

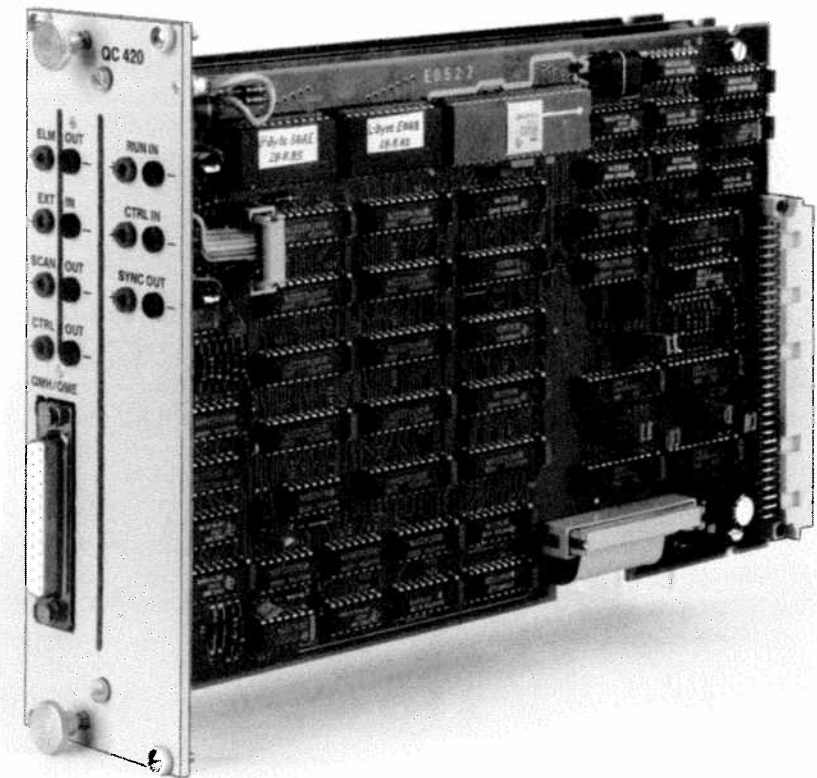
OPERATING INSTRUCTIONS

Quadrupole controller module

QC 420

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1. GENERAL

The QC 420 quadrupole controller is used within the QMS 420 control unit as an intelligent interface to the external RF generator modules and the electrometer amplifier.

The QC 420 functions as a "slave processor" and is equipped with a very fast 16/32-bit signal processor which in addition to the actual control functions also performs complex data processing such as "signal-matched filtering", algorithms for peak search (peak processing, adjust), computation of mean values, etc. These preprocessed, logically reduced and compressed measured data are output via a FIFO buffer to the data bus from where they can be picked up by the master processor of the control unit for reprocessing.

The master processor transmits a command block which determines the operating mode of the slave processor.

The QC 420 is a plug-in module for the SC 420 bus chassis and comprises 3 related circuit boards.

2. FEATURES

- Digital signal processing by means of signal processor
- Elimination of noise signals from the spectrum as well as peak processing by means of digital signal processing algorithms.
- 16 programmable cutoff frequencies for the analog prefilter (antialiasing filter).
- A/D conversion of the signal supplied by the electrometer with 16 bit dynamic range and 12 bit resolution.
- Output of mass number to the RF generator via 16 bit D/A converter
- Data output to SB 420 bus via 32 x 16 bit FIFO buffer - controlled either by interrupt or flag.
- Various "protected" analog and digital signal inputs and outputs on the rear panel.

3. SPECIFICATIONS

The QC 420 consists of the following 3 printed circuit boards:

SI 420 - Signal conditioning

AD 420 - AD/DA converter

SP 420 - Signal processing

Designation	Drawing Nr.	Order Nr.	Diagram Nr.
QC 420	BG 512 751-Z	BG 512 750-T	BG 541 351-S
SI 420	BG 512 759-Z	BG 512 758-T	BG 541 187-S
AD 420	BG 512 753-Z	BG 512 752-T	BG 541 186-S
SP 420	BG 512 771-Z	BG 512 770-T	BG 541 185-S

Supply voltages: +5 V \pm 5% typ. 2.1 A
+24 V \pm 2% typ. 0.14 A without QMH 420
-24 V \pm 2% typ. 0.13 A without QMH 420

Ambient temperatures: 0 to 50°C
Space requirements: 3 card slots
Circuit board format: SC 420
Rear panel: 173 x 59 mm
Bus interface: LSI-11
1 DC load
1 AC load

Addressing range: Complete I/O page, selectable with jumpers
Interface: 1 Control/status register QCCSR(read/write)
1 Command register QCCMR (write only)
1 Output register (FIFO) QCOUT (read only)

Data output: Via FIFO, 32 data words x 16 bits wide
Data transfer: Interrupt-controlled (2 interrupts) or
program-controlled by means of flags

Microprocessor: 16/32-bit signal processor TMS 32010
Program PROM 4K x 16 bits
Processor cycle time 200 ns

Rear-panel connectors: (also refer to 8.3)
QMG/QME connector: Connection for RF generator and
electrometer, 25-pin cannon D-type
connector.
For pin assignment and significance refer
to 8.3 and diagram for SI 420.

Socket outputs (2 mm banana sockets)

ELM OUT: Electrometer signal
Analog output voltage: \pm 10 V
Output resistance: 0 ohm
Output current: max. 2.5 mA

SCAN OUT: Mass number signal
Analog output voltage: 0 to +10.240 V
Output resistance: 0 ohm
Output current: max. 2.5 mA

SYNC OUT: Digital output
Pull-up resistor: 4.7 K to 5 V
Series resistor: 1 K

CTRL OUT: Digital output
Pull-up resistor: 4.7 K to 5 V
Series resistor: 1 K

Socket inputs (2 mm banana sockets)

EXT IN: External input signal
Analog input voltage: \pm 10 V
Differential input
Input resistor: 2 x 50 K

RUN IN: Digital input
Pull-up resistor: 4.7 K to 5 V

CTRL IN: Digital input
Pull-up resistor: 4.7 K to 5 V

4. DESCRIPTION OF THE OPERATING MODES

The operating modes described below are determined by the "signal processor program" (firmware).

The description applies to the program version with the PROM numbers BG 509 100 and BG 509 101.

4.1 SAMPLE

The intensity relating to the specified mass number is measured.

The intensity value is an arithmetic mean value developed from many individual measurements.

In this mode the selected SPEED parameter corresponds to the time during which the mean value is taken. This intensity mean is multiplied by GAIN (CALIB) and output.

4.2 ADJUST

4.2.1 General

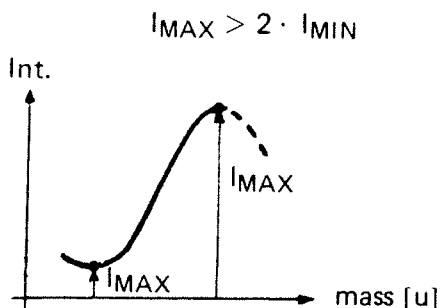
In this mode a peak is searched within a given range (refer to 4.2.3), starting with the entered first mass.

A peak is defined by 3 criteria (refer to 4.2.2). If one peak is found, the mass number (peak mass) relating to its maximum, the peak intensity, and the status code 00 are output.

