Instruction manual
970 SmartRadar ATi

CE

Honeywell Enraf

Preface

This manual is intended for technicians involved in the commissioning and service of the Honeywell Enraf series 970 SmartRadar ATi gauge.

A description preceding the technical procedures gives the technical information necessary to understand its functioning. It is recommended to read this description prior to performing any of the procedures.

For installation of the 970 SmartRadar ATi, please refer to the Installation guides of the 970 SmartRadar ATi and SmartRadar Antennas. This manual describes the commissioning and service of the basic 970 SmartRadar ATi level measurement. Other features such as level alarm output contact, temperature measurement (spot or average), analog level output and pressure measurement are described in separate manuals. For an overview, refer to the list of related documents in appendix D.

Legal aspects

The commissioning of and troubleshooting to the instrument may only be conducted by qualified engineers, trained by Honeywell Enraf and with knowledge of safety regulations for working in hazardous areas.

The information in this manual is the copyright property of Enraf B.V., Netherlands.
Enraf B.V. disclaims any responsibility for personal injury or damage to equipment caused by:

- Deviation from any of the prescribed procedures
- Execution of activities that are not prescribed
- Neglect of the safety regulations for handling tools and use of electricity

EC declaration of conformity

Refer to the EC declaration of conformity, shipped with the instrument.

Additional information

Please do not hesitate to contact Honeywell Enraf or its representative if you require any additional information.

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1   Introduction

The Honeywell Enraf 970 SmartRadar ATi is a radar based level gauge. It is designed to measure the product level in large storage tanks accurately and reliably.

The following options can be added to the basic SmartRadar:

- One hard alarm output contact, which can be linked to one of the four programmable alarms in the instrument;
- An Infra-Red connector for the configuration tool 847 Portable Enraf Terminal;
- An intrinsically safe output to connect the 977 Tank Side Indicator.

Additional sensors can be connected to the SmartRadar when the optional ICU_HPI board is installed. This provides the instrument inputs for:

- Spot temperature element (Pt100);
- HART channel for: 762 VITO Interface, which is a converter for average product (and vapour) temperature and/or water bottom measurement (via VITO temperature and/or water probes);
- HART channel for: pressure transmitters for HIMS configuration or vapour pressure measurement and for a side mounted water probe.

Standard, the SmartRadar is provided with Honeywell Enraf field bus transmission for communication with remote tank gauging systems. Optionally, the following output signals are available:

- Analog 4-20 mA level output with HART communication for other measured quantities (Honeywell Enraf field bus signal also available). This requires the optional ICU_HPO board.
- RS-232C or RS-485 serial communication (Honeywell Enraf field bus signal not available), this requires the optional ICU_RS232/485 board.
- Modbus protocol via RS-232C or RS-485.
- Foundation Field bus protocol, this requires the optional GFC board.

Basic 970 SmartRadar ATi		
Optional Hard alarm output contact		
Optional IR connector for 847 PET (Portable Enraf Terminal)		
Optional I.S. output for 977 TSI (Tank Side Indicator)		
Optional input board	**Optional output board**	
ICU_HPI board: - spot temperature element - HART channel for 762 VITO - HART channel for P1, P3	ICU_RS232/485 board: - RS-232C or - RS-485 - Modbus protocol	ICU_HPO board: - HART output and/or - analog 4-20 mA level output
		GFC board: - Foundation Field bus interface

1.1   Principle of measurement

The radar level gauge is a device that uses high-frequency (10 GHz) electromagnetic waves to determine the distance from the radar antenna to the product surface. The electro-magnetic wave is sent into the tank and reflected by the product. As an electro-magnetic wave travels with the speed of light, this measurement can not simply be done on the basis of time of flight. Instead, the phase difference between the transmitted and the received signal is measured. The corresponding travelled distance can then be calculated from this phase relation. This measurement principle is known as synthesized pulse radar (SPR).

In the 970 SmartRadar ATi the microwave signal is generated and led, via the tank separator, to the antenna (refer to figure 1.1). The radar antenna shapes the beam and sends the signal into the tank. The microwave signal reflected from the product is then received by the same radar antenna. The digital electronics in the SmartRadar ATi measure both the transmitted and the reflected signal.
After processing, the measured distance is converted into level data (innage or ullage) and made available for field communication.

1.2   Configurations

The 970 SmartRadar ATi is installed on the tank separator device.

The antenna is coupled to the 970 SmartRadar ATi via the tank separator device. The tank separator provides for adequate isolation between the tank contents and the electronics in the SmartRadar ATi. Refer to figure 1.1.

Depending on the application, different antennas are to be used.
The tank separator adapts the different type of antennas.

Item	Description
1	SmartRadar ATi
2	Tank separator
3	Antenna

For radar level measurement, tanks can be divided into 2 groups:

- Fixed-roof tanks; free space measurement (antenna types: F08 and W06);
- Tanks with a stilling well (fixed-roof and floating-roof tank); stilling well measurement (antenna types: S06, S08, S10 and S12).
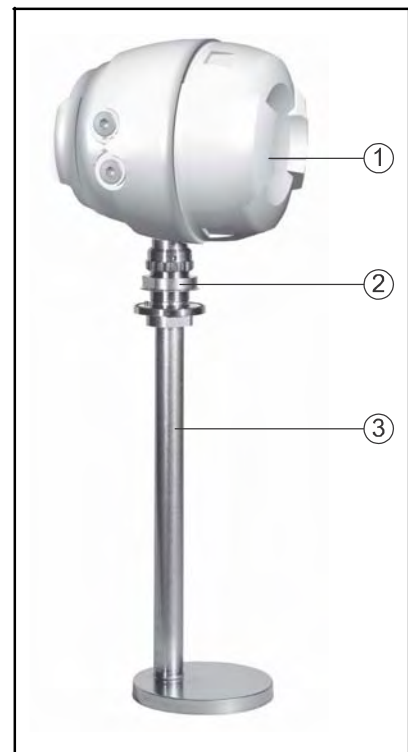
Figure 1.2 gives an overview of the installation on the different tank types.
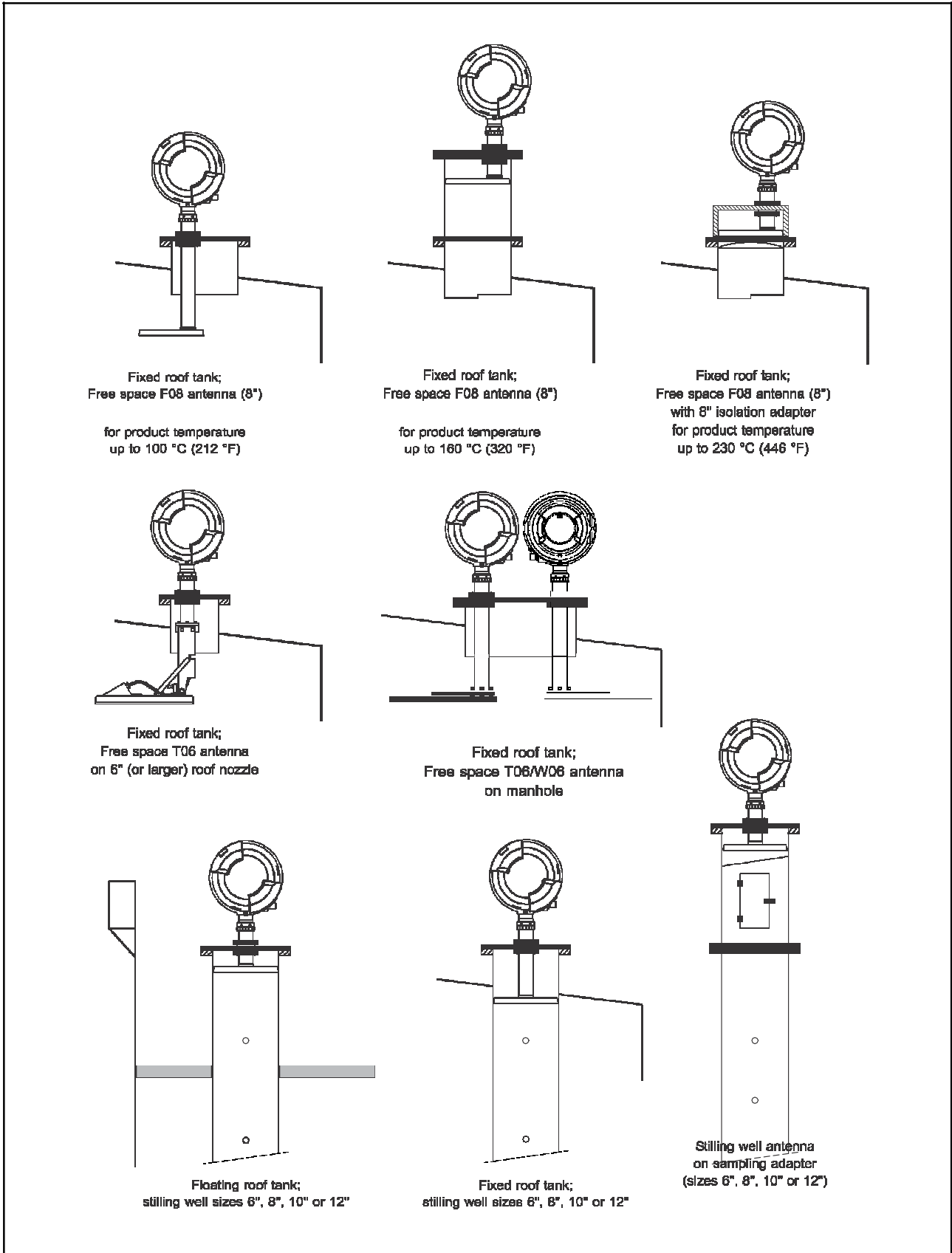
Figure 1.1   970 SmartRadar ATi configuration

Figure 1.2   Installation overview

1.3 Optional functions

Optional functions can be added in the SmartRadar ATi.
The table below gives an overview of all options and related manuals.

Option	Board	Refer to
Level alarm output relay (or digital output)	ICU	Instruction manual ICU Hard alarm output contact (4416.633)
Analog level output (4 - 20 mA)	ICU_HPO	Instruction manual Temperature, Water bottom and Analog output options (4416.644)
Spot temperature measurement	ICU_HPI	Instruction manual Temperature, Water bottom and Analog output options (4416.644)
Average temperature measurement and water bottom measurement via 762 VITO	ICU_HPI	Instruction manual Temperature, Water bottom and Analog output options (4416.644)
Pressure measurement for mass, density and/or vapour pressure via HART protocol	ICU_HPI	Instruction manual HIMS / HTG and vapour pressure (P3) measurement (4416.645)
Water bottom measurement via side mounted water probe	ICU_HPI	Instruction manual Temperature, Water bottom and Analog output options (4416.644)
RS-232C/RS-485 communication	ICU_ RS232/ 485	Instruction manual 973 SmartRadar LT RS-232/485 output communication (4416.647)
Modbus communication	ICU_RS232/ 485	Instruction manual Modbus™ protocol Honeywell Enraf gauges (4416.513)
HART communication	ICU_HPO	Instruction manual 973 SmartRadar LT HART® output communication (4416.646)
Foundation Field bus communication	GFC	Instruction manual Foundation™ Field bus communication (4416.646)

1.4 Remote monitoring

Central monitoring of the SmartRadar is possible via tank inventory systems such as Entis Pro.
Remote display can be achieved using the 977 TSI Tank Side Indicator, the 877 FDI field indicator or the 878 CPI panel indicator.

1.5 Approvals (FM, ATEX)

The Honeywell Enraf 970 SmartRadar ATi is an explosion proof instrument, which is designed to meet requirements of ATEX, Factory Mutual, and others. Measuring performance and data handling protocol meet W&M requirements.

2   Safety

2.1   Safety aspects of the 970 SmartRadar ATi

Warning
Do not use the instrument for anything else than its intended purpose.

The housing of the 970 SmartRadar ATi is explosion proof:

- II 1/2 G EEx de [ib/ia] IIB T4; KEMA 03ATEX2468 X; certified by KEMA, Netherlands
- Class I, Division 1, Groups B, C, D T4, according to ANSI / NFPA 70 (Factory Mutual)

The covers of the SmartRadar ATi are provided with blocking facilities which prevent unauthorised opening.

Optionally, programming the 970 SmartRadar ATi can be done by the 847 PET (Portable Enraf Terminal), which is an intrinsically safe device and is connected to the SmartRadar ATi via an infra-red coupling.

Caution
The 970 SmartRadar ATi is an explosion proof instrument with intrinsically safe output/input circuits. Modification to the instrument may only be carried out by trained personnel that is authorised by Honeywell Enraf. Failure to adhere to this will invalidate the approval certificate.

The emitted microwave energy is far below the accepted limits for exposure of the human body. Depending on the type of antenna, a maximum radiation of 0.1 mW/cm^2 is generated.

2.2   Personal safety

The technician must have basic technical skills to be able to safely commission the equipment. When the 970 SmartRadar ATi is installed in a hazardous area, the technician must work in accordance with (local) requirements for electrical equipment in hazardous areas.

Warning
In hazardous areas it is compulsory to use personal protection and safety gear such as:
hard hat, fire-resistive overall, safety shoes, safety glasses and working gloves.

Avoid possible generation of static electricity. Use non-sparking tools and explosion-proof testers.
Do not open any of the instrument covers while power is still connected.

Make sure no dangerous quantities of combustible gas mixtures are present in the working area.

Never start working before the work permit has been signed by all parties.

Pay attention to the kind of product in the tank. If any danger for health, wear a gas mask and take all necessary precautions.

2.3   Safety conventions

"**Warnings**", "**Cautions**", and "**Notes**" are used throughout this manual to bring special matters to the immediate attention of the reader.

- A **Warning** concerns danger to the safety of the technician or user
- A **Caution** draws attention to an action which may damage the equipment
- A **Note** points out a statement deserving more emphasis than the general text, but not requiring a "Warning" or "Caution"

3   Commissioning

3.1 Checks before starting the commissioning

Examine the mechanical and electrical installation after the 970 SmartRadar ATi is installed on the tank.

- Check the connections of all electrical cabling
- Check that all ground connections are made
- Check that non-used cable inlets are sealed with appropriate stopping plugs
- Close all covers carefully (mind O-rings) and apply power

3.2 Introduction in programming the 970 SmartRadar ATi

The item concept

The 970 SmartRadar ATi gauge is a field-configurable multi-processor instrument. This means that the instrument can be totally programmed out in the field, or remotely, without opening the gauge.
All parameters, settings, etc. are accessible either via the optional PET (Portable Enraf Terminal) or remotely with the Honeywell Enraf service tool via so-called items.
These items all have unique 2-letter indexes which allow easy access and programming. Many indexes associate with an abbreviation of the item description.

There are three different type of items:

Type of item	Description
Commands	These will force the gauge to execute a special task or function. Example: **EX** (exit). After the **EX** command, the instrument starts initialising and modified NOVRAM settings become active.
Data requests	Items for request of setup or measuring data from the gauge. Example: **JS** will return the jumper setting on the ICU board. Some of the data items are read-only.
NOVRAM Settings	All parameters which can be programmed and should not be lost after power break down, are stored in NOVRAM. The NOVRAM is a non-volatile RAM memory which does not require battery back up.

Data stored in NOVRAM can be protected by a password and/or by the Weights & Measures (W&M) jumper (refer to figure 3.1).

Protection levels are provided for all NOVRAM items, depending on the importance of an item. Protection level 2 is protected by password 2 (**W2**) and protection level 1 is protected by password 1 (**W1**).
If the NOVRAM is protected by the NOVRAM jumper (jumper J4), level 2 data cannot be changed without opening the gauge. Most data requests and commands are not password protected.

