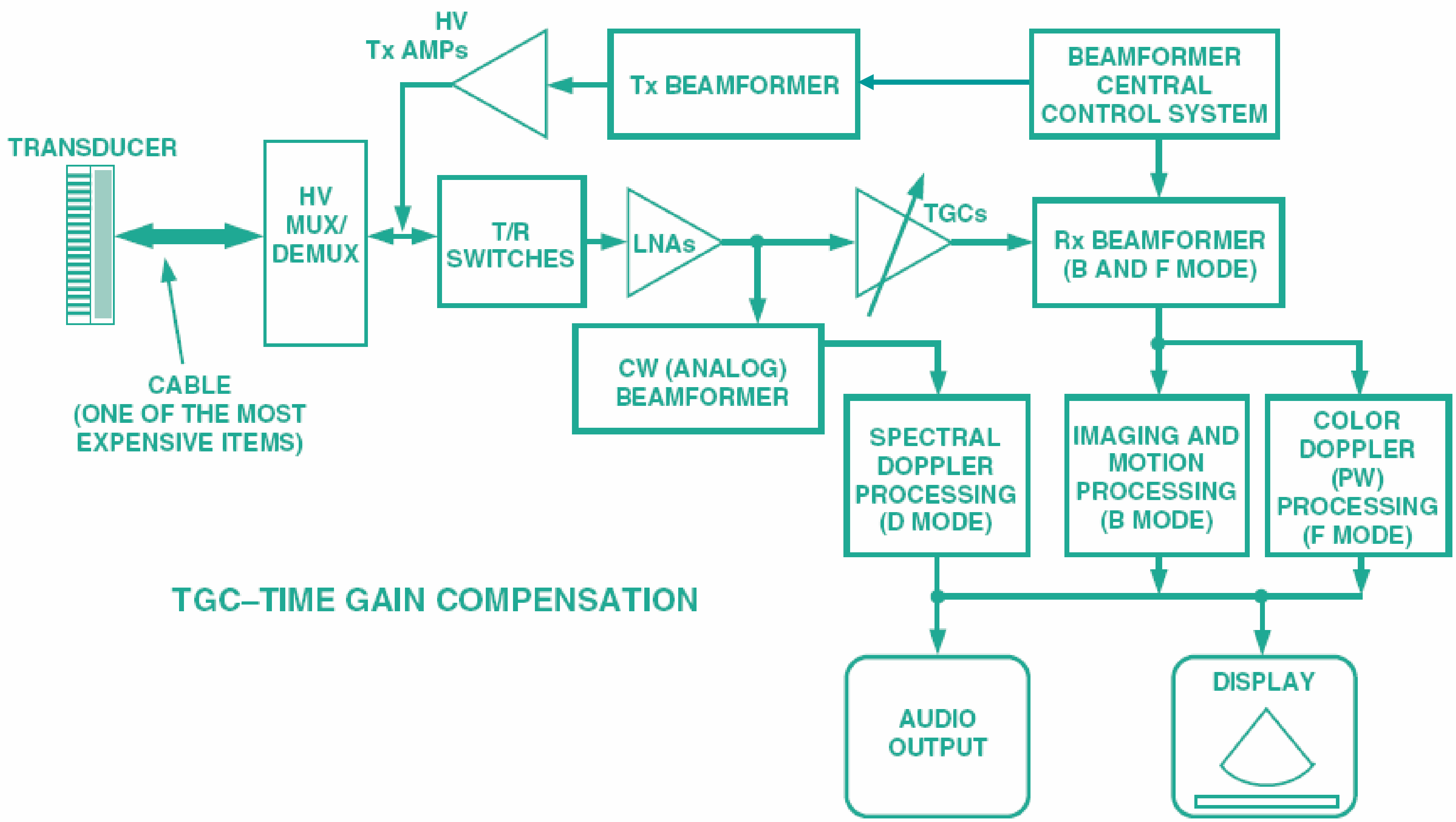
Ultrasound Imaging System Practical Components

General Block Diagram



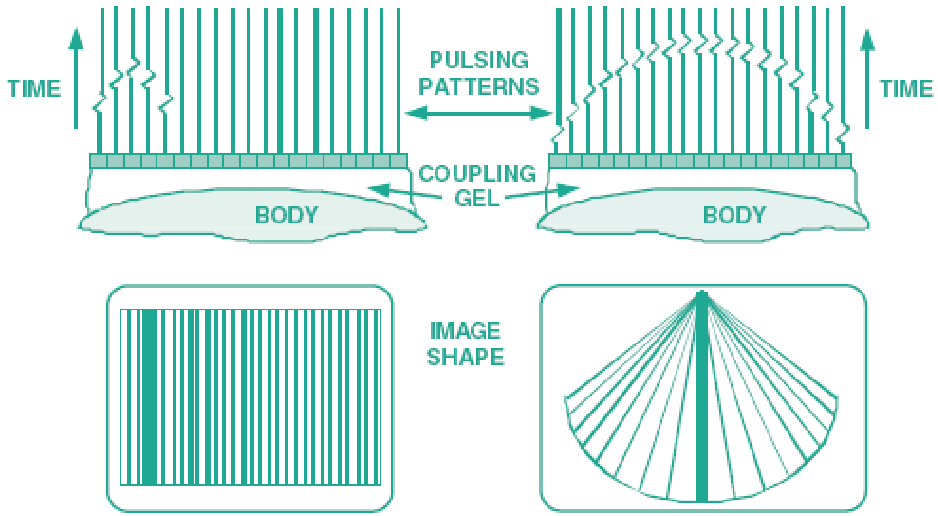


Figure 3. Linear vs. phased-array imaging.

Beamformer Design Approaches

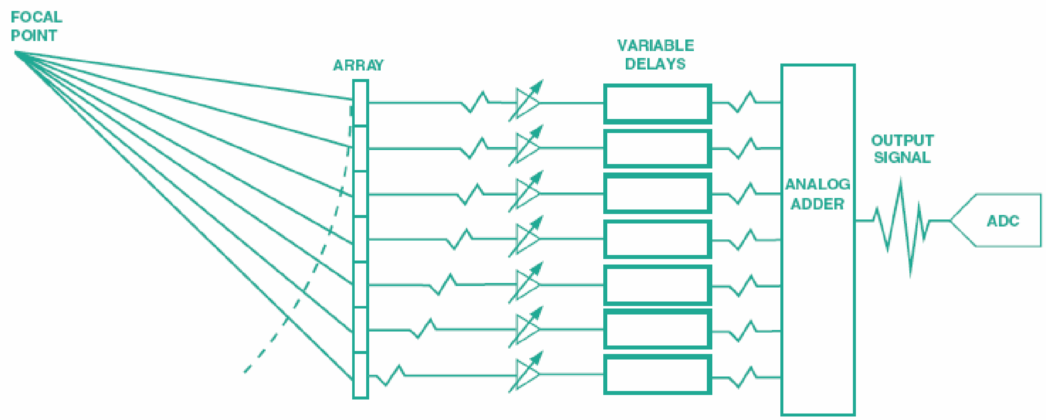


Figure 4. Simplified block diagram of ABF system.