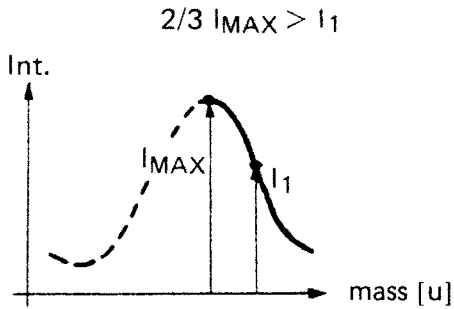
If no peak is found, the first mass, the largest intensity found, as well as a status code are output. In this case the status code contains information as to why the adjust was unsuccessful.

4.2.2 Peak criteria

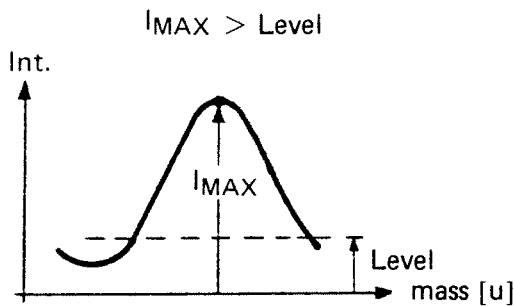
- a) The peak maximum must be at least twice as high as a preceding minimum of the intensity value.



b) After a peak maximum the measurement intensity within the search range must drop to at least 2/3 of this maximum.



c) The found peak maximum must be greater than the selected level.



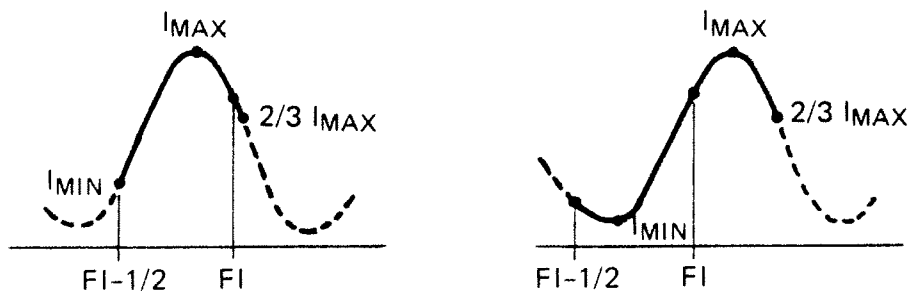
Eight different values can be selected for the height of the level:
 1, 3, 10, 30, 100, 300, 1000, 2000 mV
 (1000 mV corresponds to 10% F.S.)
 The height of the level should be selected in such a way that background and parasitic noise are below this level.

4.2.3 Search range

The normal search range extends from first mass $-1/2$ amu up to first mass $+1/2$ amu.

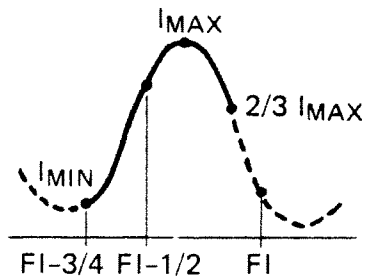
Under certain circumstances (refer to example) this search range is extended by $1/4$ amu at both ends (predictive search range extension).

a) Normal search range



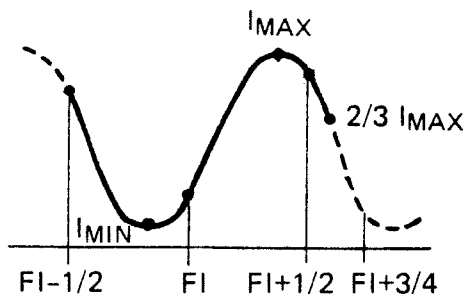
FI ... FIRST MASS (input mass number)

b) Downward extension of search range by 1/4 amu



If the intensity at $FI - 1/2$ is greater than half the intensity at FI (peak criterion a) not satisfied), a "slope test" is performed at $FI - 1/2$. If the slope at $FI - 1/2$ is rising, the start of the search is shifted downward by an additional 1/4 amu

c) Upward extension of search range by 1/4 amu.



A "slope test" occurs at $FI - 1/2$. If the slope is falling, the lower limit of the search start is not extended. At $FI + 1/2$ (normal search end), the peak criterion b) is not satisfied, however, the intensity is already lower than the preceding maximum which means that the upper limit of the search range is extended by 1/4 amu.

4.2.4 Status code

The status code supplies detailed information on possible reasons for an "unsuccessful" adjust operation.

The interpretation of the status code points to the input parameters (first mass, range, gain, level, etc.) that should be changed for the adjust to become successful.

Note: On the display of the QMS 420 the following symbols are output (interpretation of the status code) after an "ADJUST" has been performed:

- * ADJUST successfully completed
- FIRST mass to be selected somewhat larger
- ← FIRST mass to be selected somewhat smaller
- ↓ Make intensity smaller
- ↑ Make intensity larger (or possibly level smaller)

The status code consists of 2 digits.

The first digit gives information on the largest intensity measured within the search range:

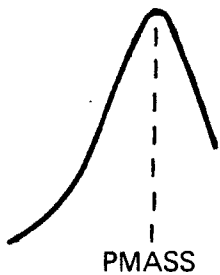
1st Digit	Intensity
0	Within the selected range (good)
1	Overdriven at least once within the search range (077777) 077777 ₈ (octal) corresponds to full scale (F.S.)
2	Smaller than selected level
3	Overdriven throughout entire search range (077777)

The second digit supplies information concerning the "location" of the "input mass number" (first mass) relative to a peak that may be expected.

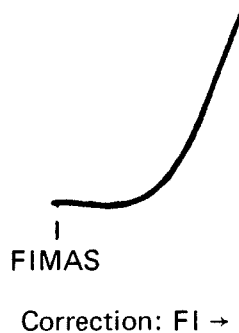
2nd Digit	"Input mass number"
0	Good
1	Too far to the "left" (too small)
2	Too far to the "right" (too large)
4	Only a little too far to the "left" (a little too small)

Examples for various status codes and corresponding intensity/mass number relation.

