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M372

LVDT/RVDT Controller M-module

User Manual

Version R1.0

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Printed in The Netherlands.

CONTENTS

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1. Introduction

1.1. Validity of the Manual

This user manual is of revision 1.0 and is valid for the M372 LVDT/RVDT Controller M-module of revision 1.x and up. The revision number (x.y) of the M372 is composed of a major number, x and a minor number y. The major number x indicates the revision of the PCB and the minor number is the firmware version. This user manual is a replacement for previous releases of the hardware manual and contains a description of both the hardware as well as the provided software.

1.2. Purpose

This manual serves as instruction for the operation of the M372 LVDT/RVDT Controller M-module, the connection of LVDT devices, and the integration on an M-module carrier. Furthermore it gives the user additional information for special applications and configurations of the assembly. The M372 is provided with example software which is also described in this manual.
Detailed information concerning the individual assemblies (data sheets etc.) are not part of this manual. The main audience are system integration engineers and software developers.

1.3. Scope

The scope of this manual is the M372 LVDT/RVDT Controller. Both the hardware and the example software are described.

1.4. Definitions, Acronyms and Abbreviations

AcQ	AcQuisition Technology bv
APIS	AcQ Platform Interface Software
LVDT	Linear Variable Differential Transformer
LVDT Device	Linear position sensor
M-module	Mezzanine I/O concept according to the M-module specification
Platform	Combination of hardware and operating system LVDT
RVDT	Rotary Variable Differential Transformer
RVDT Device	Rotary position sensor

1.5. Notes Concerning the Nomenclature

Hex numbers are marked with a leading “0x”-sign: for example: 0x20 or 0xff.
File names are represented in italic: *filename.txt*
Code examples are printed in `courier`.
Active-low signals are represented by a trailing asterisks (i.e. IACK*).

1.6. Overview

Chapter 2 is an introduction to the M372. Chapter 3 contains information about the installation and setup of the board. Chapter 4 contains detailed information on the hardware and in chapter 5 the provided example software is described. Finally an appendix can be found containing a component image, technical data and a bibliography.

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2. PRODUCT OVERVIEW

2.1. INTRODUCTION

The M372 LVDT/RVDT Controller M-module is capable of interfacing up to four LVDT/RVDT devices. Analog to digital conversions are done with 13 bit resolution using the National Semiconductor LM12458 Data Acquisition System. This device contains a sequencer that allows complex conversion algorithms to execute without host intervention. Conversion results are stored in an on-chip FIFO from which they can be read by the host.

For LVDT/RVDT signal conditioning the Analog Devices AD598 is used. This device generates the excitation for the LVDT/RVDT devices and measures the feedback on the secondary coils. As a result, it generates a DC voltage that is representative for the core-displacement.

For an in-depth discussion on the devices used, please refer to their respective data sheets.

2.2. TECHNICAL OVERVIEW

- AD598 integrated LVDT/RVDT signal conditioner for each LVDT channel
- Wide range adjustable LVDT/RVDT excitation frequency/amplitude
- Interfaces to 4/5/6-wire LVDT/RVDT devices (NOT 3-wire)
- Distance between LVDT/RVDT devices and M372 can be up to 100 metres
- LM12458 Integrated Data Acquisition System with 13-bit resolution and sequencer
- Programmable conversion rate, resolution, number of conversions and comparison limits
- Automatic calibration of the Data Acquisition System
- Interrupts on numerous programmable events (i.e. sequence completion, limit crossing)
- Operates with minimum CPU intervention after initialization

2.3. LVDT SIGNAL CHARACTERISTICS

The M372 controller must be factory configured for the required LVDT signal characteristics. Configuration must be done by Acquisition Technology according to LVDT device parameters. For more information contact your local distributor or Acquisition Technology directly.

