EMC Compliance of Digital I&C to Electric Fast Transient

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Electric Fast Transient

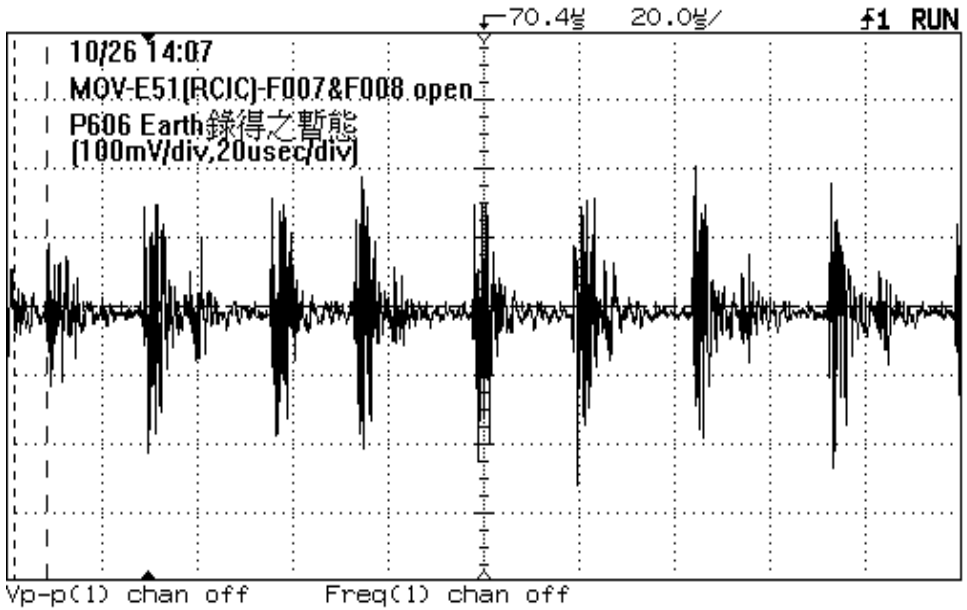


Fig. 1 Transient waveform captured at equipment ground when there's period Hi alarm caused by the operation of Motor Operated Valve of Reactor Core Isolation Cooling System.

Electric Fast Transient

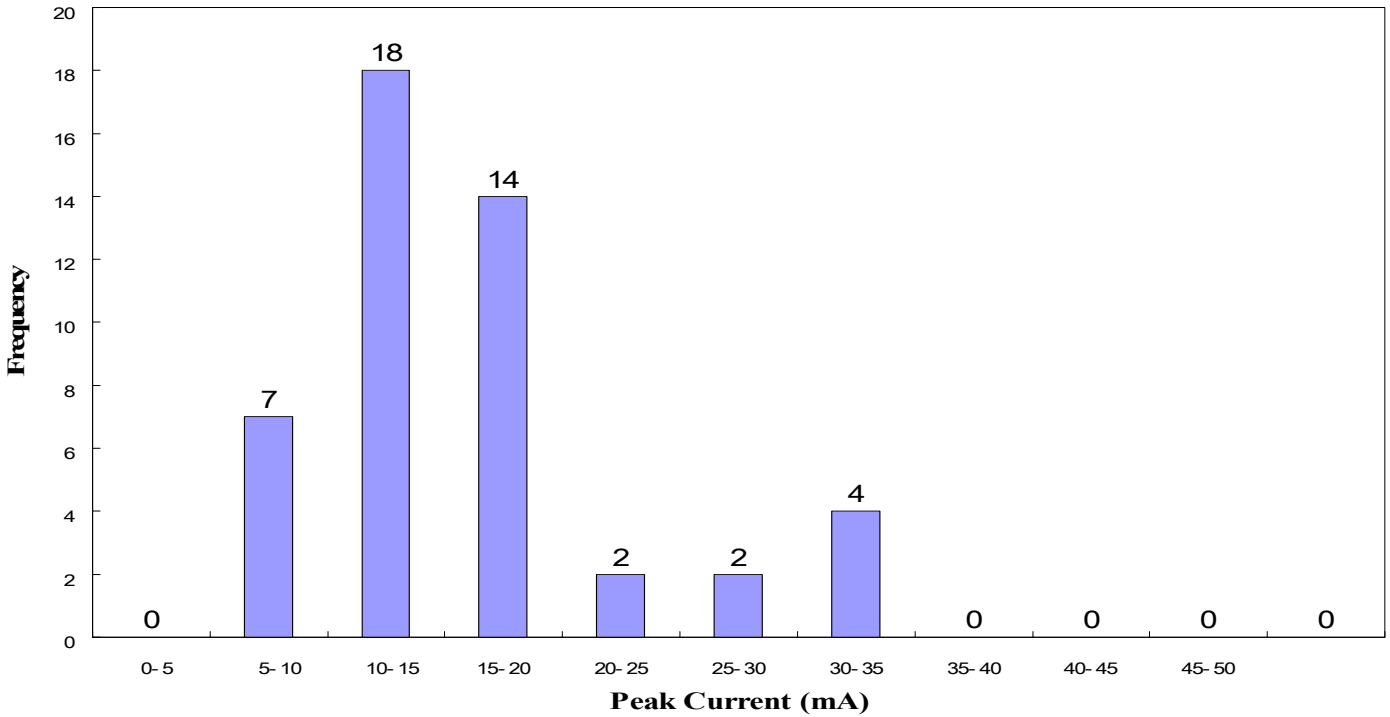
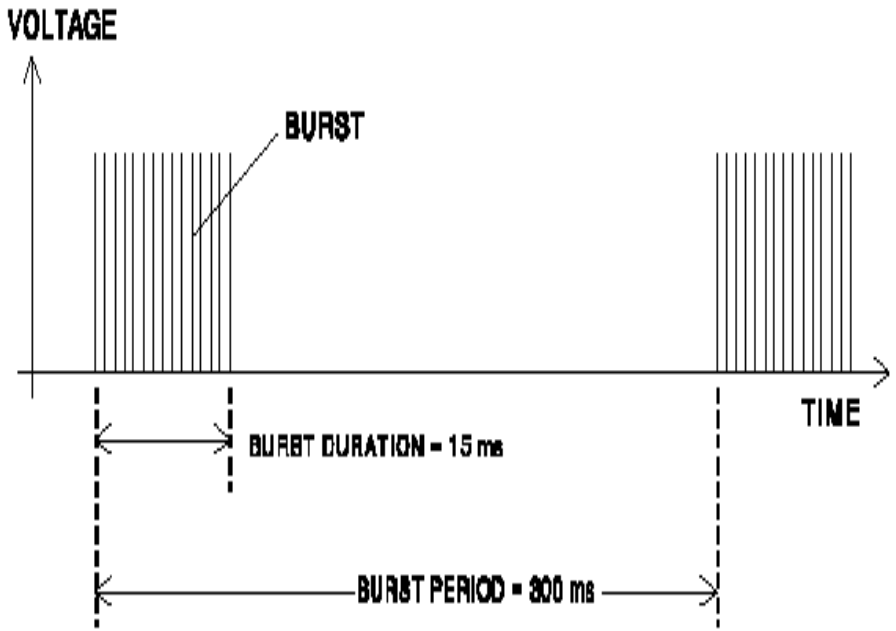
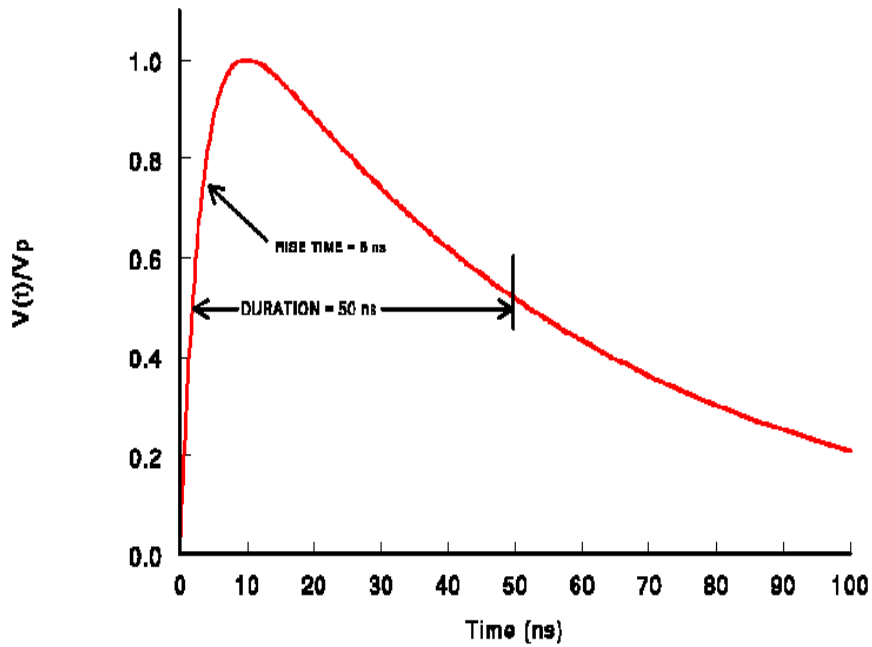


