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# Motion Run Axis Tuning (MRAT)

This information applies to the CompactLogix 5370, ControlLogix 5570, Compact GuardLogix 5370, GuardLogix 5570, Compact GuardLogix 5380, CompactLogix 5380, CompactLogix 5480, ControlLogix 5580, and GuardLogix 5580 controllers. Controller differences are noted where applicable.

Use the Motion Run Axis Tuning (MRAT) to command the motion module to run a tuning motion profile for the specified axis. The tuning motion profile consists of one or more acceleration and deceleration ramps induced by applying fixed voltages to the servo’s drive output. Note that this instruction does not at any time close the servo loop. While this instruction takes no explicit input parameters, it does derive input from the Axis Tuning Configuration parameters. The result of executing the MRAT instruction is a set of measurement data that is stored in the Axis Object for subsequent use with the Motion Apply Axis Tuning (MAAT) instruction.

## Available Languages

### Ladder Diagram



## Function Block

This instruction is not available in function block.

## Structured Text

```
MRAT(Axis,MotionControl);
```

## Operands

### Ladder Diagram and Structured Text

Operand	Type	Type	Format	Description
	<b>CompactLogix 5370, Compact GuardLogix 5370, Compact GuardLogix 5380, CompactLogix 5380, CompactLogix 5480</b>	<b>ControlLogix 5570, GuardLogix 5570, ControlLogix 5580, and GuardLogix 5580 controllers</b>		
Axis	AXIS_CIP_DRIVE	AXIS_CIP_DRIVE  AXIS_SERVO  AXIS_SERVO_DRIVE	Tag	Name of the axis to perform operation on
Motion Control	MOTION_INSTRUCTION		Tag	Structure used to access instruction status parameters.

See Structured Text Syntax for more information on the syntax of expressions within structured text.

Mnemonic	Description
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.DN (Done) Bit 29	It is set after the tuning process has been successfully completed.
.ER (Error) Bit 28	It is set to indicate that the instruction detected an error, such as if you specified an unconfigured axis.
.IP (In Process) Bit 26	It is set on positive rung transition and cleared after the tuning process is complete, or terminated by a stop command, shutdown, or a servo fault
.PC (Process Complete) Bit 27	It is set after the tuning process has been successfully completed

## Description - AXIS\_SERVO, AXIS\_SERVO\_DRIVE

The MRAT instruction is used to execute a tuning motion profile on the specified axis. During this brief tuning motion profile, the motion module makes timing and velocity measurements that serve as input data for a subsequent Motion Apply Axis Tuning (MAAT) instruction. MRAT requires no explicit input parameters; simply enter or select the desired physical axis.

If the targeted axis does not appear in the list of available axes, the axis has not been configured for operation. Use the Tag Editor to create and configure a new axis.

The MRAT instruction uses axis configuration parameters as input and output. The input configuration parameters that MRAT uses are shown in the table below.

Axis Parameter	Data Type	Units	Meaning
Tuning Direction	Boolean	-	Direction of Tuning Motion (0-Fwd, 1-Rev).
Tuning Travel Limit	Real	pos units	Maximum allowed excursion of Axis.
Tuning Velocity	Real	pos units/sec	Top Speed of Tuning Profile.
Dumping Factor	Real	-	Damping Factor used to calculate the maximum Position Servo Bandwidth.

Based on the above configuration parameters, MRAT execution generates a motion event on the specified axis that consists of a single triangular velocity profile or a series of three such profiles. Tune Velocity must be within the maximum speed capability of the drive and motor. The configured value for Tune Velocity should be set to the desired maximum operating speed of the axis so that the resulting tuning parameters are based on the dynamics of the system at that speed.

If the External Vel Servo Drive configuration bit parameter is TRUE, indicating interface to an external velocity servo drive, three pulses are applied to the axis. The tuning velocity profile for this case is shown in the diagram below.

