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List of References

The documents listed below are referenced throughout this manual.

[1] "DeviceNet Specification, Volume I: DeviceNet Communication Model and Protocol", Open DeviceNet Vendors Association, Inc. Release 2.0.

[2] "DeviceNet Specification, Volume II: DeviceNet Profiles and Object Library", Open DeviceNet Vendors Association, Inc. Release 2.0.

[3] "Sensor/Actuator Network Common Device Model", SEMI Standards Document E54.1-0097.

[4] "Sensor/Actuator Network Communications Standard for DeviceNet", SEMI Standards Draft Document E54.4-0097.

[5] "Sensor/Actuator Network Specific Device Model for Mass Flow Devices", SEMI Standards Draft Document #2253C.

[6] "Sensor/Actuator Network Standard", SEMI Standards Document E54-0097.

[7] SEMI Standards Document E52-95.

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Mass Flow Device Safety Information

Symbols Used in This Instruction Manual

Definitions of WARNING, CAUTION, and NOTE messages used throughout the manual.

Warning	**The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition, or the like, which, if not correctly performed or adhered to, could result in injury to personnel.**
Caution	**The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of all or part of the product.**
Note	The NOTE sign denotes important information. It calls attention to a procedure, practice, condition, or the like, which is essential to highlight.

Symbols Found on the Unit

The following table describes symbols that may be found on the unit.

Table 1: Definition of Symbols Found on the Unit

On (Supply) IEC 417, No. 5007	 Off (Supply) IEC 417, No. 5008	 Earth (ground) IEC 417, No. 5017	 Protective Earth (ground) IEC 417, No. 5019
 Frame or Chassis IEC 417, No. 5020	 Equipotentiality IEC 417, No. 5021	 Direct Current IEC 417, No. 5031	 Alternating Current IEC 417, No. 5032
 Both Direct and Alternating Current IEC 417, No. 5033-a	 Class II Equipment IEC 417, No. 5172-a	 Three Phase Alternating Current IEC 617-2, No. 020206	
 Caution (refer to accompanying documents) ISO 3864, No. B.3.1	 Caution, Risk of Electric Shock ISO 3864, No. B.3.6	 Caution, Hot Surface IEC 417, No. 5041	

Safety Procedures and Precautions

Observe the following general safety precautions during all phase of operation of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of intended use of the instrument and may impair the protection provided by the equipment. MKS Instruments, Inc. assumes no liability for the customer's failure to comply with these requirements.

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DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an MKS Calibration and Service Center for service and repair to ensure that all safety features are maintained.

SERVICE BY QUALIFIED PERSONNEL ONLY

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified service personnel only.

KEEP AWAY FROM LIVE CIRCUITS

Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

USE CAUTION WHEN OPERATING WITH HAZARDOUS MATERIALS

If hazardous materials are used, users must take responsibility to observe the proper safety precautions, completely purge the instrument when necessary, and ensure that the material used is compatible with sealing materials.

PURGE THE INSTRUMENT

After installing the unit, or before its removal from a system, be sure to purge the unit completely with a clean dry gas to eliminate all traces of the previously used flow material.

USE PROPER PROCEDURES WHEN PURGING

This instrument must be purged under a ventilation hood, and gloves must be worn to protect personnel.

DO NOT OPERATE IN AN EXPLOSIVE ENVIRONMENT

To avoid explosion, do not operate this product in an explosive environment unless it has been specifically certified for such operation.

USE PROPER FITTINGS AND TIGHTENING PROCEDURES

All instrument fittings must be consistent with instrument specifications, and compatible with the intended use of the instrument. Assemble and tighten fittings according to manufacturer's directions.

CHECK FOR LEAK-TIGHT FITTINGS

Before proceeding to instrument setup, carefully check all plumbing connections to the instrument to ensure leak-tight installation.

OPERATE AT SAFE INLET PRESSURES

This unit should never be operated at pressures higher than the rated maximum pressure (refer to the product specifications for the maximum allowable pressure).

INSTALL A SUITABLE BURST DISC

When operating from a pressurized gas source, a suitable burst disc should be installed in the vacuum system to prevent system explosion should the system pressure rise.

KEEP THE UNIT FREE OF CONTAMINANTS

Do not allow contaminants of any kind to enter the unit before or during use. Contamination such as dust, dirt, lint, glass chips, and metal chips may permanently damage the unit.

ALLOW PROPER WARM UP TIME FOR TEMPERATURE-CONTROLLED UNITS

Temperature-controlled unit will only meet specifications when sufficient time is allowed for the unit to meet, and stabilize at, the designed operating temperature. Do not zero or calibrate the unit until the warm up is complete.

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Sicherheitshinweise für das Massenflussgerät

In dieser Betriebsanleitung vorkommende Symbole

Bedeutung der mit WARNUNG!, VORSICHT! und HINWEIS gekennzeichneten Absätze in dieser Betriebsanleitung.

Warnung!	**Das Symbol WARNUNG! weist auf eine Gefahr für das Bedienpersonal hin. Es macht auf einen Arbeitsablauf, eine Arbeitsweise, einen Zustand oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu Verletzungen führen kann.**
Vorsicht!	**Das Symbol VORSICHT! weist auf eine Gefahr für das Gerät hin. Es macht auf einen Bedienungsablauf, eine Arbeitsweise oder eine sonstige Gegebenheit aufmerksam, deren unsachgemäße Ausführung bzw. ungenügende Berücksichtigung zu einer Beschädigung oder Zerstörung des Gerätes oder von Teilen des Gerätes führen kann.**
Hinweis	Das Symbol HINWEIS macht auf wichtige Informationen bezüglich eines Arbeitsablaufs, einer Arbeitsweise, eines Zustands oder einer sonstige Gegebenheit aufmerksam.

Erklärung der am Gerät angebrachten Symbole

Nachstehender Tabelle sind die Bedeutungen der Symbole zu entnehmen, die am Gerät angebracht sein können.

Tabelle 2: Bedeutung der am Gerät angebrachten Symbole

Ein (Energie) IEC 417, No.5007	 Aus (Energie) IEC 417, No.5008	 Erdanschluss IEC 417, No.5017	 Schutzleiteranschluss IEC 417, No.5019
 Masseanschluss IEC 417, No.5020	 Aquipotentialanschluss IEC 417, No.5021	 Gleichstrom IEC 417, No.5031	 Wechselstrom IEC 417, No.5032
 Gleich- oder Wechselstrom IEC 417, No.5033-a	 Durchgängige doppelte oder verstärkte Isolierung IEC 417, No.5172-a	 Dreileiter-Wechselstrom (Drehstrom) IEC 617-2, No.020206	
 Warnung vor einer Gefahrenstelle (Achtung, Dokumentation beachten) ISO 3864, No.B.3.1	 Warnung vor gefährlicher elektrischer Spannung ISO 3864, No.B.3.6	 Höhere Temperatur an leicht zugänglichen Teilen IEC 417, No.5041	

Sicherheitsvorschriften und Vorsichtsmaßnahmen

Folgende allgemeine Sicherheitsvorschriften sind während allen Betriebsphasen dieses Gerätes zu befolgen. Eine Missachtung der Sicherheitsvorschriften und sonstiger Warnhinweise in dieser Betriebsanleitung verletzt die für dieses Gerät und seine Bedienung geltenden Sicherheitsstandards,

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und kann die Schutzvorrichtungen an diesem Gerät wirkungslos machen. MKS Instruments, Inc. haftet nicht für Missachtung dieser Sicherheitsvorschriften seitens des Kunden.

Niemals Teile austauschen oder Änderungen am Gerät vornehmen!
Ersetzen Sie keine Teile mit baugleichen oder ähnlichen Teilen, und nehmen Sie keine eigenmächtigen Änderungen am Gerät vor. Schicken Sie das Gerät zwecks Wartung und Reparatur an den MKS-Kalibrierungs- und -Kundendienst ein. Nur so wird sichergestellt, dass alle Schutzvorrichtungen voll funktionsfähig bleiben.

Wartung nur durch qualifizierte Fachleute!
Das Auswechseln von Komponenten und das Vornehmen von internen Einstellungen darf nur von qualifizierten Fachleuten durchgeführt werden, niemals vom Bedienpersonal.

Vorsicht vor stromführenden Leitungen!
Ersetzen Sie keine Komponente von Geräten, die an Netzstrom angeschlossen sind. Unter Umständen kann gefährliche Spannung auch dann bestehen, wenn das Netzanschlusskabel von der Strmversorgung entfernt wurde. Um Verletzungen vorzubeugen sollten zuerst alle Geräte von der Stromversorgung getrennt und alle Stromkreusläufe entladen werden.

Vorsicht beim Arbeiten mit gefährlichen Stoffen!
Wenn gefährliche Stoffe verwendet werden, muss der Bediener die entsprechenden Sicherheitsvorschriften genauestens einhalten, das Gerät, falls erforderlich, vollständig spülen, sowie sicherstellen, dass der Gefahrstoff die am Gerät verwendeten Materialien, insbesondere Dichtungen, nicht angreift.

Spülen des Gerätes mit Gas!
Nach dem Installieren oder vor dem Ausbau aus einem System muss das Gerät unter Einsatz eines reinen Trockengases vollständig gespült werden, um alle Rückstände des Vorgängermediums zu entfernen.

Anweisungen zum Spülen des Gerätes
Das Gerät darf nur unter einer Ablufthaube gespült werden. Schutzhandschuhe sind zu tragen.

Gerät nicht zusammen mit explosiven Stoffen, Gasen oder Dämpfen benutzen!
Um der Gefahr einer Explosion vorzubeugen, darf dieses Gerät niemals zusammen mit (oder in der Nähe von) explosiven Stoffen aller Art eingesetzt werden, sofern es nicht ausdrücklich für diesen Zweck zugelassen ist.

Anweisungen zum Installieren der Armaturen!
Alle Anschlussstücke und Armaturenteile müssen mit der Gerätespezifikation übereinstimmen, und mit dem geplanten Einsatz des Gerätes kompatibel sein. Der Einbau, insbesondere das Anziehen und Abdichten, muss gemäß den Anweisungen des Herstellers vorgenommen werden.

Verbindungen auf Undichtigkeiten prüfen!
Überprüfen Sie sorgfältig alle Verbindungen der Vakuumkomponenten auf undichte Stellen.

Gerät nur unter zulässigen Anschlussdrücken betreiben!
Betreiben Sie das Gerät niemals unter Drücken, die den maximal zulässigen Druck (siehe Produktspezifikationen) übersteigen.

Geeignete Berstscheibe installieren!
Wenn mit einer unter Druck stehenden Gasquelle gearbeitet wird, sollte eine geeignete Berstscheibe in das Vakuumsystem installiert werden, um eine Explosionsgefahr aufgrund von steigendem Systemdruck zu vermeiden.

Verunreinigungen im Gerät vermeiden!
Stellen Sie sicher, dass Verunreinigungen jeglicher Art weder vor dem Einsatz noch während des Betriebs in das Instrumenteninnere gelangen können. Staub- und Schmutzpartikel, Glassplitter oder Metallspäne können das Gerät dauerhaft beschädigen oder Prozess- und Messwerte verfälschen.

Bei Geräten mit Temperaturkontrolle korrekte Anwärmzeit einhalten!
Temperaturkontrollierte Geräte arbeiten nur dann gemäß ihrer Spezifikation, wenn genügend Zeit zum Erreichen und Stabilisieren der Betriebstemperatur eingeräumt wird. Kalibrierungen und Nulleinstellungen sollten daher nur nach Abschluss des Anwärmvorgangs durchgeführt werden.

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Informations de sécurité pour appareils de mesure/contrôle de débit massique

Symboles utilisés dans ce manuel d'utilisation

Définitions des indications AVERTISSEMENT, ATTENTION, et REMARQUE utilisées dans ce manuel.

Avertissement	**L'indication AVERTISSEMENT signale un danger pour le personnel. Elle attire l'attention sur une procédure, une pratique, une condition, ou toute autre situation présentant un risque d'accident pour le personnel, en cas d'exécution incorrecte ou de non-respect des consignes.**
Attention	**L'indication ATTENTION signale un danger pour l'appareil. Elle attire l'attention sur une procédure d'exploitation, une pratique, ou toute autre situation, présentant un risque de dégât ou de destruction partielle ou totale du produit, en cas d'exécution incorrecte ou de non-respect des consignes.**
Remarque	L'indication REMARQUE signale une information importante. Elle attire l'attention sur une procédure, une pratique, une condition, ou toute autre situation, présentant un intérêt particulier.

Symboles figurant sur l'unité

Le tableau suivant décrit les symboles pouvant apparaître sur l'unité.