Fig. 2 Frequency distribution of current spike peaks captured at the Equipment Ground bus of the NUMAC™ WRNM system cabinet during a reactor shutdown period.

Electric Fast Transient

EFT waveform consists of repetitive bursts, it is intended to represent *local load switching on the AC power leads of equipment and subsystems*.





IEC-61000-4 EFT Immunity Test

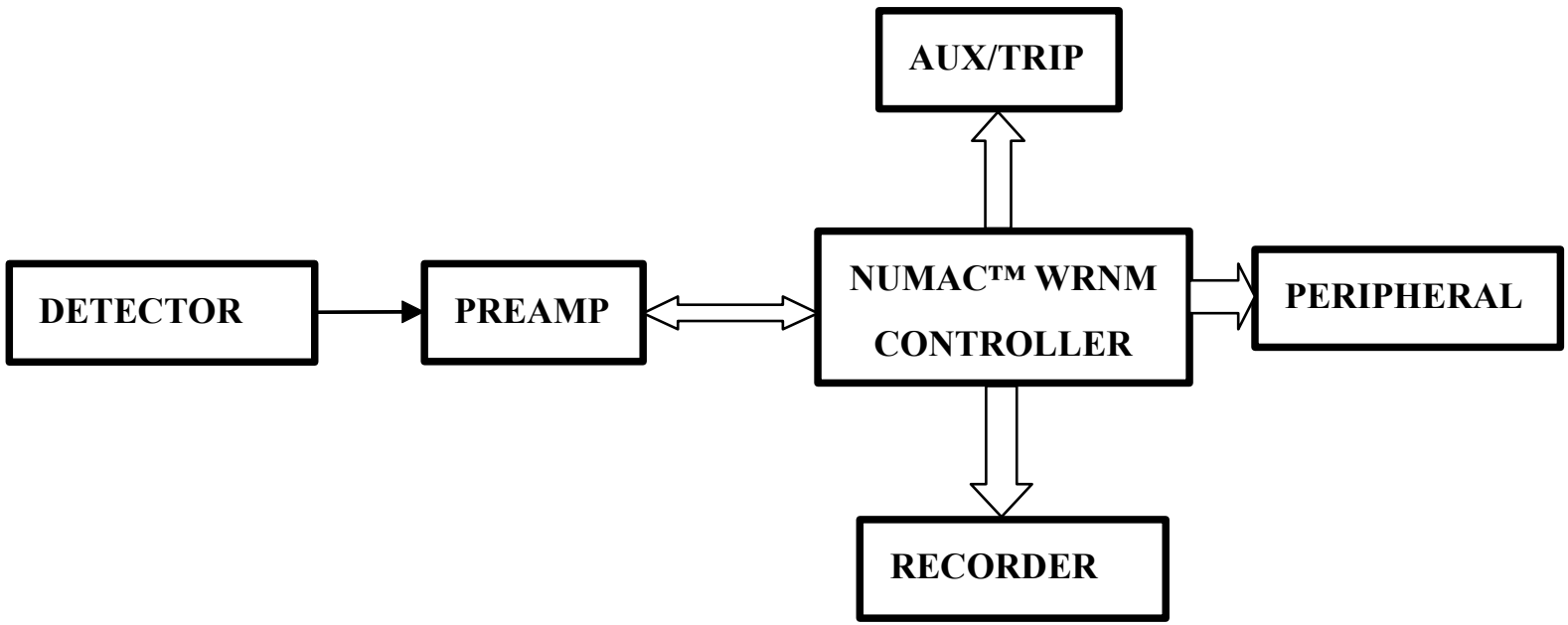
EMC Study of NUMAC™ WRNM

GE Nuclear Energy's NUMAC™ Wide Range Neutron Monitor

- ***SAFETY RELATED***
- ***DIGITAL UPGRADE I&C***
- ***CENTRAL DISTRIBUTED FRAME***
- ***MIXED MODE OPERATION***

EMC Study of NUMAC™ WRNM

NUMAC™ Wide Range Neutron Monitor



EMC Study of NUMAC™ WRNM

NUMAC™ Wide Range Neutron Monitor

Table 1 Detector Preamplifier Performance Specifications

	Counting Mode	Mean Square Voltage Mode
Band Pass	2 MHz ↔ 100 MHz	150 kHz ↔ 450 kHz
AC Voltage Gain	1000 ± 200	270 ± 20
Signal Impedance	I/P 75Ω; O/P 20Ω	“
Typical Output Waveform	100 mV pulse @ 50 ns width	100 mVp-p 250kHz square wave
Power Supply	- 15V±3V @ 100 mA	“