Protection level 1

Access to items which are not directly measurement related data, such as high level alarm (**HA**), tank identifier (**TI**), etc. is protected by password 1 (**W1**). It is possible to modify these data only after entering the correct level 1 password W1=XXXXXX, where XXXXXX is the level 1 password.
Password **W1** itself can be read protected by means of jumper J6 on the ICU board.

Protection level 2

All NOVRAM items which affect the (remote) level reading (such as reference level (**RL**) or transmission address (**TA**)) are protected by password 2 (**W2**). It is possible to modify these data only after entering the correct password W2=XXXXXX , where XXXXXX is the level 2 password. Additional measurement-related items, such as temperature items can also be protected by password 2.
Password **W2** itself can be read protected by means of jumper J5 on the ICU board. In protection level 2, the items protected under protection level 1 can be also modified.
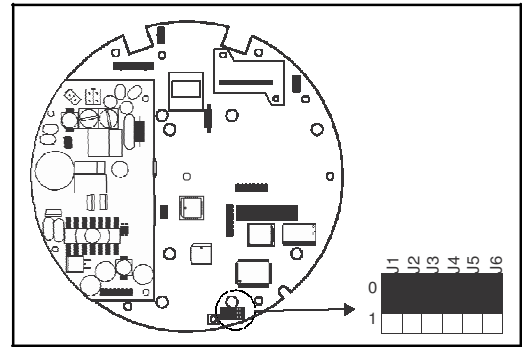
Figure 3.1 shows the jumper position on the ICU board.
The table below gives an overview of the ICU jumper functions.

Figure 3.1   Jumpers on ICU board

jumper	function	position "0"	position "1"
J1	read password 1	not protected	protected
J2	read password 2	not protected	protected
J3	W&M protection	disabled	enabled
J4 ÷ J6	no function	x	x

Indexed items

In general, items have only one setting (i.e. HA+026.0000). Indexed items have more than one setting (elements). For instance: item **OS** (obstruction zone start position). Item **OS** has ten elements, corresponding with the ten programmable obstruction zones.

OS	**OS**	**OS**	**OS**	**OS**	**OS**	**OS**	**OS**	**OS**	**OS**
element 0	element 1	element 2	element 3	element 4	element 5	element 6	element 7	element 8	element 9

Indexed items are requested by the two-character item name, followed by the element number and number of elements to be requested, separated by dots.
In general:

    XX.n.i

        where: XX   = two-character item name
               n   = element number (starts with 0)
               i   = number of elements (can be 1 or more, but maximum is 9)
For example:
    OS.0.1   <enter>   requests the first obstruction zone start position;
    OS.1.1=+012.3400 <enter>   programs the second obstruction zone start position.

Note:
    *Although it is possible to program more than one element at the time, it is **not** recommended. To avoid mistakes, program only one element at the time.*

3.3 Connection of Honeywell Enraf service tool

3.3.1 Communication via the Honeywell Enraf field bus line

By default, the 970 SmartRadar ATi is set on transmission address 00. The 970 SmartRadar ATi, and also other types of Honeywell Enraf gauges, can be connected in parallel to the Honeywell Enraf field bus line. Each instrument must have its unique transmission address.
The items can be programmed using the Portable Enraf Terminal, which is connected via the optional Infra-red connector. If this option is not present, items can be programmed remotely.

SmartRadar ATi connected to an 858 CIU
Temporary disconnect the RS-232C connection from the Entis+ (or other host) and connect it to a service PC where the Honeywell Enraf service tool is running (refer to figure 3.2a).
Mind the relation for the transmission addresses per transmission line of the 858 CIU:
    TL1 (addresses: 00 - 29),   TL2 (addresses: 30 - 59),   TL3 (addresses: 60 - 99)

The SmartRadar ATi can be connected to the desired transmission line, although its address is still at default. Thus a SmartRadar ATi with default transmission address 00 can be connected to transmission line 2 (suitable for transmission addresses 30 - 59). Due to the mechanism that the request from the host (Honeywell Enraf service tool) is transmitted over all three transmission lines, the SmartRadar ATi receives the commands. However, when the SmartRadar ATi is connected to transmission line 2 or 3, there is no response.

This concept only works if *one* new SmartRadar ATi is powered with the default transmission address 00. Also, there may not be an operational gauge with transmission address 00. If such a gauge exists, do switch it off temporarily.

Continue with section 3.3.4, programming communication parameters.

SmartRadar ATi connected to an 880 CIU Prime
HostPort 2 from the CIU Prime must be available for the connection of a service PC where the Honeywell Enraf service tool is running (refer to figure 3.2b).
To communicate via HostPort 2, the CIU Prime must be configured to CIU 858 emulation mode on HostPort 2. If HostPort 2 is in use, temporary disconnect it and temporary re-configure the CIU Prime for CIU 858 emulation via HostPort 2.

This concept only works if *one* new SmartRadar ATi is powered with the default transmission address 00. Also, there may not be an operational gauge with transmission address 00. If such a gauge exists, do switch it off temporarily.

Continue with section 3.3.4, programming communication parameters.

SmartRadar ATi connected to another type of host
Temporary disconnect the Honeywell Enraf field bus line from the host.
Use a 847 PET (Portable Enraf Terminal) with optional RS-232C PET Interface as protocol converter between Honeywell Enraf field bus signal and RS-232C to the service PC where the Honeywell Enraf service tool is running (refer
to figure 3.2c).

This concept only works if *one* new SmartRadar ATi is powered with the default transmission address 00. Also, there may not be an operational gauge with transmission address 00 connected to the Honeywell Enraf field bus line. If such a gauge exists, do switch it off temporarily.

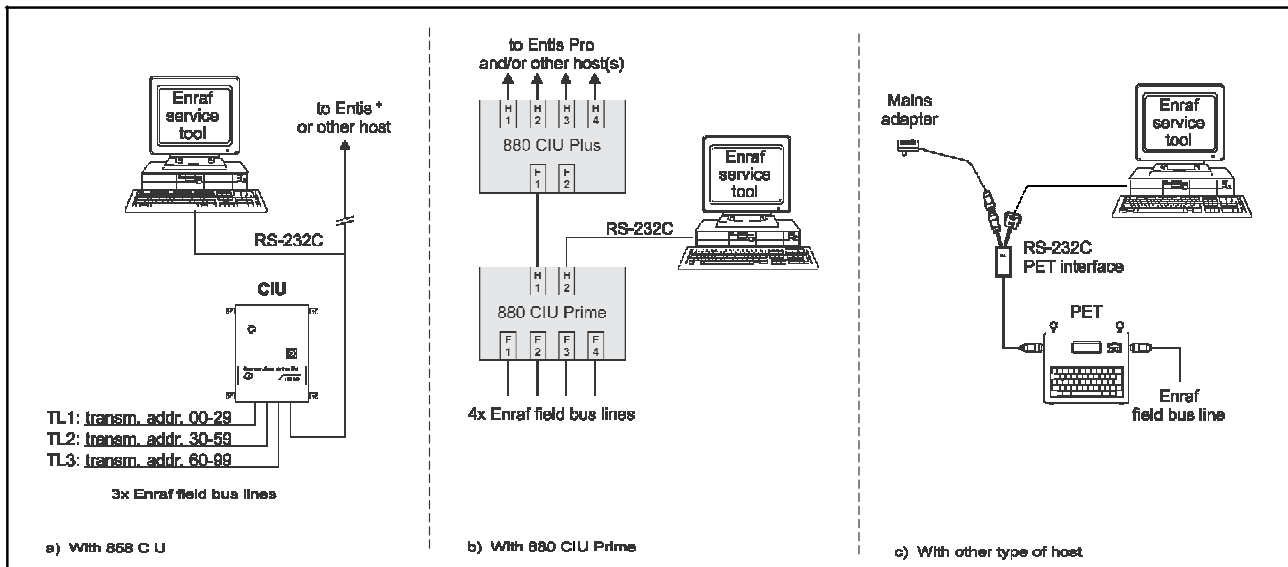Continue with section 3.3.4, programming communication parameters.

Figure 3.2   Different connections to Honeywell Enraf field bus line

3.3.2 Communication via RS-232C or RS-485

RS-232C
Connect the RS-232C transmission line from the SmartRadar ATi to a service PC where the Honeywell Enraf service tool is running (refer to figure 3.3a). Default baud rate for RS-232C is 19200 baud.

Continue with section 3.3.4, programming communication parameters.

RS-485
Connect the RS-485 transmission line (eventually via an RS-485 / RS-232C converter) to a service PC where the Honeywell Enraf service tool is running (refer to figure 3.3b).
Default baud rate for RS-485 is 19200 baud.

When more than one gauge is connected to the same transmission line (multi drop mode), make sure that only *one* new SmartRadar ATi is powered with the default transmission address 00. Also, there may not be an operational gauge with transmission address 00. If such a gauge exists, do switch it off temporarily.

Continue with section 3.3.4, programming communication parameters.

3.3.3 Communication via HART [®] signal

The SmartRadar ATi can be configured to give a 4 - 20 mA level output. In this mode it is possible to configure the SmartRadar ATi via the HART [®] communication protocol.
Connect the HART [®] transmission line via a HART [®] modem to a service PC where the Honeywell Enraf service tool is running (refer to figure 3.3c).

A maximum of 15 SmartRadar ATi's with HART [®] output signal can be connected in parallel (multi drop mode); each gauge having a unique HART [®] communication address from 1 to 15.
When more than one gauge is connected to the same transmission line (multi drop mode), make sure that only *one* new SmartRadar ATi is powered with the default communication address 0.

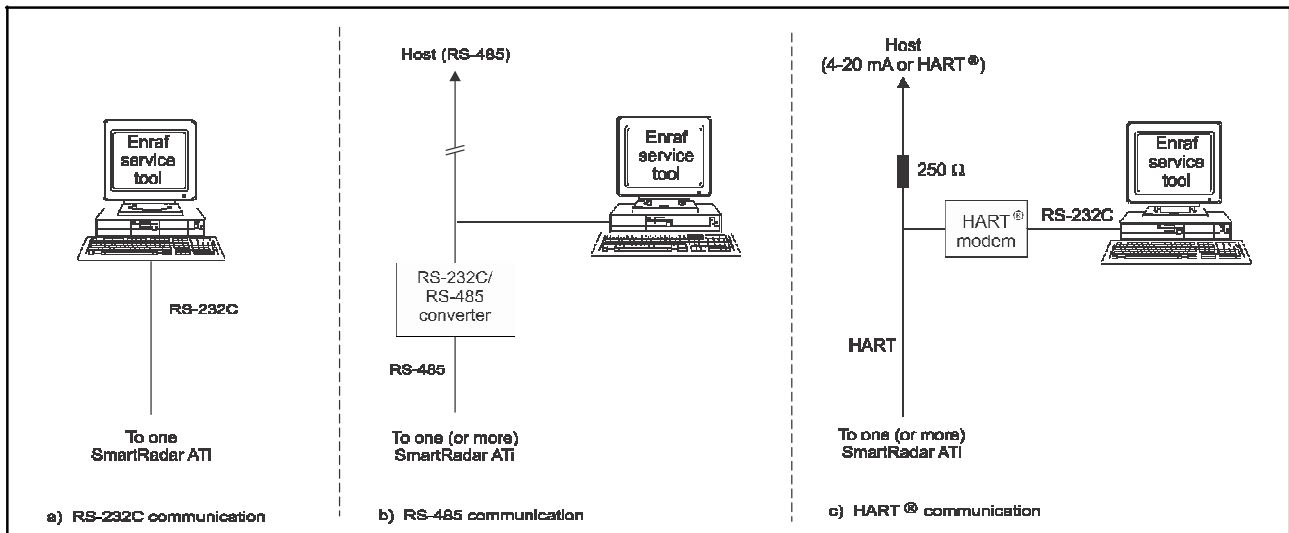Continue with section 3.3.4, programming communication parameters.

Figure 3.3   RS-232C / RS-485 and HART connections

3.3.4   Programming communication parameters

Start up the Honeywell Enraf service tool and make contact with the SmartRadar ATi to be configured.

Honeywell Enraf service tool Logger:
Go to section: Send items (2). Set the transmission address to '00' <F2> and check the CIU address <F3>.
If necessary, set record type to 'BZ' <F4> and set display <F5> to (01/02).

Honeywell Enraf service tool Ensite:
It is not recommended to make a site scan, as the transmission address is still to be changed.
Therefore, to make contact with the gauge, set the address manually in the port settings.
Select this window by: Set up, Port settings (use the extended setup window).
Check the baud rate setting (1200 baud when communicating via Honeywell Enraf field bus and HART$^®$
and 19200 baud when communicating via RS-232C or RS-485) and comport setting.
Go to the line Prefix: and set (check) the desired CIU address and set the transmission address to '00'
<TA=00>.

Note:
   *When communicating via RS-232C / RS-485, default the CIU emulation address is disabled. Hence,
   delete the part with the CIU address (delete: <CIU=0>).
   When communicating via HART$^®$, delete the part with the CIU address (delete: <CIU=0>).*

Honeywell Enraf service tool Engauge:
Select the relevant CIU Prime folder and do: Add gauge (970).
Select: Properties and check / modify the Address (00). Then click tab Verify and continue to enter all
settings.

For remote transmission, the items **TA** and **TI** must be programmed and items **GT** and **TS** should be checked. All these items reside under protection level 2. Proceed as follows:

Item	Name	Description
W2=	Protection level 2	Enter password 2. Default level 2 password: ENRAF2
TA=	Transmission address	Two digits. Enter the desired transmission address. If gauges are connected in parallel to the transmission line, each gauge must have its unique transmission address. Mind the address relation when connected to an 858 CIU:

CIU highway	Transmission address (**TA**)
TL 1	00 - 29
TL 2	30 - 59
TL 3	60 - 99

Item	Name	Description
TI=	Tank identifier	6 Characters; program the tank name into **TI** (spaces are not allowed). This name is used as subdirectory name in the Ensite service tool to store information (log file, reflection diagram, etc.) on the hard disk.
GT=	Gauge type	1 Character. **GT** represents the type of instrument. For 970 SmartRadar ATi, **GT** is B.
TS=	Transmission speed	4 Characters. For Honeywell Enraf field bus line **TS** is 1200 (default) or **TS** is 2400 baud. For HART communication, **TS** remains on 1200 (default). For RS-232C or RS-485 communication, **TS** is default 19K2 and can be set lower to: 9600, 4800, 2400 or 1200 baud.
EX	Exit	Exit protection level. After the exit command, the 970 SmartRadar ATi will perform a controlled software reset and all changes made will be effective after start-up.

Example:

The SmartRadar ATi on tank 102 will get transmission address 42. The gauge should be programmed as follows:

Item (+setting)		Description
W2=ENRAF2	<enter>	Enter password 2 (ENRAF2 is default level 2 password)
TA=42	<enter>	Transmission address equals to 42
TI=TNK102	<enter>	Tank identifier.
GT	<enter>	Check whether the gauge type item is correct; if not, change it.
TS	<enter>	Check whether the transmission speed item is correct; if not, change it.
EX	<enter>	Exit protection level.

As the transmission address (and perhaps also the baud rate) is changed, the Honeywell Enraf service tool must be adapted to the new conditions. That can be done as described earlier, or a 'site scan' can be made.

3.4 Programming the gauge

The 970 SmartRadar ATi is pre-programmed at the factory. Depending on the application, a number of additional parameters have to be set.

Note:

The items described in this section are typical for the basic 970 SmartRadar ATi.
For the optional functions / boards such as: level alarm relay output, spot temperature measurement, average temperature measurement, analog level output and HIMS (Hybrid Inventory Management System) please refer to the applicable option manuals.