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3. INSTALLATION AND SETUP

3.1. UNPACKING THE HARDWARE

The hardware is shipped in an ESD protective container. Before unpacking the hardware, make sure that this takes place in an environment with controlled static electricity. The following recommendations should be followed:

! Make sure your body is discharged to the static voltage level on the floor, table and system chassis by wearing a conductive wrist-chain connected to a common reference point.

! If a conductive wrist-chain is not available, touch the surface where the board is to be put (like table, chassis etc.) before unpacking the board.

! Leave the board only on surfaces with controlled static characteristics, i.e. specially designed anti static table covers.

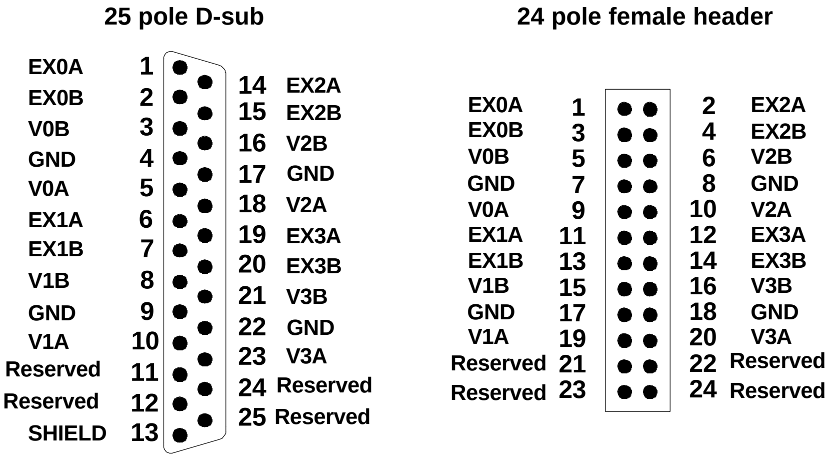
! If handling the board over to another person, touch this persons hand, wrist etc. to discharge any static potential.

IMPORTANT: Never put the hardware on top of the conductive plastic bag in which the hardware is shipped. The external surface of this bag is highly conductive and may cause rapid static discharge causing damage. (The internal surface of the bag is static dissipative.)

Inspect the hardware to verify that no mechanical damage appears to have occurred. Please report any discrepancies or damage to your distributor or to Acquisition Technology immediately and do not install the hardware.

3.2. CONNECTING THE MODULE

LVDT or RVDT device must be connected to either the 25-pole D-sub front connector or via the 24-pole P2 header. Pin assignments of both connectors can be found below.



25 pole D-sub

Signal	Pin	Pin	Signal
EX0A	1	14	EX2A
EX0B	2	15	EX2B
V0B	3	16	V2B
GND	4	17	GND
V0A	5	18	V2A
EX1A	6	19	EX3A
EX1B	7	20	EX3B
V1B	8	21	V3B
GND	9	22	GND
V1A	10	23	V3A
Reserved	11	24	Reserved
Reserved	12	25	Reserved
SHIELD	13		

24 pole female header

Signal	Pin	Pin	Signal
EX0A	1	2	EX2A
EX0B	3	4	EX2B
V0B	5	6	V2B
GND	7	8	GND
V0A	9	10	V2A
EX1A	11	12	EX3A
EX1B	13	14	EX3B
V1B	15	16	V3B
GND	17	18	GND
V1A	19	20	V3A
Reserved	21	22	Reserved
Reserved	23	24	Reserved

Figure 1 : M372 Connector layout

Note: Reserved pins must not be connected !!!!

The table below shows the relation between LVDT input channels and corresponding signals.

Channel 0		Channel 1		Channel 2		Channel 3	
Primary	Secondary	Primary	Secondary	Primary	Secondary	Primary	Secondary
EX0A EX0B	V0A GND V0B	EX1A EX1B	V1A GND V1B	EX2A EX2B	V2A GND V2B	EX3A EX3B	V3A GND V3B

The M372 supports 4-wire, 5-wire and 6-wire devices. For proper connection of a LVDT or a RVDT device to channel 0 of the M372 the primary winding of the device must be connected to the excitation output EX0A and EX0B, the secondary windings must be connected to the signal inputs V0A and V0B. The secondary windings must have a centre tap which must be connected to GND. The figure below illustrates the connection of a 5-wire device.

