Detailed Description of the EF-NMR Field Coils Controller

The smaller of the two Controller units is devoted to the Field/Gradient Coil system. Its operation is markedly simpler than the complicated timing/sequencing involved in the main Controller unit. Note that this Field Coils Controller has separate modules for the Gradient Coils and the Helmholtz Coils.

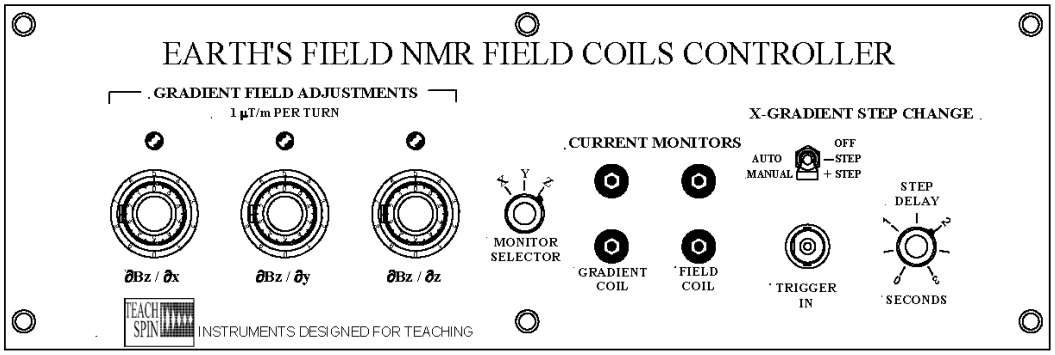
There are three ten-turn knobs which are used to hand-adjust the constant currents that are sent to the Gradient Coils; their main function is to create steady field gradients which cancel out pre-existing gradients in the ambient magnetic field at your location.

There are two Monitor points, where tip-jacks can be used to measure a *voltage* drop proportional to one of the three gradient-coil currents. A selector switch controls which of the three gradient-coil currents will be monitored. Another pair of tip-jacks permit the measurement of a *voltage* drop proportional to the Helmholtz-coil current. The Helmholtz coils, in turn, allow the addition of a spatially-uniform user-chosen increment of magnetic field to the local field. **Note that while this Controller *does* include the power supplies which run the gradient coils, it does *not* include the power supply which runs the Helmholtz coils.**

Finally, there is one module in the Field Coils Controller labeled Step Gradient. You should put its toggle switch in the uppermost, **OFF**, position for all your initial experiments. This sub-system is used only in forming a certain kind of 'spin echo' (described in Chapter 9), which it achieves by creating some step-changes-in-time in the current sent to the $\partial B_z/\partial x$ gradient coil. Those step changes are described below, and form time-dependent additions to the steady, or d.c., current sent to this gradient coil by the leftmost of the 10-turn knobs.

Controls and Connectors

Front Panel



GRADIENT ADJUSTMENTS

Three 10-turn knobs permit the user to set the current sent through the three gradient coils built into the Field/Gradient Coil assembly. Each knob can change the current over the range -20 mA to +20 mA, so each delivers current with a 4 mA/turn sensitivity. The gradient coils have been

designed so that each turn of the dial, ie. each change by 4 mA in current, creates a change of very nearly 1 μT/m in the relevant gradient. Note that for these controls to leave the ambient gradients as they are, they need to be dialed to **mid-scale**, and set to the 5.00-turn position.

GRADIENT-ADJUSTMENT LEDs

Above each of the three 10-turn dials is a red LED. Though all three ±20-mA gradient-coil current supplies are active whenever this Controller is turned on, only one of the three LEDs will be lit. Which one is lit is set by the Selector Switch in the Current Monitor module. This lit-up LED serves as another indication of which (of the three) gradient-coil currents you might be monitoring with a multimeter.

CURRENT MONITORS

For user convenience, we have installed series resistors into the three gradient-coil systems and into the Helmholtz-coil system, so as to make available front-panel connections to a potential difference which is a surrogate for the current in each of coil systems. Attach a **voltmeter** (*not* an ammeter) to the tip-jacks to read these voltages.