Step 1:   Collect the required data (such as radar position height, maximum safe fill height, alarm settings, etc.) on a piece of paper. Refer to 'Commissioning form 970 SmartRadar ATi' supplied with each gauge.

Step 2:   Proceed with programming / checking of each item for the standard gauge without optional functions (level start-up, zones / thresholds and alarm setting).

Step 3:   Check the identification code on the label of the 970 SmartRadar ATi to determine whether the gauge is equipped with one or more optional functions, and program the items for these options.

In the following sections, the items are listed that *as a minimum* should be programmed (checked) during commissioning of the level part of the SmartRadar. Commissioning is divided into the following steps:

Step 1	Selecting dimension and decimal separator (section 3.4.1)
Step 2	Level start-up (section 3.4.2)
Step 3	Level check (section 3.4.3)
Step 4	Zones and threshold settings (section 3.4.4)
Step 5	Level alarm settings (section 3.4.5)
Step 6	Ullage readout (section 3.4.6)
Step 7	Password protection (section 3.4.7)
Step 8	Options (refer to the option manual(s) of the installed options)

3.4.1 Selecting dimension and decimal separator

When one or more dimension items are changed, all items with related formats will be automatically changed and the values will be automatically converted to the new dimension. The same applies for the decimal separator. The SmartRadar ATi can be completely programmed in another dimension than it is intended to operate in. Just change the item **LD** (and any other dimension items).

Item	Name	Description
W2=	Protection level 2	Enter password 2 (default password: ENRAF2)
LD=	Level dimension	Selects and converts the level dimension. This item contains one character, which can be: M : metres; format: sign X X X separator X X X X F : feet; format: sign X X X X separator X X X I : inches; format: sign X X X X X separator X X P : fractions; format: sign X X ' X X " X X
DP=	Decimal separator	The item **DP** (decimal separator) can be: **.** : point or , : comma.
EX	Exit	Exit protection level

Standard formats

There are two standard formats; these formats are:

- Standard floating point format: sign point M M M M M M M M E sign P P
- Standard power format [dB]: sign X X X X point X

where: M = mantissa
  P = exponent
  X = value in decibel

3.4.2 Level start-up

Refer to figure 3.4 for level start-up tank parameters.

To get the level from the gauge without any compensation enabled, only the following items should be programmed.

Radar reference:

> The radar reference (zero point for the radar gauge measurement) is the roof nozzle position (refer to figure 3.4).

If the 970 SmartRadar ATi is equipped with a stilling well antenna model, item **BD** should be programmed. In all other cases skip this item and start from item **OM**.
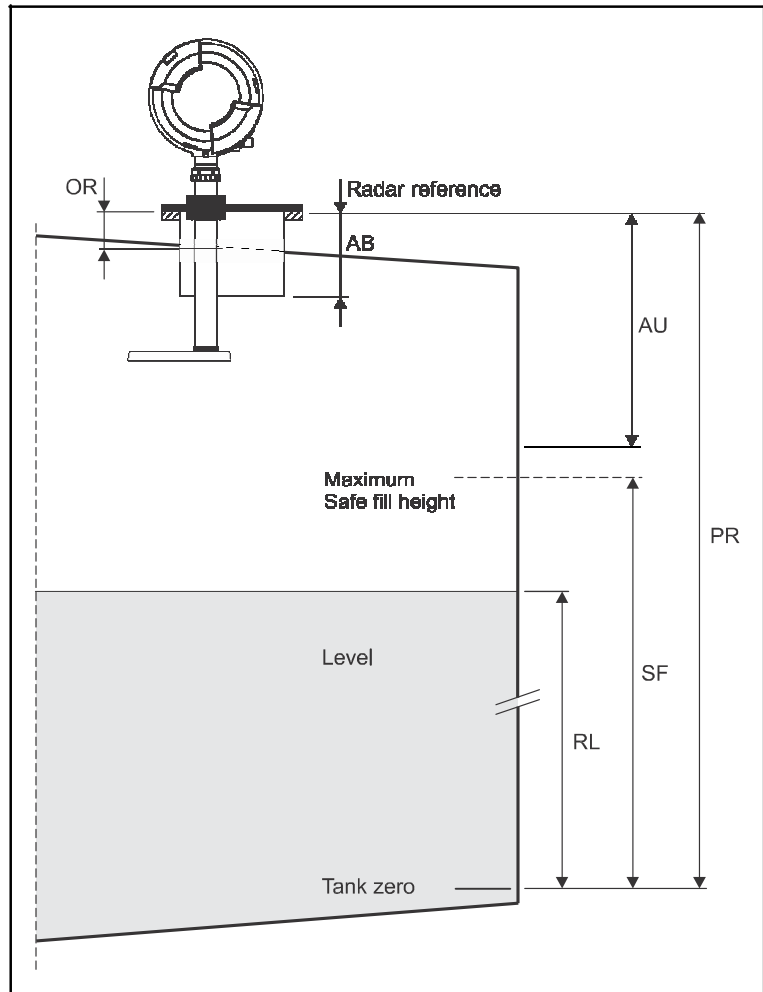

Figure 3.4 Level start-up tank parameters

Item	Name	Description
W2=	Protection level 2	Enter password 2 to alter the required settings.
BD=	Stilling well diameter	Floating point format; units: metres. This item contains the internal diameter of the stilling well (only if the SmartRadar ATi is installed on a stilling well).
OM=	Radar operational mode	This item contains one character, which determines the operational mode and depends on the antenna. F for free space measurement; S for stilling well measurement;
PR=	Position radar	Format according to item **LD**. Default: +027.0000 (m). This item represents the vertical distance from the Radar reference point to the tank zero (mostly the datum plate). When not exactly known, estimate the distance within ±1 metre (3 ft). When setting the SmartRadar ATi reference level (see section 3.4.3), the value in item **PR** is overwritten.
SF=	Maximum safe fill height	Format according to item **LD**. With this item the gauge checks if the programmed upper measuring range is valid. The following relation is valid: **SF** < (**PR** - **AU**). If a conflict is detected, a warning is given (**EE**: 07901).
AB=	Nozzle length	Format according to item **LD**. Default: +000.0000 (m). Set this item *only* when the F08 antenna is installed *inside* the nozzle. Give in this item the nozzle length. When the antenna is installed inside the nozzle, a correction is automatically applied.
OR=	Offset to roof	Format according to item **LD**. This items represents the average distance from the radar nozzle to the roof. The SmartRadar ATi uses this information to determine the position of double reflections (product surface - roof - product surface - antenna).
4V=	Level calc. decision switch	This item contains 10 positions. The 7th position enables or disables the AdvancedDSP routines: F enables AdvancedDSP level calculation - disables AdvancedDSP level calculation Refer to section 'AdvancedDSP level calculation routine' for information when to enable it, and to section 3.4.8 for other settings of item **4V**.
AC=	Averaging constant	Two digits, default value: 90. Averaging constant for output filter of radar innage (item **RI**) and radar ullage (item **RU**) value. The higher the value for item **AC**, the more damping on the radar innage and radar ullage values.
EX	Exit	After the exit command, the 970 SmartRadar ATi will perform a controlled software reset, and start up with disabled access to protected levels.

AdvancedDSP level calculation routine

Under certain installation conditions, the product level calculation can be done more accurately when the AdvancedDSP level calculation routine is enabled. In that case the calculated level is less sensitive for obstructions in the microwave path, like equalisation holes in stilling well, welding seams and multipath effect from tank shell.

Note:

AdvancedDSP level calculation can only work correctly when the level in the tank is not moving fast (less than 0.5 mm/sec).

It is advised to enable AdvancedDSP level calculation with the following antenna installation conditions:
- F08 antenna   : if **d** (distance to tank shell) is less than 0.2 x **H** (tank height), but larger than or equal to 0.1 x **H**;
- W06 antenna   : if **d** (distance to tank shell) is less than 0.2 x **H** (tank height), but larger than or equal to 0.05 x **H**;
- S06 .. S12 antennas : always, when in compliance with the stilling well conditions mentioned in the installation guide SmartRadar Antennas. Thus **not** when stilling well has slotted holes or is much contaminated.

3.4.3 Level check

Refer to figure 3.4. Check if there is a valid level reading. It is no problem if the value is incorrect, as long as there are no error status messages. Two common error status messages are discussed below.
1) Level reading 999999999 with level status FL. Check error code item **EE** (this is an indexed item!).
   If **EE** reads 07901, the maximum safe fill height (item **SF**) is set too high. Request for the "Antenna minimum ullage" (item **AU**). The following relation is valid: SF + AU < PR.
   Either distance **PR** is not correct or the maximum safe fill height (**SF**) is too large for this installation.
2) If there is a "Warning code" present, check warning code item **WC** (this is an indexed item!).
   If **WC** reads 07000, the reflected signal is not so strong that its peak rises above a threshold setting. Lower the product zone threshold (or another zone threshold where the peak is found). Refer to section 3.4.4 for more information on zones and thresholds.

Item	Name	Description
W2=	Protection level 2	Enter password 2 (default password: ENRAF2)
RL=	Reference level	Format according to item **LD**. The reference level is the actual level in the tank (obtained from e.g. manual dip)
EX	Exit	With the exit command, the actual level value in item **RL** is written in NOVRAM. Only then the value of item **RL** will be used with the next **AR** command
W2=	Protection level 2	Enter protection level 2 (default password: ENRAF2)
CM	Commissioning mode	Enter the commissioning mode to accept the reference level
AR	Accept reference	With this command, the 970 SmartRadar ATi accepts the value of the reference level and internally re-calculates the distance: radar position (item **PR**). After the controlled reset, by the **EX** command, the level reading is available.
EX	Exit	Exit protection level

With this procedure, the 970 SmartRadar ATi now measures the level value, given in item **RL**, and all relative level changes will be followed by the instrument.

3.4.4 Zones and threshold settings

The tank height is divided into 3 measuring zones: Antenna zone, Product zone and Bottom zone.
In addition, ten obstruction zones can be programmed. Refer to figure 3.5.

Please note that the X-axis from figure 3.5 indicates *ullage*. The zero point on the X-axis represents the "Radar reference". This is the nozzle height, with respect to the tank zero, on which the antenna is mounted (item **PR**; position radar). Refer also to figure 3.4.

> ### Warning
> The product reflection in the area "Antenna minimum ullage" will be indicated as product level with **reduced accuracy** and with warning code 07013: '**level above measuring range**'.
> Do not use this area as normal operational area because of the chance for a **tank overflow**.

The antenna is located inside the antenna minimum ullage area. In this area, reflections from the antenna will decrease to almost zero at 0.5 to 2 metres distance from the antenna surface (depending on the antenna).

Figure 3.6 shows a so-called reflection diagram.
The reflection diagram can be made with the Honeywell Enraf service tool.

Not all reflections in the reflection diagram are selected as possible peak for the product level. A first selection can be made by the threshold in each of the three zones. The thresholds should be set such that noise is filtered out. Only the peaks above a threshold setting are selected as possible product peak.

The antenna zone length (item **AZ**) covers the area where antenna reflections are low but still present.
The antenna zone threshold should cover the most of the antenna reflections.
The antenna zone length does not need to extend till the antenna reflections are completely zero; only until the higher reflections are covered, such as those which might be expected in the product zone.
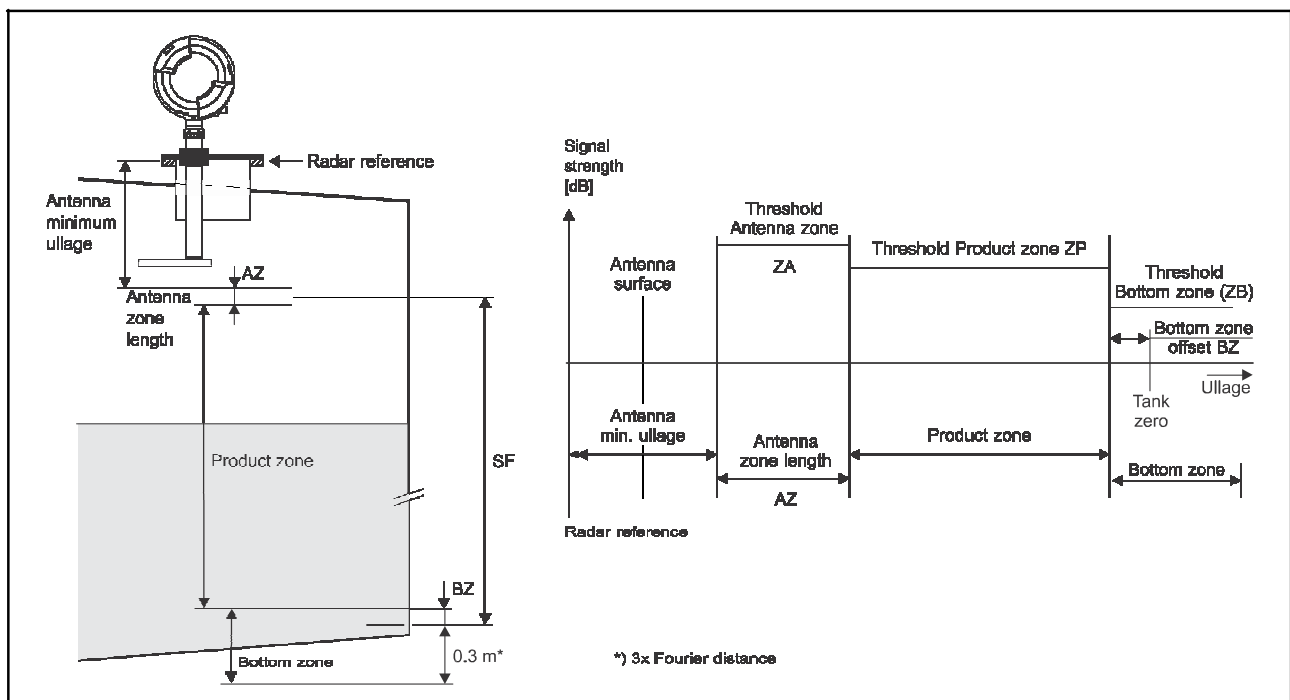Refer to example of reflection diagram in figure 3.6.
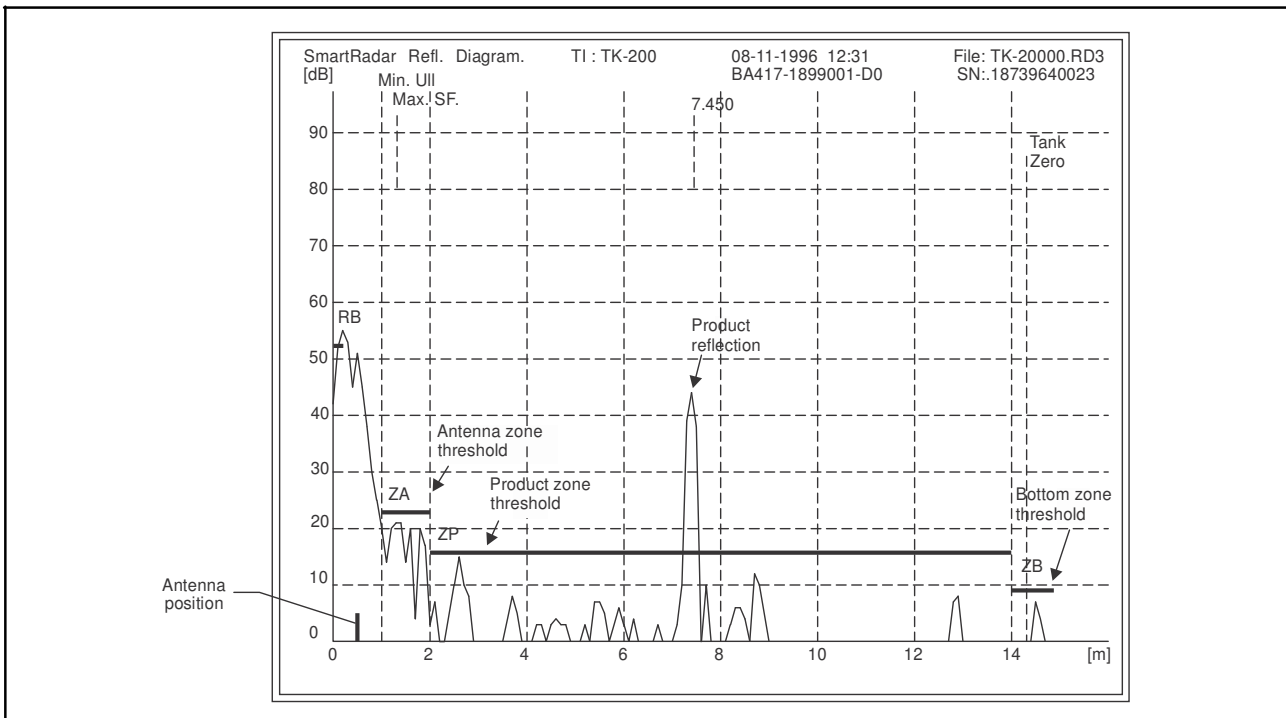

Figure 3.5 Zones and thresholds

Figure 3.6 Reflection diagram

The area between antenna zone length and the bottom zone is called "product zone". The product zone threshold can be set with item **ZP**.