EMC Study of NUMAC™ WRNM

NUMAC™ Wide Range Neutron Monitor

EMC Problems:

- *During Outage: Frequent Period Hi or Hi-Hi due to EFT (counting mode)*
- *During Startup: Hi background noise around 500kHz at intermediate range (mean square voltage mode)*

EMC Study of NUMAC™ WRNM

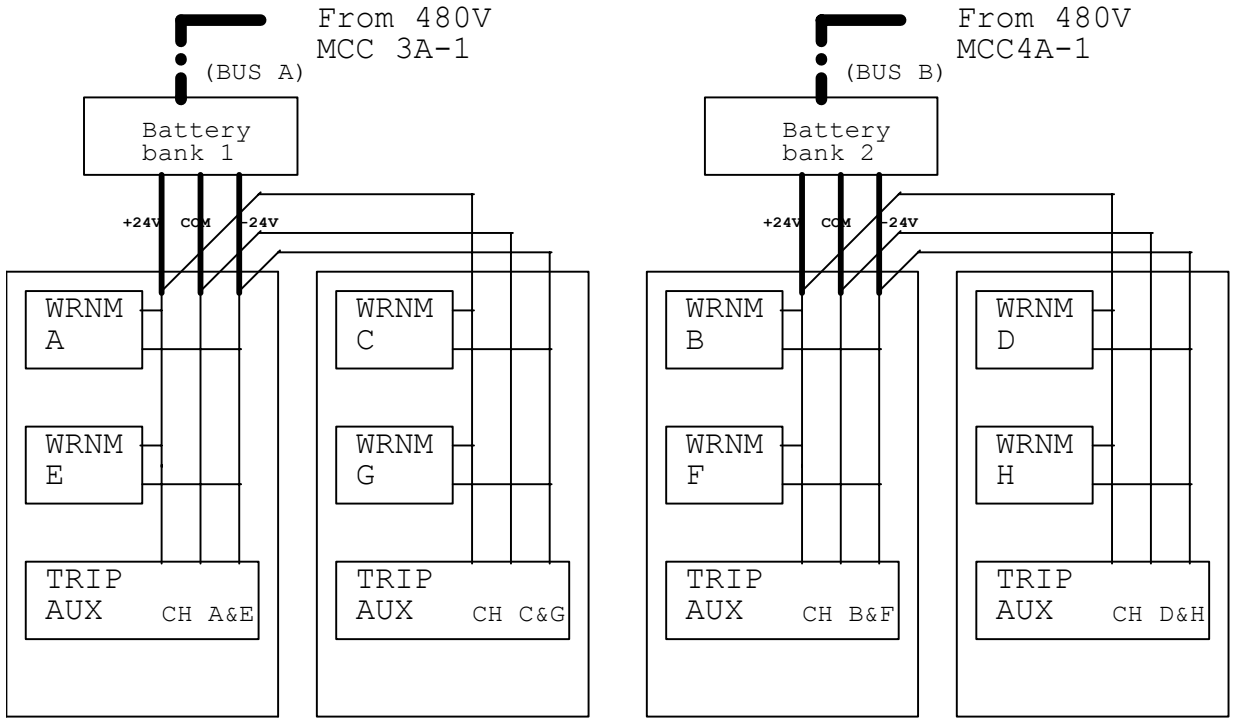


Fig.3 AC/DC Power Distribution Diagram of a complete 8-channel NUMAC™ WRNM system installed at Chin-Shan Nuclear Power Station.

EMC Study of NUMAC™ WRNM

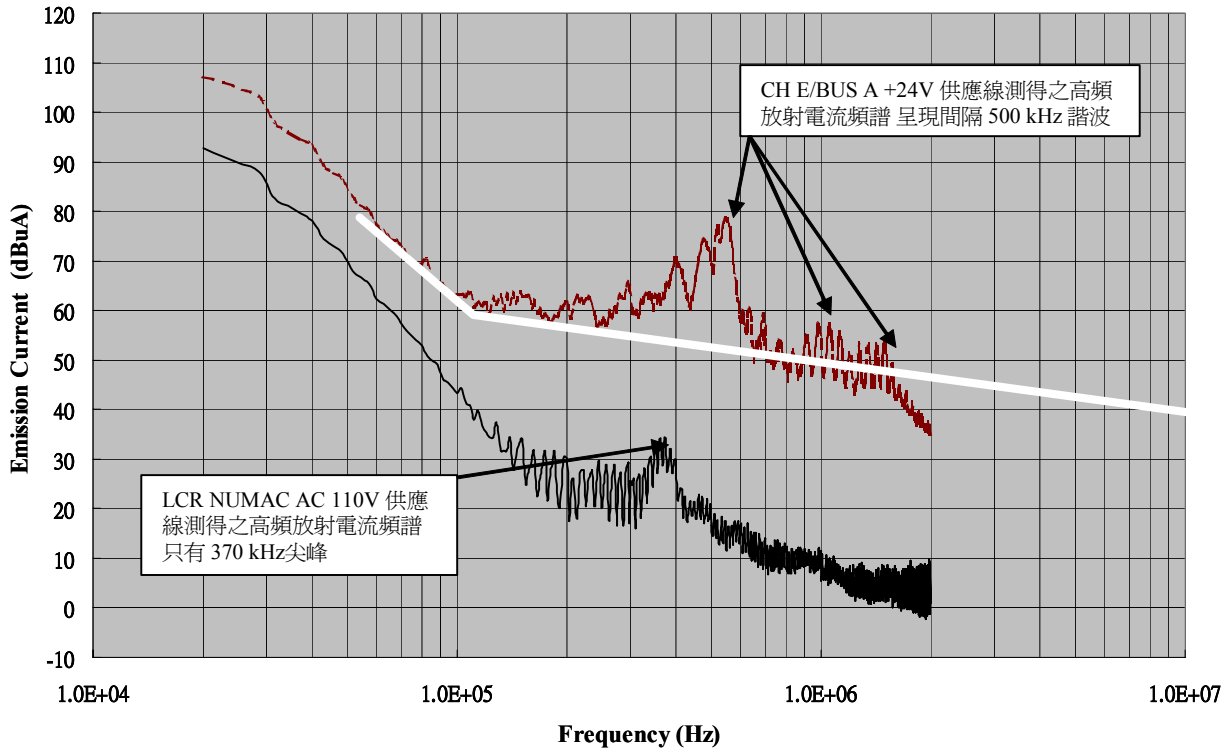


Fig. 4 Comparison of Conduction Emission Spectra at power leads of DC Powered NUMACs with AC Powered Counterpart. White Straight lines indicates the Allowable Equipment Level recommended by TR-102323-R1.