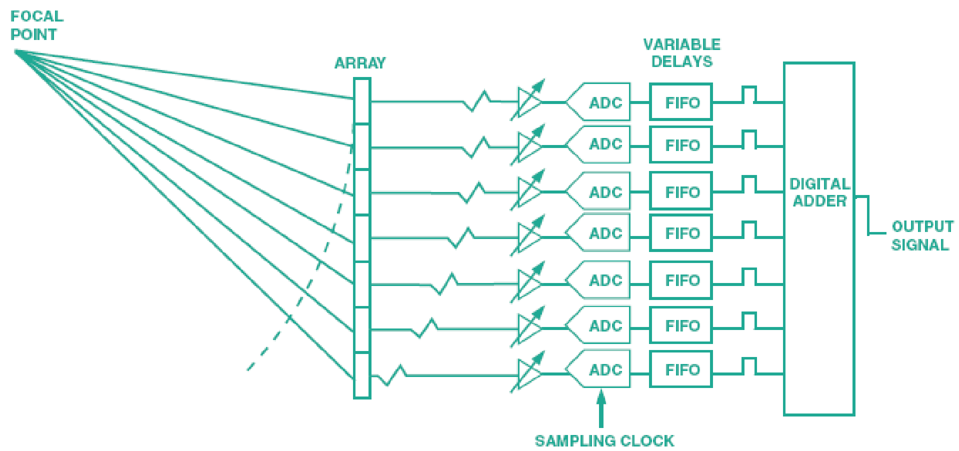


Figure 5. Simplified block diagram of DBF system.

Element Selection

Low Charge Injection 8-Channel High Voltage Analog Switches

Features

- ❑ HVCMOS® technology for high performance
- ❑ Very low quiescent power dissipation – 10µA
- ❑ Output on-resistance typically 22 ohms
- ❑ Low parasitic capacitances
- ❑ DC to 10MHz analog signal frequency
- ❑ -60dB typical output off isolation at 5MHz
- ❑ CMOS logic circuitry for low power
- ❑ Excellent noise immunity
- ❑ On-chip shift register, latch and clear logic circuitry
- ❑ Flexible high voltage supplies

Applications

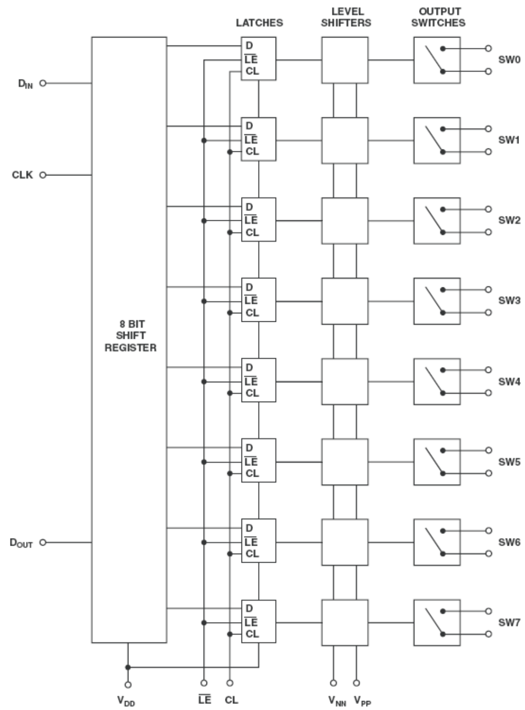
- ❑ Medical ultrasound imaging
- ❑ Piezoelectric transducer drivers

General Description

These devices are low charge injection 8-channel high-voltage analog switch integrated circuits (ICs) intended for use in applications requiring high voltage switching controlled by low voltage control signals, such as ultrasound imaging and printers. Input data is shifted into an 8-bit shift register which can then be retained in an 8-bit latch. To reduce any possible clock feed-through noise, Latch Enable Bar ($\overline{LE}$) should be left high until all bits are clocked in. Using HVCMOS technology, these switches combine high voltage bilateral DMOS switches and low power CMOS logic to provide efficient control of high voltage analog signals.

These ICs are suitable for various combinations of high voltage supplies, e.g., V_{PP}/V_{NN} : +50V/–150V, or +100V/–100V.B

Block Diagram



Logarithmic Amplifier

ANALOG DEVICES

Low Cost DC-500 MHz, 92 dB Logarithmic Amplifier

AD8307

FEATURES

- Complete multistage logarithmic amplifier
- 92 dB dynamic range: –75 dBm to +17 dBm
  - to –90 dBm using matching network
- Single supply of 2.7 V minimum at 7.5 mA typ
- DC to 500 MHz operation, ±1 dB linearity
- Slope of 25 mV/dB, intercept of –84 dBm
- Highly stable scaling over temperature
- Fully differential dc-coupled signal path
- 100 ns power-up time, 150 μA sleep current

APPLICATIONS

- Conversion of signal level to decibel form
- Transmitter antenna power measurement
- Receiver signal strength indication (RSSI)
- Low cost radar and sonar signal processing
- Network and spectrum analyzers (to 120 dB)
- Signal level determination down to 20 Hz
- True decibel ac mode for multimeters

FUNCTIONAL BLOCK DIAGRAM

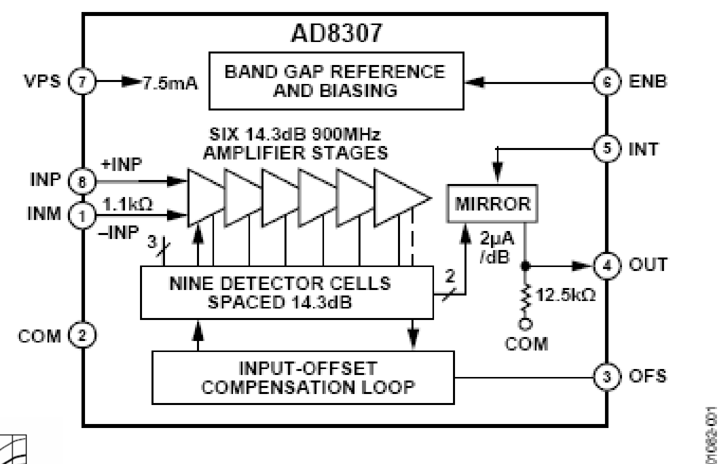


Figure 1.