The bottom zone is defined around tank zero. With bottom zone offset (item **BZ**) the position above tank zero is defined where the product zone ends and the bottom zone begins. The bottom zone extends three Fourier distances under tank zero (approximately 0.30 m).

The bottom zone definition is important in applications where the bottom can be seen through the product in the reflection diagram. At a low product level both the product reflection and the bottom reflection will then be present and the bottom reflection can be the strongest. In that case the bottom zone offset must be set large enough to make sure that when the tank is emptying the product peak enters the bottom zone first, before the bottom reflection enters the bottom zone. The bottom reflection peak enters the bottom zone in the opposite direction and the peaks merge when the tank gets empty.

The low speed of the radar signal through the liquid column gives the impression that the bottom looks further away than it really is. When the tank is emptying the bottom appears to rise. Figure 3.7 gives an example of such a situation. Item **BZ** should be set to a value of 0.4 to 0.7 metres (1' 4" to 2' 4").

When measuring the roof of a (internal) floating roof tank, the mechanism of searching for a smaller peak in front of a larger peak in the bottom zone is disabled. By setting the third element in item **4S** (2nd level calculation decision switch) to 'R' you can declare the floating roof application.

Reflections beyond the bottom zone are ignored for level detection. The bottom zone threshold can be set with item **ZB**.
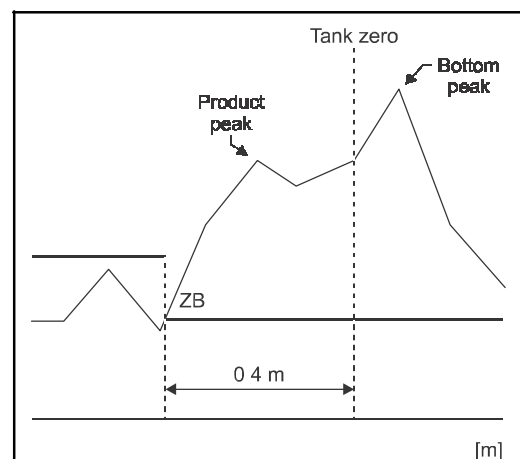

Figure 3.7 Bottom reflection and bottom zone adjustment

Changing the settings for the zones and thresholds should be done, on the basis of information from a reflection diagram.

It should be common practice at installation of the 970 SmartRadar ATi gauge to make a reflection diagram and, if necessary, adjust the zones and threshold settings.

Item	Name	Description
W2=	Protection level 2	Enter password 2
AZ=	Antenna zone length	Format according to item **LD**. If necessary, the antenna zone length can be altered.
BZ=	Bottom zone offset	Format according to item **LD**. As a default, the bottom zone starts 0.3 m above tank zero. Item **BZ** specifies this start position. If the bottom position is not exactly known, do not alter item **BZ**. However, set the bottom zone offset to a larger value when there is a strong bottom reflection.
ZA=	Antenna zone threshold	Format according to standard power format (dB). If required, the threshold of the Antenna zone can be altered with this item. Be sure to set the threshold above the antenna reflections.
ZP=	Product zone threshold	Format according to standard power format (dB). The product zone threshold should be set such that: • product reflections are passed, and • small meaningless peaks (noise) are suppressed. It is not meant to block obstructions; these are eliminated (not selected as product peak) by the peak detection software.
ZB=	Bottom zone threshold	Format according to standard power format (dB). The bottom zone threshold should be set such that: • product reflections are passed, and • small meaningless peaks (noise) are suppressed. It is not meant to block a bottom reflection; the bottom reflection will be identified by the peak detection software.
EX	Exit	Exit protection level

The peak detection software keeps a list of maximum 15 detected peaks above the threshold zones, from which one of them is the product peak. The number of detected peaks and their position and strength can be requested by the data items: **5C**, **5D** and **5E**.

Item	Name	Description
FC	Freeze RSP data	The freeze Radar Signal Processing data is a command that stores all relevant radar processing data in RAM memory. Wait approximately 5 seconds before requesting the next data.
5C	Number of peaks above threshold	This item contains the number of peaks above the threshold settings. The maximum number is 15; when more peaks are detected, only the 15 strongest peaks are listed.
5D.0.1	Position of detected peaks	Format according to item **LD** (indexed item; 15 elements). Each element contains the distance from the radar reference position to the detected peak.
5E.0.1	Amplitude of detected peaks	Format according to standard power format (dB) (indexed item; 15 elements). Each element contains the amplitude of the corresponding peak in item **5D**.

When obstructions are expected and there cannot be made a reflection diagram, these items are very helpful to select the obstruction zones. However, the best results can be obtained from the information of a reflection diagram.

Obstruction reflections

Objects that are in the microwave path will cause reflections. All reflections from objects other than the product surface are called: 'obstruction reflections'.

Note:
In the reflection diagram you will probably also see second order reflection peaks, found at double distance.

Obstruction reflections can be caused by heating coils, welding seams from tank shell or stilling well, etc. Special examples of obstruction reflections are the antenna reflection and the bottom reflection.

Obstruction reflections can influence the level measurement:
 • When an obstruction reflection is detected above the zone threshold, it becomes a candidate for the selection of the level peak. This is not a problem, as the peak detection software can handle this.
 • When the product peak approaches an obstruction peak, the two peaks will influence the calculation of their positions. The influence starts when the peaks are 0.3 m (1') apart. The obstruction reduces the accuracy of the calculated level position. In many cases this is a one-side phenomenon, where the obstruction reflection disappears as the product submerges the reflecting object.
 • The AdvancedDSP level calculation is less sensitive for the presence of an obstruction reflection. But the inaccuracy of the normally calculated level position may cause a jump of the AdvancedDSP level of 15 mm ($^{19}/_{32}$"). These jumps can be prevented by declaring an obstruction zone around the position of the obstruction peak.

The SmartRadar ATi software provides for setting of obstruction zones and obstruction threshold for each zone. This can be used to prevent obstruction reflections from appearing in the list of detected peaks. From the list of detected peaks the product level peak is selected. As explained above, the peak detection software can cope with the presence of obstruction reflections without the obstruction zone settings.
However, it is advised to define obstruction area's around obstruction peaks when the AdvancedDSP level calculation is used. It is then not required to set obstruction thresholds; only the zone definition is required.

Figure 3.8 shows a Reflection Diagram in which an obstruction is found at approximately 8 m level (6.25 m ullage). The product reflection is found at approximately 3.8 m level (10.44 m ullage).

In this example, the following settings should be selected:

Obstruction zone start at 5.95 m *ullage* (at least 0.3 m before the obstruction reflection).
Obstruction zone end at 6.55 m *ullage* (at least 0.3 m after the obstruction reflection).
Obstruction zone threshold at 5 dB.

| Item	Name	Description
W2=	Protection level 2	Enter protection level 2
OS.0.1=	Obstruction zone 1 start	Format according to item **LD**. In the above example, obstruction zone 1 start should be programmed as 5.95 m (OS.0.1=+005.9500)
OE.0.1=	Obstruction zone 1 end	Format according to item **LD**. In the above example, obstruction zone 1 end should be programmed as 6.55 m (OE.0.1=+006.5500)
OT.0.1=	Obstruction zone 1 threshold	Format according to standard power format (dB). In the above example, the threshold of obstruction zone 1 is set at 5 dB (OT.0.1=+0005.0)
OZ=	Enable / disable obstr. zones	Ten ASCII characters; either E (enable) or D (disable) the obstruction zone. For example: OZ=EDDDDDDDDD enables the first obstruction zone
EX	Exit	Exit protection level
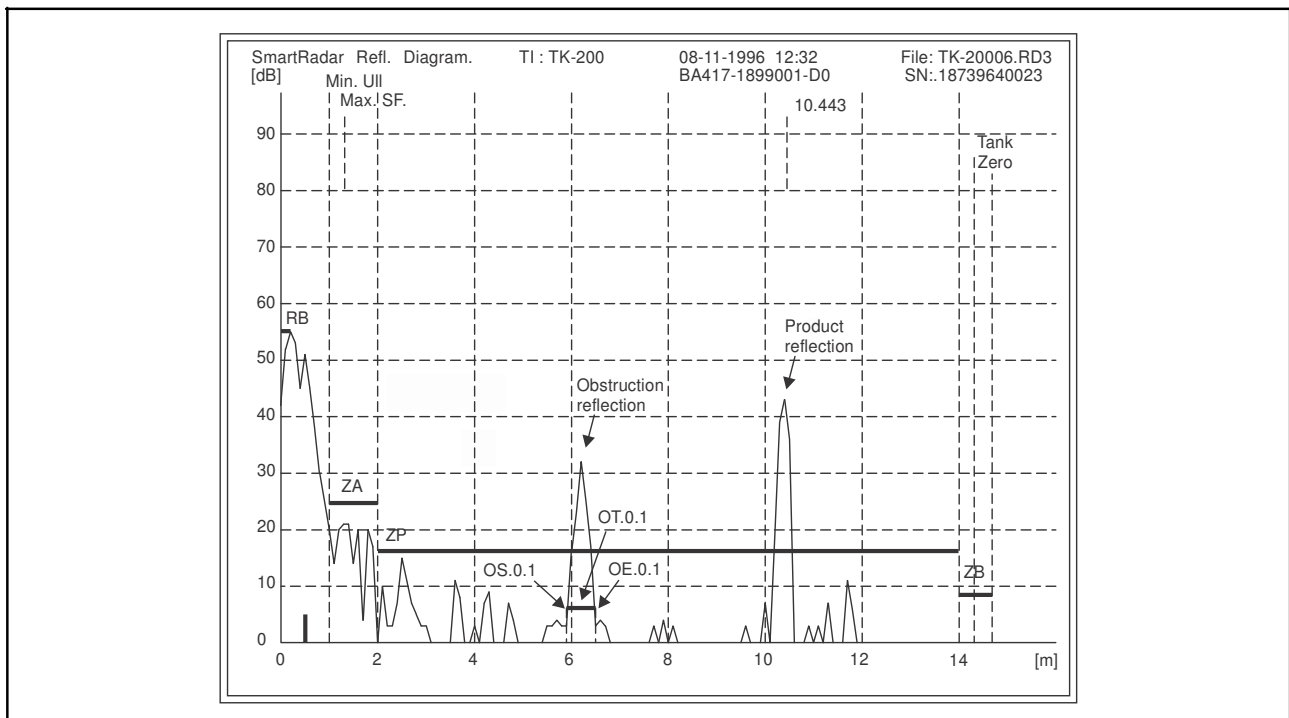
Figure 3.8 Example of determining the position of an obstruction zone

It is advised to use obstruction area's for recognizable obstruction peaks that stay below the zone threshold (for instance: welding seams from the tank shell or stilling well, or roof truss). Obstructions from welding seams can be recognized as they appear at regular intervals. Refer to figure 3.9.

Select the peaks in the reflection diagram, which are known to be caused by an obstruction.
Mark the obstructions with an obstruction zone. The length of the obstruction zone should be at least 0.6 m.
As the bottom reflection and the antenna reflection belong to the obstructions, it is advised to define obstruction zones in front of the antenna position and the bottom position.
For the AdvancedDSP level calculation, the obstruction threshold should be set below the product threshold (e.g. at 5 dB).
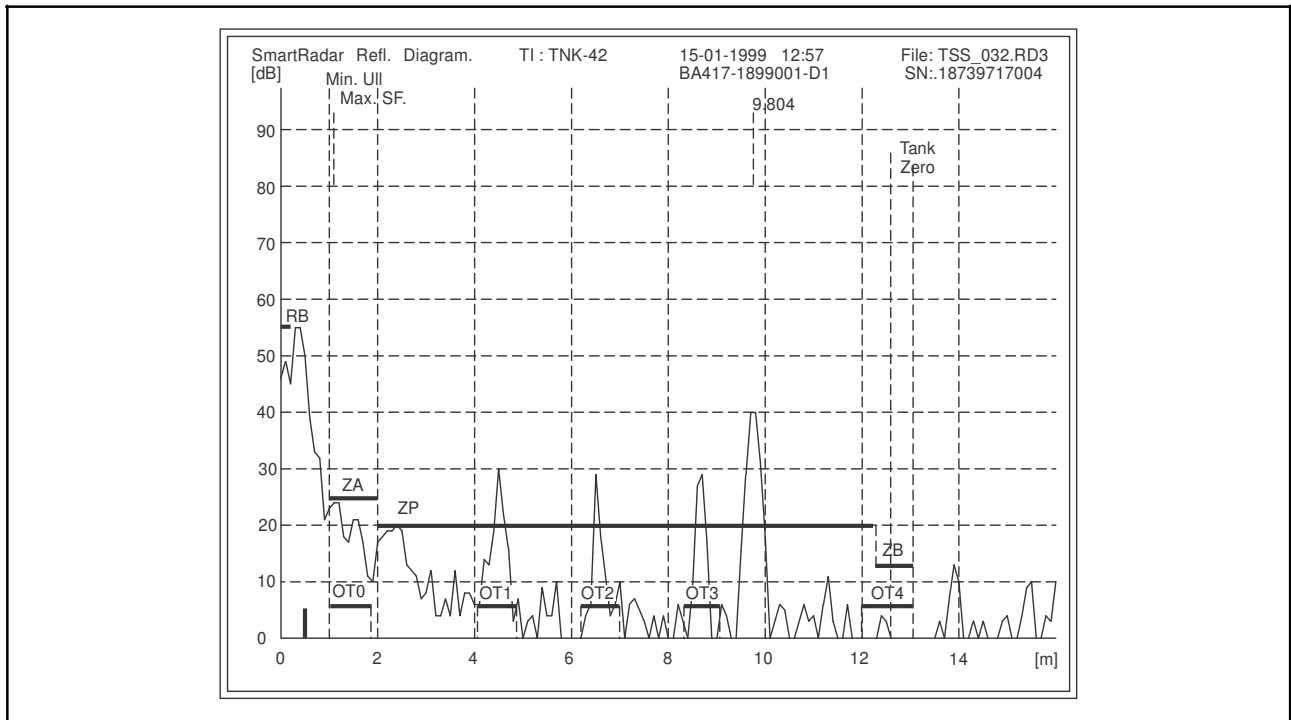

Figure 3.9 Example of reflection diagram with obstructions marked for AdvancedDSP

The reflection diagram in figure 3.9 shows three obstructions at equal distances. It can therefore be assumed that there is a fourth obstruction (at approximately 11 metres ullage), though not visible in this diagram because it is submerged. For a clear overview of all obstructions, it is recommended to make a reflection diagram when the tank is empty.