EMC Study of NUMAC™ WRNM

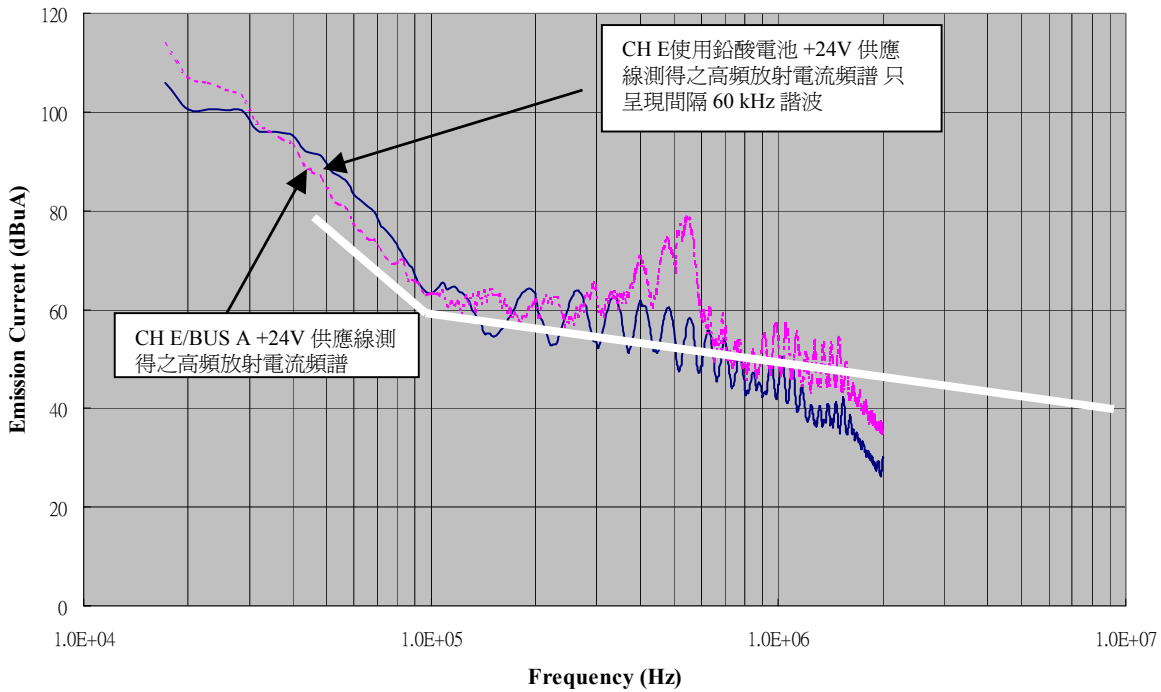
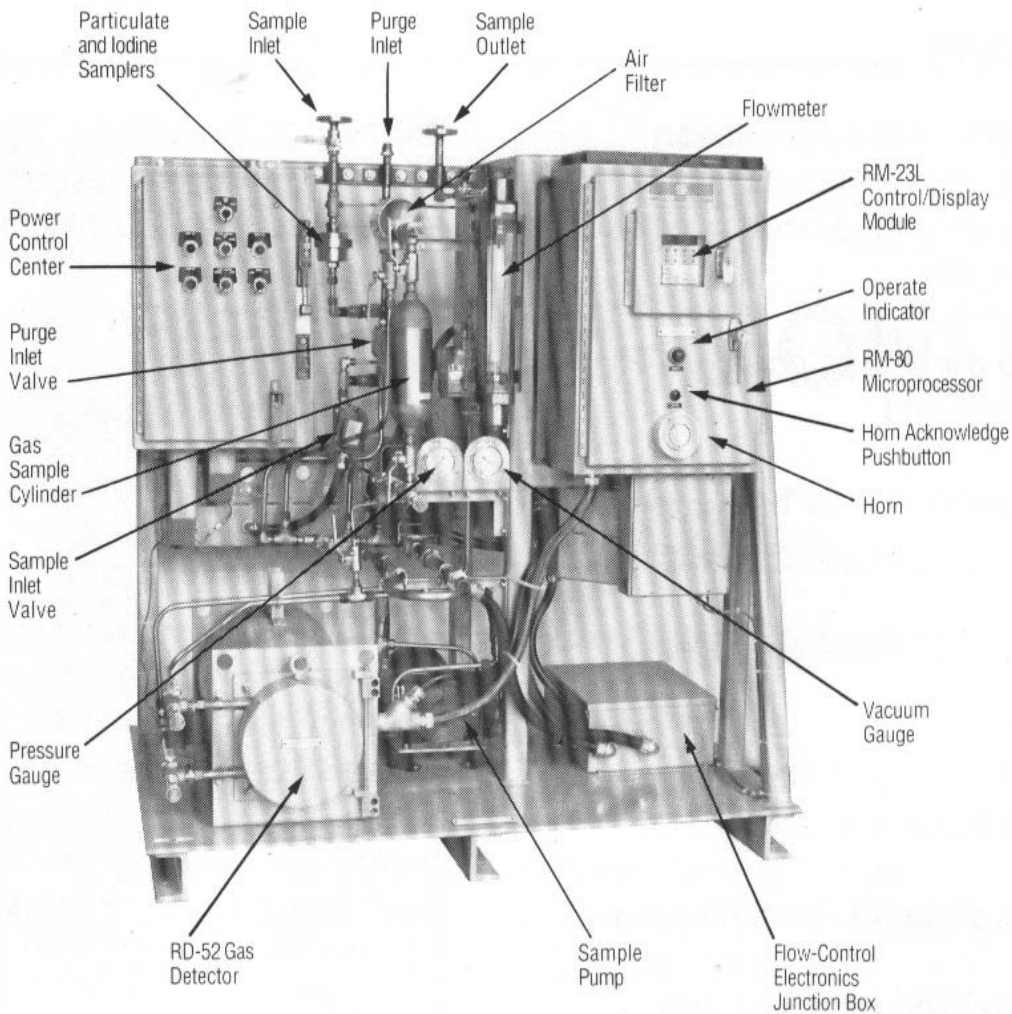


Fig. 5 Comparison of Conduction Emission Spectra of NUMAC™ WRNM powered either by a shared DC bus or a rechargeable battery.

