generating an electrical signal as a response of a physical effect, a transmission system over which the signal is transmitted, this may be a transmission line, a filter etc., and a signal processor which produces at its output the desired information.

Since the transmission systems are restricted in the available bandwidth, there evolve limitations on the transmitted signal. In the design of transmission networks the frequency concept is widely used, whereas the rise time concept is often preferred in describing the responses in the time domain. Both concepts are related to each other depending on what criterion is chosen. Conclusions as to which bandwidth requirements are needed must agree with the transient analysis.

If the output has to be a reproduction of the input with high fidelity the required system bandwidth will be much greater compared with an output which contains only the most significant energy share. The output signal will then be a distorted replica of the input, but it may be good enough for further evaluation.

Besides other definitions we refer to the frequency bandwidth of a low-pass system as being the frequency interval between zero and the 3 db cutoff points. In particular, the rise time is defined here as the time interval between 10 and 90 per cent of the final value of the output unit step response. Unfortunately both characteristics show no general relation, that means, changing the transmission system a different relationship will result.

The following examples demonstrate the situation for a unit step input function at the output of an ideal low-pass filter and a Gaussian type low-pass filter.

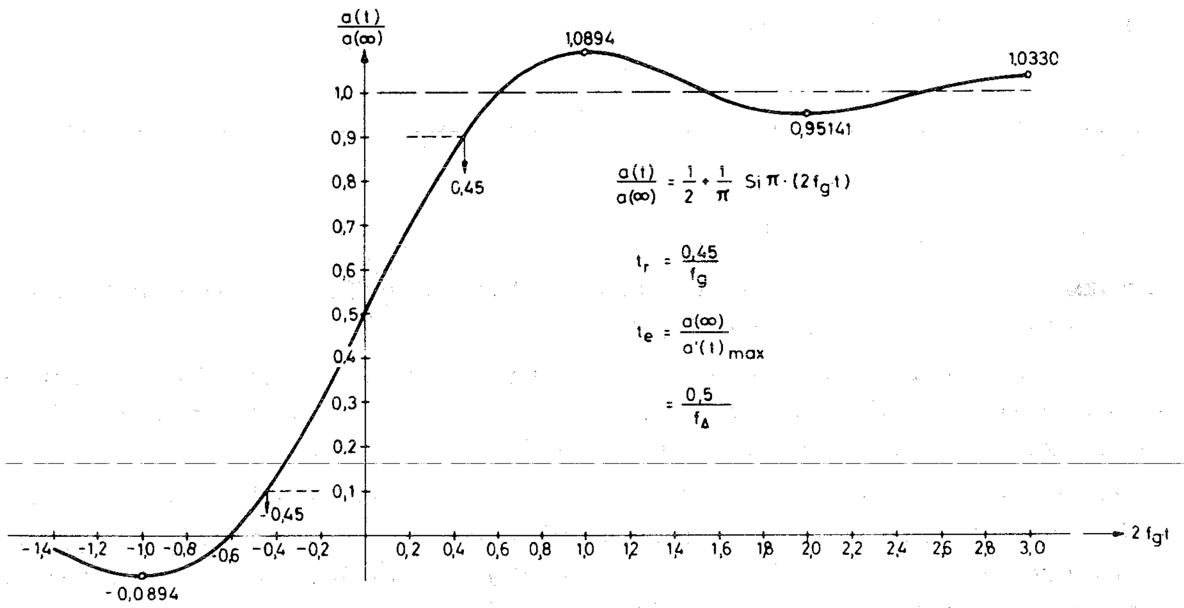


Fig. 1 Unit Step Response of an Ideal Low-Pass Filter

The response of the ideal low-pass filter is:

$$a(t) = a_0 \cdot [0.5 + 1/\pi \cdot Si(\pi \cdot 2f_g t)]$$

with f_g being the cutoff frequency point.