MONITOR SELECTOR

Each of the three gradient-coil systems has a series 100-Ω 1% resistor permanently in place in its current path. Depending on the setting of this three-position selector switch, *one* of those three voltage drops is brought out to the tip-jacks where it may be monitored. Each turn of the relevant 10-turn control will change the current by 4 mA, the gradient by 1 μT/m, and the monitor voltage by 0.4 Volts. When the monitor voltage reads zero, you can be sure the relevant gradient-coil current is zero.

GRADIENT

This labels the tip-jacks at which the voltage drop across the selected 100-Ω resistor will be connected to a meter. The full range of gradient-coil current adjustment will create a voltage drop in the -2-V to +2-V range at these monitor points.

FIELD

This labels the tip-jack at which the voltage drop across a 0.1-Ω, 1%, 5-W resistor in series with the Helmholtz Coils may be monitored at any time. The Helmholtz coils are designed for use in the ±3-A range, so the monitor voltage expected here will be in the ±0.3-V range. Note that no current will flow, and no voltage drop will arise, unless a separate Helmholtz-Coil power supply is attached at the Controller's back panel.

X-GRADIENT STEP CHANGE

This section of the Controller allows the step-wise change in time of the current in the $\partial B_z/\partial x$ gradient coil. This module is used to make possible the formation of a 'pulsed-gradient spin echo', described in Chapter 9.2 of this manual.

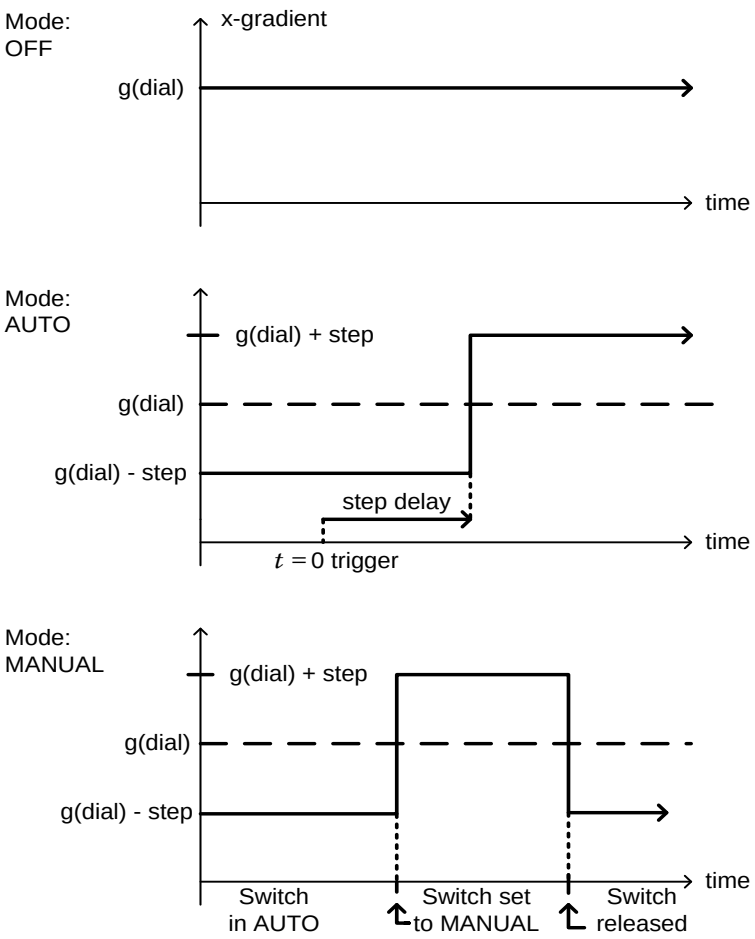


Fig. 2.3: A timing diagram, in each case showing the size of the gradient $\partial B_z/\partial x$ as a function of time, illustrating the three modes of the STEP GRADIENT function.

SELECTOR SWITCH

This is a three-position toggle switch which controls this step-change module of the Controller. Any experiments *not* involving pulsed-gradient spin echoes should be conducted with this switch in the uppermost, OFF, position. In this position, the current in the $\partial B_z/\partial x$ gradient coil is steady in time, and controlled only by the leftmost of the three 10-turn dials.