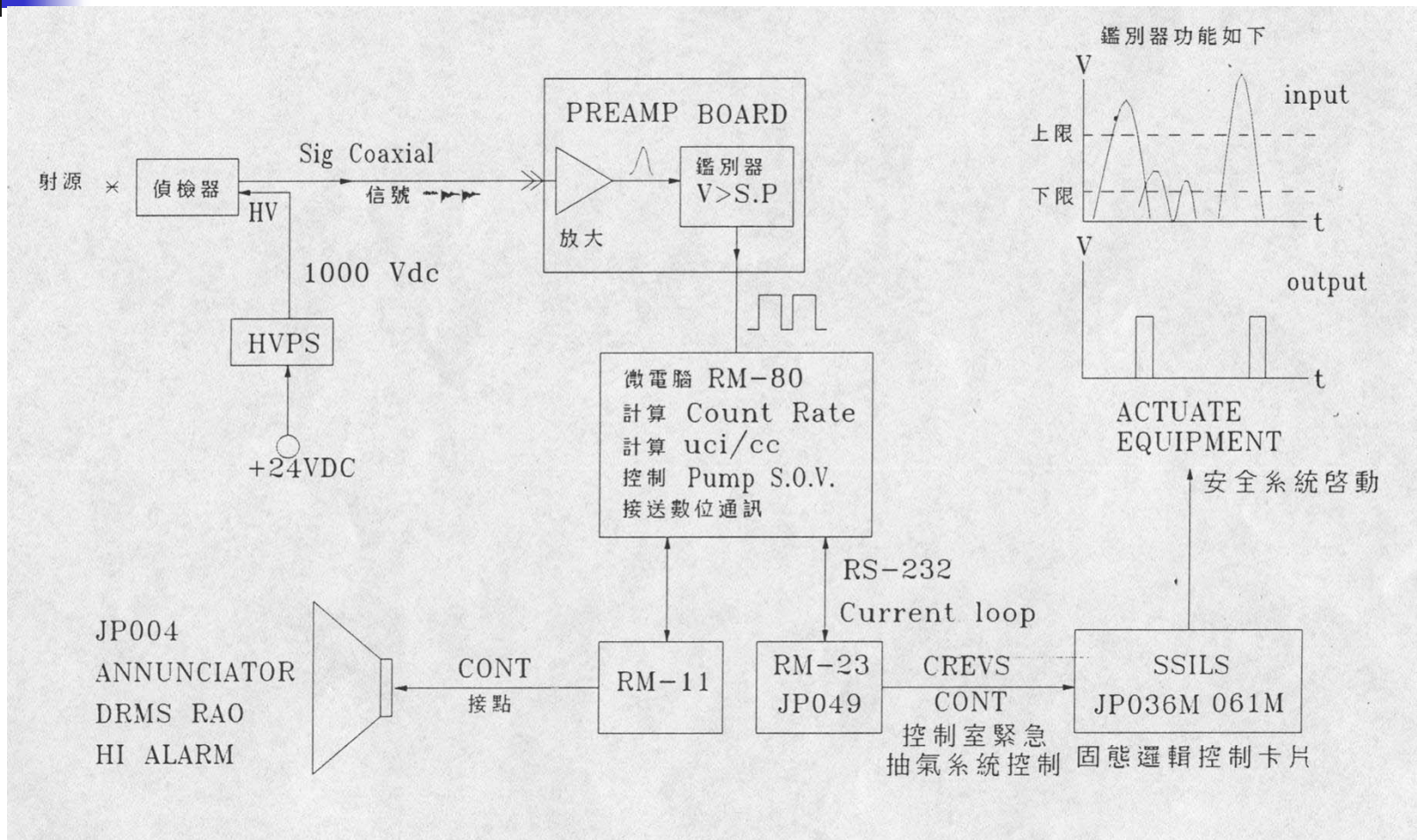
EMC Study of RM-80 Gas Monitor

RM-80 digital gas radiation monitor is product name of Sorrento Electronics, a subsidiary of General Atomics.



Gas Monitor, Front View

EMC Study of RM-80 Gas Monitor



EMC Study of RM-80 Gas Monitor

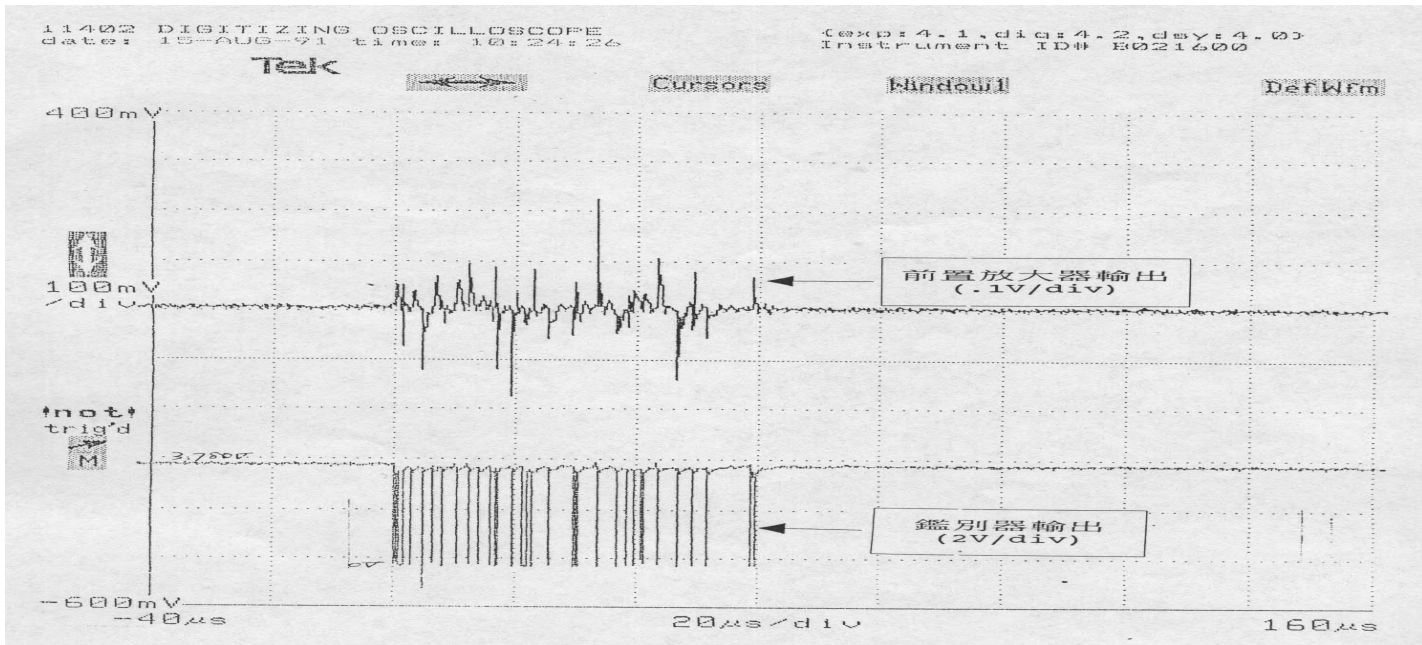


Fig. 6 Transient waveform captured at preamplifier I/O when there's Hi alarm caused by the operation of Sampling Pump of the RM-80 digital Gas Monitor.