3.4.5 Alarm settings

Refer to figure 3.10. High level alarm (**HA**) and low level alarm (**LA**) conditions are transmitted to the host via the communication lines.
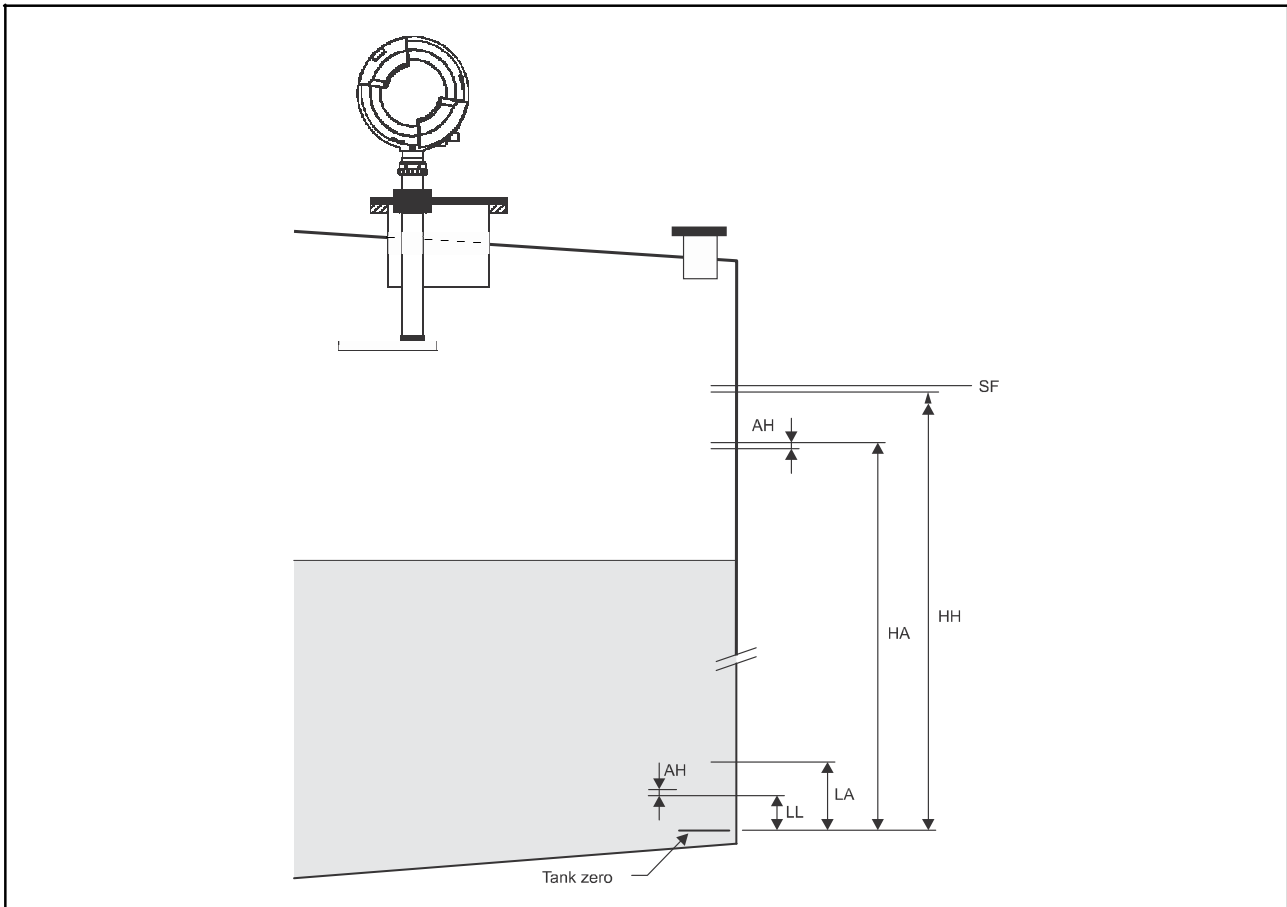

Figure 3.10 Alarm settings

Item	Name	Description
W2=	Protection level 2	Enter password 2 (default password: ENRAF2)
AH=	Level alarm hysteresis	Format according to item **LD**. Sets alarm hysteresis
HA=	High level alarm	Format according to item **LD**. High level alarm set point.
HH=	High high level alarm	Format according to item **LD**. High high level alarm set point.
LA=	Low level alarm	Format according to item **LD**. Low level alarm set point.
LL=	Low low level alarm	Format according to item **LD**. Low low level alarm set point.
EX	Exit	Exit protection level

3.4.6 Ullage readout

The two items described in this section need only be programmed, when ullage readout is required. Refer to figure 3.11.
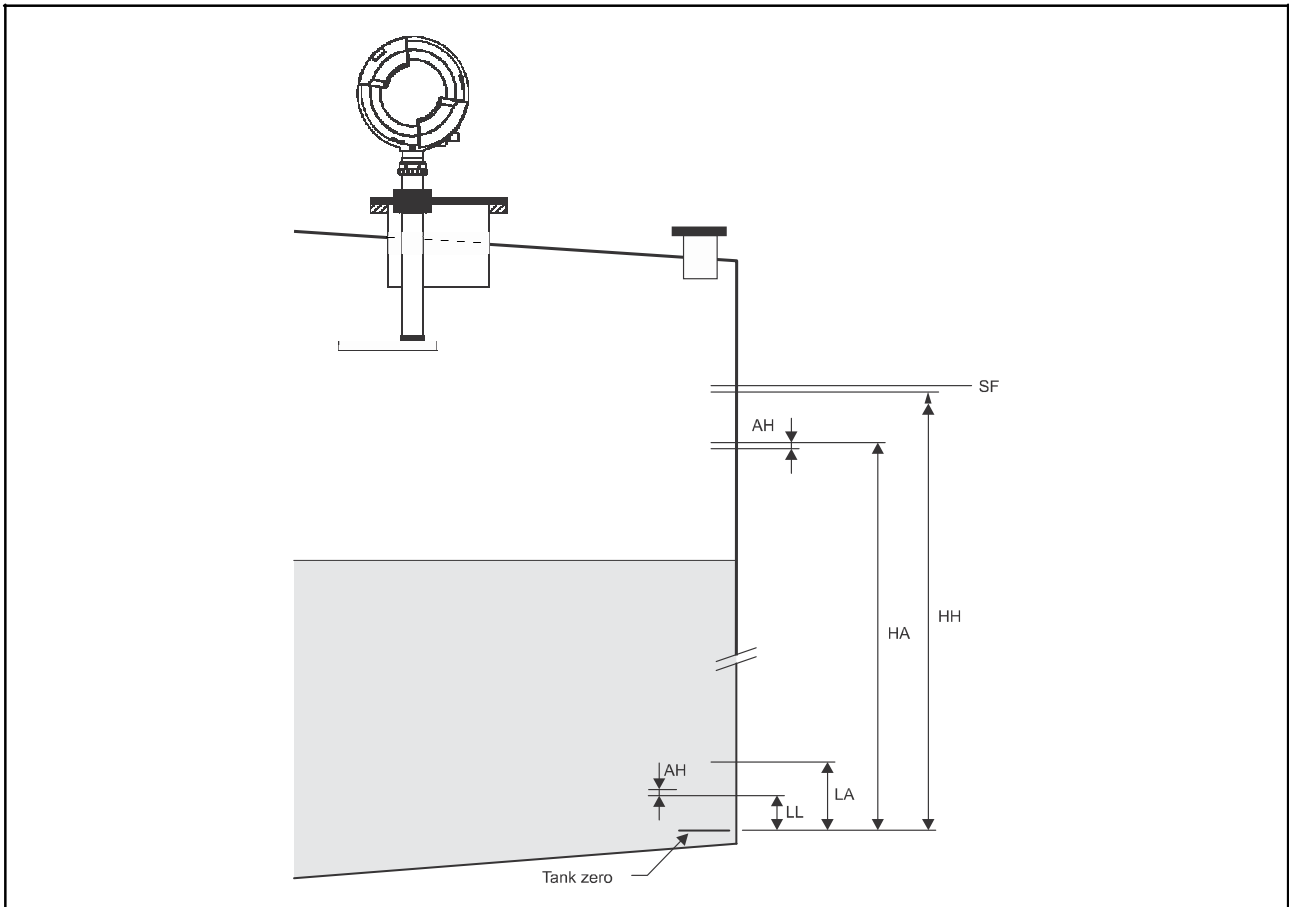

Figure 3.11   Upper reference value

Item	Name	Description
W2=	Protection level 2	Enter password 2 (default password: ENRAF2)
UR=	Upper reference	Format according to item **LD**. The upper reference value is only used when 'Ullage' is to be read from the 970 SmartRadar ATi gauge. The ullage is then calculated as: UR - 970 measured level
DE=	Level type	One ASCII character. DE = I for innage (default setting) DE = U for ullage
EX	Exit	Exit protection level

3.4.7 Password protection

Item	Name	Description
W2=	Protection level 2	Enter password 2 (default password: ENRAF2)
W1=	Password 1	6 Characters, default value W1=ENRAF1. This password can be read protected by jumper J6 on the ICU board. If this jumper is set to position 1, the password can not be read
W2=	Password 2	6 Characters, default value W2=ENRAF2. This password can be read protected by jumper J5 on the ICU board. If this jumper is set to position 1, the password can not be read
DY=	Display selection	One ASCII character. For the 970 SmartRadar ATi (which has no local display) item **DY** must be set to N.
EX	Exit	Exit protection level.

3.4.8 Detection algorithm and special settings

Presentation of the measured level is the result of a two stage process:
- stage 1: detection
- stage 2: acceptance

Detection
The detection operates on the last radar signal captured. First peaks are detected that are above the thresholds (items **ZA**, **ZB** and **ZP**). When there are peaks found, the level peak is selected from the list of detected peaks (items **5D** and **5E**).
Special fuzzy logic is built in, to select the level peak from the set of detected peaks. It is important to know that the fuzzy logic makes use of pattern recognition. Especially at very high levels it looks for patterns with second or third order echo's. In free-space applications such echo's result from reflections against the roof of the tank. Knowledge about he position of the roof is therefore important. Therefore, the distance from the nozzle to the roof must be declared in item **OR**.

Acceptance
Acceptance operates around an authorised gauge level value and the 'low product delay counter' value.
The low product delay counter value can be set with item **FI** (default value: 99; maximum value: 99).
When an authorised gauge level is present, the value is used as the acceptance criterium for the level peaks presented by the detection stage.

Successful acceptance of the latest level peak is used to update the authorised gauge level value. Consecutive rejection of level peaks and / or absence of level peaks over a number of measurements equal to the number in the low product delay counter, will result in discarding the authorised gauge level value. When the value is discarded, the last valid value is available as level value over a period of 30 seconds.

When there is no authorised gauge level value, the level peaks presented by the detection stage are used to built up the evidence needed to arrive at a new authorised gauge level value. A level must be present, at least intermittent, over a number of measurements equal to the low product delay counter, before it can become authorised.

Item	Name	Description
W1=	Protection level 1	Enter password 1
FI=	Low product reflection warning delay counter	Two digits; default value: 99. The maximum value is 99 and then the delay is approximately 1 minute. During the delay, the last valid measured level is transmitted as the product level.
EX	Exit	Exit protection level

Reduced accuracy

Obstructions in the tank may produce reflections. When the level reflection is in the neighbourhood of an obstruction reflection the accuracy of the obtained level reading is reduced. The software provides for entering data to describe obstruction zones. See items **OS**, **OE**, **OT** and **OZ**. This can be used to detect that the level reflection is in an obstruction zone. When in addition level calculation decision switch item **4V** position 2 is set to 'O', a reduced accuracy warning will be set if the level reflection is in an obstruction zone.

When the level is in the bottom zone, a bottom reflection may reduce the accuracy of the level reading. When the level calculation decision switch item **4V** position 1 is set to 'B' , a reduced accuracy warning will be produced if the level is in the bottom zone.

Peak selection with roof reflector

With light products it is possible to have a reflection from the tank bottom, specially at lower level through the product. Therefore, there is a routine that in the bottom zone is searched for a smaller peak in front of the highest peak, which is caused by the bottom.
However, when a roof reflector is used it is impossible to look through the product. That information is given in item **4S**, third position.

Item	Name	Description
W2=	Protection level 2	Enter password 2
4V=	Level calculation decision switch	Ten characters; default setting: - - - - - - - - - -

Pos. Char. Function

Pos.	Char.	Function
1	B	Reduced accuracy if level peak in bottom zone
	-	No reduced accuracy if level peak in bottom zone
2	O	Reduced accuracy if level peak in obstruction zone
	-	No reduced accuracy if level peak in obstruction zone
3	D	Double reflection detection enabled (always)
4	S	Reduced accuracy if level peak detected above the maximum safe fill height (item **SF**)
	-	No reduced accuracy in the above situation
5	P	Search for product peak before bottom reflection (always)
6	-	Not used
7	F	Enables AdvancedDSP level calculation
	-	Normal level calculation
8 - 10	-	Not used.

4S=	2nd Level calc. decision switch	Ten characters; default setting: - - - - - - - - - -	

Pos. Char. Function

Pos.	Char.	Function
1	-	Normal communication mode (other settings are used for broadcast mode)
2	P	Plain selection of peaks (only for factory testing)
	-	Intelligent peak selection
3	R	Measurement by means of roof reflector
	-	Measurement direct on product
4 - 10	-	Not used

EX	Exit	Exit protection level.

Possibility of peak selection dilemma after gauge startup

It is theoretically possible after a gauge startup, that two peaks are detected of which the second peak is at a double distance with respect to the first peak. The second peak might be a second order echo, in which case the first peak is the level peak. But it is also possible that the first peak is from an obstruction, whilst the second peak is the level peak.

In that case the first peak is used to present the level, with error code 07014 and level reading '999999999'.

In the course of the time it may become apparent which is the level peak when there is a level change. When this happens the error is removed and the correct level is presented.

When however the level in the tank does not change, it may take a long time for the situation with error 07014 to persist. That is why the operator can interfere.

With item **4W** the operator selects the first peak as level peak; with item **4X** the operator selects the second peak as level peak. In both cases the error 07014 is removed and turned into a warning 07014.

With these commands the operator can inspect the two level values involved in the dilemma and choose the level value that he judges is the product level.

In addition the operator can cancel the level selection with item **4Y**. This will restore the level failure situation with level reading '999999999' and error code 07014.

In the course of time, when there has been a sufficient level change, the start-up dilemma will be resolved. From that moment on error 07014 or warning 07014 will disappear, the level will be presented and the commands **4W**, **4X** and **4Y** will have no effect.

Item	Name	Description
4W	Select first peak	With this command, the first peak is used as level peak and error code 07014 is changed to warning code 07014. Warning code 07014 disappears when there is enough change in level to determine by the peak selection software that the selected peak indeed is the product peak.
4X	Select second peak	This command makes the second peak the level peak and error code 07014 is changed to warning code 07014. Warning code 07014 disappears when there is enough change in level to determine by the peak selection software that the selected peak indeed is the product peak.
4Y	Cancel select peak	This command cancels the **4W** or **4X** commands and the first peak is used as level peak with error code 07014. Only possible as long as there is the warning code 07014.