The evaluation yields the relation:

$$f_g \cdot t_r = 0.45$$

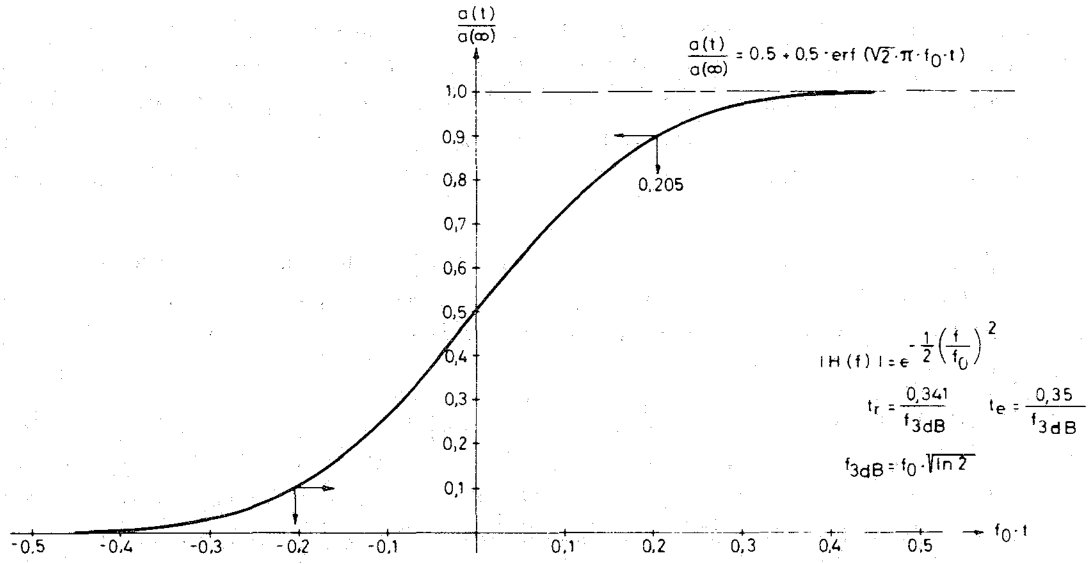


Fig. 2 Unit Step Response of a Gaussian Low-Pass Filter

The response of the Gaussian low-pass filter is:

$$a(t) = a_0 \cdot [0.5 + 0.5 \cdot \mathrm{erf}(\sqrt{2} \cdot \pi \cdot f_0 \cdot t)]$$

with f_0 being the standard deviation. The relation between rise time and 3 db cutoff frequency is found to be

$$f_{3db} \cdot t_r = 0.34$$

We note that the output pulse has a nonzero rise time which is inversely proportional to the filter bandwidth besides a here not considered time delay.

We understand that these examples are of purely academic interest, since practical transmission systems are restricted by the causality principle. But these examples give at least some insight, what the consequences will be for similar transfer functions.

A practical example is an n-stage RC amplifier. It can be shown that the relation between 3 db bandwidth and 10 to 90 per cent rise time given for a Gaussian low-pass filter can be applied within a few per cent of error for RC amplifiers. The larger n is the better is the approximation by a Gaussian type function and therefore the better is the application of the above mentioned relation.

For practical purpose this relationship has been referred to in the Specification of Amplitude Analogue Signals.

But it must be noted, that if high fidelity transmission is required the bandwidth specified must be determined by particular rise time considerations. This idea may be underlined by the next example where the input function is a ramp function with rise time T for simplicity sake measured from 0 to 100 per cent of the final value. The response to this input function of an ideal low-pass filter with different cutoff frequencies is shown in the next figure. The result is self-explainatory and is in agreement with those mentioned previously.