EMC Study of RM-80 Gas Monitor

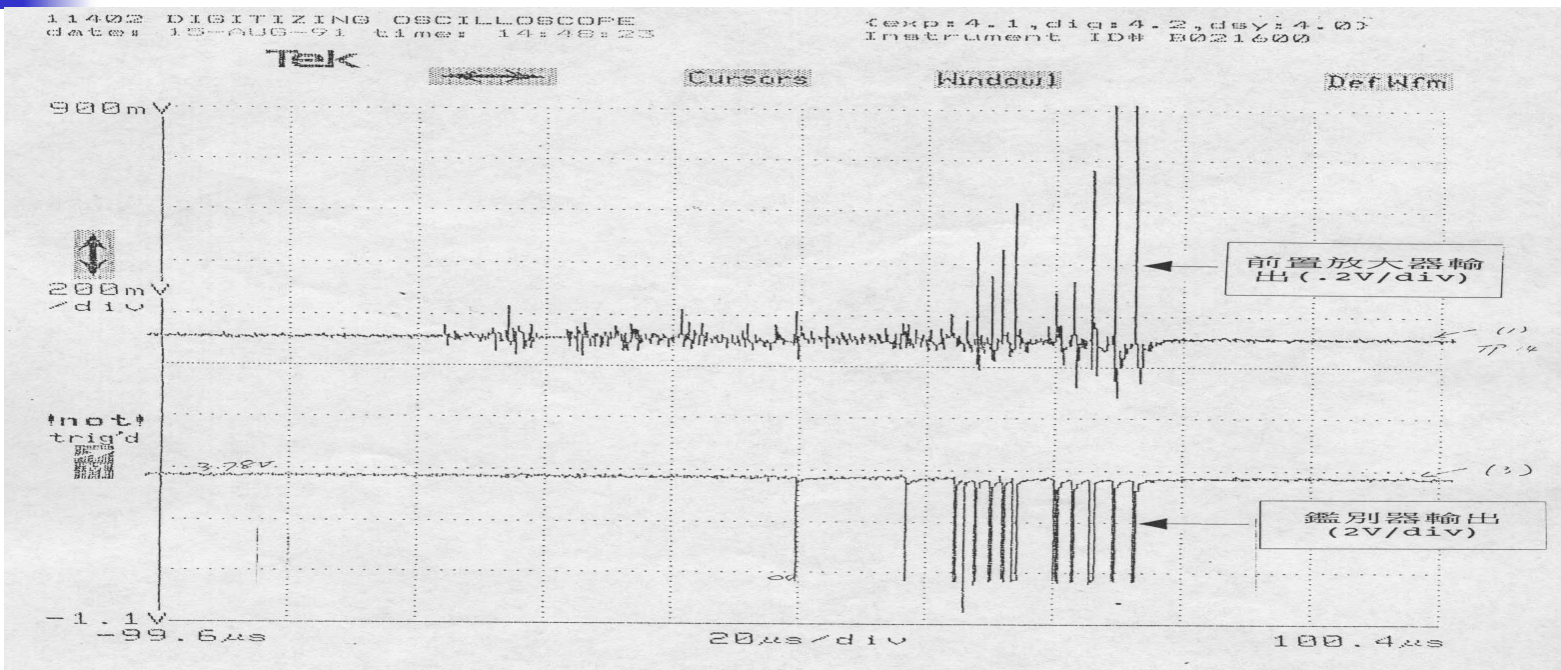
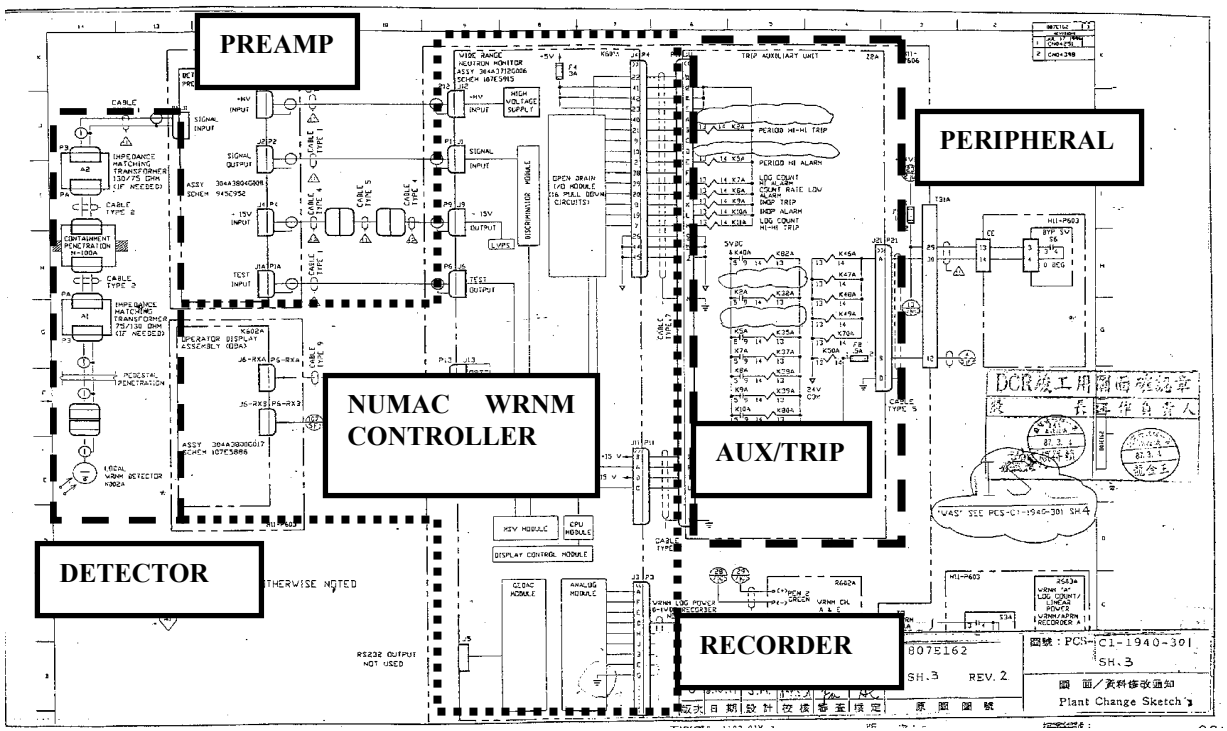


Fig. 7 Transient waveform captured at battery powered preamplifier I/O when there's Hi alarm caused by the operation of Sampling Pump of the RM-80 digital Gas Monitor.