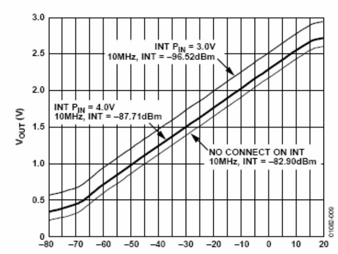


Figure 9. V_{OUT} vs. Input Level at 5 V Supply; Showing Intercept Adjustment

TGC

ANALOG DEVICES

Ultralow Noise VGAs with Preamplifier and Programmable R_{IN}

AD8331/AD8332/AD8334

FEATURES

- Ultralow noise preamplifier
  - Voltage noise = 0.74 nV/√Hz
  - Current noise = 2.5 pA/√Hz
- 3 dB bandwidth
  - AD8331: 120 MHz
  - AD8332, AD8334: 100 MHz
- Low power
  - AD8331: 125 mW/channel
  - AD8332, AD8334: 145 mW/channel
- Wide gain range with programmable postamp
  - −4.5 dB to +43.5 dB
  - +7.5 dB to +55.5 dB
- Low output-referred noise: 48 nV/√Hz typical
- Active input impedance matching
- Optimized for 10-bit/12-bit ADCs
- Selectable output clamping level
- Single 5 V supply operation
- AD8332 and AD8334 available in lead frame chip scale package

APPLICATIONS

- Ultrasound and sonar time-gain controls
- High performance AGC systems
- I/Q signal processing
- High speed, dual ADC drivers

FUNCTIONAL BLOCK DIAGRAM

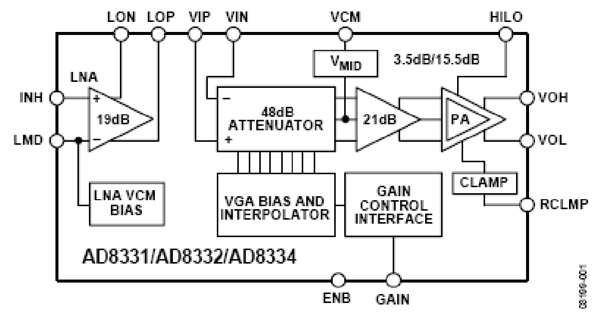
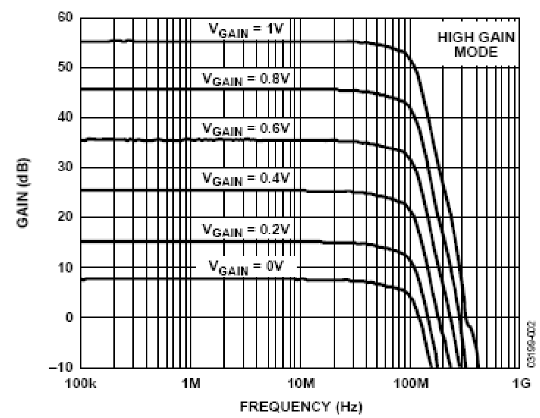


Figure 1. Signal Path Block Diagram



ADC - ABF

ANALOG DEVICES

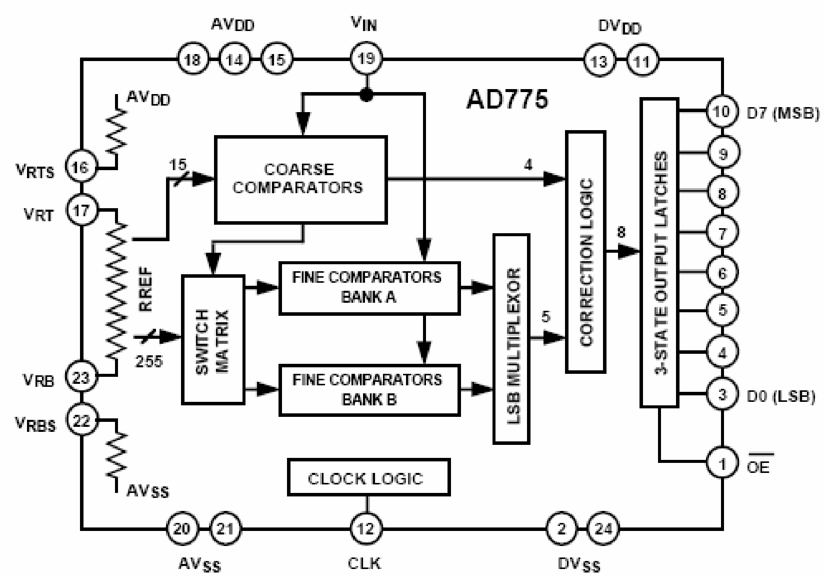
8-Bit 20 MSPS, 60 mW Sampling A/D Converter

AD775

FEATURES

- CMOS 8-Bit 20 MSPS Sampling A/D Converter
- Low Power Dissipation: 60 mW
- +5 V Single Supply Operation
- Differential Nonlinearity: 0.3 LSB
- Differential Gain: 1%
- Differential Phase: 0.5 Degrees
- Three-State Outputs
- On-Chip Reference Bias Resistors
- Adjustable Reference Input
- Video Industry Standard Pinout
- Small Packages:
  - 24-Pin 300 Mil SOIC Surface Mount
  - 24-Pin 400 Mil Plastic DIP

FUNCTIONAL BLOCK DIAGRAM



ADC - DBF

ANALOG DEVICES

Quad, 12-bit, 40/65 MSPS Serial LVDS 1.8 V A/D Converter

AD9228

FEATURES

Four ADCs integrated into 1 package
119 mW ADC power per channel at 65 MSPS
SNR = 70 dB (to Nyquist)
Excellent linearity
- DNL = ±0.3 LSB (typical)
- INL = ±0.4 LSB (typical)

Serial LVDS (ANSI-644, default)
- Low power reduced signal option, IEEE 1596.3 similar

Data and frame clock outputs
315 MHz full power analog bandwidth
2 V p-p input voltage range
1.8 V supply operation
Serial port control
- Full-chip and individual-channel power-down modes
- Flexible bit orientation
- Built-in and custom digital test pattern generation
- Programmable clock and data alignment
- Programmable output resolution
- Standby mode

FUNCTIONAL BLOCK DIAGRAM

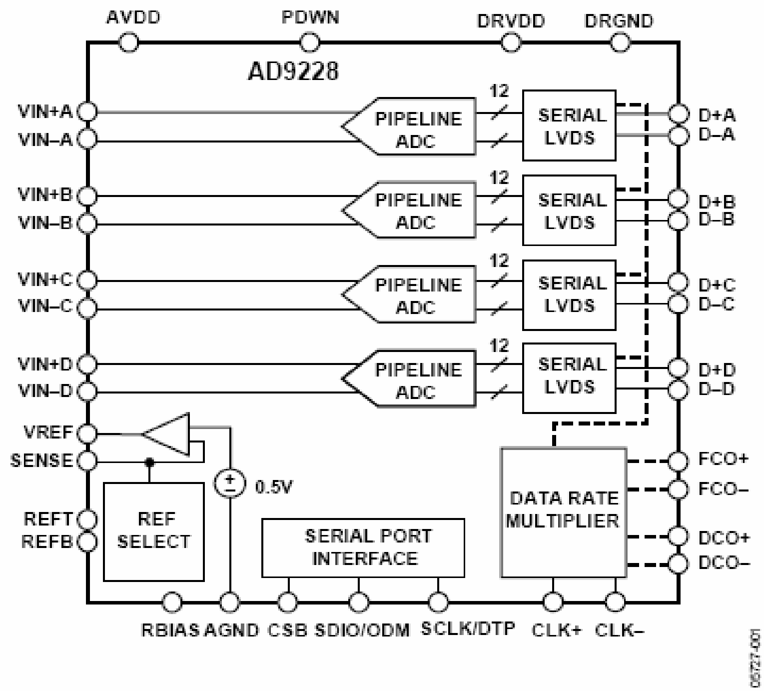


Figure 1.

