BIO-RAD

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CHEF Mapper®
Pulsed Field Electrophoresis System

Now you can accurately separate everything from Yeast Artificial Chromosomes (YACs) to M13 inserts with a single instrument. The CHEF Mapper system, based on CHEF (Clamped Homogeneous Electric Fields)[1] pulsed field electrophoresis technology, also offers the flexibility of PACE (Programmable Autonomously Controlled Electrodes)[2] technology. With its versatile PACE architecture, you can completely control electrical field vectors with respect to switch time, voltage, and angle. Consequently, you achieve higher resolution, greater speed of separation, and greater accuracy than could be obtained with previous pulsed field systems. Furthermore, the CHEF Mapper system provides fast results. Built-in protocols optimize pulsed field separations, eliminating months of trial and error.

Pulsed Field Expertise on a Computer Chip

The CHEF Mapper XA system's unique built-in algorithm automatically selects the optimum conditions for your separation. Based on 5 expert man-years of protocols, the algorithm, embedded on an EPROM chip, interrelates 11 key variables: DNA fragment size, buffer type and concentration, agarose type and concentration, buffer temperature, initial and final switch time (ramp), pulse angle, voltage gradient, and run time. See Figure 1. Protocols may be refined by using the extended, PC based, Interactive Program Disc. The PC version allows you to record a hard copy of your protocols, and includes a bar code format for fast data entry into the CHEF Mapper XA system. Alternatively, you may directly load optimized protocols from the PC to the CHEF Mapper XA system through the RS232 port and optional cable.

Auto-Algorithm mode
39.2 hour run time, 120° included angle
47 to 74 seconds switch time ramp
6 V/cm (200 V), 0.5x TBE at 14 °C
1.0% Pulsed Field Certified Agarose

Fig. 1. Auto-algorithm based separation of 400–800 kb size range. Lane 1. *Saccharomyces cerevisiae* chromosomes. **Lane 2.** lambda ladder.

Multi-Angle Switching for Maximum Speed

The CHEF Mapper system lets you choose any pulse angle from 0° to 360°. Electrophoretic separation time can be reduced, without loss of resolution, by electronically changing the pulse angle. *Schizosaccharomyces pombe* chromosomes (3.5–5.7 mb) migrate 50% faster using a 100° included angle than they do using a 120° angle.[3] See Figure 2.

Two-state mode
30 min switch time
2 V/cm (67 V), 14 °C, 1x TAE
48 hour time
0.8% Chromosomal Grade Agarose

Fig. 2. Increased mobility of *S. pombe* chromosomes. A. 100° angle. **B.** 120° angle.

Speed and Resolution for Screening Small DNAs

With the CHEF Mapper system, you can separate small DNA fragments (<50 kb) with outstanding resolution using 180° angle FIGE with asymmetric forward to reverse voltages and switch times as fast as 50 msec. This method has been shown to be superior to all other PFG techniques in this range,[4] and is the method of choice for sizing restriction digests of cosmid and phage vectors, RFLP mapping, and DNA fingerprinting. See Figure 3.

FIGE mode
180° angle
1x TAE, 14 °C
9 V//cm forward
6 V/cm reverse
Switch time 200–800 msec ramp
Forward time = reverse time
Run time = 18 hr
Lane 1: Bio-Rad's l-Hind III standard (6.6, 9.4, 23.1 kb)
Lane 2: Bio-Rad's 8–48 kb size standard (8.3, 8.6, 10.0, 12.2, 15.0, 17.1, 19.4, 22.6, 24.8, 29.9, 33.5, 38.4, 48.5 kb)

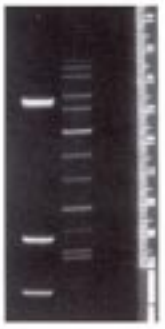

Fig. 3. High resolution of 8–48 kb size standard with asymmetric voltage FIGE.

When speed is more critical than resolution, the CHEF Mapper system allows you to separate small DNA fragments in less than an hour using narrow pulse angles (106°) and high voltage gradients (up to 9 V/cm).