Tableau 3: Définition des symboles sur l'unité

Marche (sous tension) IEC 417, No.5007	 Arrêt (hors tension) IEC 417, No.5008	 Terre (masse) IEC 417, No.5017	 Terre de protection (masse) IEC 417, No.5019
 Masse IEC 417, No.5020	 Equipotentialité IEC 417, No.5021	 Courant continu IEC 417, No.5031	Courant alternatif IEC 417, No.5032
 Courant continu et alternatif IEC 417, No.5033-a	 Matériel de classe II IEC 417, No.5172-a	 Courant alternatif triphasé IEC 617-2, No.020206	
 Attention : se reporter à la documentation ISO 3864, No.B.3.1	 Attention : risque de choc électrique ISO 3864, No.B.3.6	 Attention : surface brûlante IEC 417, No.5041	

Mesures de sécurité et précautions

Observer les précautions générales de sécurité suivantes pendant toutes les phases d'exploitation de cet appareil. Le non-respect des ces précautions ou des avertissements du manuel constitue une violation des normes de sécurité relatives à l'utilisation de l'appareil et peut compromettre la protection assurée

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par l'appareil. MKS Instruments, Inc. rejette toute responsabilité en cas de non-respect des consignes par les clients.

PAS DE REMPLACEMENT DE PIÈCES OU DE MODIFICATION DE L'APPAREIL

Ne pas installer de pièces de remplacement ni effectuer des modifications non autorisées sur l'appareil. Renvoyer l'appareil à un centre de service et de calibrage MKS pour tout dépannage ou réparation afin de garantir le l'intégrité des dispositifs de sécurité.

DÉPANNAGE UNIQUEMENT PAR DU PERSONNEL QUALIFIÉ

Le personnel d'exploitation ne doit pas essayer de sortir les composants du boîtier ou faire des réglages internes. Le dépannage est réservé au personnel qualifié.

ÉLOIGNEMENT DES CIRCUITS SOUS-TENSION

Ne pas remplacer de composants lorsqu'un câble d'alimentation est branché. Dans certaines conditions, des tensions dangereuses peuvent être présentes même après le retrait du câble d'alimentation. Pour éliminer tout risque de blessure, procéder toujours à la déconnexion et décharger les circuits avant tout contact physique.

PRÉCAUTION EN CAS D'UTILISATION AVEC DES PRODUITS DANGEREUX

Si des produits dangereux sont utilisés, l'utilisateur est responsable du respect des mesures de sécurité appropriées, de la purge complète de l'appareil quand elle s'avère nécessaire, et doit s'assurer que les produits utilisés sont compatibles avec les matériaux d'étanchéité.

PURGE DE L'APPAREIL

Après l'installation de l'unité, ou avant son retrait d'un système, purger l'unité complètement avec un gaz propre et sec afin d'éliminer toute trace du produit de flux utilisé précédemment.

UTILISATION DES PROCÉDURES APPROPRIÉES POUR LA PURGE

Cet appareil doit être purgé sous une hotte de ventilation. Le personnel doit porter des gants de protection.

PAS D'EXPLOITATION DANS UN ENVIRONNEMENT EXPLOSIF

Pour éviter toute explosion, ne pas utiliser cet appareil dans un environnement explosif, sauf en cas d'homologation spécifique pour une telle exploitation.

UTILISATION D'ÉQUIPEMENTS ET PROCÉDURES DE SERRAGE APPROPRIÉS

Tous les équipements de l'appareil doivent être conformes à ses spécifications, et compatibles avec l'utilisation prévue de l'appareil. Assembler et serrer les équipements conformément aux directives du fabricant.

VÉRIFICATION DE L'ÉTANCHÉITÉ DES CONNEXIONS

Vérifier attentivement toutes les connexions des composants pour le vide afin de garantir l'étanchéité de l'installation.

EXPLOITATION AVEC DES PRESSIONS D'ENTRÉE NON DANGEREUSES

Ne jamais utiliser des pressions supérieures à la pression nominale maximum (se reporter aux spécifications de l'unité pour la pression maximum admissible).

INSTALLATION D'UN DISQUE D'ÉCHAPPEMENT ADAPTÉ

En cas d'exploitation avec une source de gaz pressurisé, installer un disque d'échappement adapté dans le système à vide, afin d'éviter une explosion du système en cas d'augmentation de la pression.

MAINTIEN DE L'UNITÉ À L'ABRI DES CONTAMINATIONS

Ne pas laisser des produits contaminants pénétrer dans l'unité avant ou pendant l'utilisation. Des produits contaminants tels que des poussières et des fragments de tissu, de verre et de métal peuvent endommager l'unité de manière permanente.

RESPECT DU TEMPS D'ÉCHAUFFEMENT APPROPRIÉ POUR LES UNITÉS Á RÉGULATION DE TEMPÉRATURE

Les unités à régulation de température sont conformes à leurs spécifications uniquement quand on leur laisse un temps suffisant pour atteindre d'une manière stable la température d'exploitation. Ne pas remettre à zéro ou calibrer l'unité tant que l'échauffement n'est pas terminé.

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Medidas de seguridad del dispositivo de flujo de masa

Símbolos usados en este manual de instrucciones

Definiciones de los mensajes de advertencia, precaución y de las notas usados en el manual.

Advertencia	**El símbolo de advertencia indica la posibilidad de que se produzcan daños personales. Pone de relieve un procedimiento, práctica, estado, etc. que en caso de no realizarse o cumplirse correctamente puede causar daños personales.**
Precaución	**El símbolo de precaución indica la posibilidad de producir daños al equipo. Pone de relieve un procedimiento operativo, práctica, etc. que en caso de no realizarse o cumplirse correctamente puede causar daños o la destrucción total o parcial del equipo.**
Nota	El símbolo de notas indica información de importancia. Este símbolo pone de relieve un procedimiento, práctica o condición cuyo conocimiento es esencial destacar.

Símbolos hallados en la unidad

La tabla siguiente contiene los símbolos que puede hallar en la unidad.

Tabla 4: Definición de los símbolos hallados en la unidad

Encendido (alimentación eléctrica) IEC 417, N° 5007	 Apagado (alimentación eléctrica) IEC 417, N° 5008	 Puesta a tierra IEC 417, N° 5017	 Protección a tierra IEC 417, N° 5019
 Caja o chasis IEC 417, N° 5020	 Equipotencialidad IEC 417, N° 5021	 Corriente continua IEC 417, N° 5031	 Corriente alterna IEC 417, N° 5032
 Corriente continua y alterna IEC 417, N° 5033-a	 Equipo de clase II IEC 417, N° 5172-a	 Corriente alterna trifásica IEC 617-2, N° 020206	
 Precaución. Consulte los documentos adjuntos ISO 3864, N° B.3.1	 Precaución. Riesgo de descarga eléctrica ISO 3864, N° B.3.6	 Precaución. Superficie caliente IEC 417, N° 5041	

Procedimientos y precauciones de seguridad

Las medidas generales de seguridad descritas a continuación deben observarse durante todas las etapas de funcionamiento del instrumento. La fMC20A de cumplimiento de dichas medidas de seguridad o de las advertencias específicas a las que se hace referencia en otras partes de este manual, constituye una violación de las normas de seguridad establecidas para el uso previsto del instrumento y podría anular la protección proporcionada por el equipo. Si el cliente no cumple dichas precauciones y advertencias, MKS Instruments, Inc. no asume responsabilidad legal alguna.

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NO UTILICE PIEZAS NO ORIGINALES O MODIFIQUE EL INSTRUMENTO

No instale piezas que no sean originales ni modifique el instrumento sin autorización. Para asegurar el correcto funcionamiento de todos los dispositivos de seguridad, envíe el instrumento al Centro de servicio y calibración de MKS toda vez que sea necesario repararlo o efectuar tareas de mantenimiento.

LAS REPARACIONES DEBEN SER EFECTUADAS ÚNICAMENTE POR TÉCNICOS AUTORIZADOS

Los operarios no deben retirar las tapas del instrumento. El reemplazo de los componentes y las tareas de ajuste deben ser realizadas únicamente por personal autorizado.

MANTÉNGASE ALEJADO DE LOS CIRCUITOS ACTIVOS

No reemplace componentes con el cable de alimentación eléctrica conectado. En algunos casos, puede haber presente alto voltaje aun con el cable de alimentación eléctrica desconectado. Para evitar lesiones personales, desconecte siempre el cable y descargue los circuitos antes de entrar en contacto con los mismos.

TENGA CUIDADO CUANDO TRABAJE CON MATERIALES TÓXICOS

Cuando se utilicen materiales tóxicos, es responsabilidad de los operarios tomar las medidas de seguridad correspondientes, purgar totalmente el instrumento cuando sea necesario y comprobar que el material utilizado sea compatible con los materiales de sellado.

PURGUE EL INSTRUMENTO

Una vez instalada la unidad o antes de retirarla del sistema, purgue completamente la unidad con gas limpio y seco para eliminar todo resto de la sustancia líquida empleada anteriormente.

USE PROCEDIMIENTOS ADECUADOS PARA REALIZAR LA PURGA

El instrumento debe purgarse debajo de una campana de ventilación y deben utilizarse guantes protectores.

NO HAGA FUNCIONAR EL INSTRUMENTO EN AMBIENTES CON RIESGO DE EXPLOSIÓN

Para evitar que se produzcan explosiones, no haga funcionar este instrumento en un ambiente con riesgo de explosiones, excepto cuando el mismo haya sido certificado específicamente para tal uso.

USE ACCESORIOS ADECUADOS Y REALICE CORRECTAMENTE LOS PROCEDIMIENTOS DE AJUSTE

Todos los accesorios del instrumento deben cumplir las especificaciones del mismo y ser compatibles con el uso que se debe dar al instrumento. Arme y ajuste los accesorios de acuerdo con las instrucciones del fabricante.

COMPRUEBE QUE LOS ACCESORIOS SEAN A PRUEBA DE FUGAS

Antes de proceder con la instalación del instrumento, inspeccione cuidadosamente todas las conexiones de las tuberías para comprobar que hayan sido instaladas a prueba de fugas.

HAGA FUNCIONAR EL INSTRUMENTO CON PRESIONES DE ENTRADA SEGURAS

No haga funcionar nunca el instrumento con presiones superiores a la máxima presión nominal (en las especificaciones del instrumento hallará la presión máxima permitida).

INSTALE UNA CÁPSULA DE SEGURIDAD ADECUADA

Cuando el instrumento funcione con una fuente de gas presurizado, instale una cápsula de seguridad adecuada en el sistema de vacío para evitar que se produzcan explosiones cuando suba la presión del sistema.

MANTENGA LA UNIDAD LIBRE DE CONTAMINANTES

No permita el ingreso de contaminantes en la unidad antes o durante su uso. Los productos contaminantes tales como polvo, suciedad, pelusa, lascas de vidrio o virutas de metal pueden dañar irreparablemente la unidad.

CALIENTE ADECUADAMENTE LAS UNIDADES CONTROLADAS POR MEDIO DE TEMPERATURA

Las unidades controladas por medio de temperatura funcionarán de acuerdo con las especificaciones sólo cuando se las caliente durante el tiempo suficiente para permitir que lleguen y se estabilicen a la temperatura de operación indicada. No calibre la unidad y no la ponga en cero hasta que finalice el procedimiento de calentamiento.

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マスフロー機器の安全に関する情報

本取扱説明書のマーク

本マニュアルでは警告、注意、ポイントのマークを用いて重要な事項を記載しています。

警告	**この表示を無視して誤った取り扱い (手順や使用方法、条件など) をすると、人が重傷を負う可能性が想定される内容を示しています。必ずお読みください。**
注意	**この表示を無視して誤った取り扱い (手順や使用方法など) をすると、製品が損傷する可能性が想定される内容を示しています。必ずお読みください。**
ポイント	この表示は手順や使用方法、条件などに関する重要な情報が記載されていることを示しています。必ずお読みください。

本機器のマーク

以下の表では、本機器に使用されているマークについて説明いたします。

表 5: 本機器に使用されているマークについて

 オン (電源) IEC 417, No. 5007	 オフ (電源) IEC 417, No. 5008	 接地 (アース) IEC 417, No. 5017	 保護接地 (アース) IEC 417, No. 5019
 フレームまたはシャーシ IEC 417, No. 5020	 等電位 IEC 417, No. 5021	 直流 IEC 417, No. 5031	 交流 IEC 417, No. 5032
 直流と交流 IEC 417, No. 5033-a	 クラス 2 機器 IEC 417, No. 5172-a	 三相交流 IEC 617-2, No. 020206	
 注意 (付属書を参照) ISO 3864, No. B.3.1	 注意 (感電の危険あり) ISO 3864, No. B.3.6	 注意 (表面が熱くなっています) IEC 417, No. 5041	

安全対策について

本機器を使用する際は、必ず以下の安全対策を守ってください。これらの安全対策や本マニュアルの警告を無視すると、機器本来の用途の安全基準を侵害することになり、機器が提供する保護機能が損なわれる可能性があります。MKS Instruments, Inc. は、顧客側の安全対策の不履行に対しては一切責任を負いかねます。

勝手に部品を変えたり、本体を改造しないこと

本機器に代用部品を使用したり、不正な改造を加えないでください。すべての安全システムを正しく機能させるための修理やメンテナンスが必要な場合は、本機器を MKS Calibration and Service Center まで戻してください。

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修理は必ず専門の修理サービスを利用すること
オペレータは絶対に本機器を分解しないでください。部品の交換や内部の調整は必ず専門の修理サービスを利用してください。