EMC COMPLIANCE of WRNM

NUMAC™ Wide Range Neutron Monitor



EMC COMPLIANCE of WRNM

Solution Proposed by INER

- ***Replace DC/DC regulator***
- ***Grounding follow IEEE Std. 1050 -1996***
- ***Find out and isolate 500 kHz interference***
- ***Change arrangement of Noisy Auxiliary and Trip Unit w.r.t. WRNM module***
- ***Improve NUMAC^{TM} firmware***

EMC COMPLIANCE of WRNM

GENE's Solution

- ***Add in-line filter to shared DC Bus***
- ***Use 1" copper braid rounding cabinet to improve WRNM channel drawer grounding***
- ***Add ferrite bead filter to all in/out wires from Aux./Trip Unit and Preamplifier to isolate possible transient interference***
- ***Replace penetration with shielded parts***

EMC COMPLIANCE of WRNM

GENE's Solution

- ***Try NUMAC™ firmware improvement (raise transition zone for cps to msv by a factor of two, and filter out any period rate less than 1sec)***

EMC COMPLIANCE of Gas Monitor

Hardware Solution Proposed by INER

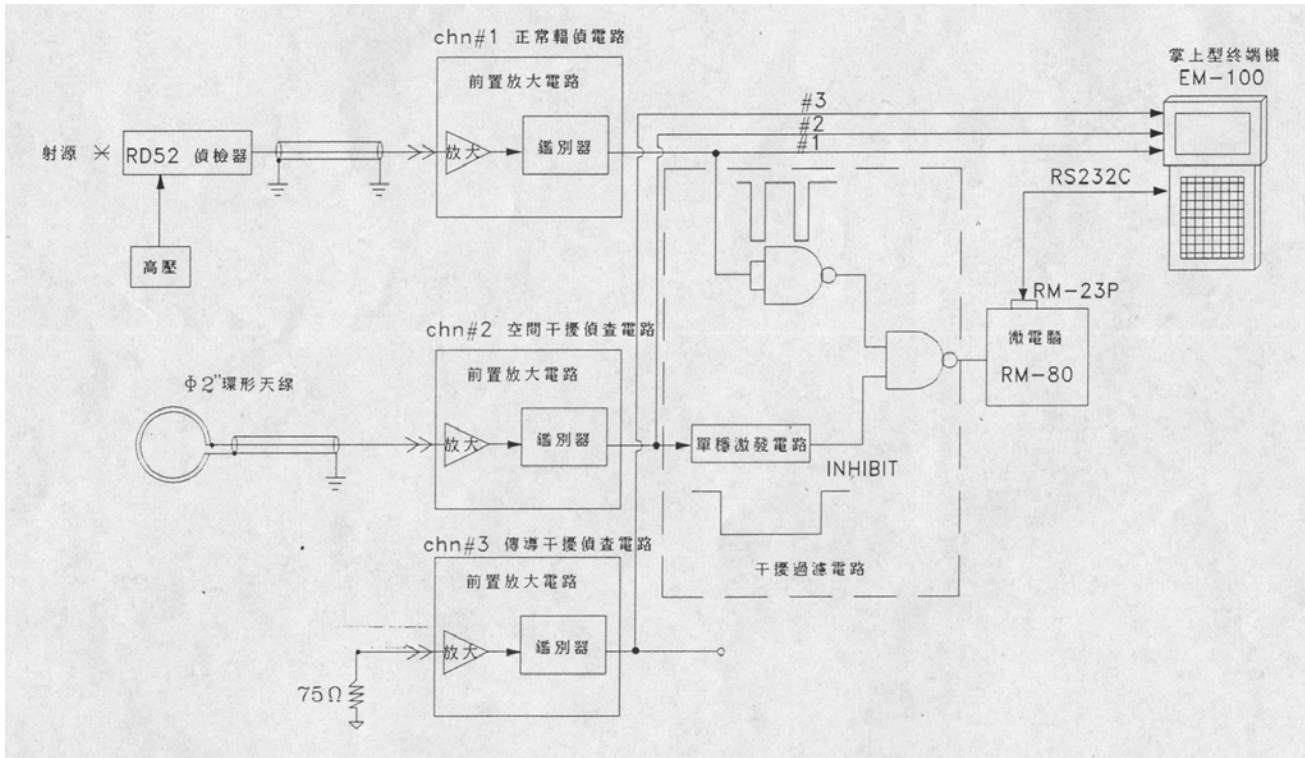


Fig. 8 Redundant preamplifier channels are used as EFT sensors for noise rejection of RM-80 Gas Monitor.

