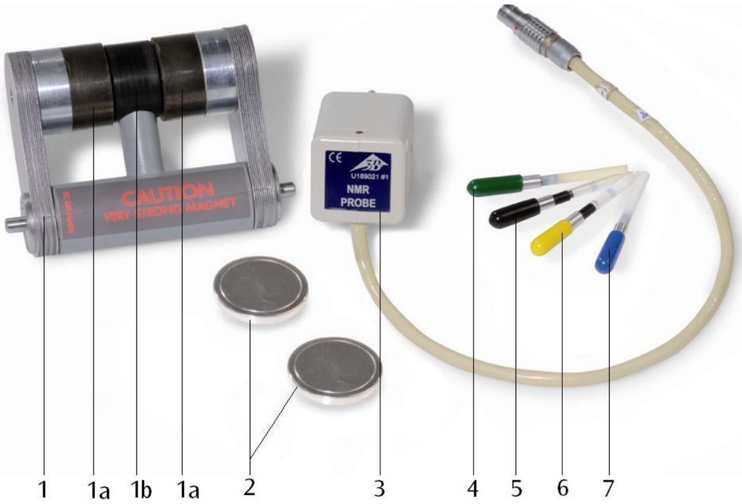
3B SCIENTIFIC® PHYSICS

...going one step further

NMR Supplementary Set 1000642

Instruction manual

10/15 ALF



1 Magnet unit
1a Magnet
1b Yoke
2 Discs for assembly
3 NMR probe
4 Polystyrene sample
5 Comparison sample
6 Glycerine sample
7 Teflon sample

1. Safety instructions

The permanent magnets can generate considerable forces of attraction and repulsion with the result that there is a risk of squashing or splintering.

- Be especially cautious when inserting magnets into the basic unit.
- Never use the magnets except as specified.

Magnetic fields can erase data from magnetic media and affect or destroy electronic or mechanical components like heart pacemakers.

- People with pacemakers should not conduct this experiment.

2. Description

The NMR supplement set is to be used with the ESR/NMR basic set (1000637 resp. 1000638) for investigating nuclear spin resonance in glycerine, polystyrene and Teflon.

The set consists of an NMR probe with a high-frequency coil, a strong and uniform permanent magnet, a glycerine sample, a polystyrene sample, a Teflon sample, an empty comparison sample and two discs for assembling the apparatus.

3. Technical data

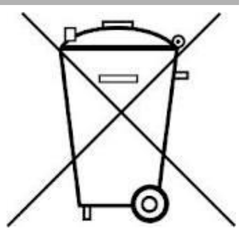
Magnetic flux of permanent magnets:	300 mT approx.
Frequency range:	11 – 15 MHz approx.

4. Maintenance and storage

- Remove any debris from the surfaces of the permanent magnet poles and of the assembly discs using a cloth with some isopropanol.
- Keep permanent magnets in a dry place.

5. Disposal

- The packaging should be disposed of at local recycling points.
- If the equipment itself needs to be scrapped, it is safe to dispose of all components other than the probe in domestic waste.



The probe should be disposed of in containers dedicated to the disposal of electrical refuse.

6. Equipment required in addition

1 ESR/NMR basic set (230 V, 50/60 Hz)	1000638
or	
1 ESR/NMR basic set (115 V, 50/60 Hz)	1000637
1 Analogue oscilloscope, 2x30 MHz	1002727
2 High-frequency cables	1002746
alternatively	
1 3B NET*log*™ unit (230 V, 50/60 Hz)	1000540
or	
1 3B NET*log*™ unit (115, 50/60 Hz)	1000539
1 3B NET*lab*™	1000544
2 High-frequency cables, BNC/4-mm plug	1002748
1 PC	

7. Operation

7.1 Assembly of the basic unit

The discs, the pole surfaces of the magnets and the probe chamber in the basic unit must all be free of grease, dust and debris.