電流が通じている回路から切断すること
電源ケーブルを接続したままで部品を交換しないでください。特定の状況では、電源ケーブルを取り外した状態でも危険な電圧が残っている場合があります。感電などの事故を防ぐため、回路に触れる前に必ず電源から切断し、放電してください。

危険な材料を使用する場合は慎重に機器を使用すること
危険な材料を使用する場合は、使用者は各自の責任の元で適切な安全対策を講じてください。必要に応じて本機器を浄化してください。また、使用する材料に対するシーリング材の耐久性を確認してください。

機器を浄化すること
本機器を取り付けた後やシステムから取り外す前に、きれいな乾燥ガスで本機器を浄化し、使用した材料を完全に取り除いてください。

浄化する場合は適切な手順で行うこと
本機器の浄化は換気フードの下で行う必要があります。また、浄化作業を行う人は必ず手袋を着用してください。

爆発の危険性のある環境で機器を使用しないこと
爆発が起きるのを防ぐため、本機器を爆発の危険性のある環境で使用しないでください。ただし、そのような環境での使用が特別に保証されている場合は除きます。

適切な金具類を使用し、手順に従って金具の締めを行うこと
金具類は本機器の仕様と一致し、機器本来の用途に適合したものである必要があります。金具類の取り付けや締めは、製造業者の指示に従ってください。

液体の漏れがないよう接続箇所を確認すること
本機器を設定する前に、すべての配管の接続を慎重に確認し、液体が漏れないようにしてください。

安全なインレット圧力で使用すること
定格の最大圧力を超える圧力の下で本機器を絶対に使用しないでください (最大許容圧力については仕様書を参照)。

適切なバーストディスクを取り付けること
圧力のかかったガスを使用する場合は、万一システムが爆発した場合にシステムの圧力が上昇するのを防ぐため、真空システムに適切なバーストディスクを取り付けてください。

本機器に異物やゴミが混入しないようにすること
本機器の使用前または使用中に、ほこりやゴミ、繊維、ガラスの破片、金属片などの異物やゴミが混入しないようにしてください。本機器が損傷する可能性があります。

温度調整された機器を十分に温めてから使用すること
温度調整された機器が適切な作動温度にならないうちに使用すると、仕様通りの動作をしないことがあります。本機器が十分に温まるまでは目盛りをゼロに合わせたり、較正しないでください。

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질량 유량 장치 안전 정보

본 지침 매뉴얼에 사용되는 기호들

매뉴얼 전체에 사용되는 경고, 주의 및 참고 메시지의 정의.

경고	**경고 표시는 위험을 나타냅니다. 이 표시는 올바르게 수행되거나 지켜지지 않을 경우, 사람에게 상해를 입힐 수 있는 절차, 수행지침, 상태 또는 이와 유사한 상황들에 대한 주의를 환기시킵니다.**
주의	**주의 표시는 위험을 나타냅니다. 이 표시는 올바르게 수행되거나 지켜지지 않을 경우, 제품의 일부나 전체에 손상이나 파손을 일으킬 수 있는 절차, 수행지침 또는 이와 유사한 상황들에 대한 주의를 환기시킵니다.**
참고	참고 표시는 중요한 정보를 나타냅니다. 이 표시는 강조할 만한 주요 절차, 수행지침, 상태 또는 이와 유사한 상황들에 대한 주의를 환기시킵니다.

장치에 표시된 기호들

다음 표는 장치에서 볼 수 있는 기호들을 설명합니다.

표 6: 장치에 표시된 기호들의 정의

 켬 (전원) IEC 417, No. 5007	 끔 (전원) IEC 417, No. 5008	 접지(지면) IEC 417, No. 5017	 보호 접지(지면) IEC 417, No. 5019
 프레임 또는 섀시 IEC 417, No. 5020	 등전위성 IEC 417, No. 5021	 직류 IEC 417, No. 5031	 교류 IEC 417, No. 5032
 직류와 교류 모두 IEC 417, No. 5033-a	 클래스 II 장비 IEC 417, No. 5172-a	 3 상 교류 IEC 617-2, No. 020206	
 주의 (동봉 문서 참조) ISO 3864, No. B.3.1	 주의, 감전 위험 ISO 3864, No. B.3.6	 주의, 표면이 뜨거움 IEC 417, No. 5041	

안전 절차 및 예방조치

본 기계의 모든 작동 시에 다음의 일반 안전 예방조치를 준수하십시오. 아래 예방조치를 준수하지 않거나 본 매뉴얼의 다른 부분에 있는 특정 경고를 준수하지 않을 경우, 기계 사용 목적의 안전 기준을 위반하는 것이 되며, 장비가 제공하는 보호기능을 손상시킬 수 있습니다. **MKS Instruments, Inc.**는 고객이 본 요건을 준수하지 않는 경우에 대해서는 어떠한 책임도 지지 않습니다.

부품을 교체하거나 기계를 개조하지 마십시오

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교체 부품을 설치하거나 기계에 허가되지 않은 어떠한 수정도 가하지 마십시오. 서비스와 수리가 필요한 경우에는 모든 안전 특성이 유지되도록 기계를 MKS 보정 서비스 센터(MKS Calibration and Service Center)로 보내주십시오.

자격이 있는 사람에게만 서비스를 받으십시오
작동하는 사람은 기계 겉면을 제거해서는 안됩니다. 부품 교체 및 내부 조정은 자격이 있는 서비스 기사에게만 받으실 수 있습니다.

전류가 통하는 회로에서 분리해 보관하십시오
전원 케이블을 연결한 채로 부품을 교체하지 마십시오. 일부 환경에서는 전원 케이블을 제거한 상태라도 위험 전압이 존재할 수 있습니다. 부상을 방지하려면, 전원을 항상 분리하고 회로를 만지기 전에 회로를 방전시키십시오.

위험한 물질과 함께 작동할 때는 주의를 기울이십시오
위험한 물질이 사용되는 경우, 사용자는 필요시 기계를 완전히 청소하여, 적절한 안전 예방조치를 준수할 책임을 지키고, 사용된 물질이 봉인 물질과 함께 사용해도 무방하다고 보증할 수 있어야 합니다.

기계를 청소하십시오
장치를 설치한 후나 시스템에서 장치를 제거하기 전에는 반드시 깨끗한 건조성 기체로 장치를 완전히 청소하여 이전에 사용된 유량 물질의 모든 흔적을 제거하십시오.

청소 시에는 적절한 절차를 사용하십시오
본 기계는 환기 후드 아래에서 청소되어야 하며, 인체 보호를 위해 장갑을 착용해야 합니다.

폭발성 환경에서 작동하지 마십시오
폭발을 방지하려면, 폭발성 환경에서 작동하도록 특별히 승인받지 않은 경우 본 제품을 폭발성 환경에서 작동하지 마십시오.

적절한 조립부품과 조임 절차를 사용하십시오
모든 기계 조립부품은 제품 사양과 일치해야 하고, 기계의 사용 목적에 부합해야 합니다. 제조업체의 지시에 따라 조립부품을 조립하고 조이십시오.

누출방지 조립부품을 점검하십시오
기계 설치를 진행하기 전에 기계의 모든 연관 연결부를 점검해 누출방지 설치가 되었는지 확인하십시오.

안전한 흡입 압력에서 작동하십시오
이 장치는 절대 정격 최대 압력보다 높은 압력에서 작동해서는 안됩니다(최대 허용 압력에 대해서는 제품 사양을 참조하십시오).

적합한 안전 파열판을 설치하십시오
가압 가스 공급원에서 작동시, 시스템 폭발이 시스템 압력 상승을 일으키는 것을 방지하기 위해 적합한 안전 파열판이 진공 시스템에 설치되어야 합니다.

장치를 오염이 없는 곳에 보관하십시오
장치를 사용하기 전이나 사용 중에는 어떠한 종류의 오염 물질도 허용해서는 안됩니다. 먼지, 때, 보풀, 유리 조각, 금속 조각과 같은 오염 물질은 영구적으로 장치를 손상시킬 수 있습니다.

온도 제어 장치의 경우 알맞은 시동 시간을 두십시오
온도 제어 장치는 장치가 설계 작동 온도와 일치하고 이 온도에서 안정화될 수 있도록 충분한 시간을 허용해야만 사양에 맞게 작동합니다. 시동이 완료될 때까지 장치를 영점 설정하거나 보정하지 마십시오.

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Chapter One: General Information

Introduction

The MC20A Mass Flow Controller (MFC) is a high flow, metal sealed subset of the Alta™ series of digital mass flow devices. As such, device operation is the same and features are similar. This document covers the DeviceNet MFC.

Based on a patented MKS Instruments measurement technique, these instruments are laminar flow controllers whose precise indication of mass flow is achieved through the use of a bypass element in parallel with the sensor tube. The controller includes a metal cover and RF bypass capacitors and incorporates a design that virtually eliminates RFI and EMI interference. The MC20A MFCs carry the CE mark indicating compliance with the EMC Directive 89/336/89.

Use the MC20A MFC when both gas flow control and gas flow measurement are required. It is supplied with a normally closed flow control valve.

The MC20A MFCs are available in a variety of configurations and types to suit your specific application needs. Appendix C, Model Code Explanation, page 97, contains the options that must be specified when ordering an MFC. Configuration choices include full scale flow range, fitting type, and electrical communications/connections.

Design Features

The design of the MC20A MFCs incorporates an advanced flow sensor, a control valve, and an optimized bypass. The latest generation two-element sensing circuit provides accurate, repeatable performance across the entire device operating range. A low temperature effect from ambient temperature change is ensured. The optimized sensor/bypass arrangement minimizes the flow splitting error for gases with different properties, which dramatically improves measurement accuracy when gases other than the calibration gas are used.

Design Features

The design of the MC20A Mass Flow Devices incorporates an advanced flow sensor, a control valve, and an optimized bypass. The latest generation two-element sensing circuit provides accurate, repeatable performance even in low flow ranges (< 10 sccm). A low temperature effect from ambient temperature change and a low attitude sensitivity effect are also ensured. The optimized sensor/bypass arrangement minimizes the flow splitting error for gases with different properties, which dramatically improves measurement accuracy when gases other than the calibration gas are used.

Digital Features

The DeviceNet interface, compliant to ODVA SEMISIG DeviceNet profile, ensures interoperability in any DeviceNet mass flow application. The digital flow calibration, coupled with a standard 11 point calibration, provides for high flow accuracy over a wide range of setpoints. In addition, the digital control loop provides very fast control response, even to low setpoints. The MC20A DeviceNet Mass Flow device accepts up to 20 gas tables.

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Reliability

To provide excellent reliability, the design contains a low mechanical and electronic components count and has successfully passed the following test:

- STRIFE, including temperature cycling and vibration (sine and random tests)

And with a metal braided, shielded cable, properly grounded at both ends:

- EMC Directive 89/336/EEC for CE Mark compliance

Cleanliness Features

The MC20A MFCs use only metal for all external seals. The metal seals eliminate gas permeation and ensure extremely low external leakage. The MC20A MFC mechanical design incorporates minimal wetted surface area and virtual leaks, assuring rapid dry-down. To further enhance its cleanliness, all internal surfaces are precision machined, electropolished, and subjected to a proprietary cleaning process under Class 100 conditions. The instrument is assembled and packaged in a Class 100 clean room environment.

How This Manual is Organized

This manual is designed to provide instructions on how to set up, install, and operate an MC20A Mass Flow Device.

Before installing your MC20A Mass Flow Device in a system and/or operating it, carefully read and familiarize yourself with all precautionary notes in the *Mass Flow Device Safety Information* section at the front of this manual. In addition, observe and obey all WARNING and CAUTION notes provided throughout the manual.

Chapter One: General Information (this chapter) introduces the product and describes the organization of the manual.

Chapter Two: Installation explains the environmental requirements and describes how to mount the instrument in your system.

Chapter Three: Overview gives a brief description of the instrument and its functionality.

Chapter Four: Operation describes how to use the instrument and explains all the functions and features.

Chapter Five: Maintenance lists any maintenance required to keep the instrument in good working condition.

Chapter Six: Troubleshooting provides a reference should the instrument malfunction.

Appendix A: Product Specifications lists the specifications of the instrument.

Appendix B: Gas Correction Factors lists the gas correction factors of commonly used gases.

Appendix C: Model Code Explanation describes the model code.

Appendix D: DeviceNet Attribute Summary summarizes the DeviceNet attributes.

Appendix E: Mass Flow Device Sizing Guidelines describes the guidelines for correctly sizing mass flow devices for your process application and is provided for reference.

Appendix F: MC20A Digital MFC Graphical User Interface describes the Windows-based graphical user interface (GUI). This appendix provides detailed information on the interface kit and user manipulation of gas tables and PID parameters.

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Customer Support

Standard maintenance and repair services are available at all of the regional MKS Calibration and Service Centers. MKS also accepts the instruments of other manufacturers for recalibration using the Primary and Transfer Standard calibration equipment located at our regional service centers.