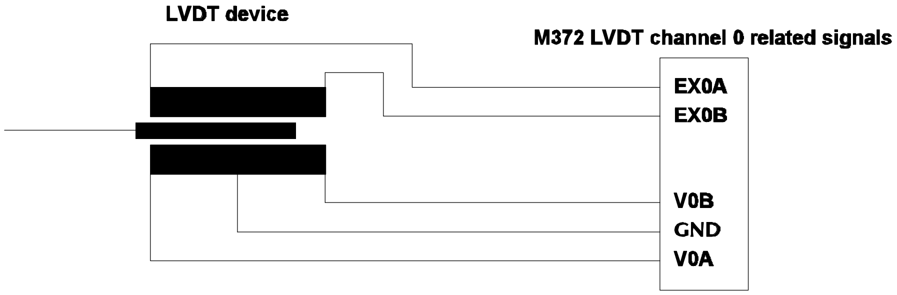


Figure 2 Connecting a LVDT device

Connection of devices to channel 1, 2 and 3 must be done in a similar way.

The specification of the excitation signal, input range and sensitivity depends on the factory configuration of the M372. A wide variety of excitation signals are supported, 2.5V, 3V, 5V @ 400Hz, 1kHz, 2.5kHz or 5kHz. The M372 must be configured for the use of a specific LVDT device. Configuration is done by Acquisition Technology based on the specification of the LVDT device. For detailed information contact your local distributor or Acquisition Technology directly.

3.3. GAIN ADJUSTMENT

The physical stroke of a LVDT device is application dependent, to provide full ADC resolution for each individual system a potentiometer is provided for adjustment of the gain. The gain can be adjusted for each channel separately. The table below shows the relation between the LVDT channel and the potentiometer. For the position of the potentiometer refer to section 6.2.

Gain Adjustment	
LVDT0	R1
LVDT1	R2
LVDT2	R3
LVDT3	R4

The gain can be adjust with two methods, statical using a voltmeter or dynamical using the software output of the M372.

! Statical Adjustment

- Connect a LVDT to channel 0
- Power-up the system
- Measure pin 3 of R1
- Move the LVDT core to the most extreme position
- Adjust R1 in such a manner that the measured voltage reaches the maximum or minimum value, either 0.00V or 5.00V (depending on the sign of the displacement)
- Repeat this for channels 1 to 3.

! Dynamical Adjustment

- Connect a LVDT to channel 0
- Power-up the system
- Start the M372 demo software described in chapter 5
- Move the LVDT core to the most extreme position
- Adjust R1 in such a manner that the output code reaches the maximum value of that direction, either +4095 or -4096 (depending on the sign of the displacement)
- Repeat this for channels 1 to 3.

4. Functional Description

The M372 LVDT/RVDT Controller M-module is build around the LM12458 Data Acquisition System by National Semiconductor. For LVDT and RVDT signal conditioning AD598 devices from Analog Devices Inc. are implemented. For interfacing to a host system the M372 features an A8/D16 M-module interface and serial ID EEPROM.