- If necessary they should be cleaned using isopropanol.
- Insert the discs into both sides of the sample chamber (see Fig. 1).

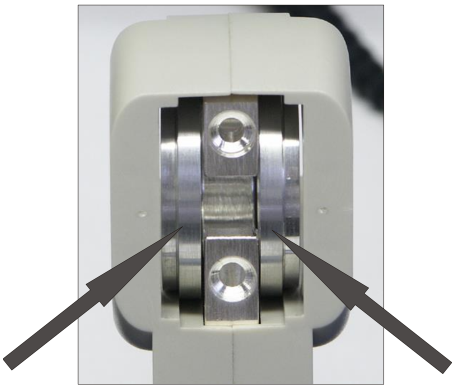


Fig. 1 Sample chamber with assembly discs inserted

- Twist the metal rod into the yoke of the magnet unit. Place the magnet unit in the clip on the basic unit as shown in Fig. 2.
- Take the magnet unit in both hands and push the yoke downwards with your thumbs (see Fig. 3).
- Push the coils over the magnets, making sure the direction if the windings is the same. The embossed arrows on the coils must point in the same direction.
- Clean any grit or metal shavings off the two magnets with a cloth.
- Move the completed magnetic unit onto the assembly discs, making sure to carry out the steps that follow: (see Fig. 4).
- Separate the two coils with your hands, pulling them outwards to increase the gap between them. You can rest your hands on the knurled screws while doing this. Push the magnets about a quarter of the way onto the assembly discs (see Fig. 4).
- Push back the two discs with your thumbs and pull on the coils to move the magnet supports into their end positions (see Fig. 5).
- Tighten both knurled screws by hand at the same time. Make sure that the magnets are accurately aligned on top of the assembly discs. If necessary, slot the discs all the way back into the probe chamber and then push the magnet supports into their end positions.