If any difficulties arise in the use of your MC20A Mass Flow Device, or to obtain information about companion products MKS offers, contact any authorized MKS Calibration and Service Center. If it is necessary to return the instrument to MKS, please obtain an RMA Number (Return Material Authorization Number) from the MKS Calibration and Service Center before shipping. The RMA Number expedites handling and ensures proper servicing of your instrument.

Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Warning **All returns to MKS Instruments must be free of harmful, corrosive, radioactive, or toxic materials.**

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Chapter Two: Installation

How to Unpack the MC20A Mass Flow Device

MKS has carefully packed your MC20A Mass Flow Device so that it will reach you in perfect operating order. Upon receiving the unit, however, you should check for defects, cracks, broken connectors, etc., to be certain that damage has not occurred during shipment.

Note Do *not* discard any packing materials until you have completed your inspection and are sure the unit arrived safely.

If you find any damage, notify your carrier and MKS immediately. If it is necessary to return the unit to MKS, obtain an RMA Number (Return Material Authorization Number) from the MKS Calibration and Service Center before shipping. Please refer to the inside of the back cover of this manual for a list of MKS Calibration and Service Centers.

Opening the Package

The MC20A Mass Flow Device is assembled, leak tested with helium, and calibrated in a clean room environment. The instrument is double-packaged in this environment to ensure maintenance of its particle free condition during shipment. It is very important to remove the packaging according to good clean room practices. To maintain at least a minimal level of clean room standards, follow the instructions below:

1. Remove all cardboard and packaging materials. Discard before entering the garmenting room.
2. Remove the outer plastic shipping container in an ante room (garmenting room) or transfer box.

   Do not allow this container to enter the clean room.
3. Remove the inner bag in the clean room.
4. Inspect for any damage.

Caution **Only qualified individuals should perform the installation and any user adjustments. Individuals must comply with all necessary ESD handling precautions while installing and adjusting the instrument. Proper handling is essential when working with all highly sensitive precision electronic instruments.**

Unpacking Checklist

Standard Equipment:

MC20A Mass Flow Device (Controller or Meter)

MC20A Mass Flow Device Instruction Manual (this book)

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Product Location and Requirements

- Ventilation requirements include sufficient air circulation
- Ambient operating temperature range: 10° to 45° C (50° to 113° F)
- Power requirement: 11-25 VDC, 500 mA maximum current @ 11 VDC (230 mA @ 24 VDC nominal)
- Storage temperature range: -20° to 65° C (-4° and 149° F)

Typically, mount the MC20A MFC in a horizontal, base down (HBD) orientation (SEMI E80-U299 Attitude #1). Prior to installation, check the outlet end of the enclosure for labels indicating alternative orientations. If no label is present, the device is configured for the standard HBD installation.

Install a separate positive shutoff valve if your system cannot tolerate any leakage through the MC20A Mass Flow Device. The internal flow control valve is not a positive shutoff valve so some leakage across the valve may occur.

Warning **Your corporate policy on handling toxic or hazardous gases supersedes the instructions in this manual. Comply with your corporate policy. MKS assumes no liability for the safe handling of such materials.**

- Install the MC20A Mass Flow Device in a "flowing" system where gas is continually added and evacuated. Do ***not*** use the controller in a "dead-ended" system (a system which cannot remove excess mass). The MC20A Mass Flow Device can not vent excess mass to the atmosphere.

Warm up time: 30 minutes

Use high purity gas filters in line upstream of the device.

Observe the pressure limits for the flow device.

Controller:

Maximum gas inlet pressure is 150 psig with properly configured valve (consult factory for cases where inlet pressure is expected to exceed 40 psig).

Operational differential pressure is:

20-50 psid

The standard valve configuration provides control over this pressure range with the outlet at atmospheric pressure.

For additional information, refer to Appendix A, Product Specifications, page 89.

Meter:

Maximum gas inlet pressure is 150 psig in all cases.

Caution **The standard MC20A product is intended for installation in horizontal, base down (HBD) orientation (SEMI E80-U299 Attitude #1).**

Check the orientation label on the outlet end of the device (on the enclosure). If you intend to install in alternative orientations, contact the MKS Service Department for assistance in reconfiguring. Refer to the inside of the back cover of this instruction manual for a complete list of MKS Calibration and Service Centers **for details.**

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Setup

This section describes how to install the MC20A Mass Flow Device into your system.

Follow the guidelines below when setting up the MC20A Mass Flow Device.

1. Set the controller into position where it will be connected to a gas supply. Installation of the MC20A in any orientation other than that for which it was configured, may cause a calibration shift. The MC20A MFC default orientation is horizontal, base down (HBD), SEMI E80-U299 Attitude #1. Prior to installation, check the outlet end of the enclosure for labels indicating alternative orientations. If no label is present, the device is configured for the standard HBD installation. If you intend to install the device in an orientation other than that indicated, contact the MKS Service Department for assistance in reconfiguring.
2. Install the flow device in the gas stream such that the flow will be in the direction of the arrow on the front of the device.
   A. Orient the unit properly.
   B. Mount the unit into place with the proper hardware. Take care that the gas flow is in the direction of the arrow on the enclosure of the unit. For surface mount versions, the gas connection is made at this time. Be sure to insert the appropriate C-seal or W-seal.
   C. Connect the gas supply (if not a surface mount unit). For VCR connections, remember to include the gasket.
   D. Perform external leak test.
   E. Using switches on top of the unit, select the baud rate and MacID, then power unit through the DeviceNet cable. The PGM position allows remote programming of valves through the DeviceNet interface. Refer to Chapter Four, page 39.
   F. Power the unit and allow 30 minute warm-up.
3. Allow adequate clearance for the DeviceNet connector.

Refer below for outline dimensions of the flow devices and locations for the mounting hardware.

Dimensions

Refer to the applicable drawings, which follow.

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Front and Back Views

The front of the MC20A MFC has an arrow to indicate the direction of gas flow through the unit. The back of the MC20A MFC contains the serial label and connector pin-outs.

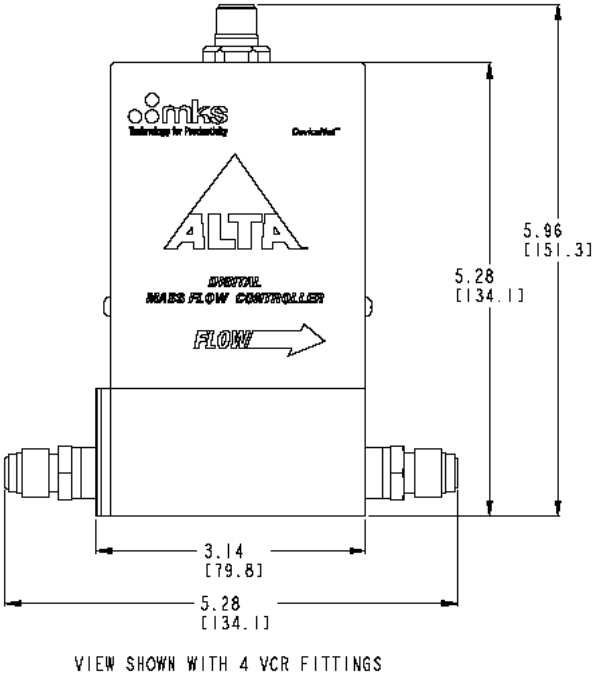


Figure 1: Front View of the MC20A MFC with 4 VCR Fittings

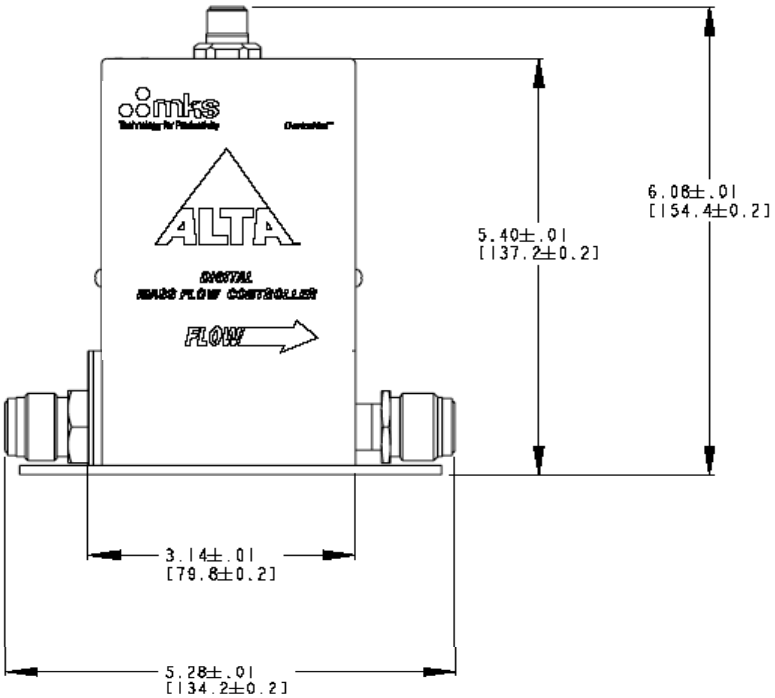


Figure 2: Front View of the MC20A MFC with 8 VCR Fittings (includes required mounting plate)

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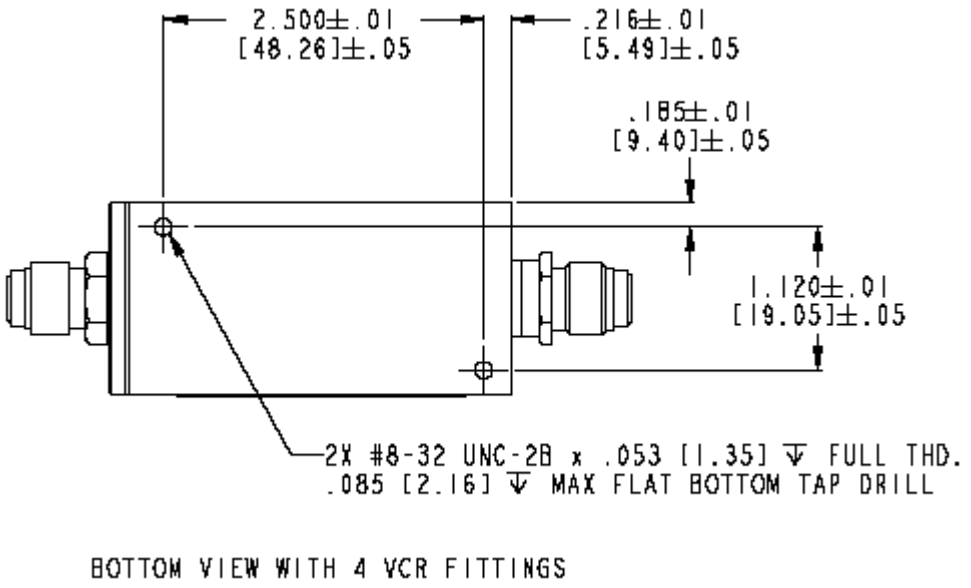


Figure 3: Bottom View of the MC20A MFC with 4 VCR Fittings

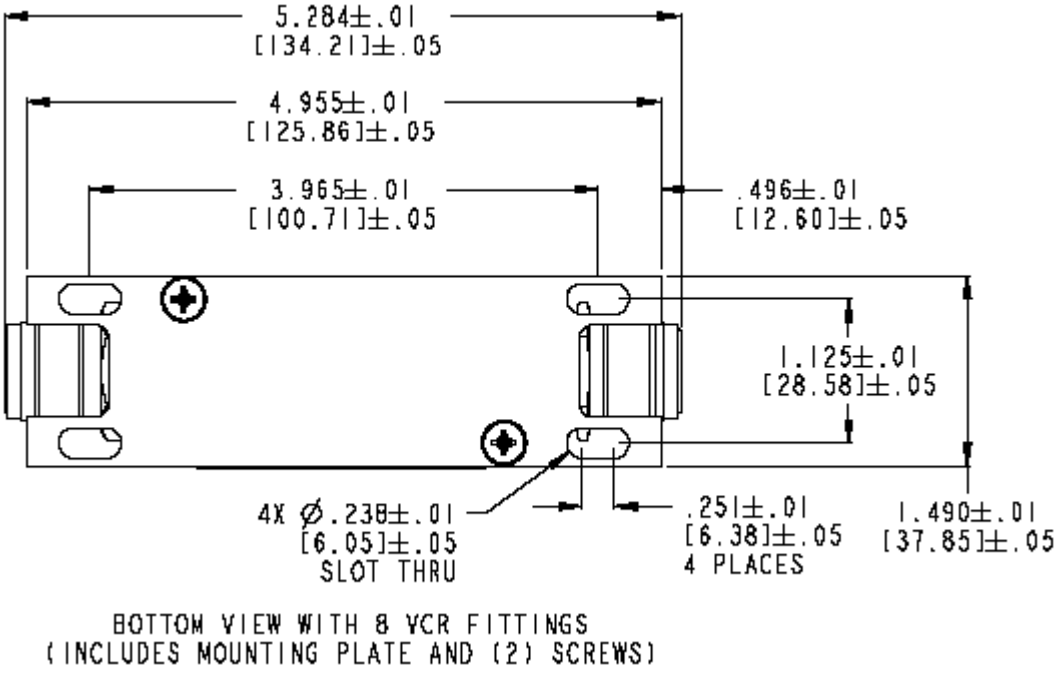


Figure 4: Bottom View of the MC20A MFC with 8 VCR Fittings (includes required mounting plate)