TIMING DIAGRAMS

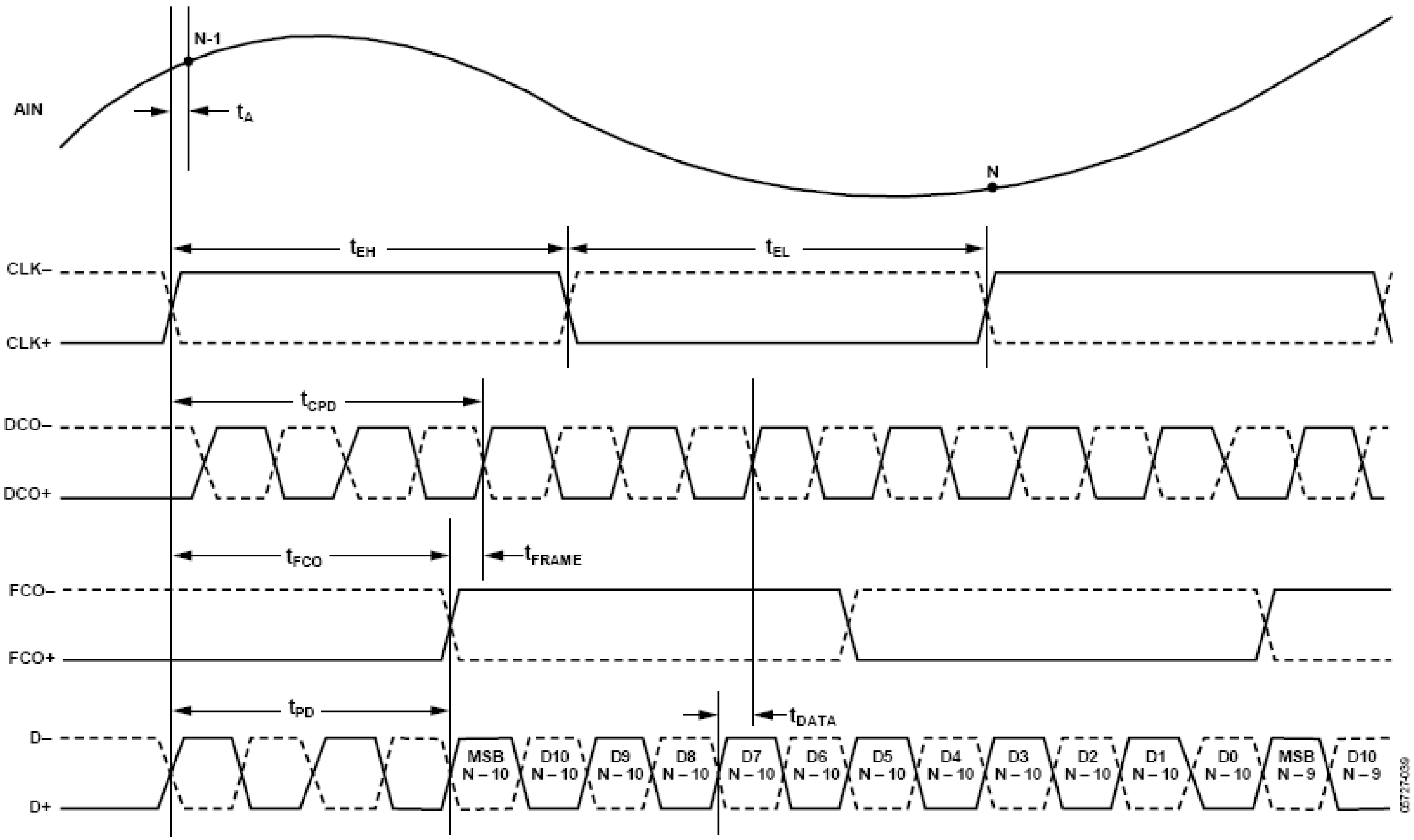


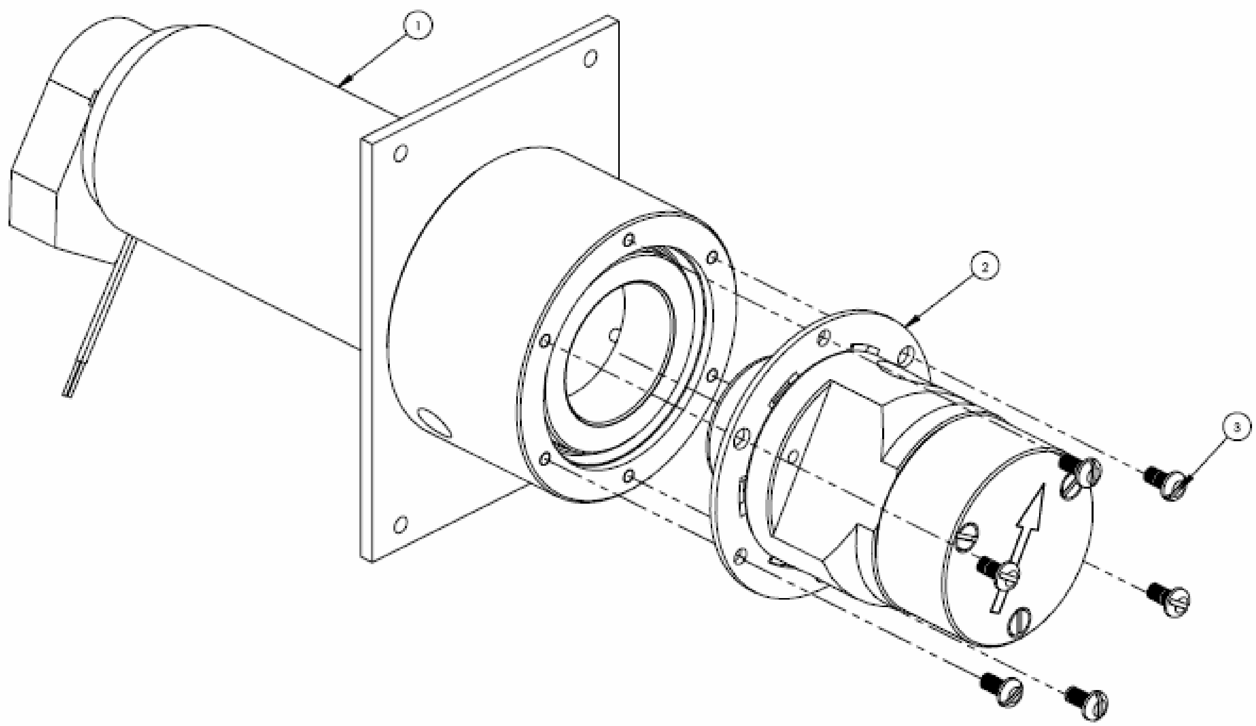
Figure 2. 12-Bit Data Serial Stream (Default)