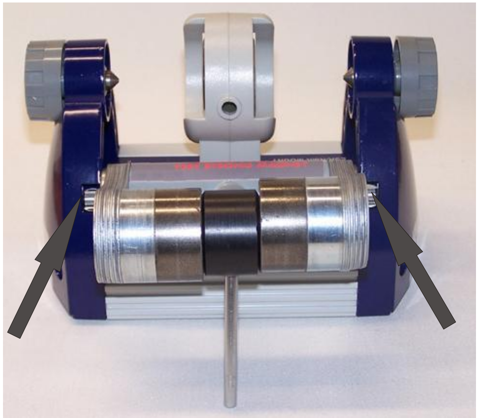


Fig. 2 Permanent magnet inserted into basic unit

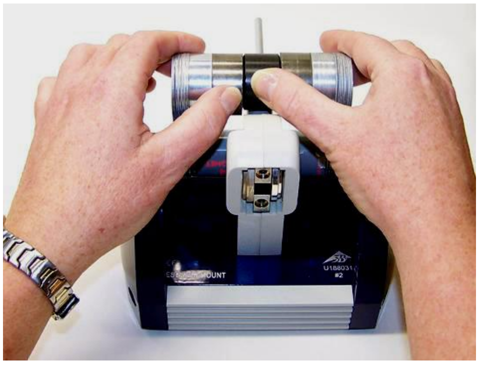


Fig. 3 Removing the yoke from the permanent magnet

Fig. 4 Pulling the two permanent magnets apart

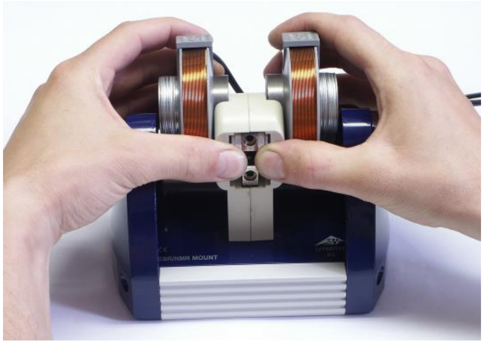


Fig. 5 Pulling the magnets onto the assembly discs

Fig. 6 Basic unit completed with permanent magnets and coils

7.1.1 Removing magnet unit

- Take the sample out of the sample chamber in the basic unit.
- Disconnect the cables between the coils and the control console.
- Loosen the knurled screws.
- Turn the basic unit so that the magnet unit is pointing forwards.
- Lift up the yoke till it is on top of the sample.
- Hold the yoke in place with your thumbs and use your fingers to pull the magnet unit towards the front till the yoke is between the two magnets. Then take the entire unit out of the basic unit (see Fig. 7).
- Take the discs out of the sample chamber.

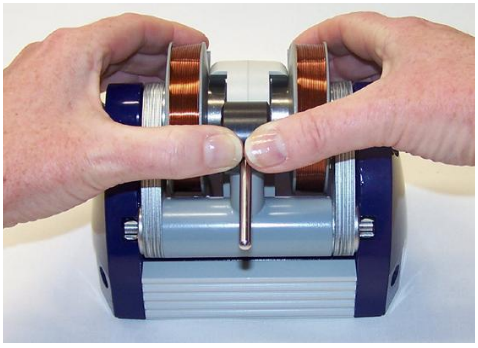


Fig. 7 Removing the magnet unit from the basic unit

7.2 Connection to control console

- Insert the probe into the sample chamber in such a way that it rests on the housing (see Fig. 8).
- Connect the cable for the probe to the “Probe In” socket of the control console, taking note of the socket's slot.
- Connect the coils to the “Coil” sockets on the back of the control console.
- Connect the control console to its power supply via the “12 VAC/1A“ socket.

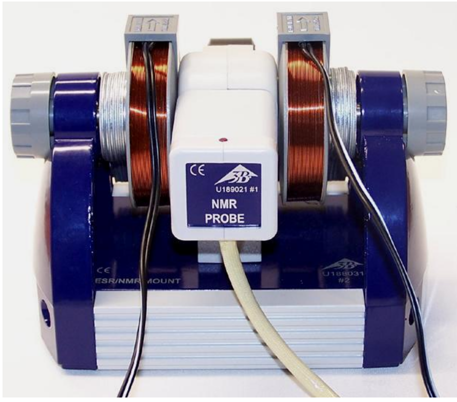


Fig. 8 Basic unit with probe

7.3 Calibration and settings

7.3.1 Using an oscilloscope

- Connect the “SIGNAL OUT” socket of the control console to channel 1 of the oscilloscope and the “FIELD OUT” output to channel 2 (see Fig. 12).
- Set the oscilloscope as follows:

  Channel 1: 0.5 V DC

  Channel 2: 0.5 V DC

  Time base: 5 ms

  Trigger from a falling edge on channel 1.

7.3.2 Using 3B NET*log*™

- Connect the “SIGNAL OUT” socket of the control console to input U_B^{IN} on the 3B NET*log*™ unit and “FIELD OUT” to the input U_A^{IN}.
- Connect the 3B NET*log*™ unit to a computer and run the 3BNET*lab*™ software
- Create a new data record from the “Measurement lab” menu and define the following parameters:

  Input A: Field, Input mode VDC, Input range 2 V

  Input B: Signal, Input mode VDC, Input range 2 V

  Measurement interval: 500 µs (2 kHz)
- Set to trigger from Input A with a falling edge and a positive trigger point at about 10 to 20%.
- Activate the “Oscilloscope” button and start measuring.

The oscilloscope window will open.

7.4 Experiment procedure

- Insert the glycerine sample (yellow top) into the sample chamber (see Fig. 9).

Fig. 9 Basic unit with glycerine sample inserted

- Set a frequency of about 13 MHz on the control console (since the frequency knob is a 10-turn potentiometer, it may need to be turned by multiple revolutions).
- Set the sensitivity to medium and adjust if necessary.