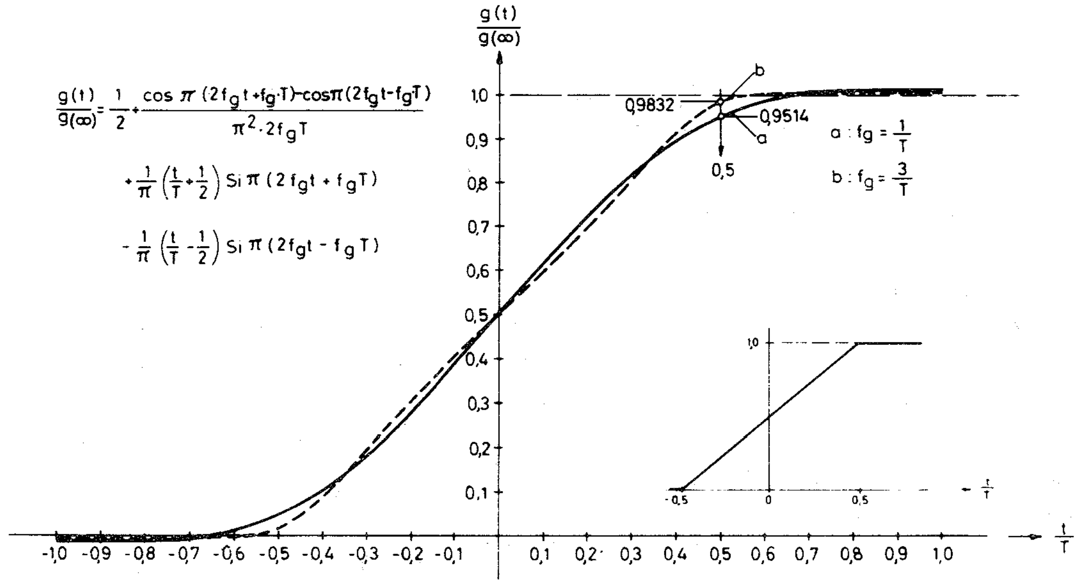


Fig. 3 Responses of an Ideal Low-Pass Filter to a Ramp Input Function

The signals are categorised into two classes according to whether their rise times are shorter or longer than 30 ns. The classification is chosen with respect to the IEC Publication 323, but with a particular modification.

Both classes refer to different signals within the equivalent circuit. The Report EUR 5100 (1972) specified the electromotive force and the 50 Ω output impedance. The first number refers to the EMF of 5 volts, the following letter indicates the positive polarity and the letter B indicates a 50 Ω output impedance.

The other class of signals, however, refers to the load characteristics. The first number describes the maximum voltage across the load, the following letter the negative polarity, and the second letter stands for the 50 Ω input impedance.

The concept in the Extension of EUR 5100 (1972) was to provide an overlapping area for several reasons. One reason was the purpose to allow as much freedom as possible in the design of units. Since there are two classes of signals this freedom is going to cause technical difficulties if the specification of EUR 5100 (1972) and the Extension are applied as they are. This means that features in the overlapping area designed according to the specification of the particular class will interfere with the must-specification of the other signal class within the CAMAC system.

In order to prevent to have two categories of equipment for the whole range of rise times besides the two classes of signals, the Working Group decided to define a definite separation between the two classes. The Working Group is aware that this is not the best solution, the best way to go would be to reconsider the necessity of the two polarities.

The signals must be according to whether their rise times are shorter or longer than 30 ns which implies a 3 db cutoff frequency of 11 MHz.

The choice of the rise time of 30 ns is in agreement with the Report EUR 5100 (1972).

6. Comments to 3.1.1. Output Voltage Range

In comparison with the class 5PB signals the class 1NB signals do not refer to an equivalent circuit of the signal source, but to the output voltage across a definite load impedance which is in any case the 50 Ω load.

This arrangement originates from the consideration that the signal source should have an output impedance of 50 Ω with a tolerance of ± 10 %. Claims were made that the signal source may also have an output impedance of a current or a voltage source, which means an impedance much larger or less compared with the 50 Ω load. The decision what is finally implemented is left to the designer. It should be noted that some complications may occur if an overall 50 Ω system is not used. For the application of class 1NB signals the 50 Ω load (input impedance) is specified with a must and therefore the output voltage range must be expressed in connection with the 50 Ω load. Exactly for this reason the tolerance of the input impedance is given in much greater detail with respect to rise times.

It has been stated already that the specifications of the 5PB signals and the 1NB signals refer to different parameters of the equivalent network circuit.

In a matched 50 Ω system the output voltage is

for the 5PB class	+ 2.5 V and
for the 1NB class	– 1.0 V.

The historical background for the choice of the 5PB class has been mentioned in the introduction. The 5PB system includes a 50 Ω output termination and a high impedance input depending on what the purpose of the design is. In the 1NB system the output voltage across a 50 Ω load is specified with – 1 V as the working range.

7. Comments to 3.1.2. Maximum Output Voltage

The combination of the specifications of both classes led to the statement that the absolute maximum range of an output must be – 7.5 V to + 7.5 V.