## Tuning Velocity Profile when True

### Instructions

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[MAAT Flow Chart \(True\)](#)

[Motion Apply Hookup Diagnostics \(MAHD\)](#)

[MAHD Flow Chart \(True\)](#)

[Motion Run Axis Tuning \(MRAT\)](#)

[MRAT Flow Chart \(True\)](#)

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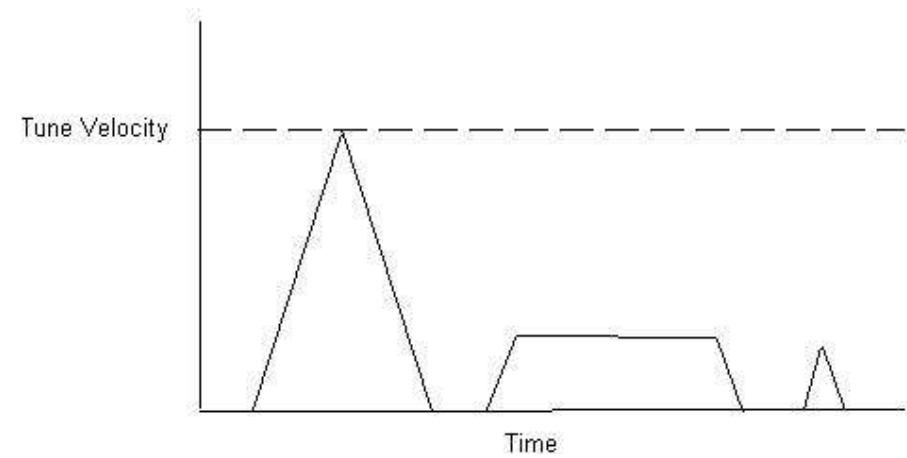
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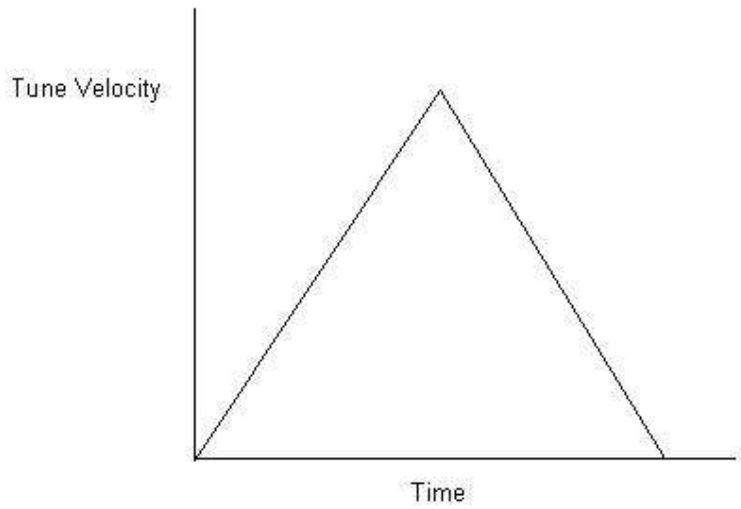
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If the External Vel Servo Drive configuration bit parameter is FALSE, indicating interface to an external torque servo drive, only one pulse is applied to the axis. The tuning velocity profile is shown below.

## Tuning Velocity Profile when False



The axis configuration parameters that MRAT generates as output depend on the External Drive configuration. If the External Vel Servo Drive configuration bit parameter is TRUE, indicating interface to an external velocity servo drive, the following output parameters are generated.

Axis Parameter	Data Type	Units	Meaning
Tune Status	Real	-	Status Report of the Tuning Process.
Tune Accel Time	Real	seconds	Measured Acceleration Time of Tuning Profile.
Tune Decel Time	Real	seconds	Measured Deceleration Time of Tuning Profile.
Tune Accel	Real	pos units/sec2	Calculated Acceleration Time of Tuning Profile.
Tune Decel	Real	pos units/sec2	Calculated Deceleration Time of Tuning Profile.
Tune Velocity Scaling	Real	mV/KCPS	Measured Velocity Scaling factor of axis Drive/Motor/Encoder system.
Tune Rise Time	Real	mV/KCPS	Measured Rise Time of Tuning Step Response Profile.
Tune Velocity Bandwidth	Real	Hertz	Computed Bandwidth of External Velocity Servo Drive

If the External Vel Servo Drive configuration bit parameter is FALSE, indicating interface to

If the External Velocity Drive Configuration bit parameter is FALSE, indicating interface to an external torque servo drive, the following output parameters are generated.

Axis Parameter	Data Type	Units	Meaning
Tune Status	Real	-	Status Report of the Tuning Process.
Tune Accel Time	Real	seconds	Measured Acceleration Time of Tuning Profile.
Tune Decel Time	Real	seconds	Measured Deceleration Time of Tuning Profile.
Tune Accel	Real	pos units/sec2	Calculated Acceleration Time of Tuning Profile.
Tune Decel	Real	pos units/sec2	Calculated Deceleration Time of Tuning Profile.
Effective Inertia	Real	mV/KCPS	Computed Effective Inertia of Drive/Motor system.
Position Servo Bandwidth	Real	Hertz	Calculated Maximum Position Servo Loop Bandwidth.