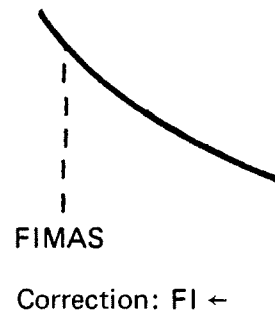
Status Code: 00



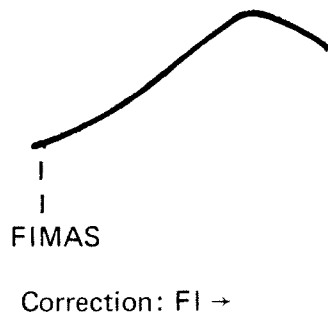
Status Code: 01



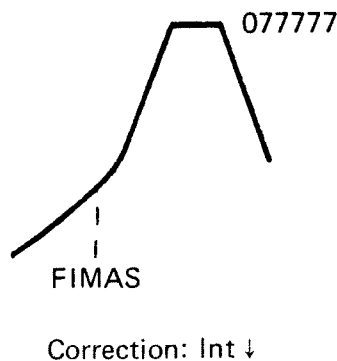
Status Code: 02



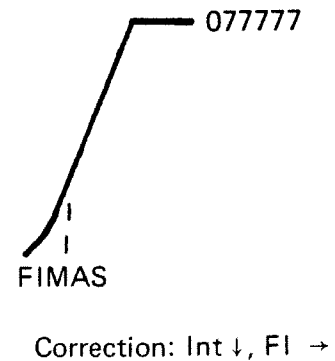
Status Code: 04



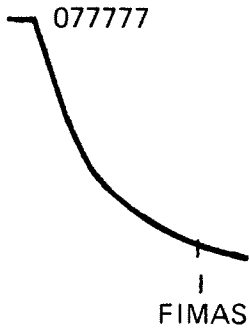
Status Code: 10



Status Code: 11

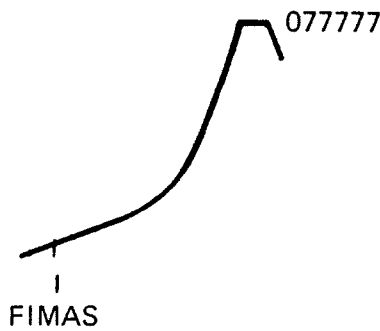


Status Code: 12



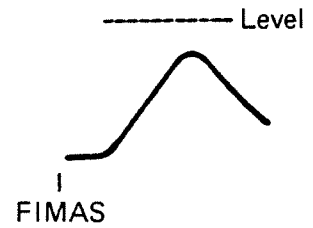
Correction: Int ↓, FI ←

Status Code: 14



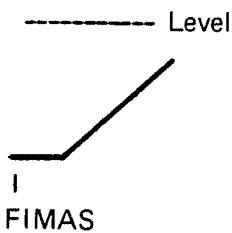
Correction: Int ↓, FI →

Status Code: 20



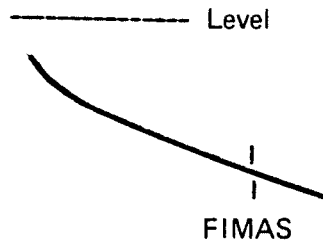
Correction: Int ↑

Status Code: 21



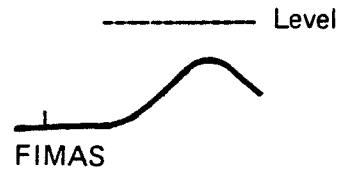
Correction: FI →

Status Code: 22



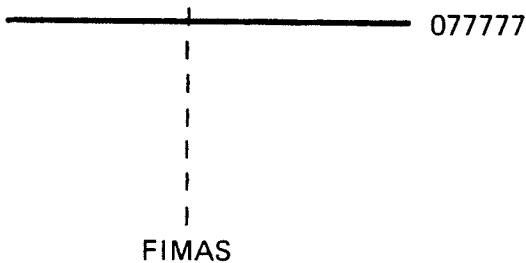
Correction: FI ←

Status Code: 24



Correction: FI →, Int ↑

Status Code: 30, 31 oder 32



Correction: Int ↓

4.2.5 Adjust duration

The duration of an adjust operation depends primarily on the selected SPEED parameter. In this case SPEED determines the dwell time (mean formation) on a given mass number. Since the average search range for an adjust operation extends across $3/4$ amu to $1 \frac{1}{4}$ amu and because a resolution of $1/64$ amu (mass range up to 1024) is used, the time for an adjust can be estimated by means of the following relation:

$$\text{Adjust time} = \text{SPEED} \times (50 \dots 80)$$

Example: SPEED 50 ms

$$t_{\text{ADJ}} = 50 \text{ ms} \times (50 \dots 80) = 2,5 \dots 4 \text{ sec}$$

For the mass range 2048 (resolution $1/32$) an adjust takes only half as long.

4.3 SCAN

4.3.1 General

This operating mode is used for recording a mass spectrum within the range of first mass through last mass (mass width). The speed of the mass scan is selected with SPEED. If the scan speed permits it, the mean value of the sampled intensity measurements (sample period is 31,25 μ s) is formed between two "mass number increment" outputs.

4.3.2 SCAN normal (SCAN-N)

The intensity mean is multiplied by GAIN (CALIB) and output via the "FIFO".



4.3.3 SCAN FIR filter (SCAN-F)

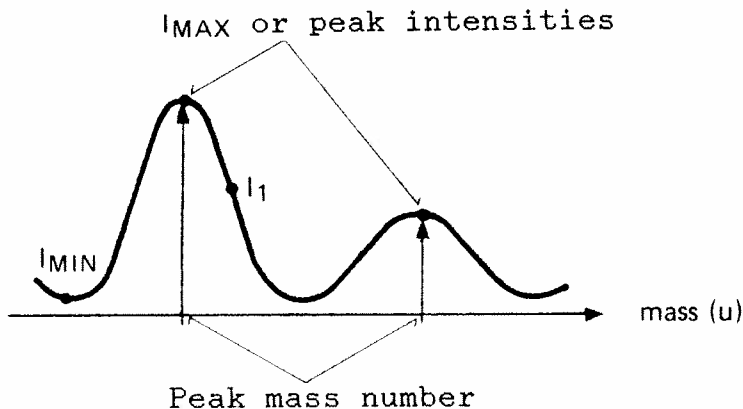
The intensity means are reprocessed with an FIR filter (see 5.). Background and parasitic noise, offsets, microphonic noise, etc. are filtered out even better by this process. The filtered measured data are multiplied by GAIN (CALIB) and output via the "FIFO" filter.



4.4 PEAK PROCESSING

4.4.1 General

Peak processing is an intelligent data reduction process. From the vast number of intensity measurements from a mass spectrum, the characteristic values for found peaks, i.e. "peak intensity" and "peak mass number" are determined in real time. Only these relevant peak value pairs are output via the "FIFO".



Peak processing is possible at all scan speeds. The peak search always ranges from first mass to last mass (width).

There are 2 peak processing modes:

4.4.2 Peak processing level (PEAK-L)

The "raw spectrum data" (without FIR filter) are used for peak processing.

The same peak criteria apply to peak detection as in adjust mode. Peak criteria (also refer to 4.2):

- a) $I_{MAX} > 2 \cdot I_{MIN}$
- b) $2/3 \cdot I_{MAX} > I_1$
- c) $I_{Peak} > Level$ ($I_{Peak} = I_{MAX} \cdot GAIN$)

4.4.3 Peak processing FIR filter (PEAK-F)

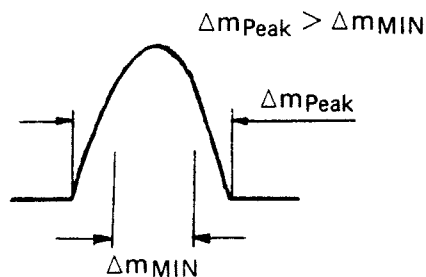
Note: Only suitable for unit resolution.

The "raw spectrum data" are preprocessed with the FIR filter (see 5.) prior to peak processing. This results in the following benefits:

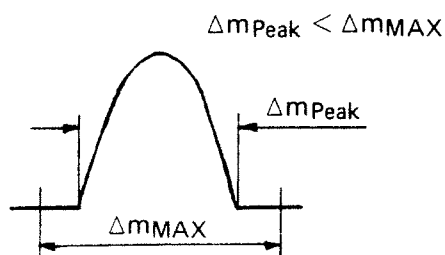
- Background and parasitic noise, offsets, microphonic noise, etc. are largely eliminated by the FIR filter.
- A low level (see 4.2) can be selected, i.e. even the smallest peaks can still be measured.
- "Too wide" and "too narrow" peaks are eliminated.