Multi State Switching for Highest Resolution

The multi state mode of the CHEF Mapper system enhances resolution in selected fragment size ranges by allowing you to combine up to 15 different electrical field vectors during a single pulse cycle. Additional vectors have been shown to increase resolution in selected size ranges.[1] Each vector can be assigned its own pulse angle, voltage, and switch time. Up to eight different blocks or regimens may be combined to separate any size of DNA. See Figure 4.

Greater Accuracy in Mapping

Accurate sizing of fragments requires an expanded linear range of separation. Switch time ramps increase the mobility of fragments in a sample as a function of molecular weight by gradually changing the switch time during the course of a run. Non-linear ramps (e.g., concave or convex shapes) have been shown to provide very linear separations from 50 kb–700 kb. Therefore, fragment sizes will be measured more precisely, and the maps you construct will be more accurate. See Figure 5.

A. Two-state mode
24 hour run time, 120° included angle
60 to 120 second switch time ramp
6 V/cm (200 V), 0.5x TBE at 14 °C
1.0% Pulsed Field Certified Agarose

B. Multi state mode
60 hour run time
State (vector)
1. 90 second switch time, -60° angle
2. 45 second switch time, 180° angle
3. 90 second switch time, 60° angle
4. 90 second switch time, -60° angle
5. 90 second switch time, 60° angle
6. 45 second switch time, 180° angle
7. 90 second switch time, -60° angle
8. 90 second switch time, 60° angle

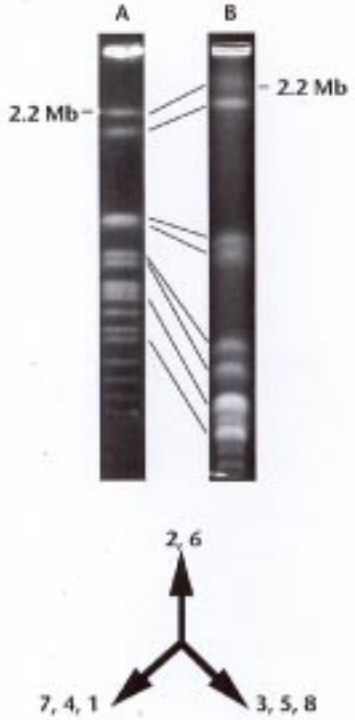

Fig. 4. High resolution separation with multiple states (vectors). *S. cerevisiae* chromosomes separated under: **A.** two-state conditions. **B.** multi state conditions. Notice separation of the co-migrating chromosomes with multi state conditions.

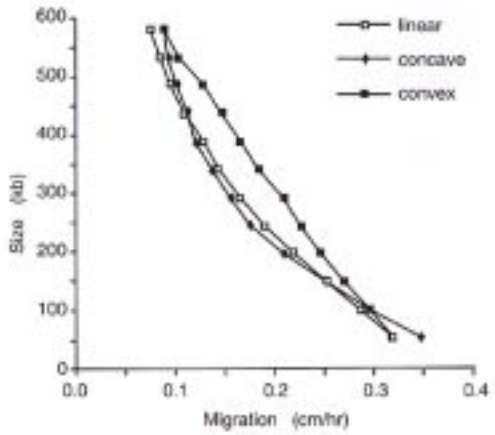

Fig. 5. Mobility effects of non-linear switch time ramps. Molecular size vs migration for linear, concave, and convex ramps. The convex ramp results in the widest linear range.

Secondary Pulses for Increased Separation

The application of additional vectors (secondary pulses[5]) of defined voltage, duration, angle, and frequency to the primary vector can enhance the separation of large DNA molecules. These secondary pulses may act by releasing DNA molecules caught in the gel matrix. See Figure 6.

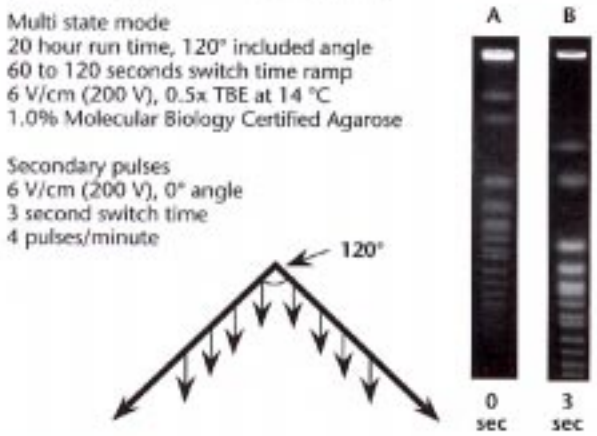

Fig. 6. Increased separation with secondary pulsed field electrophoresis (SPFE). *S. cerevisiae* chromosomes separated under **A.** two-state conditions. **B.** two-state conditions with secondary pulses.