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End View, 4 VCR

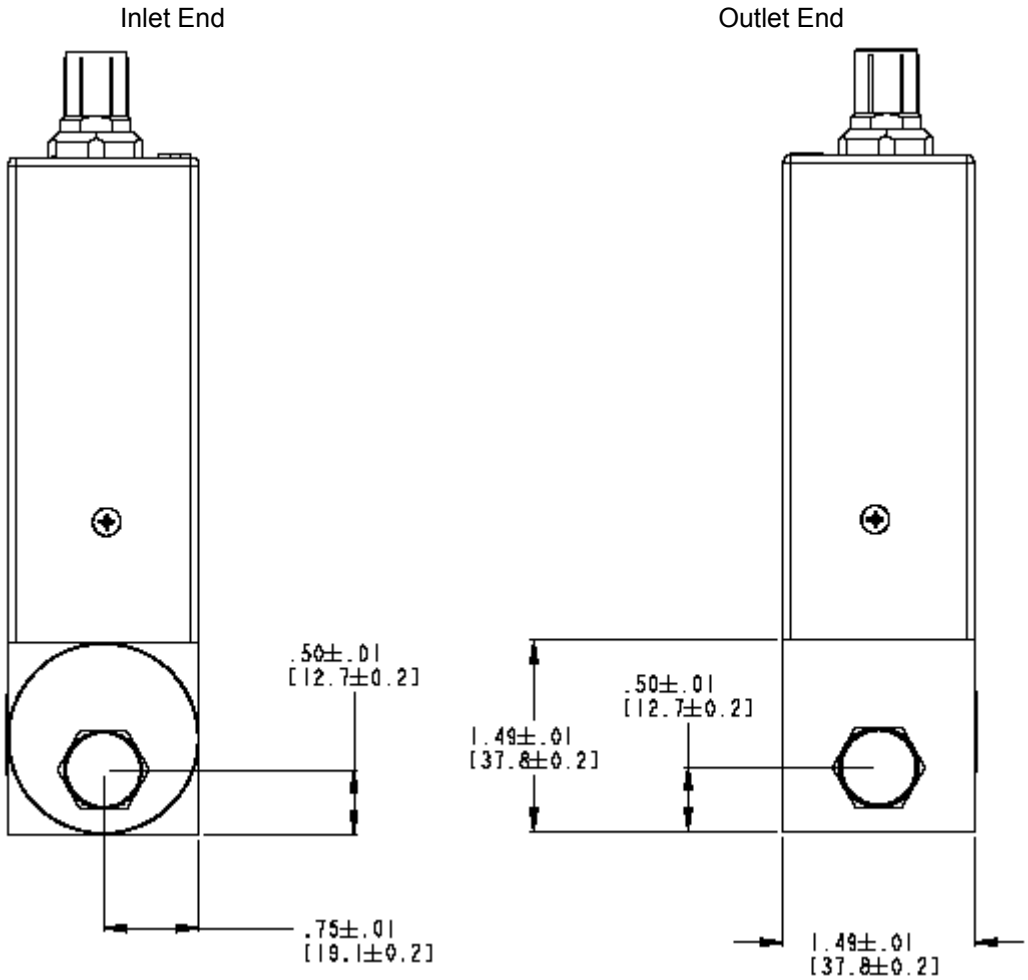


Figure 5: End View of the MC20A MFC with 4 VCR Fittings

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End View, 8 VCR

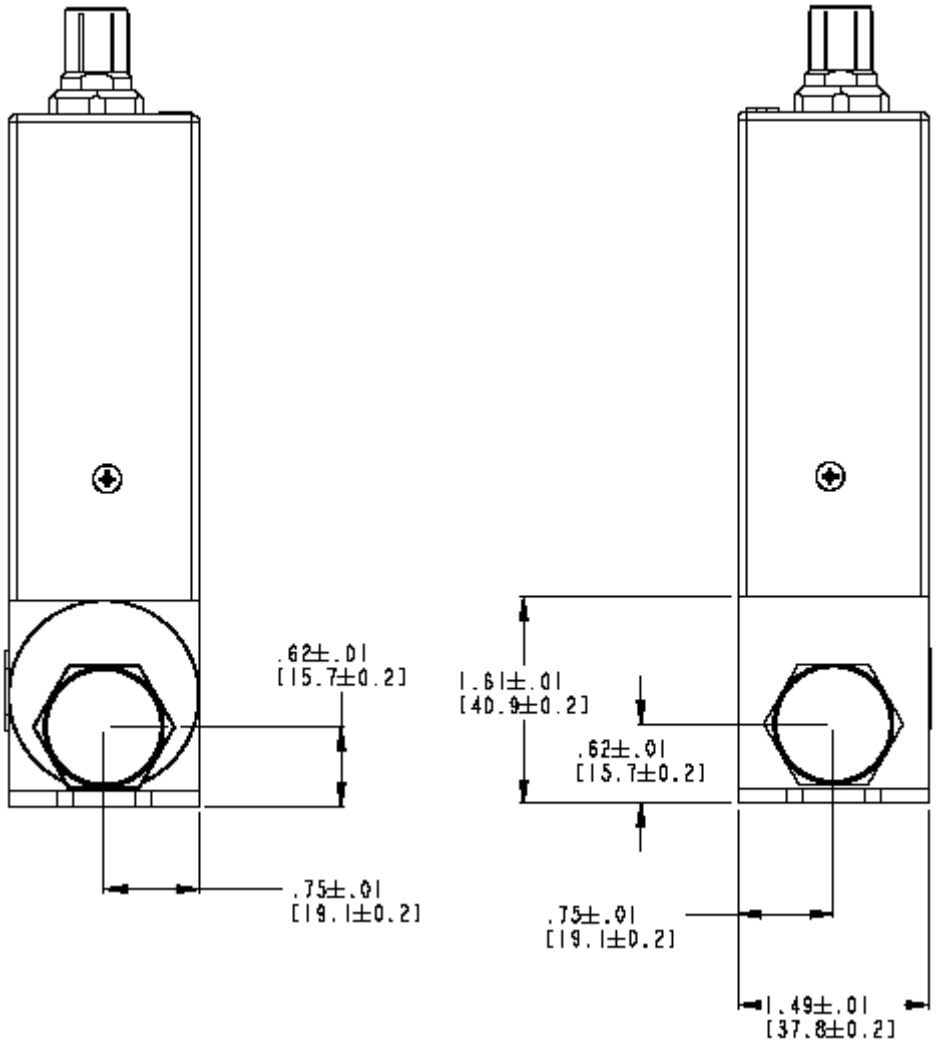


Figure 6: End View of the MC20A MFC with 8 VCR Fittings

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Top View

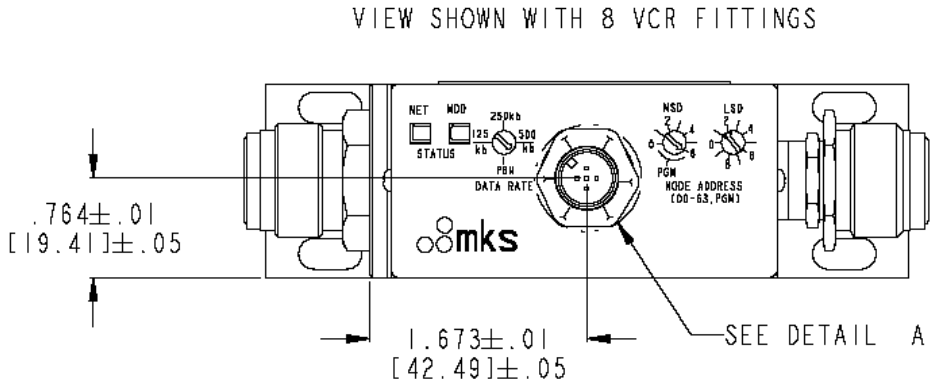


Figure 7: Top View of the MC20A MFC with DeviceNet Interface

Labels

Each MC20A unit has two serial number labels, a small one on top side and the standard, larger label on the back side. Each label shows the serial number, the model code, the full scale flow range, and the calibration gas.

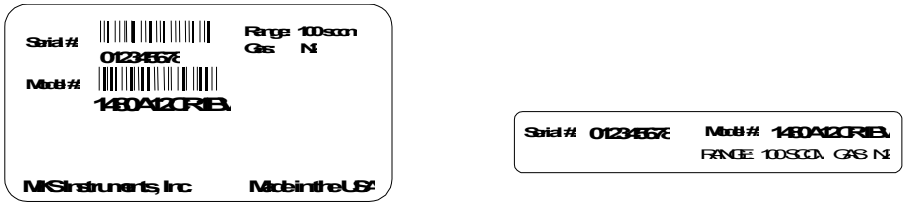


Figure 8: Serial Number Label

Fittings

MC20A MFCs are available with the following fittings:

- Swagelok VCR-4, Male (50 SLM models only)
- Swagelok VCR-8, Male (all flow ranges)

Mounting Hardware for VCR-4 Fittings

MC20A MFCs with VCR-4 male fittings have four threaded mounting holes located on the bottom or base of the unit: two #8-32 and two M4. Depending on the hole pattern chosen, use #8-32 UNC-2B or M4 hardware to mount the instrument. Figures 3 and 4, page 24, show the location and dimensions of the mounting holes for standard axial fittings.

Mounting Hardware for VCR-8 Fittings

MC20A MFCs with VCR-8 male fittings are supplied with an integral mounting plate installed. This plate includes four slotted holes that accept #12 screws.

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Gas Flow

The control valve is *not* a positive shutoff valve. Some leakage across the valve may occur. Refer to Appendix A, Product Specifications, page 89, for the leak integrity specifications. If necessary, install a separate positive shutoff valve in your system.

Note Connect the MC20A Mass Flow Device to your system so that the gas flows in the direction of the flow arrow on the front of the unit.

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Chapter Three: Overview

General Information

Typical Control System Configuration

The MC20A Mass Flow Device is used in a wide variety of control systems, most of which share several characteristics. Typically, a control system consists of four basic parts:

- Mass flow transducer
- Control electronics
- Control valve (Mass Flow Controllers only)
- Flow system (whose flow is being controlled by the MC20A DeviceNet Mass Flow Controller)

The MC20A Mass Flow Controller provides the first three components. The mass flow transducer is an MKS design. The MC20A Mass Flow Controller instrument contains the electronics necessary for flow control. The control valve included in the MC20A Mass Flow Controller is a proportional control valve. The flow system can be any process whose flow you need to control. In addition, the MC20A Mass Flow Controller is capable of metering the mass flow of the gas during the flow control operation.

Flow Measurement Overview

The MC20A MFC measures the mass flow rate of a gas and controls the flow rate according to a given setpoint. The control range is from 2% to 100% of Full Scale (F.S.) with an accuracy of ± 1% of Reading (25% to 100% of Full Scale). For setpoints between 2% and 25%, MC20A MFCs have an accuracy of ±0.25% FS.

Flow Path

Upon entering the MC20A Mass Flow Controller, the gas stream passes first through the metering section of the instrument for its mass flow to be measured. The gas moves on through the control valve, which regulates the flow rate according to the given setpoint, and then exits the instrument at the established rate of flow.

The metering section consists of a sensor tube and parallel bypass.

The geometry of the sensor tube, in conjunction with the specified full scale flow rate, ensures fully developed laminar flow in the sensing region. The bypass elements are specifically matched to the characteristics of the sensor tube to achieve a laminar flow splitting ratio, which remains nearly constant throughout each range.

Flow Control Range

The MC20A MFC can control flow over a range of 2 to 100% of full scale flow. This means that a 50 SLM MC20A MFC can control flow from 1 SLM to 50 SLM, whereas a 200 SLM instrument can control flow from 4 SLM to 200 SLM.

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Measurement Technique

The flow measurement is based on differential heat transfer between temperature sensing heater elements which are attached to the sensor tube. This senses the thermal mass movement which is converted to mass flow via the specific heat, C_p, of the gas.

Control Circuitry

The controller employs the above measurement technique and utilizes a control circuit that provides drive current for the proportioning control valve. The flow controller accepts a setpoint signal, compares it to its own flow signal, and generates an error voltage. This error signal is then conditioned by a PID (Proportional-Integral-Derivative) algorithm and amplified so that it can reposition the control valve, thus reducing the control error to zero.

With a normally closed valve is normally closed, the MC20A Mass Flow Controller instrument lifts the armature and plug assembly from the seat to regulate the gas flow rate.

Control Valve

The control valve is a specially constructed solenoid valve in which the armature (moving valve mechanism) is suspended. The arrangement ensures that no friction is present and makes precise control possible. For an MC20A Mass Flow Controller with a normally-closed valve the control current is used to lift the armature and plug assembly from the seat, allowing a controlled flow of gas.