There would be no problems with voltage sources only, but the class 1NB also permits a current source, whereas the class 5PB includes terminated and unterminated inputs. The maximum range of – 7.5 V to + 7.5 V has been chosen with reference to the IEC Recommendations.

The maximum voltage of + 7.5 V will drop to half of this value if the output is terminated with a 50 Ω load.

In order to combine the specifications of both classes within one sentence the value of 3.75 V across a 50 Ω load is chosen instead of 4 V as in the Extension (1972). The equal range with respect to the zero level is clear, if we note that the polarity must be positive for 5PB and negative for 1NB and that provision may also be made to provide the other polarity respectively.

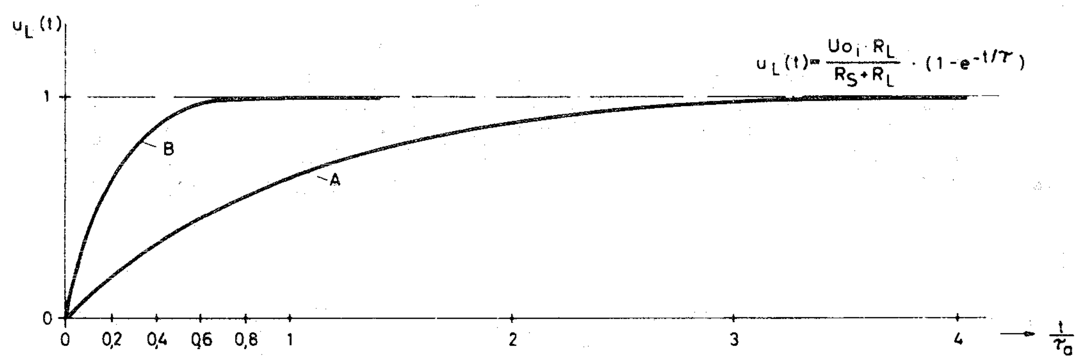
Particular care must be taken in the design of a current source which is allowed in the 1NB class in order to prevent that the maximum output voltage does not exceed ± 7.5 V. This is important for the case of misconnecting the high input impedance of class 5PB with the output of the current source.

8. Comments to 3.1.5. Output Impedance and 3.2.1. Input Impedance

In order to prevent multiple reflections the advisable technique is to design a terminated output for the 5PB class. The input for this class will usually have high input impedance to be sure that an impedance change because of temperature shifts will not influence the accuracy of pulse amplitude analysis.

The necessity of a perfect matching is essentially given for the 1NB class signals. It was the purpose of the specification to recommend a terminated 50 Ω system. Even if the use of a voltage or a current source is permitted, everything should be done to design a terminated 50 Ω system, for a perfectly matched system will cause no difficulties. Because of discontinuities reflections will occur and will be reflected at the unmatched signal source. The result is an interference at the output with the signals.

It is very often considered to use low impedance outputs to achieve faster rise times. It can be shown that a terminated 50 Ω system is also a good practice dealing with rise times in the order of a few nanoseconds. The step response of the combination of load impedance (R_L) and a parallel parasitic capacitance (C) fed by a 50 Ω (R_S) source yields a rise time of about 1 ns if the parasitic capacitance is kept below 20 pF.



A: Ri = Ra z. B. $R_S = R_L = 50\,\Omega$, $C_S = 20\,pF$, $t_r = 1{,}1\,ns$
B: Ri ≪ Ra z. B. $R_S = 0{,}1 \cdot R_L$, $C_S = 20\,pF$, $t_r \approx 44\,ps$

Fig. 4 Load Voltage as Function of Time

$$t_r = \tau \cdot \ln 9 = 2.2 \cdot \tau$$

$$\text{with } \tau = (R_S \,\|\, R_L) \cdot C$$

This is surely a very simple example but it demonstrates that a 50 Ω terminated system can provide rise times in the order of one nanosecond.