The above output parameters generated by the MRAT instruction serve as inputs to a subsequent MAAT instruction which performs further tuning calculations and applies the results to various axis’ servo and dynamic configuration parameters.

## Description - AXIS\_CIP\_DRIVE

The MRAT instruction is used to execute a tuning motion profile on the specified CIP axis. MRAT requires no explicit input parameters; simply enter or select the desired physical axis.

If the targeted axis does not appear in the list of available axes, the axis has not been configured for operation. Use the Tag Editor to create and configure a new axis.

The MRAT instruction uses the CIP Axis configuration parameters as input and output. The input configuration parameters that MRAT uses are shown in the table below.

Axis Parameter	Data Type	Units	Meaning
Tuning Direction	Short Integer	-	It determines the direction of the motion profile initiated by the Inertia Test service associated with the MRAT instruction.  0 = Unidirectional Forward  1 = Unidirectional Reverse  2 = Bi-Directional Forward  3 = Bi-Directional Reverse.
Tuning Travel Limit	Real	Position Units	It is used by the Inertia Test service, associated with the MRAT instruction, to limit the excursion of the axis during the test.

Tune Speed	Real	Position Units/sec	The Tuning Speed attribute value determines the maximum speed used by the Inertia Test service initiated motion profile. This attribute should be set to the desired maximum operating speed of the motor prior to running the test.
Tuning Torque	Real	% Rated	It determines the maximum torque used by the Inertia Test service initiated motion profile. This attribute should be set to the desired maximum safe torque level prior to running the test. The default value is 100%, which yields the most accurate measure of the acceleration and deceleration capabilities of the system.
Damping Factor	Real	-	It is used in calculating the maximum Position and Velocity Servo Bandwidth values during execution of the MRAT instruction.

The input configuration parameters can also be set using the **Axis Properties - Autotune** dialog box.

The Loop Response selection is used by the software to determine the value for the Damping Factor.

Loop Response	Damping Factor
Low	1.5
Medium	1.0
High	0.8

Based on the above configuration parameters, MRAT execution generates a motion event on the specified axis that consists of a triangular velocity profile. The tuning procedure will measure maximum acceleration and deceleration rates based on ramps to and from the Tuning Speed. Thus, the accuracy of the measured acceleration and deceleration capability is reduced by tuning at a speed other than the desired operating speed of the system.

The axis configuration parameters that MRAT generates as output for CIP axis are shown in the below table:

Axis Parameter	Data Type	Units	Meaning
Tuning Status	Integer	-	The Tune Status attribute returns status of the last run Inertia Test service that initiates a process on the targeted drive axis.
Tune Accel Time	Real	Seconds	Measured Acceleration time in seconds of the Tuning profile.
Tune Decel Time	Real	Seconds	Measured Acceleration time in seconds of the Tuning profile.
Tune Accel	Real	Position Units/sec <sup>2</sup>	Measured Acceleration of the Tuning profile.



Tune Decel	Real	Position Units/sec2	Measured Deceleration of the Tuning profile.
Tune Inertia Mass	Real	% Motor Rated / (Motor Units/Sec2)	The estimated inertia or mass for the axis as calculated from the measurements made during the tuning process.
Tune Friction	Real	% Rated	The amount of friction measured during Tuning profile. This value can be used to configure the Friction Compensation feature of the drive.
Tune Load Offset	Real	% Rated	This value represents the active load offset measured during the Tune profile. This value can be used to set the Torque Offset of the drive to cancel out the active load torque/force.
Position Servo Bandwidth	Real	Hertz	It represents the unity gain bandwidth of the position loop that is used to calculate the position loop gains.
Velocity Servo Bandwidth	Real	Hertz	It represents the unity gain bandwidth of the velocity loop that is used to calculate the velocity loop gains.

The above output parameters generated by the MRAT instruction serve as inputs to compute the Position and Velocity loop gains, Position and Velocity Error Tolerances, Feed Forward Gains, Load Ratio, Maximum Acceleration, Maximum Deceleration, System Inertia, System Acceleration and Friction Compensation.