4.1. Block Diagram

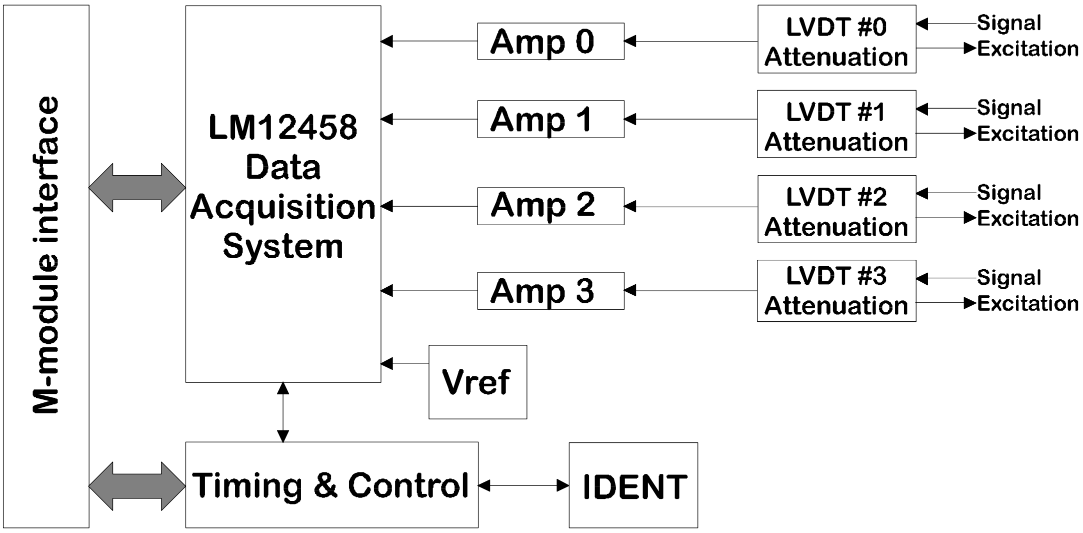


Figure 3 Blockdiagram of the M372 M-module

4.2. M-module Interface

The M372 has an A08/D16 compliant M-module interface, the following table contains an overview of the address map of the M372 module. All addresses are relative to the base address of the module.

Address offset	Width	Description
0x00 ... 0x20	16-bit	Data Acquisition System (LM12458)
0xfe	16-bit	Module identification

A full description of the Data Acquisition System (DAS) register map, configuration and usage of the device is beyond the scope of this manual. For a full description refer to the data sheet of the

LM12458. For a description of accessing the DAS please refer to the provided example software as well the LM12458 data sheet.

On address offset 0xfe the Identification EEPROM can be found. The identification of an M-module is implemented using a serial EEPROM with a 64*16 word organisation. The industry-standard component 93C46 is used in order to make the identification compatible throughout the complete range of available modules. Access to the identification EEPROM takes place through the following register:

EEPROM Offset: 0xFE

	15 4	3	2	1	0
	not used	unused	CS	CLK	DI/O
reset:		0	0	0	x

Read/Write

CS Chip-Select
This bit corresponds to the chip select input of the EEPROM.

CLK Clock
This bit corresponds to the clock input of the EEPROM.

DI/O Data input/output
This bit corresponds to the data input of the EEPROM when writing, and data output of the EEPROM when reading.

For information on controlling the EEPROM refer to the NM93C46 data sheets. A software example can be found in the file *ideeprom.c* that is part of the software distribution. For information on the memory organization refer to the M-module Specification.

4.3. ANALOG INPUT CAPABILITIES

The M372 LVDT/RVDT Controller features 7 external analog input channels. Channel 0 to channel 3 are used to acquire the conditioned LVDT/RVDT signals. Channels 4 to 7 are reserved for future use. The ADC core is implemented using a LM12458 Data Acquisition System. The analog front-end is implemented using AD598 LVDT Signal Conditioners.

! LM12458 Data Acquisition System

The LM12458 is a 12-Bit + Sign Data Acquisition System with self calibration. On the M372 the LM12458 is used with 7 DC inputs with a range of 0V to 5V. For communication with the host the LM12458 provides a set of configuration registers and a 32 sample deep FIFO which are accessible via the M-module interface (refer to section 4.2). The LM12458 features a programmable sequencer. The sequencer can be programmed to acquire the LVDT channels continuously so the host can read sample data from the FIFO at any time. For a programming example refer to chapter 5.