Hemodialysis System Practical Components

Components

- Heater control
- Proportioning pump
- Flow pumps
- Temperature measurement
- Conductivity measurement
- Ultrafiltration measurement
- Blood pump
- Safety sensors (AB, BL)
- Venous Clamp

ITEM NO.	PART NO.	QTY.	DESCRIPTION
1	MA0043	1	MOTOR ASSEMBLY
2	PU0018	1	GEAR PUMP ASSEMBLY
3	SC0001	6	SCREW, M3 x 6mm



REV.	DATE	DRAWN BY	ECN#	CHECKED BY
3	09-07-03	TF	ECN00179	DR
2	18-03-99	DR		
1	25-09-98	DR		
0	22-05-98	DR		

TOLERANCES
UNLESS OTHERWISE SPECIFIED
DIMENSION IN MILLIMETERS
X = ±1.0
X.X = ± 0.5
X.XX = ± 0.1
ANGLES = ± 2°

PROJECTION

SCALE 1:1

DWG SIZE: A4

GENERAL NOTES:
(UNLESS OTHERWISE SPECIFIED)

MATERIAL
AS NOTED ABOVE

SURFACE TREATMENT
(DIMENSIONS APPLY AFTER SURFACE TREATMENT)
NONE

Diener Precision Pumps

THIS DRAWING CONTAINS INFORMATION PROPRIETARY TO DIENER PRECISION PUMPS

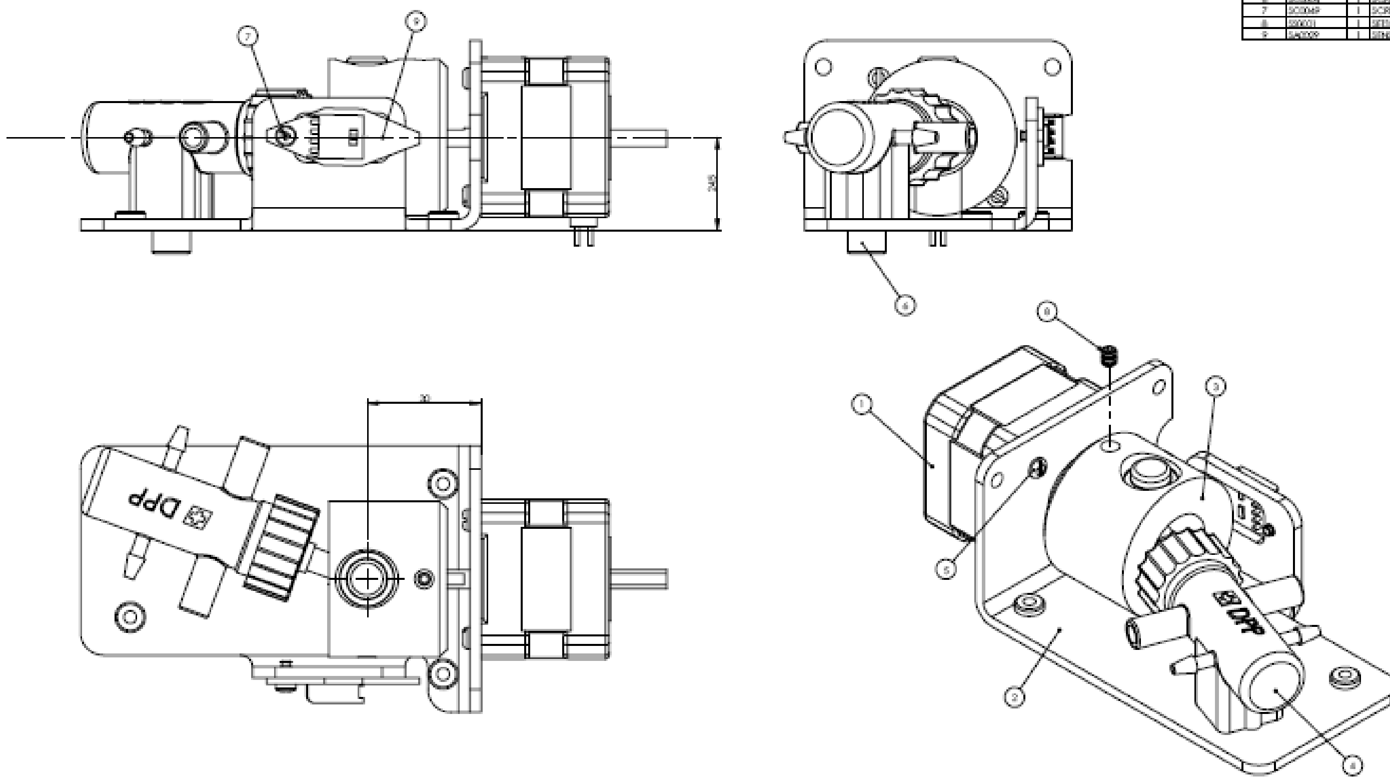
DESCRIPTION
PUMP/MOTOR ASSEMBLY

PART NUMBER
PM0059

SHEET 2 OF 2

REVISION
3

ITEM NO.	PART NO.	QTY.	DESCRIPTION
1	MO0020	1	MOTOR
2	BA0019	1	BRACKET ASSEMBLY
3	EA0012	1	ELBOW ASSEMBLY
4	PP0003	1	PISTON PUMP
5	SC0001	2	SCREW, M3 x 6mm
6	SC0004	1	SCREW, M4 x 12mm
7	SC0049	1	SCREW, 8mm P-T
8	SS0001	1	SETSCREW
9	SA0029	1	SENSOR ASSEMBLY



REV.	DATE	DRAWN BY	ECN#	CHECKED BY
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3	[illegible]	[illegible]	[illegible]	
2	[illegible]	[illegible]		
1	[illegible]	[illegible]		
0	[illegible]	[illegible]		

TOLERANCES
UNLESS OTHERWISE SPECIFIED
DIMENSION IN MILLIMETERS
X = ±1.0
X.X = ±0.5
X.XX = ±0.1
ANGLES = ±2°

PROJECTION

SCALE 1:1 | DWG SIZE: A3

GENERAL NOTES:
(UNLESS OTHERWISE SPECIFIED)