In conventional PFGE systems, variations in temperature and ionic strength due to buffer breakdown can cause fluctuations in voltage, leading to variations in pulse angle which result in loss of reproducibility and resolution. The CHEF Mapper system prevents that problem by using a patented technology called Dynamic Regulation[6] (DR). With DR, the voltage across each electrode pair is monitored and regulated at the proper level. That way, no matter what the buffer conductivity, temperature, or gel size, the electric field remains homogeneous throughout the run. DR strictly maintains the electronically generated pulse angle so you get straight, reproducible lanes and better resolution.

The CHEF Mapper System is Easy to Use

The CHEF Mapper system is easy to operate, even for beginners. Its two-line fluorescent display prompts you for all information to set up a run. Any program generated may be edited on the CHEF Mapper system, and then stored in its long-term memory (up to 20 programs). The instruction manual also includes parameters for numerous common separations, bar code formatted for immediate entry.

Protection from Power Outages

The CHEF Mapper system has its own built-in power supply, switcher, and electronics for maintaining the electric fields. The parameters are battery backed up in memory so that a run will automatically restart after power outages less than 3 hours.

Versatile Electrophoresis Cell

The electrophoresis cell has these convenient features:

- 11 x 43 x 44 cm, horizontal format, acrylic construction
- 24 individually replaceable 0.02" diameter platinum electrodes
- Accommodates 14 cm (w) x 13 cm (l), 21 x 14 cm, and 14 x 21 cm gel formats
- Temperature probe through the lid, with digital readout on the cooling module panel
- Safety interlocked lid

Precision Cooling System

Temperature regulation is one of the keys to high resolution separations. The CHEF Mapper XA system includes the Cooling Module. This direct buffer chiller precisely maintains temperatures from 5 °C to ambient. The Cooling Module is compact and lightweight (42 cm long x 23 cm wide x 24 cm high, 14 kg). Maximum cooling capacity is 75 W of input power at a set temperature of 14 °C. Buffer is circulated through the system using the Variable Speed Pump. The flow rate is easily adjusted by a dial on the pump.

Service and Support

In addition to the CHEF Mapper system, Bio-Rad has a range of agaroses, pulsed field size standards, and other accessories as described on the following page. All of Bio-Rad's PFGE products are backed by years of electrophoresis experience and expertise to help you through all phases of sample preparation, separation, and detection, as well as system troubleshooting. We also provide periodic procedural and algorithm updates, technical support, and a strong service organization to give you immediate solutions to any problems.

References

1. Chu, G., Vollrath, D. and Davis, R., *Science*, **234**, 1582 (1986).
2. Clark, S., Lai, E., Birren, B. and Hood L., *Science*, **241**, 1203 (1988).
3. Lai, E., Birren, B., Clark, S., Simon, M. and Hood, L., *BioTechniques*, **7**, 34 (1989).
4. Birren, B., Lai, E., Hood, L. and Simon, M., *Anal. Biochem.*, **177**, 282 (1989).
5. Zhang, T. Y., Smith, C. L. and Cantor, C. R., *Nucleic Acids Res.*, **19**, 1291 (1991).
6. US Patent 4,878,008 issued to Bio-Rad Laboratories, Inc.