! AD598 LVDT Signal Conditioners

LVDT signal conditioning is handled by AD598 devices from Analog Devices. The AD598 is able to convert the mechanical transition of a transducer to a dc voltage with a high degree of accuracy and repeatability. The AD598 contains a low distortion sine wave oscillator to drive the LVDT primary. The LVDT secondary output consists of two sine waves that drive the AD598 directly. The AD598 operates upon the two signals, dividing their difference by their sum, producing a scaled DC output.
The AD598 uses a ratiometric architecture that eliminates the necessity of adjustments, influence of transformer null voltage and primary to secondary phase shift.
Although the AD598 requires no adjustments, for each LVDT channel gain adjustment is provided to adapt the mechanical stroke to the full resolution of the analog to digital converter, for details refer to section 3.3.

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5. SOFTWARE

This chapter describes the example software which is available for the M372 LVDT/RVDT Controller M-module. The example software is available in ANSI-C source code and consists mainly of an M372 function library which provides functions for easy access to the M372 and a demo program which illustrates the usage of the software library.

The M372 library functions are APIS based, physical accesses and interrupt support are handled by APIS, AcQ Platform Independent Interface Software. The next section contains general information on APIS, for detailed information please refer to the APIS Programmer's Manual.

5.1. APIS SUPPORT

AcQ produces and supports a large number of standard M-modules varying from networking and process I/O to motion control applications. Physically, the M-modules are supported by a large number of hardware platforms: VMEbus, PCI, CompactPCI as well as a wide variety of operating systems: OS-9, Windows NT, Linux etc.

APIS offers a way to program platform independent applications, example- and test software for controlling hardware. Application software written for APIS only needs re-compiling for a particular platform and is operational with little effort (provided that the application is operating system independent).

5.1.1. CONCEPT

Hardware accesses to registers and memory are handled by APIS. Some minor operating system dependent functions frequently used in hardware related software, such as interrupt handling and a delay function are also provided by APIS.

APIS platform support consists of an Application Programming Interface in the form of definition files coded in ANSI-C and platform dependent modules e.g. source files, libraries and/or drivers.
In the most simple outline, a platform dependent APIS module consist of nothing more then macro definitions in which APIS calls are substituted by direct hardware accesses. But in most cases an APIS module will consist of a library with interface routines and in some implementations a device driver is needed for interaction with the operating system.

5.1.2. API

The Application Programming Interface for APIS is implemented in two ANSI-C coded definition files: *apis.h* which contains general definitions and *platform_apis.h* which contains platform specific definitions and references to the APIS function calls.

The application source file must include the APIS header file *apis.h*. Porting of the application to a platform, consists of re-compiling the source code with a defined pre-processor macro for selection of the used platform. The APIS header file contains generic APIS definitions and includes a platform specific header file according to the platform selection macro.

APIS calls are translated to the platform specific calls in the APIS header file and the platform specific definition file *platform_apis.h* (*platform* is a name that identifies a hardware and operating system combination, e.g. i4000os9).

The macro PLATFORM must be defined, either via a pre-processor definition provided at compile time or via a macro-definition in the application source.

5.1.3. CODE GENERATION

APIS based example software is available in ANSI-C source code. Source code files must be compiled with the pre-processor definition PLATFORM set to a valid value, conforming the target platform. Building of the example software for the M372 is platform dependent, for details refer to the release notes of the APIS support package of the target platform and the APIS Programmer's Manual.

Examples of APIS supported platforms are i4000os9, i2000dos, i3000win etc.

5.2. TYPE DEFINITIONS AND STRUCTURES

The table below contains a list and description of all types and structures used in the M372 example software (standard ANSI-C types are not listed).