If the Gain Tuning Config Bits parameter bit zero is the Run Inertia Test Bit. This bit determines whether or not the MRAT tuning instruction will send a Test Inertia service to the drive to perform an inertia measurement. If this bit is set, the Inertia Test shall be performed. If the bit is clear, the MRAT will immediately complete without an inertia measurement. It will only calculate the Pos and Velocity Servo Loop Bandwidths based on the Loop response or the Damping factor.

## Tune Status Parameter

Conditions may occur that make it impossible for the controller to properly perform the tuning operation. When this is the case, the tuning process is automatically aborted and a tuning fault reported that is stored in the Tune Status output parameter (GSVable). It is also possible to manually abort a tuning process using a Motion Axis Stop (MAS) instruction which results in a tuning fault reported by the Tune Status parameter. Possible values for Tuning Status are shown in the table below.

Status Code	Code	Meaning
Tune Success	0	Tune process has been successful.
Tune In Process	1	Tuning is in progress.
Tune Aborted	2	Tuning Process was aborted.
Tune Time-out	3	Tuning Process has timed out.
Tune Servo Fault	4	Tuning Process Failed due to Servo Fault.

Tune Travel Fault	5	Axis reached Tuning Travel Limit.
Tune Polarity Fault	6	Axis motion heading in wrong direction due to incorrect motor/encoder polarity configuration.
Tune Speed Fault	7	Axis tuning speed too low to achieve minimum measurement accuracy.
Tune Configuration Fault	8	The specified axis tuning configuration is not allowed and a fault occurs.

**Important:** The Tune Status Parameter is not to be mistaken for the .STATUS sub-tag of the MRAT instruction.

To successfully execute a MRAT instruction on an axis, the targeted axis must be configured as a Servo Axis Type and the axis must be in the Axis Ready state. If any of these conditions are not met than the instruction errs.

**Important:** When the MRAT instruction is initially executed the In Process (.IP) bit is set and the Process Complete (.PC) bit is cleared. The MRAT instruction execution can take multiple scans to execute because it requires transmission of multiple messages to the motion module. The Done (.DN) bit, is not set immediately, but only after these messages are successfully transmitted. The In Process (.IP) bit is cleared and the Process Complete (.PC) bit is set at the same time that the Done (.DN) bit is set.

In this transitional instruction, the relay ladder, toggle the Rung-condition-in from cleared to set each time the instruction should execute.

## Affects Math Status Flags

No

## Major/Minor Faults

None specific to this instruction. See Common Attributes for operand-related faults.

## Execution

## Ladder Diagram

Condition/State	Action Taken
Prescan	The .EN, .DN, .ER, and .IP bits are cleared to false.
Rung-condition-in is false	The .EN bit is cleared to false if either the .DN or .ER bit is true.
Rung-condition-in is true	The .EN bit is set to true and the instruction executes.
Postscan	N/A

## Structured Text

Condition/State	Action Taken
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Condition/State	Action Taken
Prescan	See Prescan in the Ladder Diagram table.
Normal execution	See Rung-condition-in is false, followed by rung is true in the Ladder Diagram table.
Postscan	See Postscan in the Ladder Diagram table.

## Error Codes

See Error Codes (ERR) for Motion Instructions.

## Extended Error Codes

Extended Error Codes provide additional instruction specific information for the Error Codes that are generic to many instructions. The following Extended Error codes help to pinpoint the problem when the MRAT instruction receives a Servo Message Failure (12) error message.

Associated Error Code (decimal)	Extended Error Code (decimal)	Meaning
SERVO_MESSAGE_FAILURE (12)	Process terminated on request (1)	Tune execution followed by an instruction to shutdown/disable drive, or a motion stop instruction or a Processor change requests a cancel of Tune.
SERVO_MESSAGE_FAILURE (12)	Object Mode conflict (12)	Axis is in shutdown.
SERVO_MESSAGE_FAILURE (12)	Device in wrong state (16)	Incorrect Tune Process order. (SERCOS)

## Status Bits

### MRAT Changes to Status Bits

Bit Name	State	Meaning
DriveEnableStatus	TRUE	Axis is in Drive Control state with the Drive Enable output active while the Tuning Profile is running.
TuneStatus	TRUE	The axis is running a tuning process.

## Examples

When the input conditions are true, the controller commands the servo module to run a tuning motion profile for axis1.

## Ladder Diagram





1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000

# See also

[MRAT Flow Chart \(True\)](#)

[Motion Configuration Instructions](#)

[Structured Text Syntax](#)

[Common Attributes](#)

[Motion Error Codes \(.ERR\)](#)

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