3.4.9 Additional adjustment with measurement on stilling well

The propagation speed of the microwave, and hence the level measurement, depends on the inner diameter of the stilling well. The smaller the diameter, the lower the propagation speed, resulting in a larger measured radar ullage.
Item **BD** holds the inner diameter of the stilling well. When the real value of the inner diameter differs from the setting in item **BD**, the SmartRadar has a 'gain' error in the level measurement.

It is therefore recommended to check the level reading of the SmartRadar ATi with some manual dips at different static levels over the full operating range.

Note:
After commissioning, the AdvancedDSP routines require one complete passage through the full operating level range, before the optimum accurate level reading is obtained.

A level gain error, when present, can be corrected in two ways:

- ullage correction table
- adjustment of item **BD**

For the correction via the ullage correction table, refer to the description of items **CW**, **CL** and **CS**.
The correct value for the stilling well diameter can be calculated with the following equation:

$$BD_{new} \bullet \frac{0.036568}{\sqrt{1 \& \varepsilon_{scale}^2 \times \left(1 \& \dfrac{0.0013372}{BD_{orig}^2} \right)}}$$

where:

BD_{new} : recalculated stilling well diameter [m]
BD_{orig} : original stilling well diameter [m]
ε_{scale} : scale error (relative gain error)
example: 10 mm gain error on 20 m range: $\varepsilon_{scale} = 20 / (20 + 0.010) = 0.9995$.
for the sign of the scale error, refer to figure 3.12. If α is positive, the scale error sign is positive; if a is negative, the scale error sign is negative.
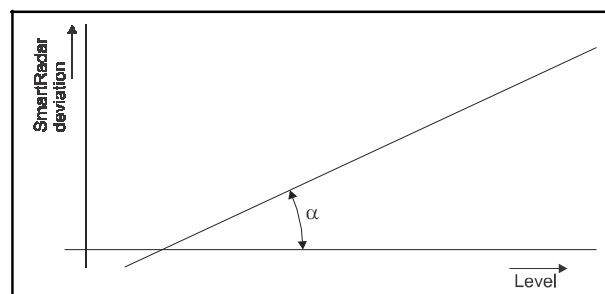

Figure 3.12 Sign of scale error

An example with an S10 antenna:
Item **BD** is programmed as 254 mm.
At 19 m level, the deviation of the SmartRadar ATi level is: -2 mm;
At 2 m level, the deviation of the SmartRadar ATi level is: +3 mm.

$$BD_{new} = \frac{0.036568}{\sqrt{1 - \left(\frac{17}{17 - 0.005}\right)^2 \times \left(1 - \frac{0.0013372}{0.254^2}\right)}} = 0.2576 \text{ [m]}$$

Note:
> *After the new stilling well diameter is programmed, the SmartRadar ATi must be set to level with the **RL** and **AR** sequence.*

Hence, the procedure to follow is:

Item	Name	Description
W2=	Protection level 2	Enter password 2.
BD=	Stilling well diameter	Recalculated stilling well diameter.
RL=	Reference level	Reference level from manual measurement.
EX	Exit	Exit protection level.
W2=	Protection level 2	Enter password 2.
CM	Commissioning mode	Enter commissioning mode to accept the reference level.
AR	Accept reference	The reference level, given by item **RL**, will now be accepted as the radar level.
EX	Exit	Exit protection level.

3.5 Data items

The table below lists a number of data items. They contain measured data, verification data and diagnostic data.

The verification data can be used to check the peak selection result. The radar status indicates the validity of the measured data.

The diagnostic data provide low level error information about the instrument (refer to section 4.5).

Item	Description	
RD **RI** **RU**	Measured data	Product reflection signal strength (dB) Innage (format according to item **LD**); the value is preceded by two characters from radar status item **QR** Ullage (format according to item **LD**); the value is preceded by two characters from radar status item **QR**
5C **5D** **5E** **RT** **QR**	Verification data	Number of detected peaks Position of detected peaks (format according to item **LD**; indexed item, 15 elements) Amplitude of detected peaks (standard power format; indexed item, 15 elements) Internal temperature of 970 SmartRadar ATi (format according to item **TD**) Radar status; refer to section 4.5.2
EB **EE** **EP** **WC**	Diagnostic data	Error DAB request Error ICU (APU part) request (indexed item, 10 elements) Error ICU (XPU-2 part) request Warning code ICU (APU part) (indexed item, 10 elements)

4   Service and troubleshooting

The 970 SmartRadar ATi does not require preventive maintenance.

For mechanical and electrical installation details, refer to the installation guides of the Antennas and the SmartRadar ATi

Depending on the application, the Antenna may over time become too contaminated for accurate level measurement. This condition is then signalled by the built-in diagnostics of the 970 SmartRadar ATi. Then a warning code (WC: 07001) is generated. In that case, the Antenna should be cleaned.

4.1   SmartRadar ATi layout

The SmartRadar ATi housing consists of two sections: the electronic compartment and the terminal compartment (refer to figure 4.1).
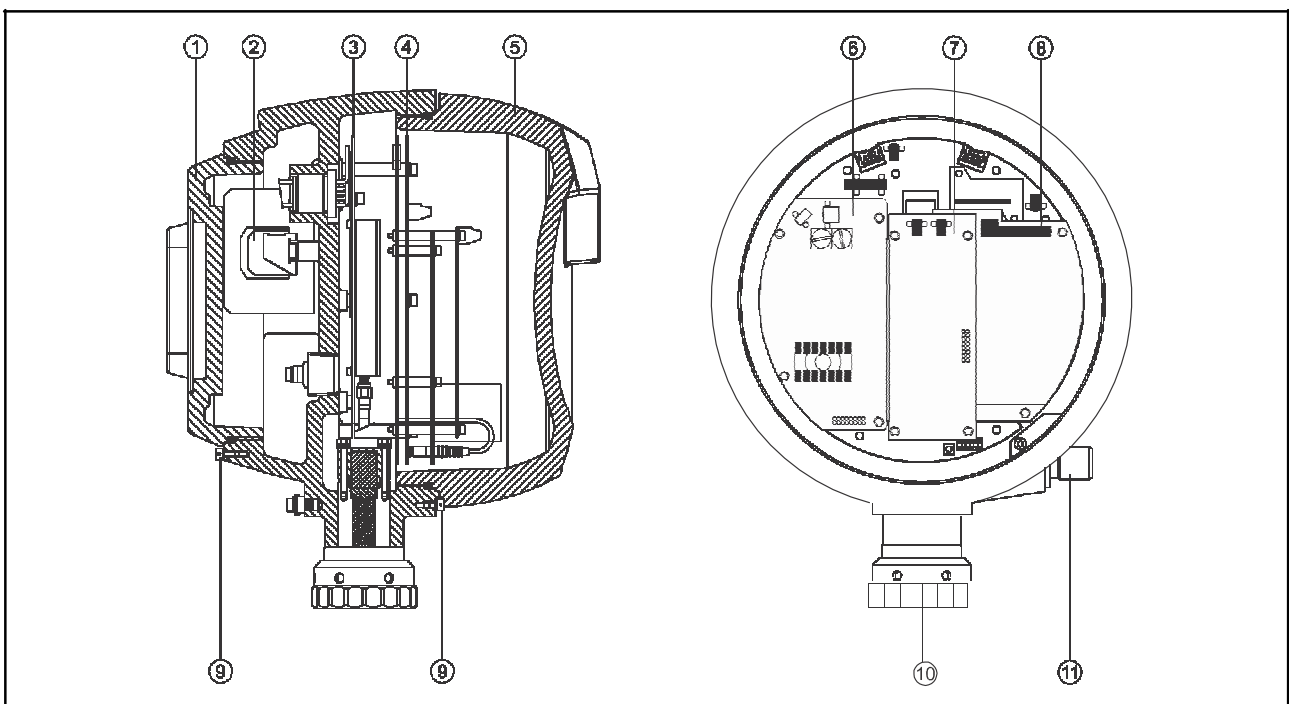

Figure 4.1 Lay-out 970 SmartRadar ATi

Item	Description	Item	Description	Item	Description
1	Rear cover	5	Front cover	9	Cover blocking devices
2	Terminals	6	ICU_GPS board (supply board)	10	Tank separator coupling
3	RFB-3 / DAB board	7	ICU_RS232/RS485 board or ICU_HPO board (optional)	11	Infra-red connector (optional)
4	ICU board	8	ICU_HPI board (optional)		

The electronic compartment can be accessed by removing (unscrewing) the front cover (5).
The terminal compartment can be accessed by opening the rear cover (1).

4.2   The instrument covers

The SmartRadar ATi enclosure is water proof IP67. For this purpose, the covers are fitted with O-rings.
Check the O-rings before closing the instrument.

Caution
Do not damage the thread of the covers and 970 housing and keep the thread free of dirt.
After opening, grease it lightly with anti seize grease.
When closing, never tighten the covers before the threads are properly engaged.
The covers should be turned counter-clockwise until the thread "clicks" in place,
then turn clockwise until the covers are fully closed.

4.3   Min max diagram

One of the features of the 970 SmartRadar ATi is that the instrument keeps track of the measured reflections.
The minimum and maximum product reflection strength, measured at each Fourier interval, is stored.
Whenever a larger reflection strength is measured at a specific Fourier interval, the previous value is
overwritten. The same is done for the minimum reflection strength value. In this way, a reflection history is
present in the instrument.

The minimum and maximum reflection strength values can be retrieved by the Honeywell Enraf service tool
producing a so-called "min max diagram". Figure 4.2 gives an example of a min max diagram.
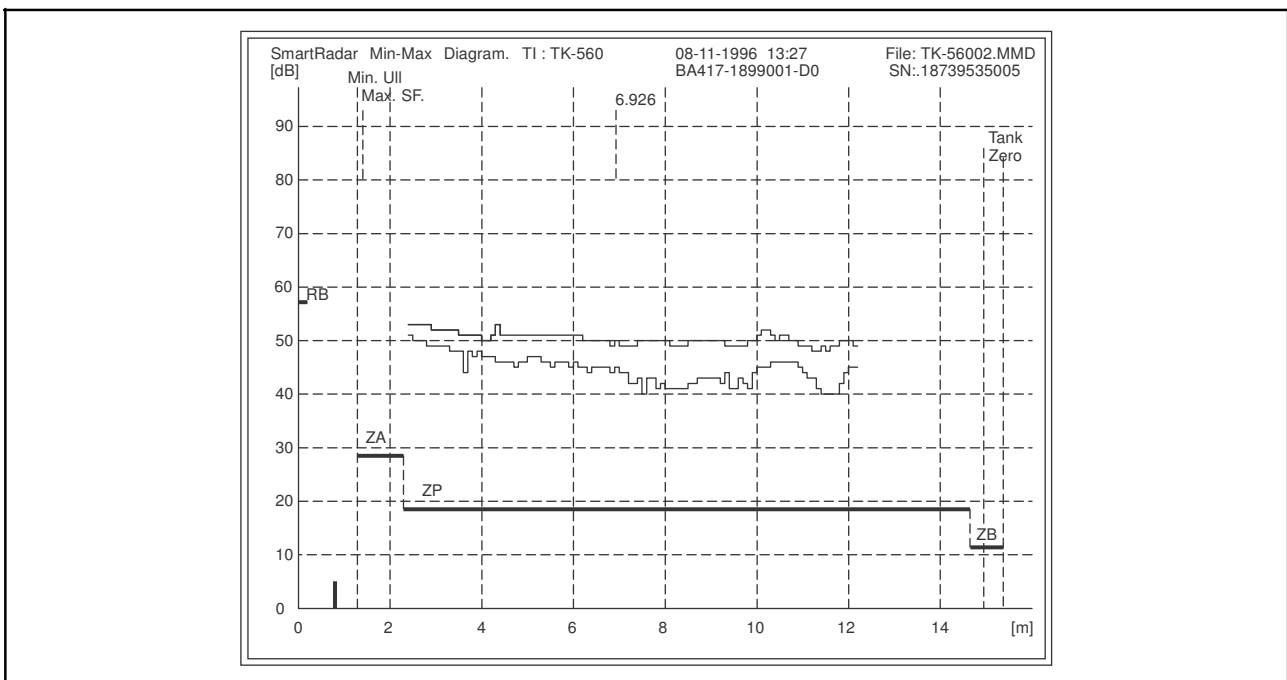

Figure 4.2   Example of min max diagram

In the example above, all measured product reflections are well above the product zone threshold.
However, if some of the minimum reflections where found just above or at the product zone threshold, this is
a signal that the product zone threshold should be lowered (or the gain, item **5O**, should be increased).

The memory of the min max diagram can be cleared with command **CZ**.

Item	Name	Description
W2=	Protection level 2	Enter password 2.
CZ	Clear min max diagram	Clears all elements of item **4T** by writing 30$_H$ in them (sets **4T** to default).
EX	Exit	Exit protection level.

4.4 Alarm loop checking

Normally, level alarms can be verified when the level reaches the low level or high level alarm set point.
The level alarms and, if applicable, the hard alarm contact coupled to one of the level alarms, can be checked by a "loop check" command. This is independent of the actual level value.

The level alarm signalling can be checked in several ways:
- via the communication line to the host
- via the hard alarm output contact

When enabled, the alarm test (item **AT**) can be given. The specified alarm is then toggled for one minute. Item **AT** has 8 positions; four character pairs are used to specify the desired alarm for testing: HH, HA, LA and LL. Each alarm can be tested individually, or the alarms can be tested simultaneously.

Item	Name	Description
LE	Loop check enable	The loop check enable item enables or disables the alarm test with item **AT**. • E : enables alarm test with item **AT** • D : disables alarm test with item **AT** If the alarm test is required, check if item **LE** is set to "E". If item **LE** is set to "D", change the setting to "E".
AT=	Alarm test	The alarm test item toggles the specified level alarm for one minute. The settings for the alarms to be tested are as follows: aabbccdd (8 ASCII characters) where: aa : HH high high level alarm test - - no high high level alarm test bb : HA high level alarm test - - no high level alarm test cc : LA low level alarm test - - no low level alarm test dd : LL low low level alarm test - - no low low level alarm test For example: AT= - - HALA - - toggles the high and low level alarm for one minute.

Note:
When, as in the above example, a high and low alarm are toggled at the same time, the high alarm prevails over the low alarm on the communication line. It is therefore recommended to check only one alarm at the time.

4.5 Error codes and status information

The 970 SmartRadar ATi is an instrument with error reporting. Detected errors can be requested by the 847 PET (optional) or by the Honeywell Enraf service tool.

The following items provide the error data of the processor boards:

EB	Error request RFB-3 / DAB board
EE	Error request ICU board (APU part)
EP	Error request ICU board (XPU-2 part)
WC	Warning code ICU board (APU part) (not a real error, but a warning that the level may not be accurate)

These items contain an error (warning) code of the last occurred error condition. The error data can be read as long as the gauge is not reset.

Besides the error data, data items from level, and optional functions such as temperature and analog level output, contain one or more status characters which also give valuable information. Most status characters are bit coded. Appendix B contains an ASCII table for conversion of a status character into bits.
Bits are numbered from 0 to 7 from right to left.

An example for a bit coded status character:
a status character reads: **F**;
written out in bits (refer to Appendix B):   **0100 0110**;
(b7=0, b6=1, b5=0, b4=0, b3=0, b2=1, b1=1, b0=0).

Bit 7 is always a '0' and bit 6 is always a '1', to avoid 'control' characters.
Look up the description of the particular error (e.g. **QR** in section 4.5.2) to find the description of the meanings allocated to each bit of the character. Only the bits set to '1' represent an actual status.

4.5.1 XPU-2 error code (item EP) of ICU board

The XPU-2 error code is a three-digit number. When the XPU-2 detected an error about a certain item, that item follows the error code, separated by a space.
For instance: 067 LL : invalid level format in item **LL**.