Ordering Information

Catalog Number	Product Description
Systems	
170-3670	**CHEF Mapper XA Chiller System,** 120 V, includes CHEF Mapper XA power module, embedded auto algorithm for protocol optimization, interactive algorithm program disc, bar code reader, electrophoresis cell, Cooling Module, Variable Speed Pump, Temperature Probe, 12 feet Tygon tubing, 14 cm wide x 13 cm long casting stand, 10 Well Comb and Comb Holder, Screened Cap, Disposable Plug Molds, leveling bubble, cables, *S. cerevisiae* standards, 0.5 A FB fuses, 2, Pulsed Field Certified Agarose, 5 g, Chromosomal Grade Agarose, 5 g, instruction manual
170-3671	**CHEF Mapper XA Chiller System,** 100 V
170-3672	**CHEF Mapper XA Chiller System,** 220 V
170-3673	**CHEF Mapper XA Chiller System,** 240 V
Accessories	
170-3654	**Cooling Module,** 120 V
170-3688	**Cooling Module,** 100 V
170-3655	**Cooling Module,** 220/240 V
170-3644	**Variable Speed Pump,** 120 V
170-3656	**Bar Code Reader**
170-3632	**Cable,** PC to CHEF Mapper XA system
170-3665	**Temperature Probe**
170-3646	**Electrodes,** standard gauge (0.01"), 6
170-3648	**Electrodes,** thick gauge (0.02"), 6
170-3711	**Screened Caps,** 5
170-3713	**50 Well Disposable Plug Molds,** 5
170-3689	**Standard Casting Stand,** includes 14 x 13 cm frame and platform
170-3699	**Combination Comb Holder**
170-3704	**Wide/Long Combination Casting Stand,** includes 21 x 14 cm frame and platform

Catalog Number	Product Description
170-4326	**10 Well Comb,** 14 cm wide, 1.5 mm thick
170-4325	**10 Well Comb,** 14 cm wide, 0.75 mm thick
170-4324	**15 Well Comb,** 14 cm wide, 1.5 mm thick
170-4323	**15 Well Comb,** 14 cm wide, 0.75 mm thick
170-4322	**20 Well Comb,** 14 cm wide, 1.5 mm thick
170-4344	**30 Well Comb,** 14 cm wide, 1.5 mm thick
170-3627	**15 Well Comb,** 21 cm wide, 1.5 mm thick
170-3628	**30 Well Comb,** 21 cm wide, 1.5 mm thick
170-3645	**45 Well Comb,** 21 cm wide, 1.5 mm thick
170-3623	**Preparative Comb,** 14 cm wide, 1.5 mm thick (plus 2 outer wells for size standards)
170-4046	**Leveling Table,** 20 cm x 30 cm
170-3643	**Gel Scoop**
170-3625	**Gel Stops,** 4
165-5031	**GS Gene Linker UV Chamber,** 120 V
165-5032	**GS Gene Linker UV Chamber,** 220 V
165-5033	**GS Gene Linker UV Chamber,** 240 V
165-5034	**GS Gene Linker UV Chamber,** 100 V
162-0196	**Zeta-Probe GT Charged Nylon Membrane,** 30 cm x 3.3 m roll
162-0197	**Zeta-Probe GT Charged Nylon Membrane,** 20 cm x 3.3 m roll
Agaroses and Size Standards	
162-0017	**Low Melt Preparative Grade Agarose,** 25 g
162-0019	**Low Melt Preparative Grade Agarose,** 100 g
162-0133	**Molecular Biology Certified Agarose,** 100 g
162-0134	**Molecular Biology Certified Agarose,** 500 g
162-0135	**Chromosomal Grade Agarose,** 25 g
162-0136	**Chromosomal Grade Agarose,** 100 g
162-0137	**Pulsed Field Certified Agarose,** 100 g
162-0138	**Pulsed Field Certified Agarose,** 500 g
170-3605	**DNA Size Standard,** *S. cerevisiae,* 25–40 lanes
170-3633	**DNA Size Standard,** *S. pombe,* 25–40 lanes
170-3635	**DNA Size Standard,** lambda ladder, 25–40 lanes
170-3624	**DNA Size Standard,** 5 kb ladder, 20–30 lanes
170-3667	**DNA Size Standard,** *H. wingei,* 5 blocks
170-3707	**DNA Size Standard,** 8–48 kb
170-3591	**CHEF Mammalian Genomic DNA Plug Kit**
170-3592	**CHEF Bacterial Genomic DNA Plug Kit**
170-3593	**CHEF Yeast Genomic DNA Plug Kit**

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