Peak criteria:

- a) Peak width must be greater than a minimal width $\Delta m_{MIN} = 1/3$ amu



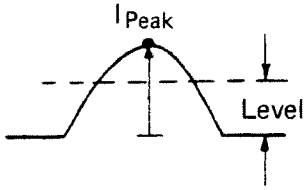
- b) Peak width must be smaller than a maximum width $\Delta m_{MAX} = 1 1/2$ amu



c) Peak height must be larger than the selected level

$$I_{\text{peak}} > \text{level}$$

$$(I_{\text{Peak}} = I_{\text{MAX}} \times \text{Gain})$$



5. DESCRIPTION OF THE FIR FILTER

The FIR (Finite Impulse Response) filter used in the QC 420 is a software-implemented digital filter.

This filter performs the following functions:

- Removes interference (noise, etc.) from the spectrum signals coming from the electrometer.
- Eliminates zero point shifts (DC offset) of the spectrum signal.
- Permits better separation of adjacent peaks.
- Simplifies the algorithm of the peak search (peak processing).
- Enables detection of very small peaks.

The transfer function (weighting function) of the filter has been selected in such a way that all of the foregoing characteristics are optimally satisfied.

The output signal of the filter is obtained by forming the convolution product between the signal and the filter transfer function.

$$f_2(m) = f_1(m) * h(m)$$

where

$f_2(m)$ is the output signal as a function of the mass number

$f_1(m)$ is the input signal as a function of the mass number

$h(m)$ is the pulse response or the filter transfer function

* is the convolution operator

Since all signal processing is digital, the convolution is performed discretely according to the following formula:

$$\text{Formula } f_2(m) = k \cdot \sum_{i=1}^N h(i) \cdot f_1(m-i)$$

or

$$\text{Formula } f_2(m) = k \cdot (h_1 \cdot f_{1N-1} + h_2 \cdot f_{1N-2} + \dots + h_{N-1} \cdot f_{12} + h_N \cdot f_{11}).$$

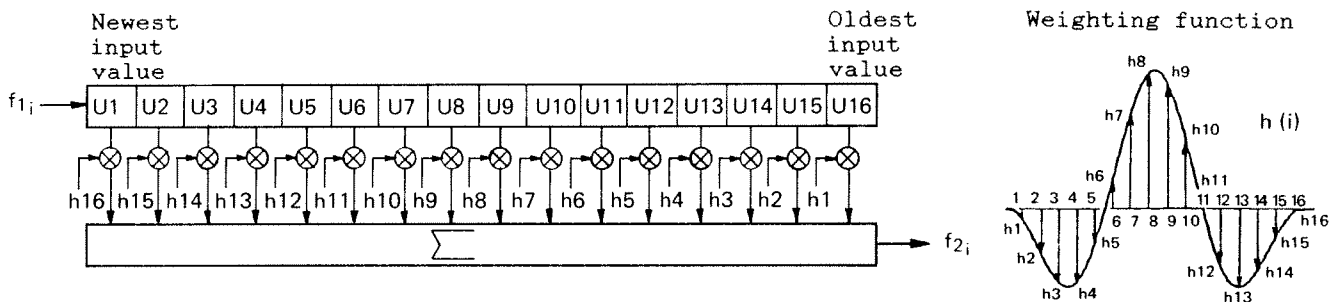
where

k is the scaling factor

$N = 16$ for mass resolution of $1/16$ amu
 $N = 32$ for mass resolution of $1/32$ amu
 $N = 64$ for mass resolution of $1/64$ amu

Each individual output value of f_2 is consequently a mean from 16, 32 or 64 input values f_1 which has been weighted with the filter transfer function (see Fig. 5.1).

FIR filter structure



$h_1 \dots h_{16}$ discrete support values of the weighting function or filter coefficients

Fig. 5.1

The discrete convolution process can also be illustrated by shifting the weighting function step-by-step relative to the input signal and by forming the convolution product (scalar product) in each resulting observation window (see Fig. 5.2).

Principle of discrete convolution

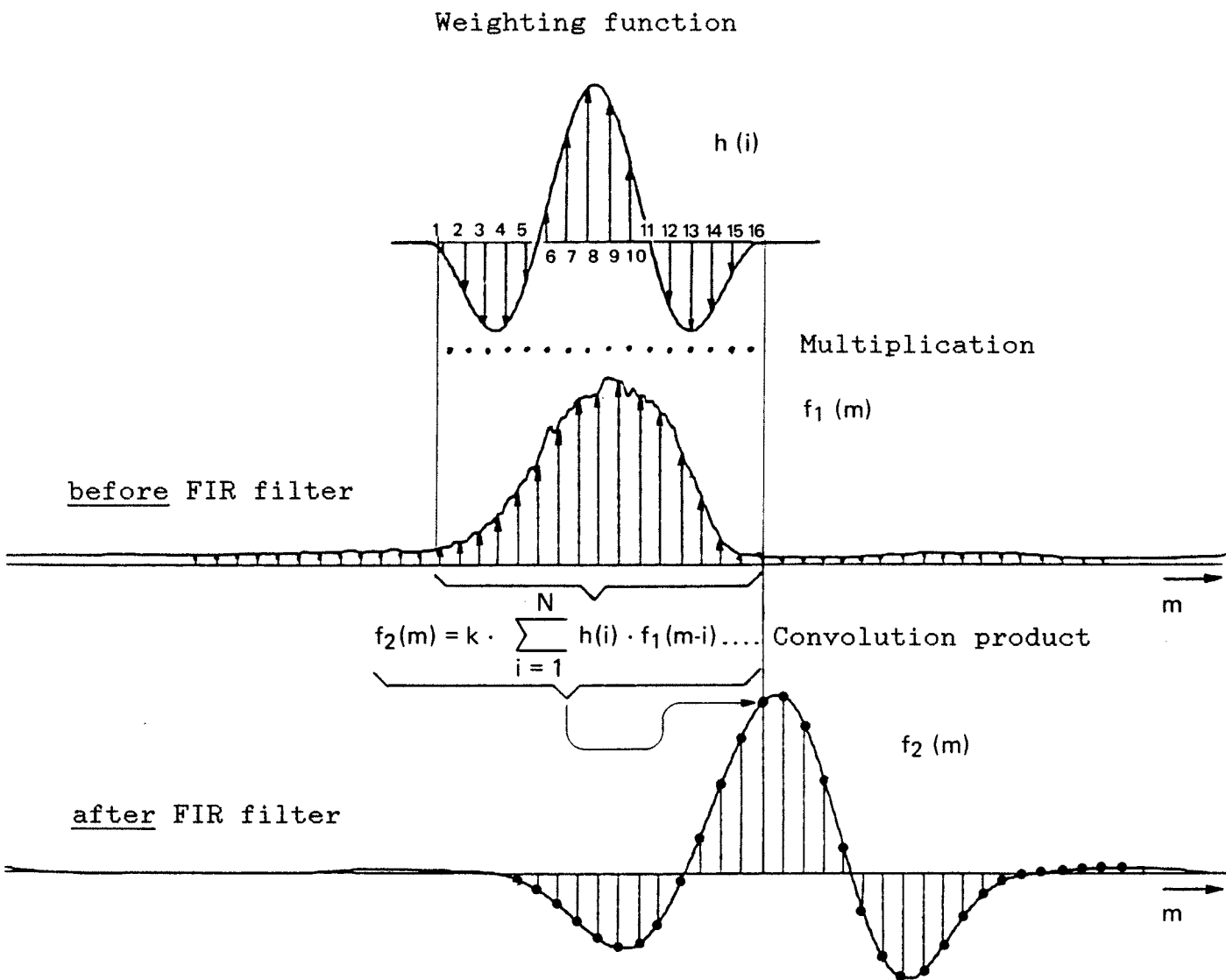


Fig. 5.2.