How the MC20A Mass Flow Controller Works

The MC20A Mass Flow Controller compares the flow reading to the setpoint, and positions the valve to maintain, or achieve, the setpoint rate. The controller functions as a PID (Proportional-Integral-Derivative) controller. The Proportional (P), Integral (I) and the Derivative (D) terms can be adjusted digitally through the DeviceNet connection on the MC20A Mass Flow Controller. To facilitate PID adjustment, MKS Instruments offers a graphical user interface (GUI), which allows for easy communication with the device.

Example

Assume that your MC20A Mass Flow Controller is positioned upstream of the process chamber. The MC20A Mass Flow Controller is positioned *before* the chamber so it will regulate the flow rate of the gas entering the process chamber.

When the actual flow rate reading is *less than* the setpoint value, the MC20A Mass Flow Controller opens the valve to increase the amount of gas entering the system. As the valve opens, assuming adequate differential pressure across the flow controller, gas enters the process chamber, so the flow rate rises to meet the setpoint value.

When the actual flow rate reading is *more than* the setpoint value, the MC20A Mass Flow Controller closes the valve to decrease the amount of gas entering the system. As the valve closes, there is a reduced flow of gas entering the process chamber, so the flow rate decreases to meet the setpoint value.

Note The MC20A Mass Flow Device must have sufficient pressure on its inlet side to achieve the setpoint.

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Overview of MC20A DeviceNet Digital Operation

Your MC20A DeviceNet Mass Flow Device complies with Volume 1 of the ODVA DeviceNet Specification, Release 2 and the associated SEMI-SIG requirements. A detailed software attribute summary pertaining to the DeviceNet communications is provided in Appendix D, page 100.

Gas Tables

Each MC20A Mass Flow Device supports 20 gas calibration tables. The user may copy factory calibrations into new tables to accommodate alternative gases or adjust the full scale flow rate. It is also possible, if certified flow standards are available, to create entirely new calibration tables with up to 21 points. The standard factory calibration contains 11 points.

Tables 0-5 are reserved for MKS factory use only. They may be copied but not erased or edited.
Tables 6-19 may be user created.

The nameplate gas, as the controller is delivered from the factory, is placed in Table 1. Table 0 is reserved for the base factory calibration. Tables 2-5 are reserved for additional factory tables, including tables for process gases (based on the base calibration) and also calibrations performed with alternative gases.

Associated with each table are the PID control parameters. This allows each gas table to have its own optimized PID settings. Activating a particular table automatically activates the associated PID settings. Thus, different process gases can be chosen and the optimum PID parameters can be selected.

Gas tables and associated PID parameters are accessed through the Controller Calibration Object, class code 102 (0x66) as presented in Chapter Four, page 39.

Alternatively, users may access and adjust gas tables through an MKS-supplied GUI communications kit (fully described in Appendix F, page 134). This includes a GUI CD and security hard key and is available in two versions: MKS P/N 133900-G1 with USB port hard key and P/N 133900-G2 with parallel port hard key.

Gas Calibration Table Tagging

All gas calibration tables created at the MKS factory are tagged in a manner which prevents editing or deletion in the field. This ensures that vital calibration and PID tuning information is not lost during subsequent field adjustment. In order to perform a field calibration or change PID parameters, a new table must be created. This is very straight foreword. Commonly, the user desires to change the PID tuning parameters to meet a particular process requirement but would like to maintain the original gas calibration. In such a case, key attributes (gas table and PID parameters among others) in the base instance of Controller Calibration Object can be read and then copied to a second instance, which then can be edited.

User Access

MC20A DeviceNet Mass Flow devices can operate in the following two different access modes:

User mode:	The user mode is available to any operator. It offers access to a limited set of parameters. In user mode, it is possible to operate the device and view many functions but make few changes. The ODVA specification dictates the level of access to all non-propriety objects and attributes.
Calibration mode:	The calibration mode is for use by supervisory personnel at OEM and end user sites. It provides read only access to most functions and write access to certain select functions. A password is required to enter calibration mode.

The device returns the operating mode status to attribute 100(0x64) in the S-Device Supervisor Object.

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Per ODVA requirements, limiting access rights is only possible on attributes in manufacturer specific objects. In MC20A DeviceNet Mass Flow devices, the object of interest is the Controller Calibration Object, class code 102 (0x66). Specific access rights are listed in Table 7, page 34.

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Table 7: User and Calibration Access Rights
Controller Calibration Object only, Class Code 102 (0x66)

Access Level	User Mode	Calibration Mode
Read Only	All Instances: Calibration tables (0x1A – 0x2E) kP (0x01) kI (0x02) kD (0x03) Sensor Speed-up Tau (0x0A) Counts, full scale (0x65) "Factory Tag" Status (0x11)	Factory Tagged Instances: Same as User Mode for all instances.
Read and Write	No write access.	Instances NOT Factory Tagged: Calibration tables (0x1A – 0x2E) kP (0x01) kI (0x02) kD (0x03) Sensor Speed-up Tau (0x0A) Counts, full scale (0x65) "Factory Tag" Status (0x11)

Graphical User Interface

To simplify copying of gas tables and editing PID control variables, MKS offers a PC-based graphical user interface (GUI) kit. This consists of a CD with software and a security hard key that plugs into either the USB or parallel port of the PD, depending on the kit configuration. With a USB hard key, the kit part number is 133900-G1. With a parallel hard key, the part number is 133900-G2.

"Additional Scalar"

When creating new gas tables based on copying an existing calibration table, an Additional Scalar term is required that relates the full scale flow and Gas Corrections Factor (GCF) for the new table to those of the original calibration table that is being copied. The GCFs for common gases are available in Appendix B, page 91.

Additional Scalar = (Original Cal. FS Range/Target FS Range) X (GCF of Target Gas/GCF of Cal. Gas)

Additional Scalars are associated with the gas calibration tables, but are found in the "S-Calibration Object" (class code 0x34) as attribute 7. Also related to creating new gas tables and found in the S-Calibration Object are gas standard number, gas symbol, and full scale flow amount. Refer to Chapter Four, page 39, for more detail.

When copying tables using the MKS graphical user interface, the Additional Scalar is automatically calculated and loaded.

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Tuning the MC20A Mass Flow Controller

Tuning optimizes the MC20A Mass Flow Controller's control of flow rate. The Proportional (P), Integral (I), and Derivative (D) terms adjust the response of the MC20A Mass Flow Controller to changes in either setpoint mass flow rate or system mass flow rate. The controller responds to changes in either the flow rate of the system or the setpoint value.

Accessing PID Variables

The PID tuning parameters are associated with specific gas tables. This allows each gas to have it's own optimized PID values, facilitating gas switching while in service. In technical DeviceNet terms; gas tables and their associated PID values share the same "S-Calibration Object" (class code 0x34) instances.

As with gas tables, PID settings made at the MKS factory are tagged and may not be edited. This is for the user's protection, preventing accidental resetting of values, which may leave a unit inoperable. However, it in no way limits the options available to the user. The user, operating in "calibration mode," simply populates a new instance with gas table and PID values that may be obtained by copying the contents of an existing instance. The resulting information may then be edited as needed to obtain the desired performance. The PID values are located in attributes 1, 2, and 3 of the Controller Calibration Object (class code 0x66).

This approach provides significant flexibility of operation with multiple PID settings to be used with the same gas (but different gas tables).

For most users, editing PID variables is most readily accomplished using the MKS-supplied graphical user interface.

Error Signal

An error signal is the difference between the measured mass flow rate and the setpoint mass flow rate. The error signal is the basis for the operation of the PID algorithm.

Proportional Term

When the Proportional (P) term, or gain, is multiplied by the error signal, a proportional valve drive signal results. The higher the Proportional (P) control, the greater the change in valve drive signal for a given error signal. Typically, a higher Proportional (P) control setting yields a faster response. However, too high a Proportional (P) control setting will cause the mass flow rate to oscillate around the setpoint. Too low a Proportional (P) control setting will result in a slow response from the mass flow controller. Figures 9 and 10 show the effects of the Proportional (P) term.

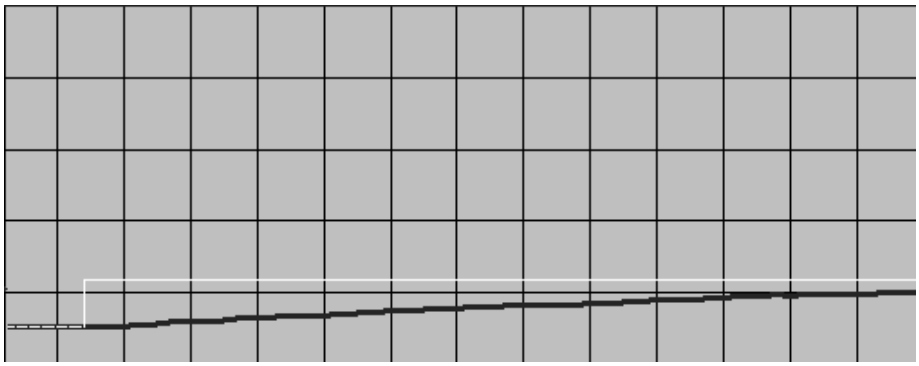


Figure 9: Effects of the Proportional Term (Low Proportional Term)

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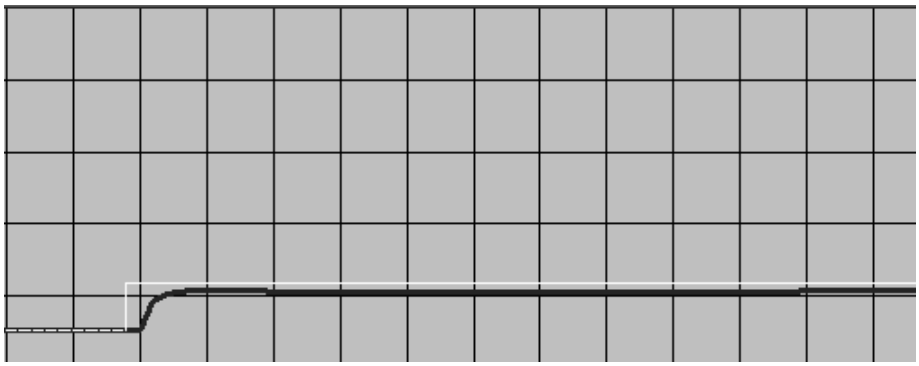


Figure 10: Effects of the Proportional Term (High Proportional Term)

Integral Term

The action of the Integral (I) term creates a valve drive signal that is proportional to the magnitude and sign of the area under the error signal curve (error signal with respect to time). Therefore, as time passes, the integral term acts to position the valve to reduce the error signal to zero. An increase in the integration time increases the period of time over which the error signal is generated, and the system response gets slower. Figures 11 and 12 show the effect of the Integral term.

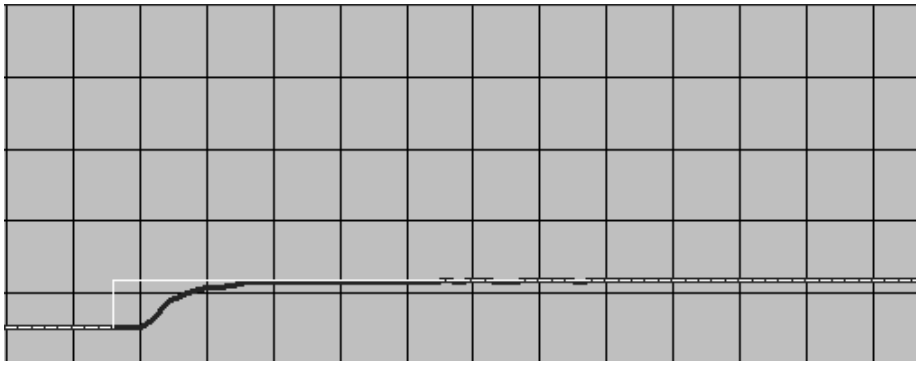


Figure 11: Effects of the Integral Term (Low Integral Term)

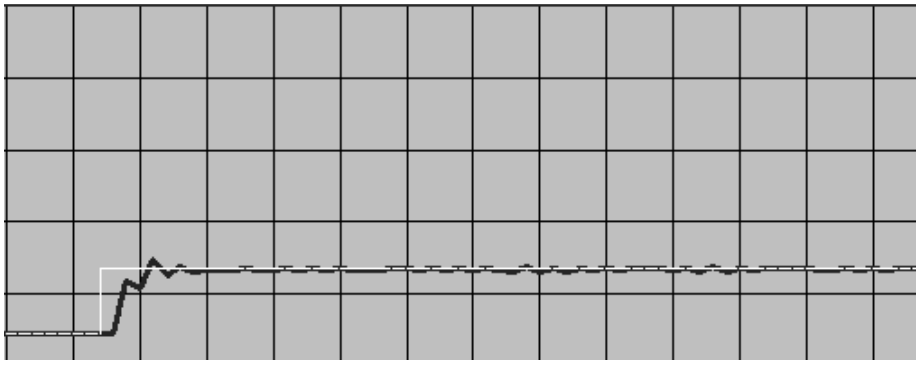


Figure 12: Effects of the Integral Term (High Integral Term)

Note To *shorten* the integration time, *increase* the I term setting.