At the optimum setting, the LED can be seen to flicker slightly. If the LED lights up fully, the signal is overloaded.

- Carefully adjust the fine setting using the frequency selector knob seeking out a peak in the signal between about 1 ms to 1.5 ms in width.

Note:
When looking for the peak, it can be helpful to loosen the knurled screws a bit to change the strength of the magnetic field and thus the signal. In order to optimise the signal refer to section 7.5.

- Vary the frequency to bring it to the middle of the peak and write down what that frequency is.
- Carry out the experiment again with different material samples.

For the polystyrene sample (green top) the frequency will be in the same range as for the glycerine sample. For the Teflon sample (blue top) the frequency will be lower (see Figs. 13 to 15).

Another experiment can be carried out in which the stalk of a plant can be inserted into the sample chamber for its resonant frequency to be determined.

7.5 Optimisation of signal

If the signal is fuzzy (width of signal > 2ms), there are several ways it can be improved. The basic requirement for this is that some kind of signal, no matter how poor its quality, needs to be obtained for the glycerine sample. The objective is to obtain a signal with a median width of 1 ms.

7.5.1 Use the two knurled screws to vary the pressure on the assembly discs and observe the signal as you do so. It may be necessary to tighten the two screws to differing degrees.

7.5.2 Pull the probe out some of the way (up to 5 mm) and observe the signal.

7.5.3 Slightly loosen the two knurled screws and move the magnets about 1 to 2 mm away from their end positions. To do this, use your thumbs to push back the two coils while resting your fingers on the base unit (Fig. 10). Tighten the knurled screws while observing the peak.

Fig. 10 Moving the magnets

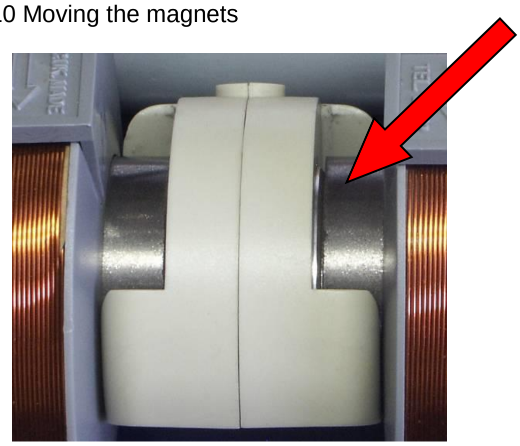


Fig. 11 Magnet moved out of its end position

7.5.4 Slightly loosen the two knurled screws and move the magnets about 1 to 2 mm away from their end positions, then move them back to the ends. In doing so, move the two discs a little further forward. Tighten the knurled screws while observing the peak.

7.6 Evaluation

Resonant frequencies of material samples

Glycerine (^{1}H)	42.58 MHz/T
Polystyrene (^{1}H)	42.58 MHz/T
Teflon (^{19}F)	40.06 MHz/T
Plant stalk (^{1}H)	42.58 MHz/T

Therefore, in a constant magnetic field:

$$\nu_{Glycerine} = \nu_{Polystyrene}\ , \quad \frac{\nu_{Teflon}}{\nu_{Glycerine}} = 0.941$$