The weighting function (pulse response) of the filter is a type of reference function for the signal to be selected. Similarly to a correlation, the convolution process consists of shifting the signal and the reference relative to each other while the degree of similarity between the two is continuously determined. The convolution differs from the correlation only in that the direction in the reference is reversed.

Measurements in comparison

Figs. 5.3 and 5.4 give a comparison between the SCAN-Normal and SCAN-FIR modes. Particular attention should be given to the excellent separation effect of the FIR filter with respect to adjacent peaks in logarithmic representation.

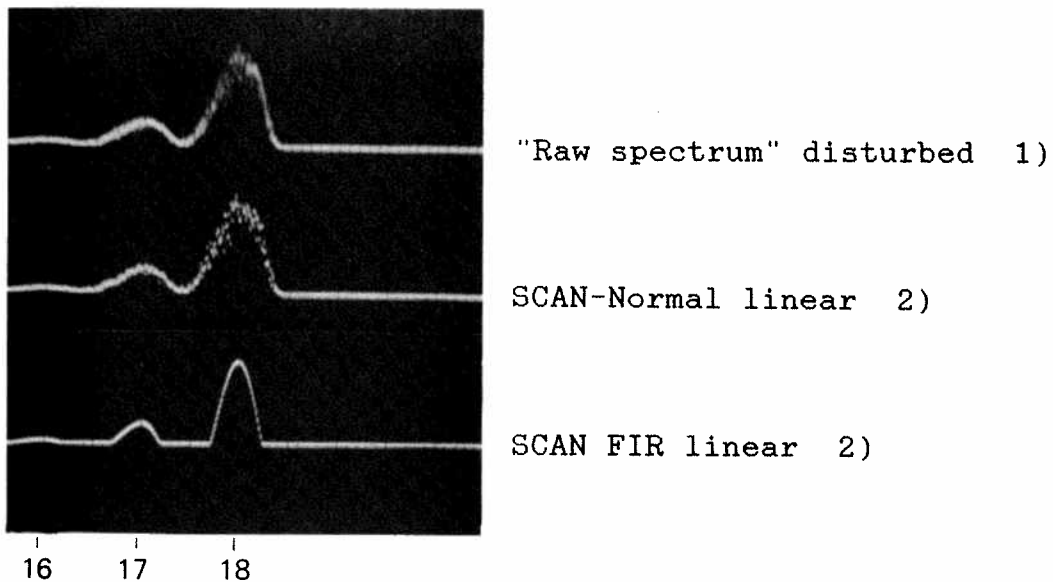


Fig. 5.3

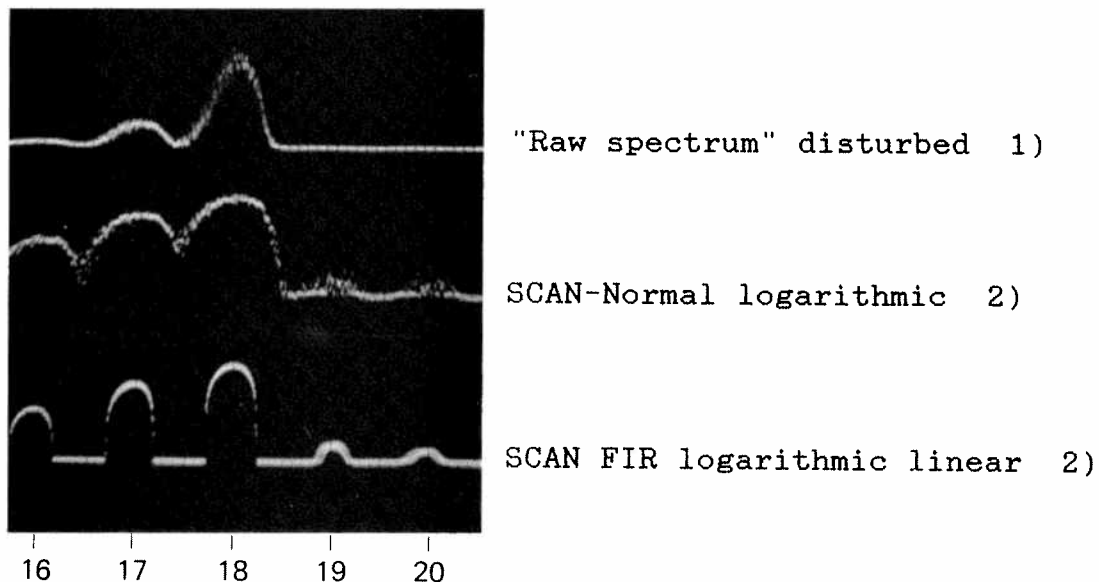


Fig. 5.4

PTOT = $1 \cdot 10^{-7}$ mbar, RANGE E-07, SEM 2900 V, FILTER 18 μ s
SPEED 10 ms/amu, FIRST 15.55 amu, WIDTH 5 amu

- 1) Signal on output ELM OUT
- 2) Signal on output of an AO 420

Overrange input signals

(Overranging of the electrometer)

A special routine is used for overrange input signals because the FIR filter algorithm would supply incorrect results in this case.

Since the FIR filter output signal lags behind the input signal by the constant value of $1/2$ amu ($1/2$ mass unit) (a phenomenon that is inherent to all FIR filters) with the consequence that the FIR output signal has its "negative backswing" precisely at the moment that the input signal has its peak or possibly its "overrange", the following procedure is used for detecting such overranges:

The scanned input signal values (signal values at the input of the FIR filter) are checked for overrange (F.S.) during the observation window where the filter output signal is negative. If the number of overranges counted during this observation phase exceeds a preset limit, the output signal is set to full scale (F.S.) regardless of the value supplied by the FIR filter (see Fig. 5.5).