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Derivative Term

The action of the Derivative (D) term creates a valve drive signal that is proportional to the rate of change of the error signal over time. In moderate amounts, it can be used to reduce overshoot within the system by adding predictive capabilities to the control algorithm. At high rates of change of the error signal as it approaches the setpoint quickly (negative slope of the absolute error over time), the derivative term reduces the effects of the Proportional term. Excessively high Derivative term values can result in instability of the controller. In general, MC20A mass flow controllers control well with the Derivative term equal to zero.

Optimizing PID Control Settings

Optimizing the MC20A Mass Flow Controller response *in your system* involves adjusting the Proportional, Integral, and Derivative (PID) terms. Since every system is different, the optimum PID settings may vary. Operating pressures, process gas density, and target setpoints, all contribute to determining the ideal settings.

Guidelines for Flow Control Tuning

- Tuning is best done with setpoint changes from zero to the target flow rate.
- Units are usually delivered with P values between 2600 and 20,000, I values between 350 and 1000, and the D term set at zero. The P term is generally around 20 times the value of the I term. After optimizing for your process, the PID values generally will remain within this range.
- Increasing the I term will reduce response time, especially at setpoints below 20% of full scale, but promote flow overshoot during setpoint changes. Increasing the P term reduces the overshoot because the controller is able to respond more quickly to the indicated overshoot. However, an excessive P term will cause controller oscillation, a highly undesirable condition. Thus, caution must be exercised in setting the P term aggressively.
- Any adjustments to the P and I terms (D is generally kept at zero) should be done incrementally. For improved response, I should be *increased* in increments of 20 and P in increments of 400 between response tests. If excessive overshoot is observed, the P value may be increased somewhat but should not be allowed to exceed 10,000. For improved control stability, the I term should be *decreased* in similar increments (20 for the I term and 400 for the P term).

The Gas Correction Factor (GCF)

A Gas Correction Factor (GCF) is used to indicate the ratio of flow rates of different gases which will produce the same output voltage from a mass flow device. The GCF is a function of specific heat, density, and the molecular structure of the gases. Since flow devices are usually calibrated with nitrogen, nitrogen is used as the baseline gas (GCF = 1). Appendix B*, Gas Correction Factors*, page 91, lists the gas correction factors for the most commonly used gases. If the gas you are using is not listed in the appendix, you must calculate its GCF using the following equation:

$$GCF_x = \frac{(0.3106)\ (S)}{(d_x)\ (Cp_x)}$$

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where:

GCF_X = Gas Correction Factor for gas X

d_X = Standard Density of gas X, g/l (at 0° C and 760 mmHg)

Cp_X = Specific Heat of gas X, cal/g ° C

0.3106 = (Standard Density of nitrogen) (Specific heat of nitrogen)

S = Molecular Structure correction factor where S equals:

1.030 for Monatomic gases

1.000 for Diatomic gases

0.941 for Triatomic gases

0.880 for Polyatomic gases

Note When using the GCF, the accuracy of the flow reading may vary by ±5%, however, the repeatability will remain ±0.2% of F.S.

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Chapter Four: Operation

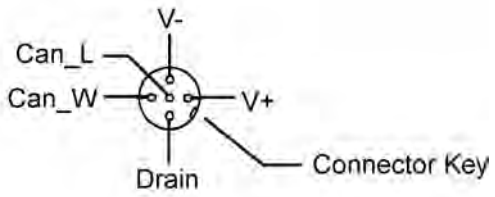
DeviceNet Connector

The MC20A Mass Flow devices have one 5-pin, male DeviceNet connector that provides the communications interface with the DeviceNet network, electrical power from the network bus, and shielding for the instrument signals. Refer to the figures beginning on page 23 for the location of the connector.

Table 8: DeviceNet Communications Connector Pinout

Pin Number	Signal Name
1	Drain
2	V+
3	V-
4	CAN_H
5	CAN_L

Figure 13: DeviceNet Connector Pin Diagram



Power Requirements

The MC20A Mass Flow Controller requires an input voltage of 11.0 to 25.0 VDC with <500 mA max @ 11 VDC (230 mA @ 24 VDC, nominal). The input voltage, provided by the DeviceNet network, is introduced to the mass flow controller through the 5-pin micro-style connector located on top of the instrument.

DeviceNet Controls and Indicators

The top panel, shown in the figure on page 27, of the MC20A Mass Flow device contains several DeviceNet controls and indicators.

The mass flow device has two standard bi-color (green/red) DeviceNet status LEDs, (Module Status LED and Network Status LED) located on top of the instrument, as shown in the figure on page 27. The power-up sequence of these LEDs conforms to the requirements in the ODVA DeviceNet Specification, Volume 1 [1].

Module Status LED

The Module Status LED indicates the status of the individual device, as defined in Table 9, page 39. If no problems are detected, the Module Status LED illuminates a solid green. If a fault condition is detected, the Module Status LED illuminates a solid red. The type of error condition is indicated by whether the light is solid or flashing. Two types of fault condition are reported:

- A flashing red LED indicates a major recoverable fault condition
- A solid red indicates a major unrecoverable fault condition

Table 9: Module Status LED Indicators

LED Status	Signal Name

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Solid Green	System Functioning Normally
Flashing Green	Wink ON
Flashing Red	Recoverable Fault
Solid Red	Unrecoverable Fault
Dark	Power is OFF
Flashing Red/Green	Self-Testing

Recoverable Fault Condition

A checksum error with the EEPROM is a major recoverable fault. This fault condition sets its exception status bit, and the Module Status LED flashes red. The flashing continues until:

- The exception status bit is reset
- A new parameter is saved to EEPROM

Or:

- Power is turned off.

This complies with Volume I of the DeviceNet Specification, Release 2.0.

This fault condition erases all user-changed parameters. The factory defined default values are loaded in the EEPROM so that the unit can operate. See *Exception Alarm Status* in Table 11, page 45, for the information on the exception alarm status bit.

Unrecoverable Fault Condition

A hardware problem with the EEPROM, or a memory problem with the RAM are major unrecoverable faults. This fault condition sets its exception status bit, and the Module Status LED illuminates solid red, complying with Volume I of the DeviceNet Specification.

Note A major unrecoverable fault prevents operation because the device cannot communicate on the network. Contact MKS Instruments, Inc. for assistance.

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Network Status LED

The Network Status LED indicates the status of the communications link. If no problems are detected, the Network Status LED illuminates a solid green. A red, dark, or flashing green Network Status LED indicates a fault condition.

Table 10: Network Status LED Indicators

LED Status	Meaning
Solid Green	Communications link is OK. The device is online and connections are established.
Flashing Green	The device is online but no connections are established. The device has passed the Dup_MAC_ID test and is online, but has no established connections to other nodes.
Solid Red	Critical link failure. The device has detected an error that prevents network communication (Duplicate MAC_ID or bus-off.).
Dark	Not powered / Not online. The device has not completed the Dup_MAC_ID test, or the device is not powered; check the module status LED.

Baud Rate and MAC ID Switches

The baud rate and MAC ID (node address) for your device can be set through software commands using standard DeviceNet protocol over the network, or manually using the rotary switches located on the top panel of the device. The baud rate and MAC ID switches allow you to easily configure units without an operational network, or to network multiple units quickly.

The baud rate and MAC ID rotary switches support an assigned *network* position, labeled on the device as "PGM" to indicate software operation.

If the rotary switch is in the network (PGM) position at power-up, the baud rate or address is read from the non-volatile memory. Any changes to the values must be made over the network; any changes in the rotary switch positions after power-up are ignored.

If the rotary switch is *not* in the network (PGM) position at power-up, the baud rate or address is read directly from the switches.

Note The DeviceNet General Error Codes are listed in the ODVA DeviceNet Specification, Volume 1 [1].

Baud Rate Switch

The 4-position rotary switch, shown in Figure 14, page 42, is used to select the DeviceNet baud rate. The choices are: PGM (the baud rate is read from the non-volatile memory), 125, 250, and 500 Kb.

The switch positions are numbered in a clockwise direction, to correspond to the increasing address values.

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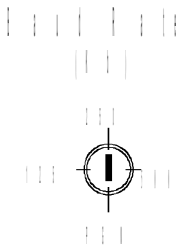


Figure 14: Baud Rate Rotary Switch

MAC ID (Node Address) Switches

Two 10-position rotary switches, shown in Figure 15, are used to set the MAC ID (node address).

The MAC ID is an integer identification value assigned to each node on the DeviceNet network.

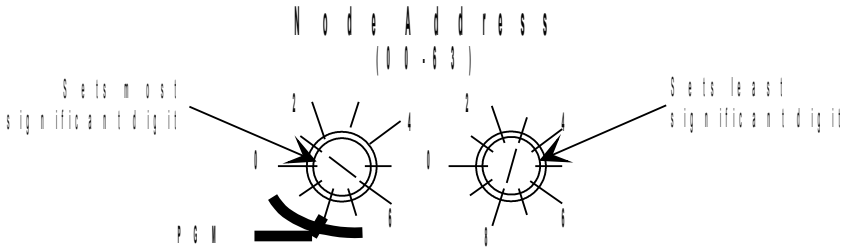


Figure 15: MAC ID (Node Address) Rotary Switches

The valid MAC ID switch positions are 0 to 63. Use the switch on the left to set the most significant digit (MSD), that is, the factor of ten (10, 20, 30...60). Use the switch on the right to set the least significant digit (LSD), that is, the increments of one (1, 2, 3...9). The switch positions are numbered in a clockwise direction, to correspond to the increasing address values.

Note Setting the switches to a value that is greater than 63 is the same as setting the rotary switch to the "PGM" position (the baud rate is read from the non-volatile memory).

Note The MAC ID switch on the top of the device must be set to the network (PGM) position at power up in order for changes to be made over the network. Any changes in the rotary switch positions after power up are ignored.

Power Up

At power-up, flow device performs checks on its communications link and internal diagnostic checks of the EEPROM and RAM. The results of these checks are indicated by the color (green or red) and condition (solid or flashing) of the status LEDs on top of the instrument. The following LED sequence occurs when the MC20A is powered up (times are approximate):

1. The Module Status LED flashes first GREEN for ¼ second, then RED for ¼ second, then turns OFF.
2. The Network Status LED flashes first GREEN for ¼ second, then RED for ¼ second, then turns OFF.
3. The Module Status LED flashes from GREEN to RED for five seconds while the device is initializing. The Network Status LED remains OFF.

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4. The Module Status LED illuminates solid GREEN when initialization is complete.
5. When the device establishes communication with other devices on the network, the Network Status LED illuminates GREEN.

Note If the power up LED sequence does not function properly, contact MKS for assistance.

See the figures beginning on page 27 for the location of the Network Status LED and the Module Status LED. See DeviceNet Controls and Indicators, page 39, for more information on the operation of the Network Status LED and the Module Status LED.

Warm Up Time

After installation and power up, allow the MC20A Mass Flow Device to warm up for a minimum of 30 minutes.

How to Zero the Flow Device

Although MKS flow devices are zeroed at the factory prior to shipment, it is normal to check the zero and re-zero them, if needed, when they are first installed on the tool.

A mass flow device will provide a zero output signal under “no flow” gas conditions. Zero offset from improper zeroing procedures can contribute to flow measurement inaccuracy. This is more apparent at the lower end of the device range.

In order to complete a true zeroing of the device, ensure the following conditions are satisfied prior to beginning the procedure.

Device is installed in the orientation intended for final use (i.e. horizontal base down, vertical flow up, etc.).

Device is powered at operating temperature, preferably for 30 or more minutes.

Devices subject to ambient temperatures other than room temperature (23º C) should be zeroed under those conditions.

Pressure drop and flow across the device is reduced to zero. Depending on the gas panel configuration, this may be done by one of the following procedures.

For Systems With Upstream and Downstream Positive Shut-Off Valves

1. Close both the upstream and downstream shut-off valves.
2. Set the controller to 100% setpoint.
3. Allow pressure across the device to equilibrate as flow output approaches zero and stabilizes.
4. To ensure that actual flow remains at zero, keep the shut-off valves closed.
5. Provide zero setpoint.
6. Wait one minute and activate the zero function. The zero function may be activated in two different ways:
   - Using the set zero command, service code 75 (0x4B) in the S-Analog Sensor Object (class code 0x31).
   - Communicating digitally through the software GUI by clicking the Remote Zero button on the main screen.

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For Systems With Downstream Valve Only

1. Zero the device at typical operating inlet pressure.
2. Close the downstream shut-off valve.
3. Set the device to 100% setpoint (controllers only).
4. Allow pressure to equilibrate across the device as flow output approaches zero and stabilizes.
5. Provide zero setpoint to the controller.
6. Wait one minute and activate the zero function. The zero function may be activated in two different ways:
   - Using the set zero command, service code 75 (0x4B) in the S-Analog Sensor Object (class code 0x31).
   - Communicating digitally through the software GUI by clicking the Remote Zero button on the main screen.