MATERIAL
AS NOTED ABOVE

SURFACE TREATMENT
(DIMENSIONS APPLY AFTER SURFACE TREATMENT)
NONE

Diener Precision Pumps

THIS DRAWING CONTAINS INFORMATION PROPRIETARY TO DIENER PRECISION PUMPS

DESCRIPTION
PUMP/MOTOR ASSEMBLY

PART NUMBER
PM0040

SHEET 1 OF 1

REVISION
4

Performance

Nominal Gear Width	9mm
Repeatability (at fixed inlet/outlet pressure)	±3% above 1000 rpm
Minimum Inlet Pressure	-670mmHG
Maximum Oulet Pressure	5 bar
Maximum Differential Pressure	5.8 bar
Speed Range	300 to 3000 rpm
Internal relief valve (bypass)	Yes (adjustable by customer)
Relative Humidity Range (operating)	10 - 80%
Fluid Temperature Range*	+5°C to +100°C
Ambient Operating Temperature Range	+5°C to +50°C
Maximum "dry running" time**	2 minutes
Noise specification	None

Electrical

Motor Type	24 volt brushless-dc
Nominal Power	35 watts
Input Power	24VDC+/- 0.5 VDC
Speed Control	0 to 5 vdc input
Tachometer	2 pulses/revolution
Maximum current input	2 amps
Electrical Connector	none
Cable	4 X #22AWG, sheilded & grounded internally

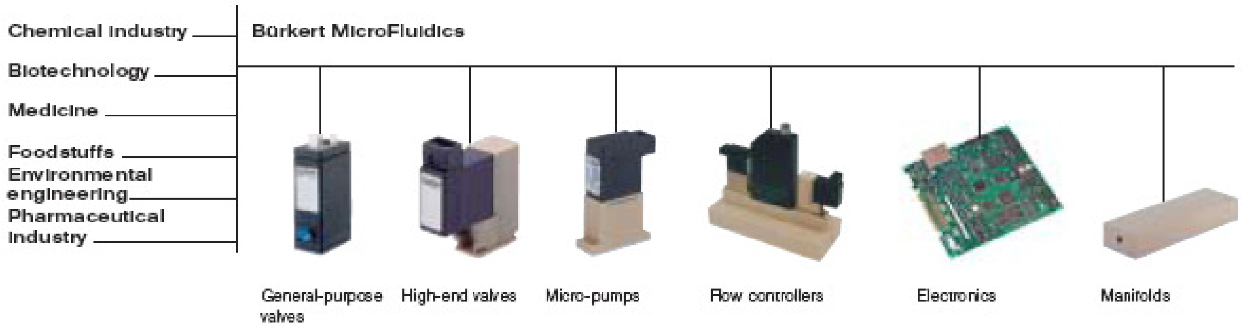
Physical

Inlet/Outlet port size	1/8"-27 N.P.T.
Power Transmission	Magnetically coupled
Dimensions	See dimensional layout drawing
Storage Temperature Range	5°C to +120°C
Relative Humidity Range	5-100%
Weight (dry)	1.5 kg

Wetted Materials of Contstruction

Stainless Steel	DIN 1.4436 (AISI 316L)
Static O-rings	Silicone
Gears/Bearings	PEEK[1]

Valves



	Connectors									Body material											Sealing material				
	Flange	G thread	NPT thread	UNF 1/4-28 thread	M5 thread	Tube spigot	Cable plug	Rectangular plug	Leads	SS	Brass	PPS	PA	PVC	PP	PTFE	ETFE	PEEK	PCTFE	PVDF	FFKM	FPM	EPDM	PFTE	NBR
Type 0124		•	•				•								•					•	•	•	•		•
Type 0127	•	•	•	•		•	•		•								•	•	•	•	•	•			
Type 6604	•			•		•		•	•									•			•				
Type 6606	•	•	•	•		•	•	•	•								•	•	•	•	•				
Type 6608	•	•	•					•	•									•			•				
Type 0330		•	•				•			•	•											•	•		•
Type 0331	•	•					•			•	•											•	•		•
Type 6124	•			•		•		•	•									•				•	•		
Type 6126	•				•	•	•	•	•			•										•	•		
Type 6128	•	•	•				•	•	•			•										•	•		
Type 6104	•							•	•				•									•			
Type 6106	•						•	•	•				•									•			
Type 0121		•	•				•		•	•				•	•	•				•	•	•	•		
Type 0330 A		•	•				•			•												•			
Type 6011 A	•	•					•			•	•											•			
Type 6013 A	•	•					•			•	•											•			
Type 2822	•	•	•				•		•	•	•											•	•		
Type 6021		•	•				•			•	•											•	•		
Type 6022		•	•				•			•	•											•	•		
Type 6023		•	•				•			•	•											•			

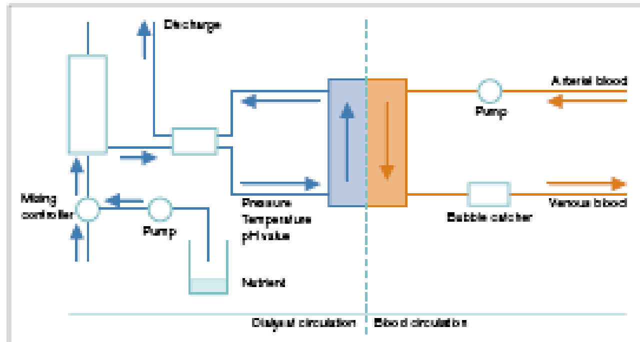
4. Technology for infusion, hemodialysis and anesthesia

MicroFluidics in medicine

4.1. Kidney dialysis machines

In the generic sense, dialysis is a process for separating low-molecular-weight substances from a fluid by diffusion of these substances through a semipermeable membrane. Use of dialysis in medicine is more than familiar as the principle of the "artificial kidney" for hemodialysis. Similarly, however, dialysis is also used in biotechnology as a "membrane bioreactor" for conducting fermentation processes under specific boundary conditions.

Dialysis in medicine largely replaces the function of the kidney by filtering out water, metabolic end products (e.g. urea) and other toxins from the blood. Blood purification is performed in the dialyser by means of a semipermeable membrane which separates the circuit of the blood to be purified from that of the purification fluid (dialysate). The toxic substances and water from the blood pass through the membrane into the dialysate and are thus removed. The dialysate (deionised water) is enriched with nutrients and its nutrient content, temperature and other parameters are constantly monitored.



Dialysis process

MicroFluidics, including an automatic control and monitoring system, forms the technical basis of a kidney dialysis machine, whose functions are transport, dosing, mixing, distribution and measurement.