OVERRANGE DETECTION

Number of overranges

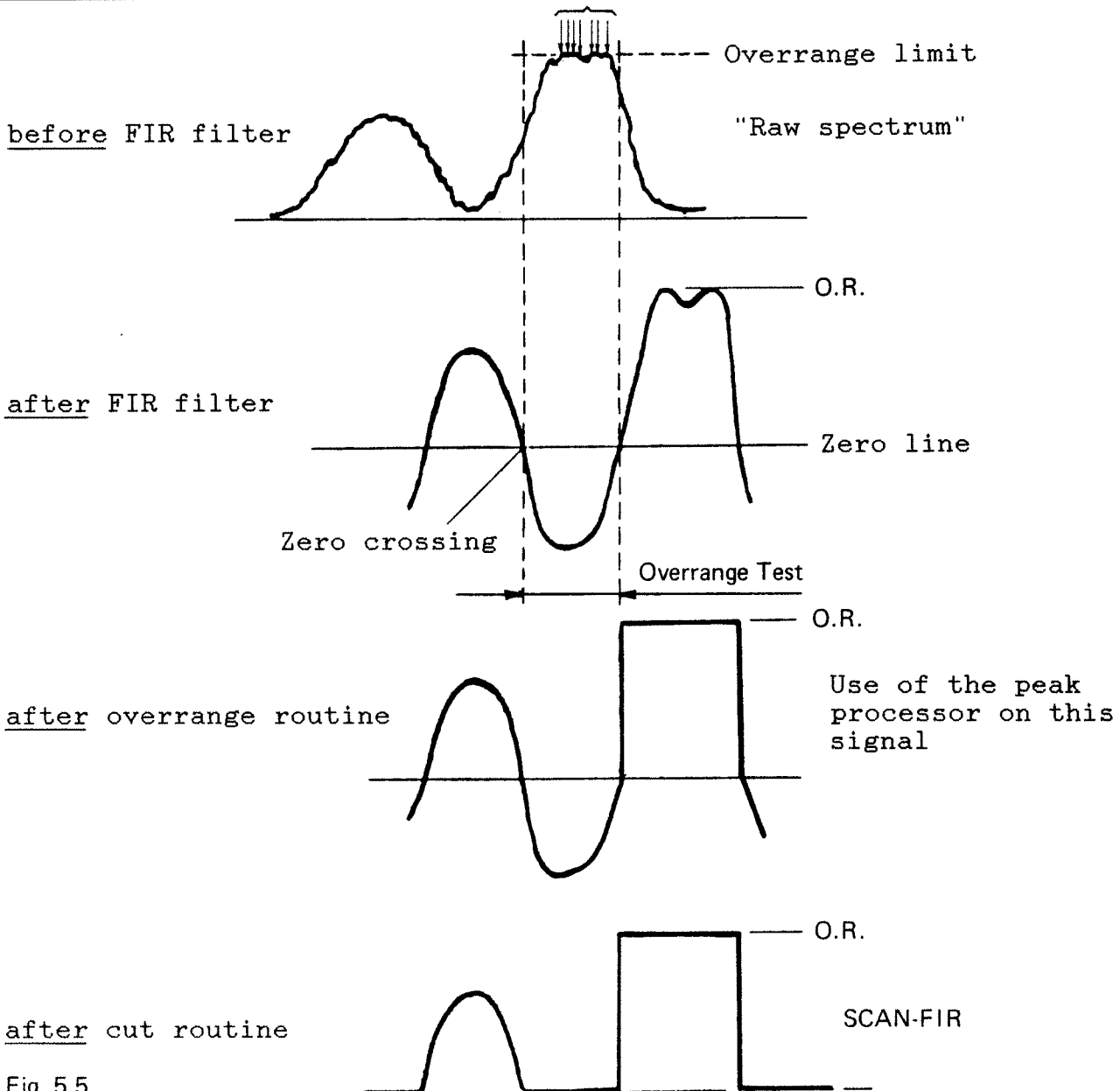


Fig. 5.5.

Fig. 5.6 illustrates by way of example the flow diagram and the corresponding measured values for SCAN-F mode (scan with FIR filter).

SCAN with FIR filter

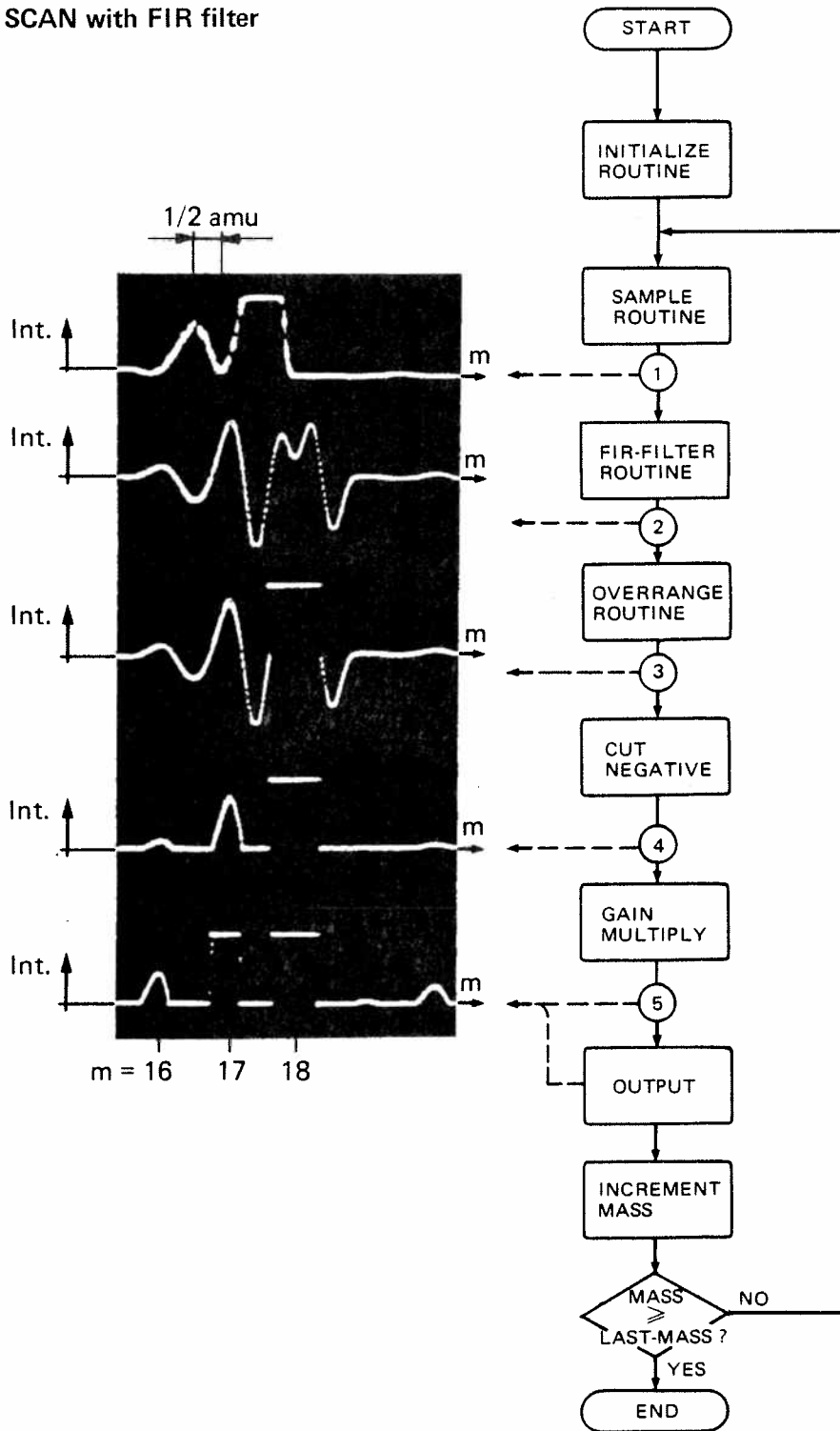


Fig. 5.6.

6. DESCRIPTION OF THE BLOCK CIRCUIT (Fig. 6.1)

The QC 420 consists of 3 related functional assemblies SI 420, AD 420, and SP 420.

6.1 SI 420 signal conditioner

In the SI 420 the input and output signals are conditioned for the subsequent processing steps. The interface connector for the QMH RF generator as well as jacks for the rear panel connections ELM OUT, EXT IN, SCAN OUT, and CTRL OUT are also located on this printed circuit board.

The input multiplexer can be switched to one of the following four signals:

- Electrometer measurement signal "EP" (normal situation)
- An external signal applied via the EXT IN sockets on the back panel
- SCAN output signal (only for test purposes)
- RESOLUTION output signal (only for test purposes)

The signal selected by the multiplexer is input to a 2-stage low-pass filter that features a programmable "cut off-frequency". This filter is used not only for suppressing the noise voltage superposed on the desired signal, but also for "limiting the bandwidth" for the subsequent "digital signal processing" (antialiasing filter).

The filtered signal is amplified in the subsequent amplifier stage either by a gain factor of 1 or 10. The conditioned signal is then input to the A/D converter system of the AD 420.