EMC COMPLIANCE of Gas Monitor

Hard&Firm-ware Solution Proposed by INER

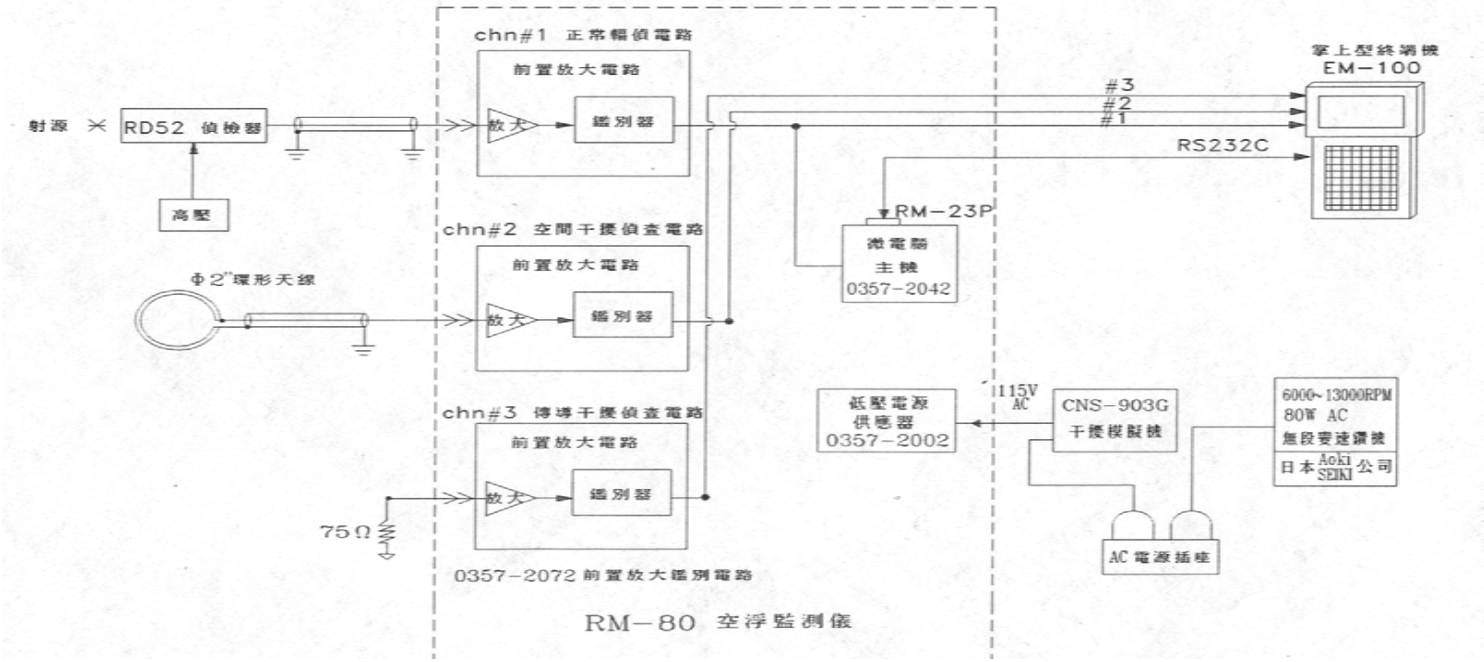


Fig.9 Redundant preamplifier channels are used as EFT sensors for signal verification and validation of RM-80 Gas Monitor.

EMC COMPLIANCE of Gas Monitor

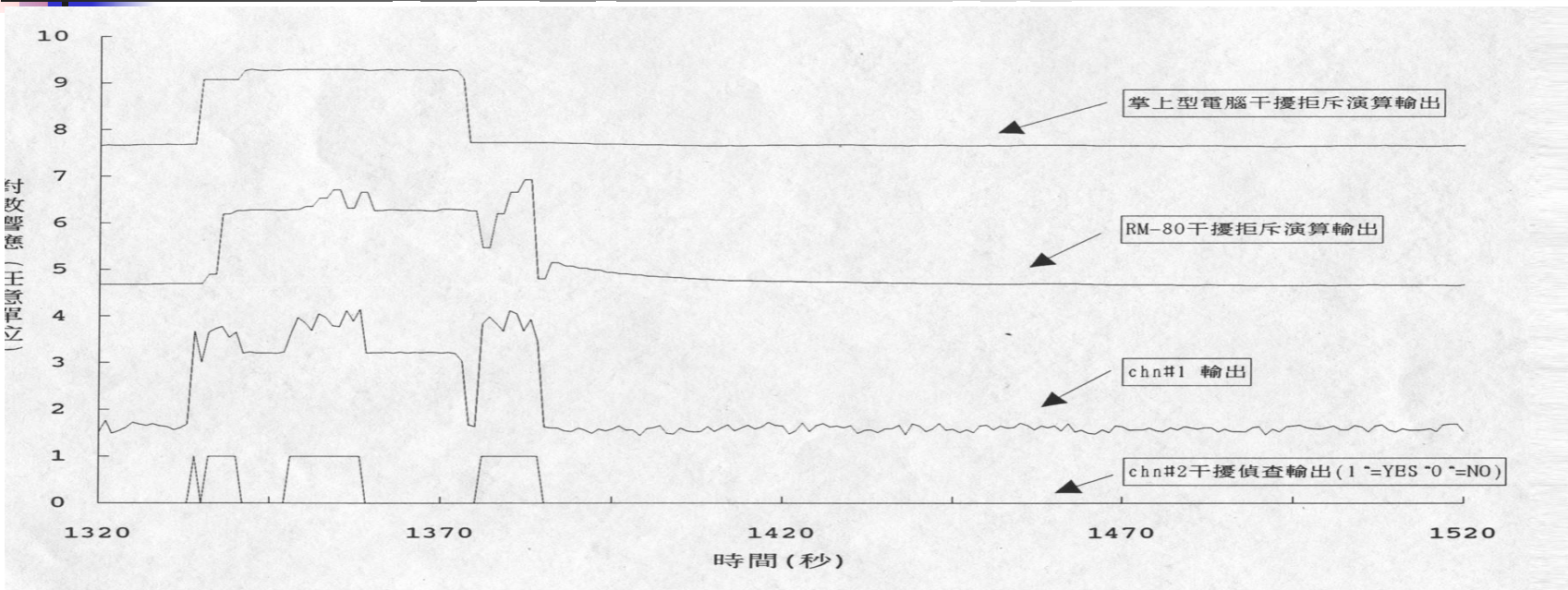


Fig.10 Improved response characteristics of RM-80 Gas Monitor in a radiation field mixed with EFT noise. The traces from bottom to top are : firmware applying noise sensor and rejection algorithm; without noise sensor but rejection algorithm, detector channel output, noise sensor channel output.

Discussion

- ***Technically speaking, there are no EMC problems for modern digital I&Cs, because there are always solutions.***
- ***Problems of EMC compliance are risk (lost due to false alarms and regulatory requirements) and cost (schedule, budget, and staffing cost) – take no action or update existing I&Cs.***

Discussion

5. DECISION RATIONALE

Based on the highest value and reasonable impact for problem solution capability (especially regulatory burden), the second alternative, updating existing guidance by developing an enhanced technical basis, has been chosen. The highest value will be achieved by reviewing revised and new consensus EMC standards (both domestic and international), assessing the applicability and equivalence of each technical element embodied in the standards, reevaluating the electromagnetic environment characteristic of nuclear power plants and the technical basis for the current operating envelopes, determining testing methods that can address the open EMC issues, and identifying equivalent suites of test methods from the alternative standards and the conditions under which they may be applied. This approach will contribute to satisfying the safety goal for nuclear power plants.

Cited from paragraph " Regulatory Analysis" of "Draft Regulatory Guide DG-1119 (proposed Rev. 1 of Reg. Guide 1.180)," USNRC, Aug. 2002, Div. 1.

Reg. Guide 1.180: "Guidelines for Evaluating EMI/RFI In Safety-Related I&C Systems"