Some ICU (XPU-2 part) error codes of item **EP** are listed below, with suggestions for solving the problem.
For a complete overview, refer to item help in the Honeywell Enraf service tool.

000	No error	
014	NOVRAM operation error	Set item **03** to'@'; Check all settings, there may be an error
051	Unknown item	Item not known to SmartRadar ATi, check for correct item
056	Wrong protection level	First enter protection level 1 or 2
067	Invalid level format	Check item **LD**, then give the setting in the correct level format
075	Invalid density format	Check item **DI**, then give the setting in the correct density format
076	Invalid floating point format	Give setting in correct floating point format (refer section to 3.3.1)
082	Invalid password	Give the correct password for **W1** and **W2**
089	Invalid pressure format	Check item **PI**, then give setting in the correct pressure format
101	Watchdog reset error	The watchdog reset is a sign that there is a serious fault, caused by interference, or a faulty ICU board
137	No optional board	Missing optional board; either not well connected to the ICU board, or optional board is defective
200	Invalid indexed item format	Wrong indexed item format; use points between indexes
201	Invalid indexed item start index	Wrong indexed item element number; too large or invalid
202	Invalid indexed item index length	Wrong indexed item length; can be between "1" and "9"
999	Fatal ICU error	Serious internal ICU software error; check contents of item **00** and report to Honeywell Enraf Delft

4.5.2 APU warning code (item WC), error code (item EE) and status request (item QR) of ICU board

Some ICU (APU part) warning codes of item **WC** (indexed item of 10 elements) are listed below, with suggestions for solving the problem. For a complete overview, refer to item help in the Honeywell Enraf service tool.

00000	No warning	
07001	Sensor contaminated	Clean the antenna
07005	Top / bottom clipping in raw samples A-channel	Lower A-channel gain in item **5O**, or enable automatic amplification
07006	Top clipping raw samples A-channel	control item **4M**
07007	Bottom clipping raw samples A-channel	
07013	Level above measuring range	Level measured with reduced accuracy and close to antenna!
07014	Ambiguous init situation	Select first peak or select second peak command has been issued. Warning code disappears after peak detection routine has detected a certain (valid) level change.
07200	Reduced accuracy	Not enough points in table or level too close to antenna (within 4 m) for AdvancedDSP level calculation. This is automatically corrected when level in tank changes.
07201	A-channel measurement error after start-up	This will be solved when the level in the tank reaches the reference level, or when a new **RL** level is entered, followed by the **AR** command
21005	Maximum safe fill (item **SF**) exceeded	Iten **SF** must not be zero and not exceed the range (**PR** - **AU**)

Some ICU (APU part) error codes of item **EE** (indexed item of 10 elements) are listed below, with suggestions for solving the problem. For a complete overview, refer to item help in the Honeywell Enraf service tool.

00000	No errors encountered	
07000	Low product reflection	No product reflection above threshold; check with a reflection diagram and lower threshold value in item **ZP** if possible
07005	Top / bottom clipping in raw samples A-channel	Lower A-channel gain in item **5O**, or enable automatic amplification
07006	Top clipping raw samples A-channel	control item **4M**
07007	Bottom clipping raw samples A-channel	
07009	No peak detected	Make a reflection diagram to find the peak (or use items **5C**, **5D** and **5E**) Set reference level (item **RL**) in accordance with the product peak and proceed with accept reference procedure
07014	Ambiguous init situation	Select first peak (item **4W**) or select second peak (item **4X**), after verification of level by means of manual measurement
07101	Antenna zone out of range	The antenna and bottom zone may not overlap; check items **AZ** and **BZ**
07102	Antenna zone end before begin	Check sign of item **AZ** (should not be negative)
07103	Antenna zone threshold out of range	Item **ZA** must be between 0 and 90 dB
07104	Product zone threshold out of range	Item **ZP** must be between 0 and 90 dB
07106	Start bottom zone after bottom end	Bottom zone (item **BZ**) must be within measuring range (40 metres). Check also item **PR**
07107	Bottom zone threshold out of range	Item **ZB** must be between 0 and 90 dB
07108	Obstruction zone start out of range	Obstruction zone start and end must be within measuring range
07109	Obstruction zone end out of range	(40 metres). Check also item **PR**
07110	Obstruction zone position switch	Define obstruction zones in consecutive order
07112	Obstruction zone threshold out of range	Item **OT**.*n.i* must be between 0 and 90 dB
07113	Short measuring range	Antenna zone (item **AZ**) and bottom zone (item **BZ**) may not overlap
07170	Stilling well diameter out of range	Item **BD** must be between +0.0440 and +0.3353 metres range
07172	Operation mode unknown	Item **OM** must be either 'F' or 'S'
07173	Antenna mode / Operation mode conflict	Wrong type of antenna used (i.e. stilling well antenna on a free space SmartRadar ATi)
07901	Maximum safe fill (item **SF**) exceeded	Item **SF** must not be zero and not exceed the range (**PR** - **AU**)
18001	Relay error	Check item **AX**, or replace ICU board
21003	Ullage correction table error	Check item **CL**; each level may only be entered once
99999	Value at initialization	

Item **QR** consists of 2 bytes (Byte 0, Byte 1) with status information of the ICU board (APU part).

Status byte 0:	Status byte 1:
bit 0 : Low level alarm	bit 0 : Level fail
1 : Low low level alarm	1 : Warning (for example: sensor contaminated)
2 : High level alarm	2 : Last valid level used
3 : High high level alarm	3 : Reduced accuracy
4 : General ICU fail	4 : Out of measuring range (close to antenna)
5 : Init / No previous store command	5 : Blocked
6 : 1	6 : 1
7 : 0	7 : 0

4.5.3 DAB error code (item EB) and status request (item QH) of RFB-3/DAB board

Some RFB-3/DAB error codes of item **EB** are listed below, with suggestions for solving the problem. For a complete overview, refer to item help in the Honeywell Enraf service tool.

0000	No errors encountered	
0051	Antenna parameter can not be stored	SEEPROM for the antenna or the SmartRadar ATi is defective, or write protect strap is in protect position
0053	SmartRadar ATi parameters can not be stored	
0054	SmartRadar ATi calibration parameters can not be stored	
0055	Antenna SEEPROM is write protected	Write protect strap is in protect position
0056	SmartRadar ATi SEEPROM is write protected	
0057	SmartRadar ATi calibration SEEPROM is write protected	

Item **QH** consists of 2 bytes (Byte 0, Byte 1) with status information of the RFB-3 / DAB board.

Status byte 0:
    bit 0 : SEEPROM write allowed
        1 : SEEPROM write busy
      2-5 : 0
        6 : 1
        7 : 0

Status byte 1:
    bit 0 : Reduced accuracy
        1 : Non fatal RFB-3/DAB error
        2 : Fatal RFB-3/DAB error
        3 : EXT line level
        4 : Sweep ready (if externally triggered)
        5 : Number of ADCs (0: 1 ADC; 1: 2 ADCs)
        6 : 1
        7 : 0

4.6   Updating software

The 970 SmartRadar ATi is a multiple microprocessor gauge. If a new software version is installed, or an option board is added, it may be necessary to replace one or more of the program memories (EPROM) on the processor boards of the 970 SmartRadar ATi.

The actual version of the installed software can be checked with item **SV**. In case of a software update, check whether the contents of item **SV** correspond with the documentation accompanying the new software.

Because of the strict relationship between the various processor boards, it may become necessary to replace the memory of more than one processor board. Such a change may require an initialization of the NOVRAM, followed by re-programming the user parameters.

The table below gives the software versions for the different processor boards which can operate together.

Processor	ICU board (XPU-2 part)	ICU board (APU part)	RFB-3 / DAB board	Optional board
Software version	XPU K1.1	APU E1.0	DAB C1.0	HPI A1.1 HPO A1.0 HPO A1.1

Note:
   Because software updates of different processor boards may be required in the future, this table may not be up to date. For further information, contact Honeywell Enraf or the local representative.

Before changing the software (EPROM's), make a log file with the Honeywell Enraf service tool.
In this way, the settings already given to the instrument, are saved on disk and can be re-loaded into the instrument after the software update.

Warning
Switch off supply before opening any of the covers.

Proceed as follows:

   Switch off mains supply and open cover of electronic compartment.

4.6.1   Replacing software (EPROM) on ICU_HPO board

Refer to figure 4.3 and to Appendix C.

Locate ICU_HPO board (2).
Remove EPROM and insert new EPROM (mind notch!).

If software on other boards needs to be changed, refer to the relevant sections in subchapter 4.6.
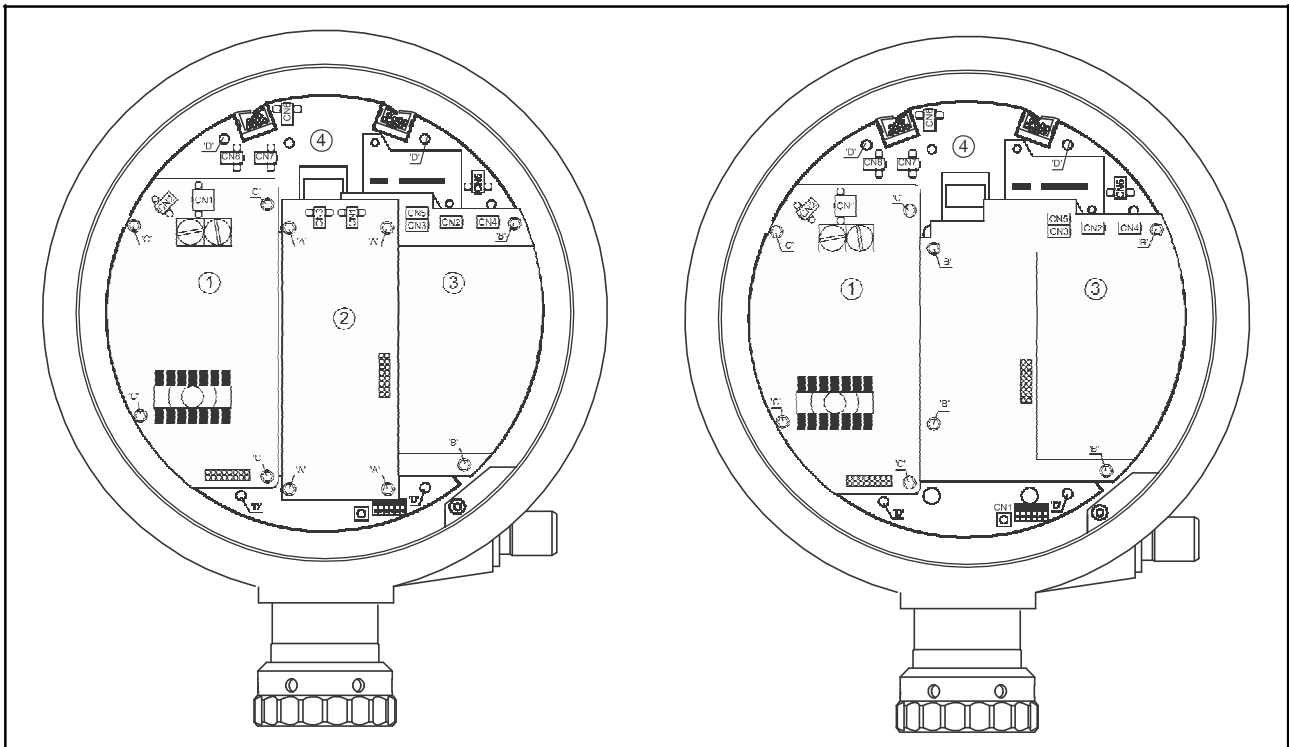Otherwise, refer to sections 4.6.5 and 4.6.6.

Figure 4.3 Removing of boards for changing software (EPROM's)

Item	Description
1	Supply board (ICU_GPS)
2	Optional communication board (ICU_RS232/485 , ICU_HPO or GFC)
3	Optional interface board (ICU_HPI)
4	ICU board

4.6.2 Replacing software (EPROM) on ICU_HPI board

Refer to figure 4.3 and to Appendix C.

When no optional communication board (ICU_RS232/485 or ICU_HPO) is installed;
    Locate ICU_HPI board (3).
    Remove EPROM and insert new EPROM (mind notch!).

When an optional communication board (ICU_RS232/485 or ICU_HPO) is installed;
    Loosen the 4 Allen head screws, marked "A" in figure 4.3 (use Allen head key 2.5 mm).
    Pull optional communication board away from ICU_HPI board so that it is released from its interconnector and move it aside.
    Locate ICU_HPI board (3).
    Remove EPROM and insert new EPROM (mind notch!).
    Put optional communication board in place (mind the interconnector!) and secure it with the 4 Allen head screws.

If software on other boards needs to be changed, refer to the relevant sections in subchapter 4.6.
Otherwise, refer to sections 4.6.5 and 4.6.6.

4.6.3 Replacing software (EPROM's) on ICU board

Refer to figure 4.3 and to Appendix C.

a) XPU-2 EPROM / NOVRAM:
When no optional interface board (ICU_HPI) is installed;
Locate ICU board (4).
Remove EPROM and insert new EPROM (mind notch!).
Remove NOVRAM and insert new NOVRAM (mind notch!).

When optional interface board (ICU_HPI) is installed;
When optional communication board (ICU_RS232/485 or ICU_HPO) is installed;
Loosen the 4 Allen head screws, marked "A" in figure 4.3 (use Allen head key 2.5 mm).
Pull optional communication board away from ICU_HPI board so that it is released from its interconnector and move it aside.
Loosen the 4 Allen head screws, marked "B" in figure 4.3 (use Allen head key 2.5 mm).
Pull optional interface board away from ICU board so that it is released from its interconnector and move it to above. Locate ICU board (4).
Remove XPU-2 EPROM and insert new EPROM (mind notch!).
Remove NOVRAM and insert new NOVRAM (mind notch!).
Put ICU_HPI board in place (mind the interconnector!) and secure it with the 4 Allen head screws. Put optional communication board in place (mind the interconnector!) and secure it with the 4 Allen head screws.
When no optional communication board (ICU_RS232/485 or ICU_HPO) is installed;
Loosen the 4 Allen head screws, marked "B" in figure 4.3 (use Allen head key 2.5 mm).
Pull optional interface board away from ICU board so that it is released from its interconnector and move it to above.
Locate ICU board (4).
Remove XPU-2 EPROM and insert new EPROM (mind notch!).
Remove NOVRAM and insert new NOVRAM (mind notch!).
Put ICU_HPI board in place (mind the interconnector!) and secure it with the 4 Allen head screws.

b) APU EPROM's:
Loosen the 4 Allen head screws, marked "C" in figure 4.3 (use Allen head key 2.5 mm).
Pull supply board away from ICU board so that it is released from its interconnector and move it to the right.
Locate ICU board (4).
Remove APU EPROM's and insert new APU EPROM's (APU-L and APU-H) (mind notch!).
Put ICU_GPS board in place (mind the interconnector!) and secure it with the 4 Allen head screws.

If software on the RFB-3 / DAB boards needs to be changed, refer to the next section.
Otherwise, refer to sections 4.6.5 and 4.6.6.

4.6.4 Replacing software (EPROM) on RFB-3 / DAB board

The ICU_GPS board and eventually installed optional boards can remain on the ICU board. However, all wiring connected to them must be, temporary, disconnected.
- connectors CN2 and CN4 on ICU_GPS board
- connectors CN1 and CN2/3 on optional communication board
- connectors CN2, CN3, CN4 or CN5 on optional interface board
- connector CN5 on ICU board (blue wires, marked 7 and 8)
- connector CN6 on ICU board (white wires, marked T , T)
- connector CN7 or CN8 on ICU board (black wires, marked 5 and 6)

When the optional Infra-Red connector is installed, also disconnect temporary the cable to CN1 on ICU board (black cable next to XPU-2 jumpers).