The output amplifier for the analog signals SCAN and ELECTROMETER are mainly used for decoupling and buffering. The amplifier for the electrometer output signal also functions as a polarity inverter.

The output drivers for the control signals wired to the QMH connector as well as for the CTRL OUT signal are used for decoupling and level shifting.

The RFOK monitoring signal from the quadrupole RF generator (QMH) is conditioned by means of a Schmitt trigger circuit and then taken to the control/status register on the SP 420.

The multiplexer setting, the filter frequency, the subsequent gain (x 1 or x 10), as well as the polarity of the electrometer signal available on the rear panel can be selected through the program.

6.2 AD 420 A/D - D/A converter

The A/D converter system employs the companding principle and is implemented with two 12-bit A/D converters, the quantization voltages of which differ in the ratio of 1:16. This means that smaller signals are quantized in finer increments than large signals.

This process which is supported by the signal processor software thus represents a quasi 16-bit A/D conversion.

The D/A converter system consists of a 16-bit D/A converter for outputting MASS and an 8-bit D/A converter for outputting RESOLUTION. Both signals are transmitted to the SI 420. The corresponding data values are supplied by the signal processor.

The control register serves as an interface register for various control signals that are transmitted to the SI 420.

The ± 15 V required for supplying the various analog components on the SI 420 and AD 420 circuit boards are prepared by means of linear voltage regulators from the ± 24 V made available by the BS 420 bus.

6.3 SP 420 signal processor unit

The SP 420 signal processor unit functions as a very fast intelligent slave processor. It receives its jobs from the master processor via the BS 420 system bus. The measured data processed by the signal processor partially with the aid of complex software algorithms, and the status information can be picked up under control of the master processor via the system bus, and can be retransmitted or reprocessed.

The following communication interfaces to the BS 420 system bus are available:

- a) Command register (QCCMR) for data or command transmission from the master to the slave.
- b) Control status register (QCCSR) for transferring control information from the master to the slave, as well as for transferring status information from the slave to the master.
- c) FIFO memory (32 x 16-bit words) for outputting data from the slave to the master.

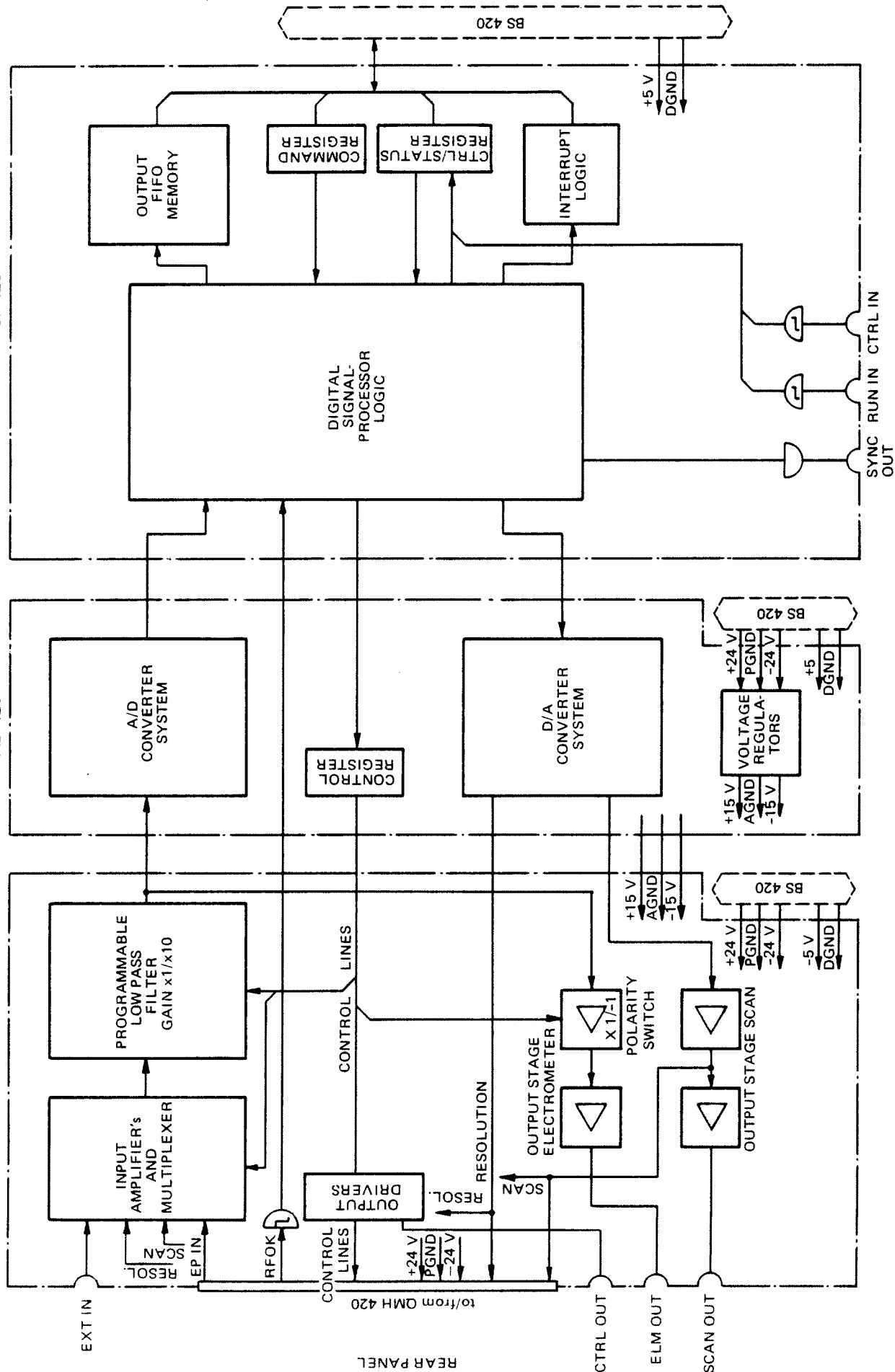
The data output can be flag-controlled either by means of status information in the control status register, or interrupt-controlled by means of the interrupt logic.

Signal processor data (e.g. MASS, RESOLUTION) can also be output via the two D/A converters on the AD 420.

The digital SYNC output on the rear panel of the QC 420 is also driven by the signal processor.

The digital inputs RUN and CTRL IN on the rear panel of the QC 420 can be interrogated by the master via control status register.

The signal processor logic comprises the signal processor TMS 32010 itself, the program memory (PROM), as well as ancillary circuits.



REAR PANEL

Fig. 6.1 QC 420

7. CONFIGURATION

A complete QC 420 plug-in module comprises the 3 printed circuit boards SI 420, AD 420, and SP 420.