cf. Figs. 13, 14, 15 where

ν (Glycerine) = 12.854 MHz

ν (Polystyrene) = 12.854 MHz

ν (Teflon) = 12.100 MHz

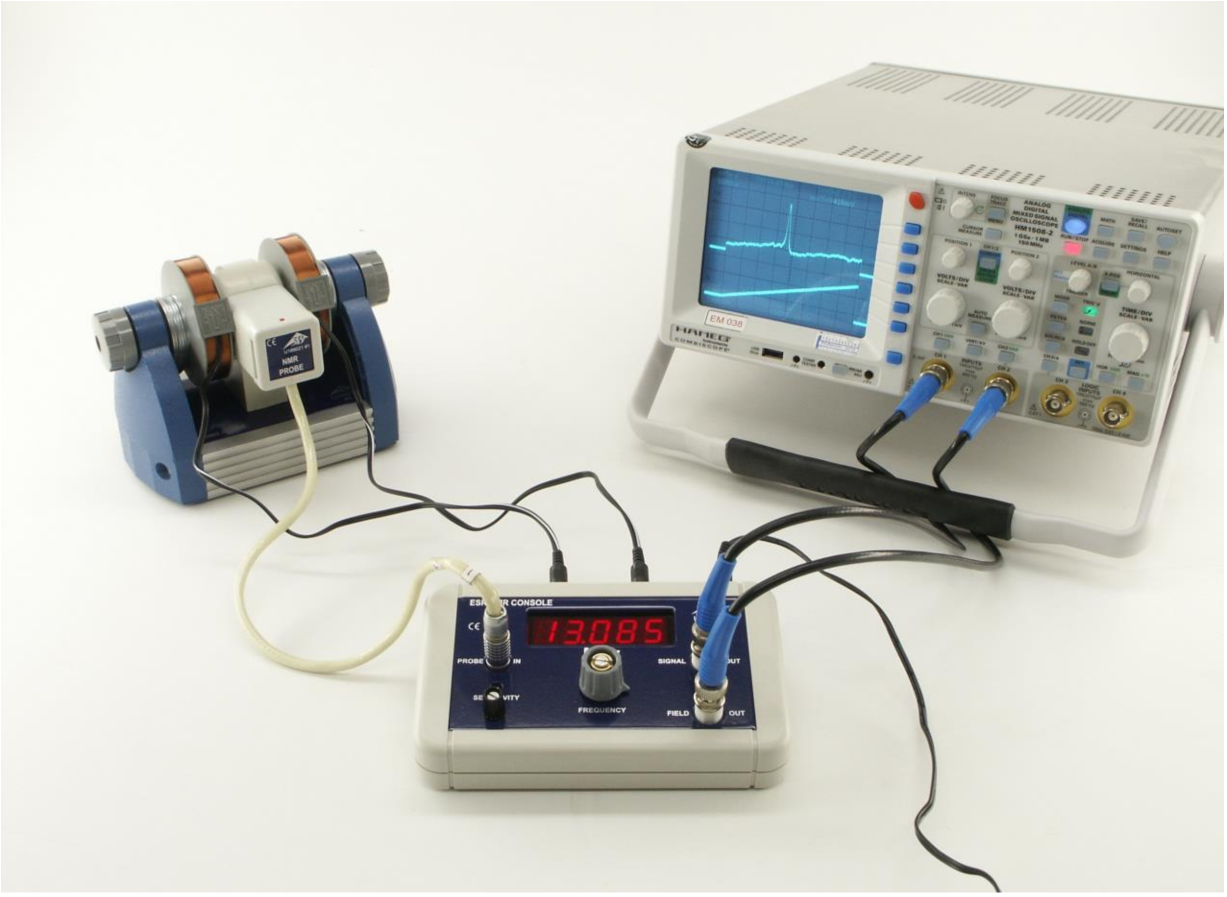


Fig. 12 Experiment set-up featuring NMR unit with an oscilloscope

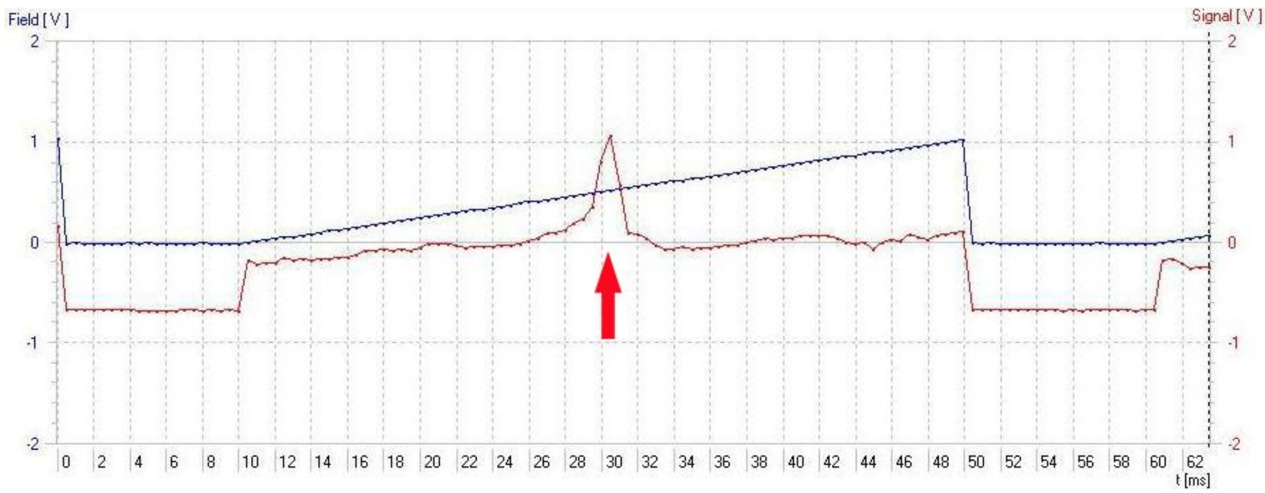