Specific MicroFluidic tasks and requirements
Circulating the blood
Transporting the purification fluid
Dosing the nutrient solution

4.2. Adsorbers

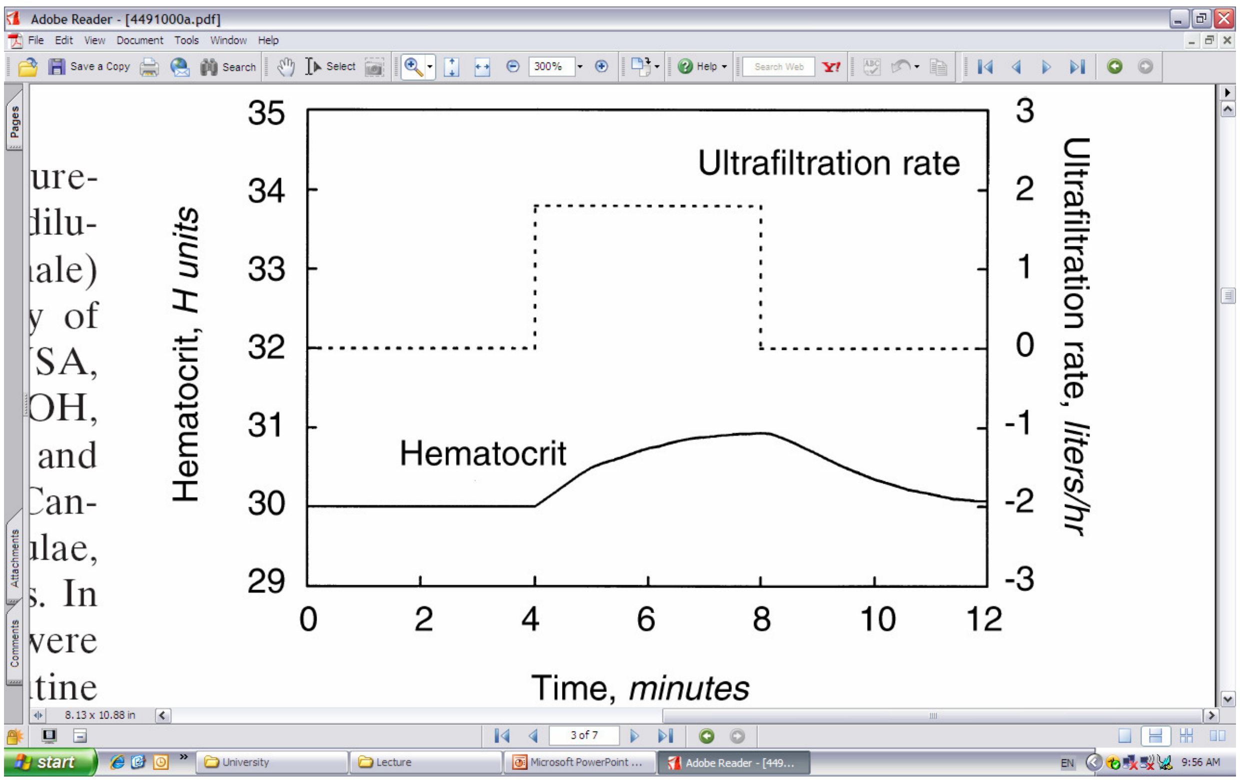
In the case of the adsorber process, pathogenic substances, e.g. cholesterol, are removed from the blood outside of the body. The blood flows out of the patient's vein into the adsorber in which suitable materials selectively remove the substances from the blood. A special machine ensures that the blood circulates through the adsorber.

4.3. Cell separators

The cell separator is a device for obtaining blood components. Fields of application include removal of diseased cells or blood plasma from a patient's blood or collecting cells from a patient's own blood for subsequent back-transfusion.

Ultrafiltration Measurement

- Flowmeter-Based (Dialysate side)
- Hematocrit-Based (Blood side)



Crit-Line TQAIII

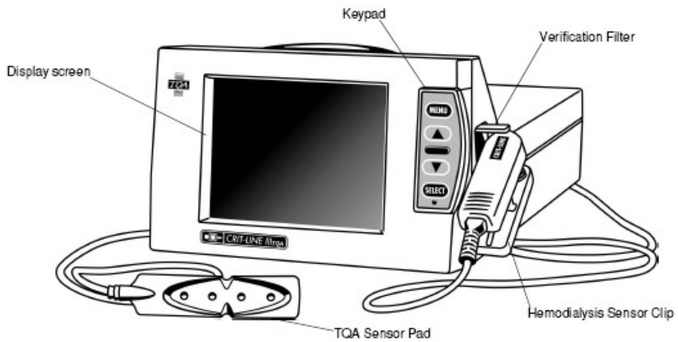


Fig. 1 The CLM III TQA monitor

7.2 Standard Specifications

Instrument Range
Hematocrit (Hct): 5 Hct - 60 Hct
Oxygen Saturation: 55% - 100%

Operating and Storage Temperature
50 F° to 104 F°
(10 C° to 40 C°)
Avoid extreme temperatures during transportation (<32 F°, >110 F°)

Hematocrit Accuracy (±1 SD)
10 Hct - 60 Hct:± 1 Hct

Oxygen Saturation Accuracy
55% - 100%: ±2 Sat % (Hct ≥ 18)
10% - 45%: Unspecified

Access Blood Flow
Estimates flow rates
50 ml/min – 2500 ml/min ±15%

Recirculation Capability
Estimates recirculation values >4%

Percent Blood Volume Change Accuracy
Approximately ±3BV% (based on Hct)

Battery Capacity
2 Hours continuous on full charge

Full Charge Time
36 Hours

Physical Dimensions
5.25" H, 8.25" W, 11.63" L 5 lbs.

HD Blood Flow Rate Capability
50 ml/min - 1300 ml/min

Internal Data Storage
Sufficient to store 26 hours of data

Input
12VDC/1 Ampere/12W
1.2A max

Power Supply Unit
Universal regulated supply
100 VAC - 240 VAC
12 VDC/1.25 Ampere output

Communications Ports
8 Position Keyed Modular Jack (RJ-45)
Serial Port
DB-25 female Parallel Port

> ***NOTE:** Equipment connected to this monitor should comply with IEC 950 and be kept out of patient reach.*

Electrical Shock Protection
Class II
Internally Powered
Type BF

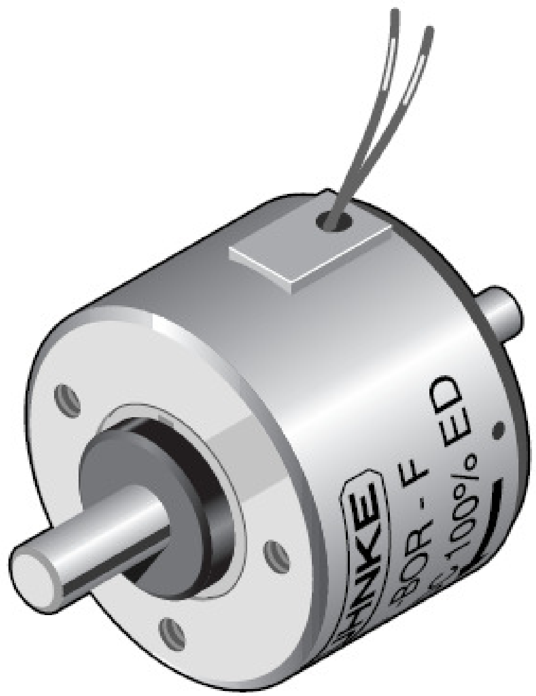
Water Protection
Splashproof

Anesthetic Suitability
Not Suitable

Mode of Operation
Continuous

Battery
Type: Rechargeable Sealed Lead Battery
(12V, 2A-h) Battery is replaceable
Polarity: +/- (labeled on battery)
Mode of Insertion: Via 2 pin molex connector (replaceable)