The following flat-cable connections exist between the individual p.c. boards:

- a) 34-conductor connection between SI 420 and AD 420
- b) 26-conductor connection between AD 420 and SP 420

7.1 Factory setting

Addressing

Control/status register	QCCSR (base address)	175540
Command register	QCCMR	175542
FIFO output	QCOUT	175544

Jumpers inserted on SP 420: A5, A6, A8, A9, A11, A12

Interrupt vectors

REQUEST A: data/frame interrupt	320
REQUEST B: ready/error interrupt	324

Jumpers inserted on SP 420: V4, V6, V7

16-BIT D/A CONVERTER (MASS) on AD 420

Converter type	Output voltage	Data format	Jumper J4
DAC 701	0 to 10 V	16-bit unsigned	2 - 3

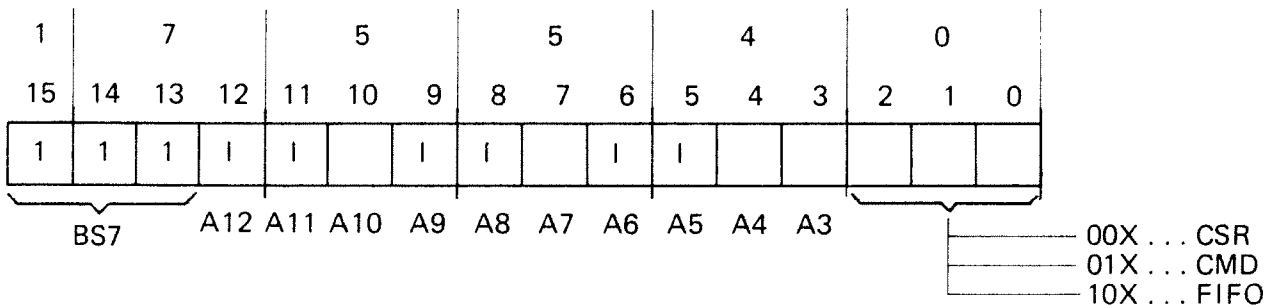
Service jumpers on AD 420: inserted jumpers J5, J6

7.2 Address selection (SP 420)

The QC 420 occupies 4 addresses of which 3 are used. The QC 420 can be used throughout the entire I/O address range (160000 to 177770).

The base address is set with the jumpers A3 through A12.

Example:

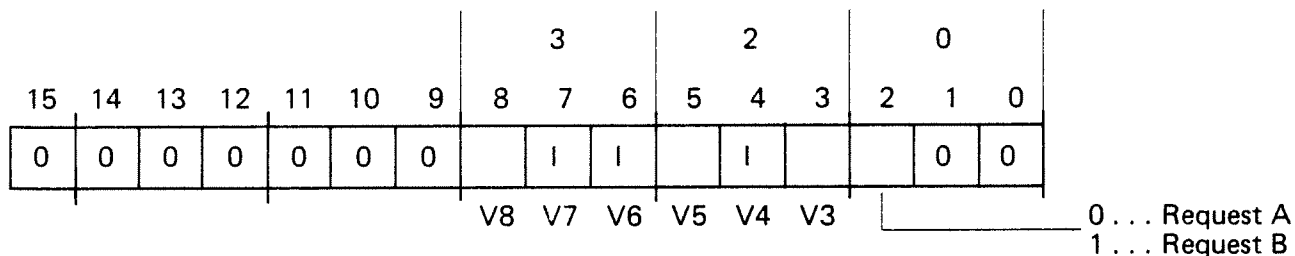


Jumper inserted (I) ... corresponding address bit = 1
 CSR ... Control/Status Register
 CMD ... Command Register
 FIFO ... FIFO Output

7.3. Interrupt vectors (SP 420)

The QC 420 occupies two adjacent vector addresses. These can be within the vector address range (000 - 374). The vector base address is set with jumpers V3 through V8.

Example:



Jumper inserted (I) ... corresponding address bit = 1

7.4 16-BIT D/A CONVERTER ON AD 420

It is also possible to use a bipolar D/A converter (other software required!).

Converter type	Output voltage	Data format	Jumper J4
DAC 703	-10 to +10 V	16-bit two's complement	1 - 2

8. INSTALLATION

8.1. Important information

Please read the Section "Installation of Modules" in the SC 420 Operating Instructions.

- The unit and any external voltage source must be switched off before any manipulations are performed on the module.
- The connection cables should not be confused with the cables of other modules.

8.2 Installation in SC 420

The QC 420 occupies three slots in the SC 420. When selecting the slots, the desired "horizontal interrupt priority" which is dependent on specific card slots must be taken into consideration.

Slot J5 ... highest interrupt priority
 Slot J18 ... lowest interrupt priority

The interrupt control is used by the QC 420!

The configuration table associated with a unit gives information on the correct placement of the module.

8.3 Connectors

QMH/QME connector: 25-pin cannon D-type connector for QMH 400 (RF generator to QMG 420)
 or the
 QME 112 (mass filter electronics to QMG 112)
 or the
 EA 420 (electrometer adapter to QMG 311)

Separable connection QC 420 - QMH 400 - QME 112 - EA 420
 (pin assignment)

QC 420 (J2)	PIN Flow	QMH 400 (J1)	QME 112 (J3)	EA 420 (J1)
+24V	3 →	+24V	+24V	+24V
+24V	15 →	+24V	+24V	+24V
+24V	16 →	+24V	+24V	+24V
GND	4 --	GND	GND	GND
GND	6 --	GND	GND	GND
GND	17 --	GND	GND	GND
GND	19 --	GND	GND	GND
-24V	1 →	-24V	-24V	-24V
-24V	2 →	-24V	-24V	-24V
-24V	14 →	-24V	-24V	-24V
SCREEN	22 --	SCREEN	SCREEN	-
MASS300 H	9 →	-	-	MASS300 H
EP2 H	13 →	EP2 H	-	-
EP+	7 ←	EP+	EP+	EP+
EP-	20 ←	EP-	EP-	EP-
RESOL+	8 →	RESOL+	SEM+	-
RESOL-	21 →	RESOL-	SEM-	-
SCAN+	5 →	SCAN+	SCAN+	SCAN+
SCAN-	18 →	SCAN-	SCAN-	SCAN-
MODE1 H	11 →	MODE1 H	MODE1 H	-
MODE2 H	23 →	MODE2 H	MODE2 H	-
-	25 --	-	DSP EMIS H	-
RFOK L	10 ←	RFOK L	EMISOK L	GND
RANGE0 H	12 →	RANGE0 H	RANGE0 H	RANGE0 H
RANGE1 H	24 →	RANGE1 H	RANGE1 H	RANGE1 H

Socket terminals (2 mm banana sockets):

All sockets for rear-panel inputs or outputs are protected with diode resistance networks. The "-" terminals are connected via a ≥ 100 ohm resistor to GND (refer to circuit diagram).

Socket outputs:

ELM-OUT: The filtered analog electrometer signal which is proportional to the partial-pressure intensity is available on the electrometer output.

SCAN-OUT: The SCAN output supplies in SCAN and in SAMPLE mode an analog voltage that is proportional to the mass number.

SYNC-OUT: This output signal can, for example, be used for triggering an oscilloscope.

CTRL-OUT: The use of this digital output is defined by the software in the LSI-11 and in the QC 420.

Socket inputs:

EXT-IN: If this input source is selected the signal is processed in the same way as the electrometer signal.
Input voltage: ± 10.240 V

RUN-IN: The use of this digital input is defined by the software in the LSI-11 computer.

CTRL-IN: The use of this digital input is defined by the software in the LSI-11 computer.

9. PROGRAMMING

Detailed information for the programmer can be found in the engineering manual.

10. MAINTENANCE AND TROUBLESHOOTING

The QC 420 requires no scheduled maintenance. In case of malfunctions, particular attention should be paid to the flat-cable connections between the individual circuit boards.

If a fault is suspected in the QC 420, we recommend replacement of the complete plug-in module.

The engineering manual of the QC 420 may also be consulted as an aid for localizing a fault.

11. ACCESSORIES

2 mm banana plugs for the rear-panel socket outputs
(Order No. B 4711 152 NZ + B 4711 152 MA black)
(Order No. B 4711 152 N2 + B 4711 152 MA red)

APPENDIX A:

Component arrangement SI 420

BG 512 759-Z