AUTO

The middle position of this toggle switch puts the current in the $\partial B_z/\partial x$ coil into a different mode, in which its value is fixed by the sum of two terms. The first of these is set by the leftmost 10-turn dial, and the second is an offset of fixed magnitude and negative sign. That's the meaning of the '- STEP' indication next to the switch. (The *size* of that offset is set by a user-adjustable control on the back panel.)

MANUAL

The bottom position of the three-position toggle switch is spring-loaded, and reverts to the AUTO position when released. Deflecting the switch from AUTO to MANUAL will cause a change in the

current in the $\partial B_z/\partial x$ coil from the previous (10-turn dial setting *minus* offset) to a temporary value of (10-turn dial setting *plus* offset). That's the meaning of the '+ STEP' indication next to the switch. The '+ STEP' condition will persist as long as the toggle switch is held in the lowest position.

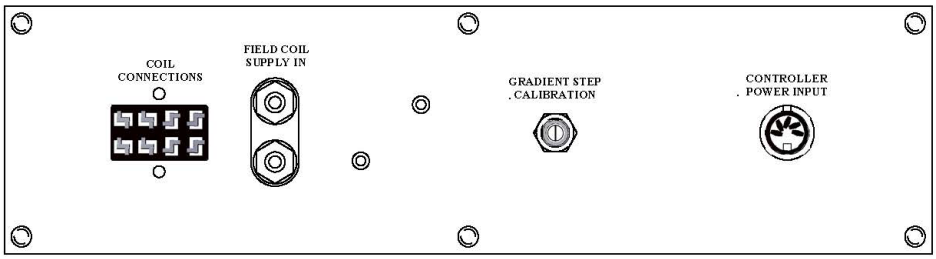
TRIGGER IN

As an alternative to the MANUAL mode, of hand-initiating a gradient step, this input, together with the AUTO setting of the selector switch, permits an externally-initiated reversal of the step-gradient from the '- STEP' to the '+ STEP' condition. The input is designed to accept a negative-level, negative-going pulse, such as the second of the pulse pair which emerges from the TRIGGER OUTput of the (main) EF-NMR Controller. If this triggering pulse is present at the beginning of the free-induction-decay interval, and the selector toggle switch is in the AUTO position, then the gradient will have the value given by (10-turn dial setting *minus* offset) for part of the free-induction-decay interval, and will automatically change to the value given by (10-turn dial setting *plus* offset) after a selected time delay.

STEP DELAY

This one-turn dial control applies only in the AUTO mode of the selector toggle switch. It controls how much time is spent in the (10-turn dial setting *minus* offset) mode, before the current in the $\partial B_z/\partial x$ coil changes to the (10-turn dial setting *plus* offset) mode. That time delay is variable in the range 0-3 seconds.

Back Panel



COIL CONNECTIONS

The eight-wire cable that connects to the Gradient and Helmholtz Coils plugs into this socket.

FIELD COIL SUPPLY IN

These terminals are the place to connect an external power supply to energize the Helmholtz coils. They are designed for a 0-36 Volt, 0-3 Ampere current-controlled d.c. power supply. The coil current passes through the power supply, the Helmholtz Coils, and the 0.1-Ω monitor resistor. The Helmholtz-coil system is 'floating', not connected to ground at any point in the Controller. So the external power supply used for it may be floating, negative-grounded, or positive-grounded.

If the Helmholtz Coils are not being used, then a ground connection to the black terminal of these connections will ground the windings of the Helmholtz coil, to serve as partial electrostatic shielding of the EF-NMR head.

GRADIENT STEP CALIBRATION

This one-turn locked dial controls the size of the 'step' which is applied, in the AUTO or MANUAL gradient step-change mode, alternatively subtracted from and added to, the current in the $\partial B_z/\partial x$ gradient coil. If you wish to change the size of this offset, you will need first to loosen the hex nut on the shaft-lock of the potentiometer involved. You can re-tighten that locking nut once you have made a new setting in the size of the gradient-step current.

CONTROLLER POWER INPUT

The special connector from the wall-transformer power unit plugs into the Controller at this point. As there is no separate on-off switch in the Controller, power will be present when this connection is made, and the wall-transformer unit is active.
Note that the wall transformers for the (main) Controller, and for the Field/Gradient Coil Controller, are identical and compatible, so either may be used to power either Controller.