Name	Type	Description
INT8	char	8-bit signed data
UINT8	unsigned char	8-bit unsigned data
INT16	short	16-bit signed data
UINT16	unsigned short	16-bit unsigned data
INT32	long	32-bit signed data
UINT32	unsigned long	32-bit unsigned data
PHA8	volatile unsigned char *	8-bit physical access
PHA16	volatile unsigned short *	16-bit physical access
PHA32	volatile unsigned long *	32-bit physical access
APIS_PATH	unsigned long	APIS physical path ID
APIS_HANDLE	void *	APIS physical path handle
APIS_WIDTH	int	APIS access size in bytes
IDCODE	union {	ID EEPROM contents
	struct {	
	short synccode,	Sync code (0x5346)
	modnum,	Module number (binary coded)
	revision,	revision number
	modchar,	Module characteristics
	res[4];	reserved
	char manstr[16];	manufacturer string
	} id;	ID data
	short reg[16];	raw data
	}	

M372_DEV	struct {
	APIS_HANDLE apis_handle
	}
		M372 Device structure, currently only used to store the APIS handle, may be expanded for future functionality

M372_OPEN_T	int	Argument for m372_open()

M372_READ_T	struct{
	UINT16 lvdt_val[4];
	} M372_READ_T;
		LVDT measurement results
		Argument for m372_read()

5.3. Library Function Return Values

Each library function returns a result which is either an APIS error code or an M372 library error code. APIS results have bit #15 cleared, library results have bit #15 set. For an overview of APIS error codes refer to the APIS programmer's manual, for an overview of the library result codes refer to the table below:

Result	Hex	Description
NOERR	0x0000	No error
ERR_CALTIMEOUT	0x8100	Calibration timeout
ERR_IDEEP	0x8300	Reading module ID failed
ERR_MODID	0x8500	Module is not an M372

5.4. Function Reference

This section contains the reference of the functions provided by the M372 APIS-based software library.

m372_open() — Open M372 device

Syntax: `int m372_open(APIS_PATH path_id, M372_DEV *device, M372_OPEN_T *cal)`

Description: Open a hardware path to an M372, check APIS version compatibility, verify module ID by reading the identification EEPROM and initialize the M372. The function initializes the provided device structure of type M372_DEV. The programmer must make sure that enough space is available for the device structure.

Arguments: APIS_PATH path_id
Module APIS path id

M372_DEV *device
Pointer to M372 device

M372_OPEN_T *cal
If TRUE full calibration of the LM12458 is performed

Returns: APIS error code or M372 library error code

m372_close() Close M372 device

Syntax: `int m372_close(M372_DEV *device)`

Description: Close an M372 device, consequently a reset of the LM12458 will be performed and allocated memory is freed.

Arguments: M372_DEV *device
Pointer to M372 device

Returns: APIS error code or M372 library error code

m372_read() Get LVDT measurement results

Syntax: `int m372_read (M372_DEV *device, M372_READ_T *pData, UINT32 *count)`

Description: Read LVDT/RVDT input values of the M372.

Arguments: M372_DEV *device
Pointer to M372 device.

M372_READ_T *pData
Measured pData:

```
typedef
{
        UINT16 lvdt_val[4];    // LVDT inputs
} M372_READ_T
```

UINT32 *count
size of measured data in bytes.

Returns: APIS error code or M372 library error code

5.5. SOFTWARE DISTRIBUTION

This section gives an overview of the software distribution.

File	Description
M372\SOFTWARE\m372rel.txt	Release notes
M372\SOFTWARE\LIB\m372lib.c	ANSI-C M372 APIS software library
M372\SOFTWARE\LIB\m372lib.h	Definitions for the M372 library
M372\SOFTWARE\LIB\m372defs.h	Definitions for the M372
M372\SOFTWARE\EXAMPLE\m372demo.c	Demo program for M372
M372\SOFTWARE\EXAMPLE\makefile.bor	Borland C makefile for M372 on i2000
M372\SOFTWARE\EXAMPLE\makefile.os9	OS9 makefile for M372 on i4000
MMODID\SOFTWARE\LIB\modideep.c	ANSI-C ID EEPROM APIS software library
MMODID\SOFTWARE\LIB\ideeprom.h	Definitions for the ID EEPROM library

M372 example software is APIS based, therefore APIS support for the target platform is required for code generation.