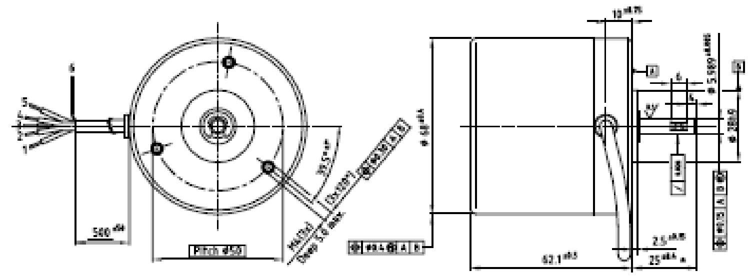
Venous Clamp



Motors

BL58 EB Brushless DC motor 35 Watt

Dimensional drawing



Motor data

Motor order number	Shaft length 25 mm	4322 016 58001
	Shaft length 20 mm	4322 016 58002 *

Nominal Voltage	[V]	24
No load Speed (V in = 4V)	[rpm]	3650
No load Current (V in = 4V)	[mA]	280
Nominal Current limitation (V in = 4V)	[A]	2.0
Maximum torque	[mNm]	110
Maximum output power	[W]	35
Operating temperature range	[°C]	0 to 90
Thermal resistance from housing to ambient	[K/W]	3.7
Rotor inertia	[kgm²]	120x10⁻⁷
Mass of motor	[g]	550

Maximum radial load 20 mm from mounting front (no axial load towards flange)	[N]	40
Maximum axial load – towards flange (no radial load) – from flange	 [N] [N]	 18 10

Thermal motor protection :
Motor shuts down if the motor flange temperature reaches approx. 93°C
Motor restarts if the flange temperature is cooled down to approx. 80°C

For thermal reasons it is advised to mount the motor on a heat conducting frame if high output power is desired.

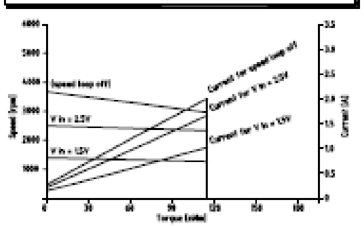
* Shaft 20 mm for combination with gearboxes.

Electrical Connection

Lead no.	Lead colour	Function	Description
1	brown	FW/RV	Direction control input : 'High' CW, 'Low' CCW (shaftside) (do not leave this lead floating)
2	white	V in	Input voltage (setpoint) for speed loop Resulting speed approx. 1000 rpm/V V in > 4 V : motor at full speed, speedloop off (open loop)
3	green	FG	Frequency generator output, 36 ppr ; R out = 4k Ohm (approx)
4	black	GND	Motor return, ground (0 V)
5	red	Vp	Motor supply voltage +24 V (min. 14 V – max 30 V)
6	bare	shield	Shield for cable and connected to motor housing

		min.	typ.	max.
Lead 1				
input 'high'	[V]	4.1	5	
input 'low'	[V]		0	1.9
abs. max/min. input	[V]			±30
Lead 2				
abs. max./min. input	[V]			±30
Lead 3				
output 'high', not loaded	[V]	4.0	4.5	5.0
output 'low', not loaded	[V]	0	0.1	0.2

Performance curve



Product combinations

- Gearbox S64A
- Gearbox S69A
- Gearbox P58A
- Gearbox P59A

Options

- Square mounting flange
- Shaft diameter, 7 or 8 mm
- Speed loop with frequency input
- Protection class upto IP67DS

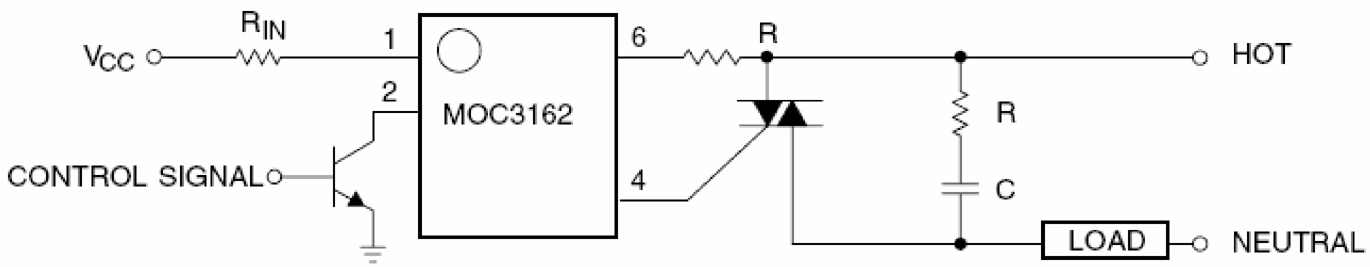
Features

- Adjustable speed loop
- Direction control input (forward / reverse)
- Frequency Generator output (speed sensing)
- Thermal motor protection
- Long life (20.000 hours)
- Low EMI
- Protection class IP54

1999-10-06 / subject to change

PREMOTEC
PRECISION MOTOR TECHNOLOGY BV
Internet : www.premotec.com – E-mail : sales@premotec.com
Precision Motor Technology b.v. – Kerkeplaat 16 – 3313 LC – Dordrecht – The Netherlands – Tel.: +31 78 621 99 40 – Fax.: +31 78 621 48 28

Line Voltage Control



DESIGN RULE: V_{peak}/I_{peak} = 180 /1 amp = 180 ohms
(Assume the line voltage is 115 volts RMS)

Ultrasound Assignment

1. Design an 8-channel ultrasound system based on analog beamforming technology. Estimate the cost of such system and the advantages/disadvantages of this design.
2. Design an 8-channel ultrasound system based on digital beamforming technology. Estimate the cost of such system and the advantages/disadvantages of this design.
3. Provide a survey of the product lines of 5 commercial ultrasound imaging system manufacturers. Sort their products into categories (low-end, mid-range and high-end systems).

Hemodialysis Assignment

- Design a basic hemodialysis system that utilizes an ultrafiltration estimation method based on hematocrit value measurement.
- Provide a short survey of practical ultrafiltration rate estimation methods currently in use by hemodialysis companies.
- Provide a survey of the product lines of 5 commercial hemodialysis system manufacturers. Sort their products into categories (low-end, mid-range and high-end systems).