It is not difficult to provide a 50 Ω output impedance for low frequency applications and the tolerance of the 5 % causes no particular problem. However, the specification of 1NB class signals demands the implementation of a 50 Ω input (load impedance) with a tolerance scheme with respect to different rise times. The reason for this tolerance scheme is well understood if the connectors are taken into consideration. Unfortunately there exists a technical limitation which is caused by the properties of the connectors. The load is linked together with the other network via connectors. Mechanical size and costs restrict the use to a limited number of types. The properties of the connectors do not allow a narrow tolerance scheme for the full range of pulse rise times.

$$\mathrm{SWR} \approx 1 + 2 \cdot \rho \qquad \rho \ll 1$$

$$\rho \approx 0.5 \cdot \frac{\Delta Z_L}{Z_W}$$

The LEMO type 00250 connectors show an SWR (Standing Wave Ratio) in the order of 1.05 to 1.10 with 1 ns test pulses. The values for 250 ps test pulses are in the order of 1.1 to 1.2. The specification has been chosen according to practical rise times so that the technical values do not limit the use.

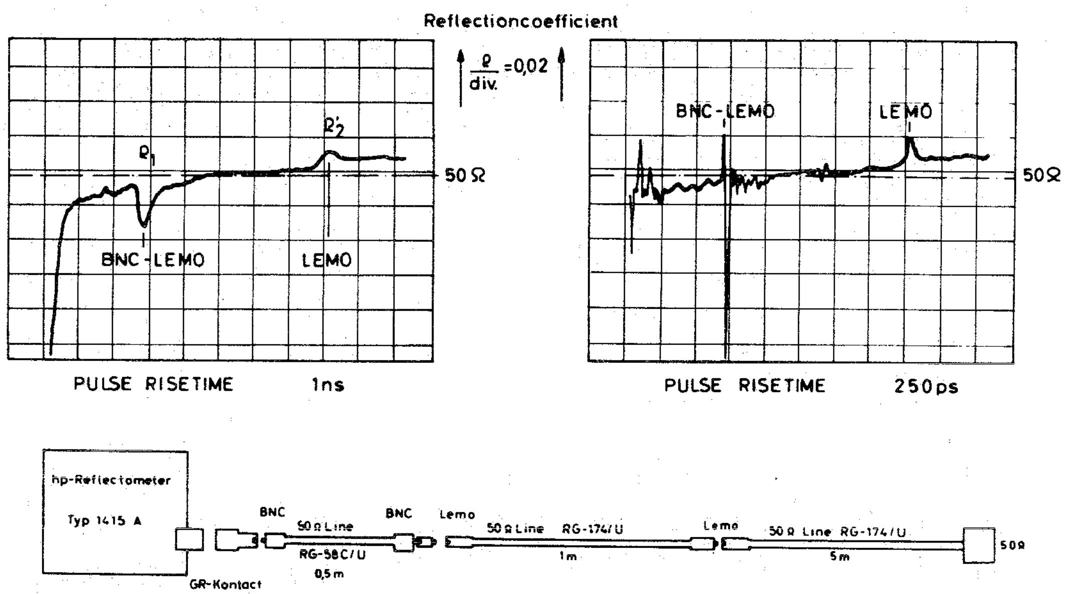


Fig. 5 Voltage Step Responses of Connectors

But any other connector type may be used if its properties as well as its mechanical conditions are compatible. The specification does not limit the use of the connectors for shorter rise times, which means that they may show in such a case higher SWR's.

Since many readers from different background will read the specifications some misunderstanding will probably occur if they come to the point where they try to understand the difference between a terminated and an unterminated input. These words are obviously used here in the sense of a termination with 50 Ω, and the network is called unterminated if the load impedance is not 50 Ω. This is probably the root for some misunderstanding and in future work this difficulty should be overcome.

References

[1] Analogue Voltage and Logic Levels for Mains Operated Nuclear Instruments
Publication 323, International Electrotechnical Commission, Genève, 1970

[2] CAMAC: A Modular Instrumentation System for Data Handling. Revised Description and Specification.
Euratom Report EUR 4100e (1972), Commission of the European Communities, Luxembourg, 1972

[3] CAMAC: A Modular Instrumentation System for Data Handling. Specification of Amplitude Analogue Signals.
Euratom Report EUR 5100e (1972) (to be published in 1972)

[4] CAMAC – Specification of Amplitude Analogue Signals. Extension of the Specification of Amplitude Analogue Signals (EUR 5100 [1972]) and Comments of the ESONE Working Group.
Bericht KFK 1641, Gesellschaft für Kernforschung, Karlsruhe, 1972