Fig. 13 Screenshot from 3BNET*lab*™ (Glycerine ν = 12.854 MHz)

Fig. 14 Screenshot from 3BNET*lab*™ (Polystyrene ν = 12,854 MHz)

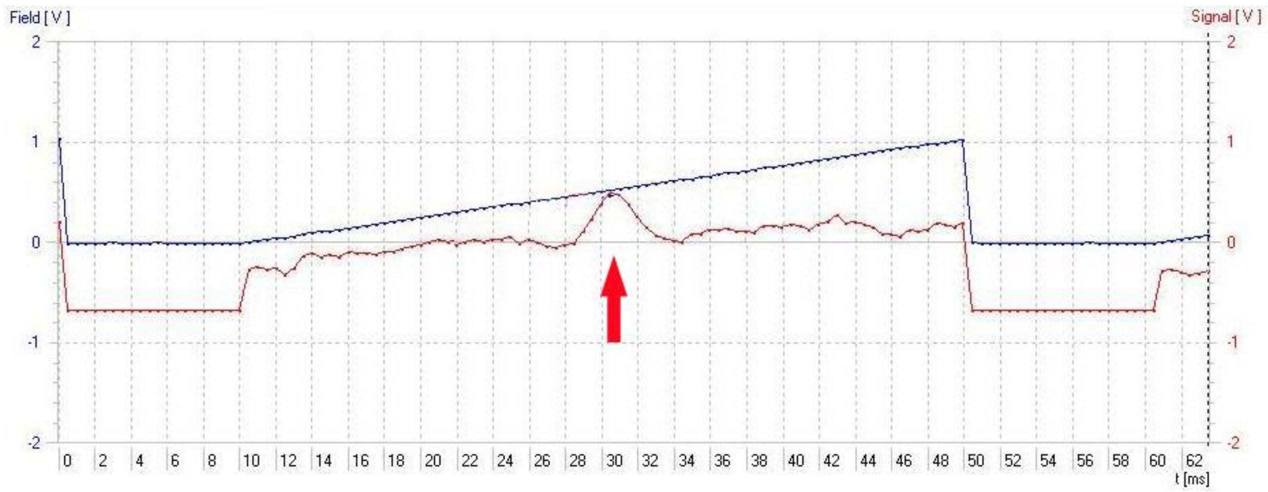


Fig. 15 Screenshot from 3BNET*lab*™ (Teflon ν = 12,100 MHz)