The following figure is an example of the M372 software integrated in the APIS environment on an i4000/OS-9 target platform.

```
+---PROJECT                           AcQ’s distribution
     +---APIS                         APIS basis distribution
     |    +---DOC                     APIS documentation
     |    +---SOFTWARE
     |         | readme.txt           Distribution overview
     |         +---COMMON
     |         |    +---DEFS
     |         |    |    apis.h       General definitions
     |         |    +---OS9TRAP
     |         |    |   +--CMDS
     |         |    |       apistrap  OS-9 trap handler
     |         |    +---....
     |         +---I4000OS9           i4000/OS-9 support
     |         |    relnotes.txt      Release notes / version info
     |         |    apis_i4000os9.h   Platform specific definitions
     |         |    apis_i4000os9.c   Platform support library
     |         +---....
     |
     +---M372                         M372 distribution
     |    +---SOFTWARE
     |         | m372rel.txt          Release notes / version info
     |         +---LIB                M372 support libraries
     |         +---EXAMPLE            M372 example software
     +---MMODID
          +---SOFTWARE
               +---LIB
                    modideep.c        M-module ID EEPROM library
                    ideeprom.h        M-module ID definitions
```

Code generation is platform dependent, for information on building the software please refer to the release notes of the target platform and the APIS Programmer’s Manual.

6. ANNEX

6.1. BIBLIOGRAPHY

Specification for M-module interface and physical dimensions
M-module specification manual, April 1996, MUMM.
Simon-Schöffel-Strasse 21, D-90427 Nürnberg, Germany.

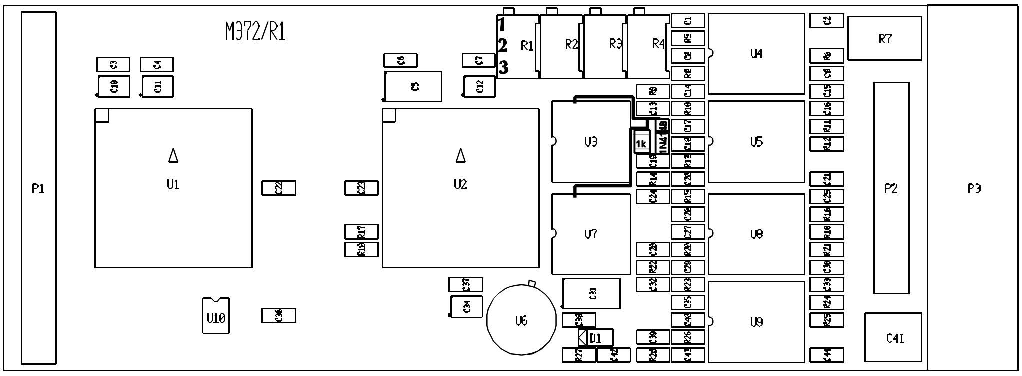
APIS Programmer's Manual
AcQuisition Technology
P.O. Box 627, 5340 AP Oss, The Netherlands.
Downloadable from www.acq.nl

Data Sheet of the LMD12458 Data AcQuisition System
National Semiconductor Corporation
1111 West Bardin Road; Arlington, TX76017, United States

Data Sheet of the NM93C06
Memory Databook
National Semiconductor Corporation
1111 West Bardin Road; Arlington, TX76017, United States

Data Sheet of the AD598 LVDT Signal Conditioner
Special Linear Reference Manual
Analog Devices Inc.
One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, United States

6.2. COMPONENT IMAGE



6.3. TECHNICAL DATA

Slots on the base-board:
Requires one 16-bit M-module slot.

Connection:
To base-board via 40 pole M-module interface.
To peripheral via 25 pole D-sub connector.

Power supply:
+5VDC ±10%
+12VDC ±10%
-12VDC ±10%

Temperature range:
Operating: 0..+60°C.
Storage : -20..+70°C.

Humidity:
Class F, non-condensing.

6.4. DOCUMENT HISTORY

! Version 1.0
Replacement for M372 LVDT/RVDT Hardware Manual R1.1