Loosen the 4 Allen head screws, marked "D" in figure 4.3 (use Allen head key 3 mm).
Pull ICU board with mounting plate away from RFB-3 / DAB board so that it is released from its interconnector.
The RFB-3 / DAB board is now visible (refer to Appendix C).
Remove DAB EPROM and insert new DAB EPROM (mind notch!).
Put ICU board with mounting plate in place (mind the interconnector!) and secure it with the 4 Allen head screws. Insert all connectors which where disconnected.

4.6.5 NOVRAM init

Check whether jumper J4 on the ICU board is set to position "0" (refer to section 3.2). If the jumper is placed in position "1", change it temporary to position "0".
Close covers and apply power.

If NOVRAM needs to be formatted, proceed as follows:

a) If Infra-Red connector is present:
Issue the command **IN** on the PET three times in sequence. After the third time the NOVRAM will be formatted and the message: "NV-data initializing" appears.

Note:
Any other command in between the three IN commands, either from the PET or the Honeywell Enraf field bus, will abort the init procedure. To avoid requests from the Honeywell Enraf field bus, they can be disconnected temporarily.

When the NOVRAM formatting is ready, the message: "NV-data init completed" will be shown.
Re-enter the items: **TA** (transmission address)
                                 TI   (tank identifier)
                                 TS   (transmission speed)
                                 GT   (gauge type)
Refer to section 4.6.6 Re-load user parameters.

b) Without Infra-Red connector, hook-up Honeywell Enraf service tool as described in section 3.3.
Select on the Honeywell Enraf service tool the feature: send items.
Select transmission address 00, and give the command **IN** three times in sequence.
When the NOVRAM formatting is ready, the message: "NV-data init completed" will be shown in the communication window.
Program the required transmission address (item **TA**) and the required tank identifier (item **TI**).
Refer to the next section Re-load user parameters.

4.6.6 Re-load user parameters

If not yet done, check whether jumper J4 on the ICU board is set to position "0" (refer to section 3.2). If the jumper is placed in position "1", change it temporary to position "0". Close covers and apply power.
Proceed as follows:
Re-transmit the log file from the Honeywell Enraf service tool.
Program all new settings which are required with the updated software.
Set the SmartRadar ATi to the correct level (check by means of a manual measurement) by using the **RL**, **AR** procedure (refer to chapter 3.4.3).
Make a new log file and a reflection diagram with Honeywell Enraf service tool for future reference.

If jumper J4 on the ICU board was temporary set from position "1" to position "0", proceed as follows:
Switch off supply, open electronic compartment cover.
Change jumper J4 to position "1".
Close cover and apply power.

Appendix A   Article and part numbers

It is recommended to keep one set printed circuit boards on stock for spare.
Refer to the figure on the next page.

No.	Description		Part. no.
1	Front cover		0186.853
2	O - ring	(215 x 4 NBR70)	2132.990

3
 	
3[a,b]
	Communication board
	   ICU_RS232/485 board
	   ICU_HPO board
	   GFC board
	Spare set screws, option
		(option)
		(RS-232C or RS-485)
		(analog 4-20 mA + HART[®])
		(Foundation Field bus comm.)
		(screws, spacers, connector)
			
			0973.911
			0973.912
			0690.605
			0973.991

4	Fuses (2 x)	(ac supply: 1.6 A, 250 V) (dc supply: 2.0 A, 250 V)	2655.177 2655.178
5 5[a,b]	ICU_GPS board Spare set screws, standard	(supply: 110 - 240 Vac) (supply: 24 - 64 Vdc) (screws, washers)	0973.930 0973.931 0973.990
6 6[a,b]	ICU_IS board Spare set screws, option	(option) (screws, spacers, connector)	0973.550 0973.991

7
 	
7[a,b]
	ICU_HPI board
	   for VITO temperature and/or water probe
	   for VITO temperature and/or water probe and HART[®] devices
	   for spot temperature Pt100
	   for spot temperature Pt100 and HART[®] devices
	   for spot temp., VITO temp. and/or water probe and HART[®] devices
	Spare set screws, option
		(option)
		
		(screws, spacers, connector)
			
			0973.920
			0973.921
			0973.922
			0973.923
			0973.924
			0973.991

8 8[a-d]	ICU board Spare set screws, standard	(basic version) (with alarm relay) (screws, washers)	0973.601 0973.603 0973.990
9 9[a]	Infra-Red connector O - ring	(option) (part of IR connector assembly)	0854.380 2132.210
10	Terminals (grey)	(8 x)	2635.308
11	Terminals (blue)	(9 x)	2635.309
12	O - ring	(160 x 4 NBR70)	2132.989
13	Rear cover		0186.854
	Grease, anti seize		4000.015
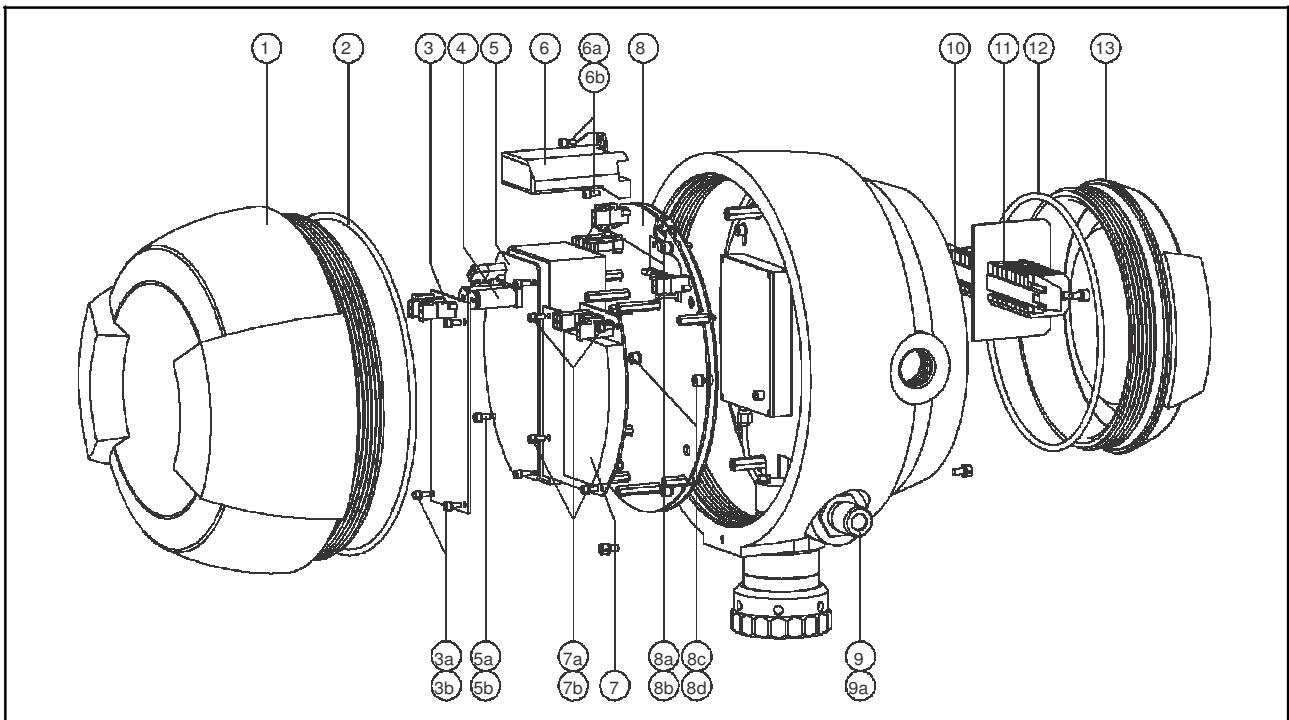
Exploded view 970 SmartRadar ATi

The part numbers of the EPROM's (and NOVRAM) are shown in table below. For software compatibility, refer to table in section 4.6 (page 43).

EPROM	Part no.	EPROM	Part no.
ICU - APU L&H (set)	0181.302	ICU_HPI	0181.311
ICU - XPU-2	0181.301	ICU_HPO	0181.320
RFB-3 / DAB	0181.352	NOVRAM (ICU - XPU-2)	2518.929

Parts in the 970 SmartRadar ATi can be easily exchanged, with the exception of the RFB-3 / DAB board. That is because of the calibration of the VCO part and the quartz microwave feed through in the SmartRadar ATi housing.

Antennas can be changed regardless the type or stem length. When the antenna is changed for another type, or for the same type but with a different stem length, the antenna calibration parameters in the DAB SEEPROM must be altered (refer to nearest Honeywell Enraf office for information about these parameters). Refer to table on next page for the part numbers. Also the tank separator can be changed.

Tank separator	Part no.
for all antenna models	0873.880
O - ring for enclosure against flange / adapter plate	2132.817
O - ring for enclosure of antenna stem	2132.334

Antenna type part numbers

Antenna type	Stem length [mm]	Part number
S06 6" stilling well	0050 0300 0500 0800	0873.911 0873.913 0873.915 0873.918
S08 8" stilling well	0050 0300 0500 0800	0873.921 0873.923 0873.925 0873.928
S10 10" stilling well	0050 0300 0500 0800	0873.931 0873.933 0873.935 0873.938
S12 12" stilling well	0050 0300 0500 0800	0873.941 0873.943 0873.945 0873.948
F08 8" free space	0050 [1] 0300 0500 0800	0873.971 0873.973 0873.975 0873.978
W06 WALP 6" x 12"	0050 0300 0500 0800	0873.961 0873.963 0873.965 0873.968

[1]   For demo purposes only

Appendix B   ASCII table

HEX		MSB		0	1	2	3	4	5	6	7
BIT				6 5 4	6 5 4	6 5 4	6 5 4	6 5 4	6 5 4	6 5 4	6 5 4
LSB	3	2	1	0	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
0	0	0	0	0	NUL	DLE	SP	0	@	P		p
1	0	0	0	1	SOH	DC1	!	1	A	Q	a	q
2	0	0	1	0	STX	DC2		2	B	R	b	r
3	0	0	1	1	ETX	DC3	#	3	C	S	c	s
4	0	1	0	0	EOT	DC4	$	4	D	T	d	t
5	0	1	0	1	ENQ	NAK	%	5	E	U	e	u
6	0	1	1	0	ACK	SYN	&	6	F	V	f	v
7	0	1	1	1	BEL	ETB		7	G	W	g	w
8	1	0	0	0	BS	CAN	(	8	H	X	h	x
9	1	0	0	1	HT	EM	)	9	I	Y	i	y
A	1	0	1	0	LF	SUB		:	J	Z	j	z
B	1	0	1	1	VT	ESC	+	;	K	[	k	{
C	1	1	0	0	FF	FS		<	L	\	l	l
D	1	1	0	1	CR	GS		=	M	]	m	}
E	1	1	1	0	SO	RS		>	N	^	n	~
F	1	1	1	1	SI	US	/	?	O	_	o	DEL

Appendix C   PCB layout
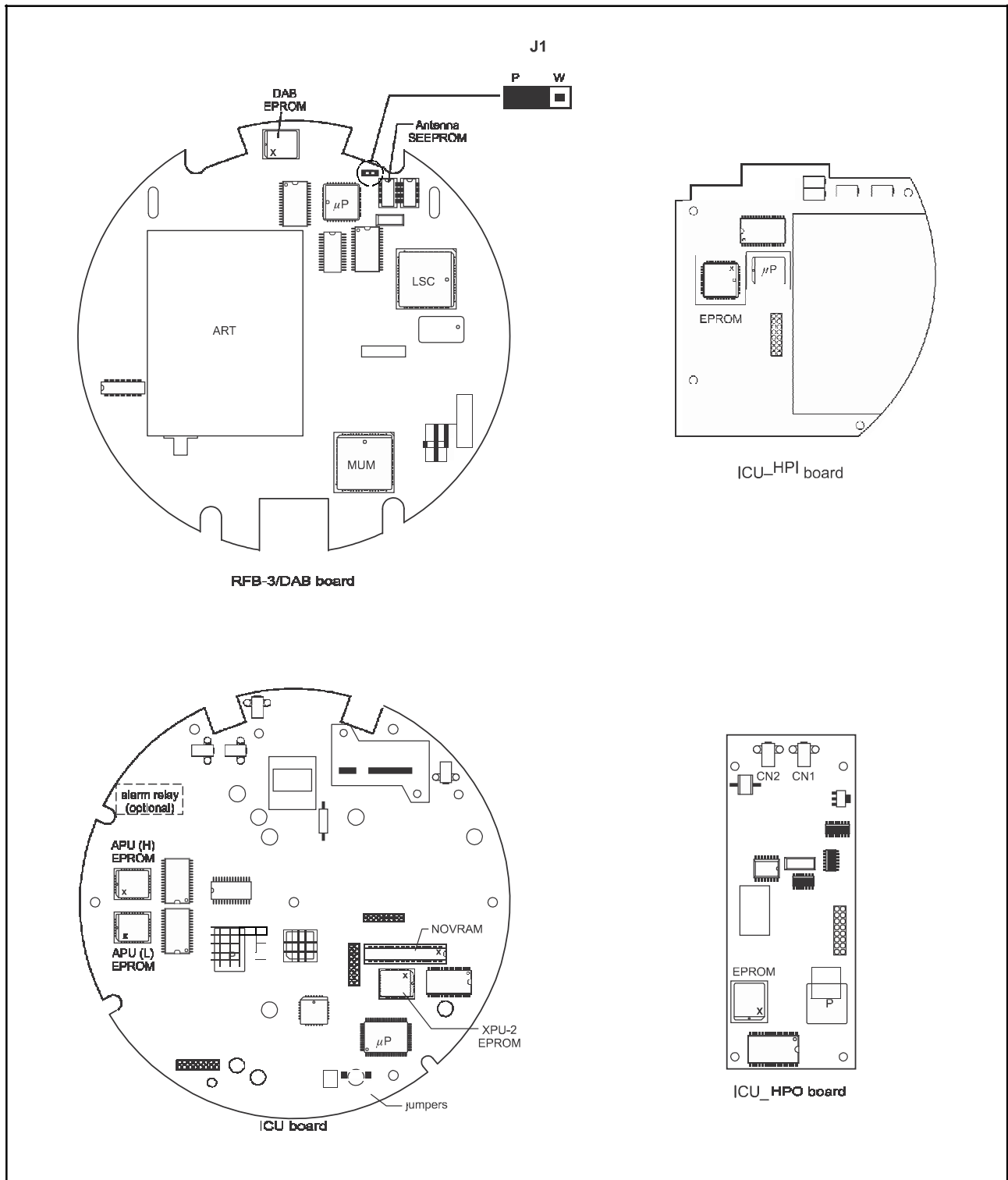
Layout of different processor boards

The *x* inside the EPROM in the figure above notes the notch on the EPROM. The notch of the EPROM *must* fit with the notch of the EPROM socket on the processor board.

Appendix D   Related documents

Title

Installation guide 970 SmartRadar ATi
Installation guide SmartRadar Antennas
Model 970 SmartRadar ATi Safety instructions for installation, commissioning, operation and maintenance

Instruction manual 973 SmartRadar LT Hard alarm output contact

Instruction manual ENSITE service tool
Instruction manual 847 PET

Instruction manual Temperature, Water bottom and Analog output options
Instruction manual HIMS / HTG and vapour pressure (P3) measurement

Instruction manual 973 SmartRadar LT HART[®] output communication
Instruction manual 973 SmartRadar LT RS-232/485 output communication
Instruction manual Modbus™ protocol Honeywell Enraf gauges
Protocol manual SmartRadar

Item documentation Honeywell Enraf series 854, 873, 877 & 973 gauges

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Instruction manual 970 SmartRadar ATi Honeywell Enraf