For Systems With Upstream Valve Only

1. The device may be re-zeroed with the downstream line under vacuum or atmosphere.
2. Close the upstream valve.
3. Set the device to 100% setpoint (controllers only).
4. The device may be evacuated to vacuum or exposed to atmosphere on the downstream side.
5. For either case, the downstream pressure must be kept constant to ensure there are no fluctuations in pressure drop across the device, which could induce false flow readings.
6. Allow pressure to equilibrate across the Mass Flow device as flow output approaches zero and stabilizes.
7. Provide zero setpoint to the controller.
8. Wait one minute and activate the zero function. The zero function may be activated in two different ways:
   - Using the set zero command, service code 75 (0x4B) in the S-Analog Sensor Object (class code 0x31).
   - Communicating digitally through the software GUI by clicking the Remote Zero button on the main screen.

DeviceNet Protocol

Use this manual with the ODVA DeviceNET Specification Volume I and Volume II [1, 2], and the SEMI Standards Common and Specific Device Models [3, 4]. Refer to those documents for a complete functional description of the MC20A Mass Flow device.

This chapter defines the application specific objects used by MKS DeviceNet device. It also defines how system requirements are mapped to specific objects and attributes in the DeviceNet protocol. Tables defining the attributes and supported services for each object model are provided. The objects, attributes, and services described in this manual comply with the definition of an interoperable device on a semiconductor equipment sensor/actuator network proposed by SEMI [3, 4].

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Object Models

The object models used by the MC20A Mass Flow device are listed in Table 11. The attributes and services associated with each object Model are defined in this chapter.

Descriptions are supplied throughout this document for attributes and services that are either MKS specific, or require additional specifications beyond the DeviceNet and SEMI specifications [1,2,3,4].

Table 11: Object Models Present in the MC20A

Object Model	Class Code (hex)	Maximum Instances	Functions / Attributes:	See Page
Identity	01	1	General Information per ODVA: Vendor Device Type Product Code Revision Status Serial Number Product Name	47
Message Router	02	1	Routes incoming messages to the appropriate object	49
DeviceNet	03	1	Defines the physical network connections: MAC ID Baud Rate Allocation Information	51
Assembly	04	Process variable	Groups attributes of multiple objects into a single assembly	53
Connection	05	Process variable	Defines the messaging connections	58
S-Device Supervisor	30	1	General information per SEMI Device Type Standard Revision Manufacturer Manufacturer Model Number Firmware/Hardware Revisions Serial Number Device Configuration Device Status Exception Status Exception Detail Alarm Exception Detail Warning Alarm/Warning Enable Run Hours Visual Indicator Operating Mode Ambient Temperature Visual Indicator (“wink function”)	63

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Table 11: Object Models Present in the MC20A (continued)

Object Model	Class Code (hex)	Maximum Instances	Functions / Attributes:	See Page
S-Analog Sensor	31	1	General flow information: Flow Data Type Flow Units Reading Valid Indicated Flow Value Trip Point Status Trip Point Alarm Enable Trip Point Warning Enable Flow Full Scale Zero Data Type Alarm/Warning Trip Points Averaging Time (Filter Settling Time) Select Active Gas Flow Hours Flow Totalizer	69
S-Analog Actuator	32	1	Valve information: Valve Data Units Valve Override Selector Valve Drive Level Value Valve Exception Status Valve Safe State Valve Alarm/Warning Enable Valve Alarm/Warning Error Band	74
S-Single Stage Controller	33	1	Setpoint information: Setpoint Data Type Setpoint Units Setpoint Value Setpoint Status Setpoint Alarm/Warning Enable Setpoint Alarm/Warning Error Band Ramp Rate Setpoint Settling Time	77
S-Gas Calibration	34	20	Gas calibration information: Standard Number Valid Sensor Instance Full Scale Calibration Date Calibration Gas Number Number of Points Calibration Pressure Calibration Temperature Gas Symbol	79

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Table 11: Object Models Present in the MC20A (continued)

Object Model	Class Code (hex)	Maximum Instances	Functions / Attributes:	See Page
Bulk Word	64	1	MFC Hardware Calibration Information	79
Bulk Float	65	1	MFC Hardware Calibration Information	79
Controller Calibration	66	1	MFC Tuning Information	82

Identity Object

The identity object (Class Code 01_{hex}) includes identity and general information about the MKS Type MC20A Mass Flow device with DeviceNet, including the serial number, device type, model number, firmware revisions, hardware revisions, and system status. It is required on all mass flow controller and mass flow meter devices.

The Identity Object includes the standard DeviceNet Identity Object instance attributes defined in the ODVA DeviceNet Specification, Volume II [2]. Additional attributes of the DeviceNet Object, specific to the MC20A instrument, comply with the SEMI Standards [3,4].

The identity object supports the attributes listed in Table 12.

Table 12: Identity Object Attributes

Attribute ID# (hex)	Description	Data Type	Access	Non-Volatile Memory	Data Variable	Initial Setting
01	Vendor ID	UINT	Get	Y	None	36
02	Device Type	UINT	Get	Y	None	26
03	Product Code	UINT	Get	Y	None	4
04	Revision Major Revision Minor Revision	STRUCT OF: USINT USINT	Get	Y	None	 01 01
05	Status	UINT	Get	Y	None	0
06	Serial Number	UDINT	Get	Y	None	device specific
07	Product Name Length Name	STRUCT OF: USINT STRING [16]	Get	Y	None	 16 MC20A DeviceNet
08	State	USINT	Get	Y	None	0
100	Controller Rev Major Revision Minor Revision	STRUCT OF: USINT USINT	Get	Y	None	 01 01

Vendor ID

Attribute ID #1 reports the registered vendor of the device. MKS Instruments, Inc. is identified as vendor #36.

Device Type

Attribute ID #2 reports the type of device on the network, in accordance with the ODVA DeviceNet Specification, Volume II.

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Product Code

Attribute ID #3 reports the product code as the integer 4 per the ODVA DeviceNet Specification, Volume II.

Revision

Attribute ID #4 reports the software revision per the ODVA DeviceNet Specification, Volume II. The major revision number will increment as functional enhancements are implemented. The minor revision number will increment if minor software changes and bug fixes are incorporated.

Status

Attribute ID #5 reports the device status per the ODVA DeviceNet Specification, Volume II. The status of the device is determined from the bit positions that are set in the returned unsigned integer value. A short table describing the status bytes is given below:

Table 13: Status Bytes

Status Information		
Bit Position	**Field Description**	**Field Interpretation**
00	owned	0 = not owned 1 = owned (allocated)
01	reserved	0
02	configured	0
03	reserved	0
04	vendor specific	0
05	vendor specific	0
06	vendor specific	0
07	vendor specific	0
08	minor configuration fault	0 = no fault 1 = minor configuration fault
09	minor device fault	0 = no fault 1 = minor device fault
10	major configuration fault	0 = no fault 1 = major configuration fault
11	major device fault	0 = no fault 1 = major device fault
12	reserved	0
13	reserved	0
14	reserved	0
15	reserved	0

Serial Number

Attribute ID #6 reports the device serial number per the ODVA DeviceNet Specification, Volume II. The serial number in encoded in the product during the manufacturing process and is guaranteed to be unique across all product lines produced by MKS Instruments, Inc.

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Product Name

Attribute ID #7 reports the product name as MC20A DeviceNet, per the ODVA DeviceNet Specification, Volume II.

State

Attribute ID #8 reports the device state per the ODVA DeviceNet Specification, Volume II. The device state reflects whether any errors have occurred during operation and the severity of the errors. The following device states are supported. The only exit from a Major Unrecoverable Fault condition is a power cycling of the device. This can be accomplished by physically disconnecting and then reconnecting the device to the DeviceNet network.

Table 14: State Bytes

State Information		
State	**Interpretation**	**Cause**
0	Non-Existent	
1	Self Test	
2	Standby	
3	Operating	Normal Operating Mode
4	Major Recoverable Fault	See S-Device Supervisor alarm detail
5	Major Unrecoverable Fault	See S-Device Supervisor alarm detail

Controller Rev

Attribute ID #100 reports the controller revision. The major revision number will increment as functional enhancements are implemented to the control algorithm and controller firmware. The minor revision number will increment if minor software changes and bug fixes to the controller firmware incorporated.

The supported DeviceNet services are listed in Table 15.

Table 15: Identity Object Supported Services

Service ID# (hex)	Service Name	Data Type	Service Type	Description
0E	Get_Attribute_Single	UINT	Request	Reads the object attribute.
05	Reset	USINT	Request	Place the object into its INITIALIZING state. Emulates a power cycle.

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Message Router Object

The Message Router Object (Class Code 02_{hex}) interprets incoming messages and routes it to the proper device object. The MKS Type MC20A Mass Flow device with DeviceNet supports few message router attributes.

For a description of the Message Router Object, refer to Volume II of the OVDA DeviceNet Specification.

The message router object supports the attributes listed in Table 16.

Table 16: Message Router Object Attributes

Attribute ID# (hex)	Description	Data Type	Access	Non-Volatile Memory	Data Variable	Initial Setting
02	Number of Connections	UINT	Get	Y	None	2

The supported DeviceNet services are listed in Table 17.

Table 17: Message Router Object Supported Services

Service ID# (hex)	Service Name	Data Type	Service Type	Description
0E	Get_Attribute_Single	UINT	Request	Reads the object attribute.

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DeviceNet Object

The DeviceNet Object (Class Code 03_{hex}) contains attributes defining the configuration and status of physical attachments to the DeviceNet network. The DeviceNet Object supports the attributes listed in Table 18.

Table 18: DeviceNet Object Attributes

Attribute ID# (hex)	Description	Data Type	Access	Non-Volatile Memory	Data Variable	Initial Setting
01	Node Address	USINT	Get/Set	Y	0 to 63	63
02	Data Rate	USINT	Get/Set	Y	0 = 125k 1 = 250k 2 = 500k	0
03	Bus-Off Interrupt	BOOL	Get		00 = Hold bus-off state when it occurs 01 = Restore bus, if possible	0
04	Bus-Off Counter	USINT	Get/Set			0
05	Allocation Information Allocation Choice Byte Master's Node Address	STRUCT of: BYTE USINT	Get		 0 = Explicit 1 = Polled 0 to 63, 255 255 = Not Allocated	 1 255
06	MAC ID Switch Change	BOOL	Get	N		0
07	Data Rate Switch Change	BOOL	Get	N		0
08	Current MAC ID Switch	USINT	Get	N		
09	Current Data Baud Rate Switch	USINT	Get	N		

Node Address

Attribute ID #1 defines the Node Address (network address) of the device per the DeviceNet Specification, Volume II. Any address from 0 to 63 can be used. The MC20A is shipped with the address set to 63.

The Node Address, also known as the MAC ID, is set using two BCD rotary switches located on the top of the device, as described previously. Valid MAC ID addresses are 0 to 63 (0x00 to 0x3F). Setting the MAC ID address to a value greater than 63 will disable the rotary switches and allow the internal software setting of the MAC ID. The software setting defaults to the last hardware setting stored in non-volatile memory. The rotary switches are only read during power up.

Data Rate

Attribute ID #2 defines the data rate of the device per the DeviceNet Specification, Volume II. The data rate can be set to 125k, 250k, or 500k, where:

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Table 19: Data Rate Byte

Data Rate Information	
State	**Interpretation**
0	125 k (initial)
1	250 k
2	500 k
3	Software settable

The MC20A is shipped with the data rate set to 125 K. The value returned will be the switch value if the switch value is less than 4 or it will return the last data rate.

Bus-Off Interrupt

Attribute ID#3 reports whether an interrupt resets the bus, or the bus is held off.

Bus-Off Counter

Attribute ID#4 reports the number of times the MC20A unit has gone bus-off, per the DeviceNet Specification, Volume II. Whenever the bus-off counter is reset, the value returns to 0 regardless of the data value provided in the communication.

Allocation Information

Attribute ID #5 indicates whether a Master/Slave connection set has been allocated, which device has performed the allocation, and which connections are allocated.

MAC ID Switch Change

Attribute ID#6 reports whether the MAC ID rotary switches have been changed since the unit was last powered up.

Data Rate Switch Change

Attribute ID#7 reports whether the data rate rotary switch has been changed since the unit was last powered up.

Current MAC ID Switch

Attribute ID#8 reports the current value of the MAC ID rotary switch settings.

Current Data Rate Switch

Attribute ID#9 reports the current value of the data rate rotary switch setting.

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DeviceNet Object Supported Services

The four services listed in Table 20 support the DeviceNet Object.

Table 20: DeviceNet Object Supported Services

Service ID# (hex)	Service Name	Data Type	Service Type	Description
0E	Get_Attribute_Single	USINT	Request	Reads the object attribute.
10	Set_Attribute_Single	USINT	Request	Modifies the object attribute.
4B	Allocate_Master_Slave	BYTE, USINT	Request	Allocates the Predefined Master/Slave Connection Set.
4C	Release_Master_Slave	BYTE	Request	Releases the Predefined Master/Slave Connection Set.

Assembly Object

The Assembly Object (Class Code 04hex) binds the attributes of multiple other objects, allowing a single connection to carry data to or from them.

Table 21: Assembly Object Attributes

Attribute ID# (hex)	Description	Data Type	Access	Non-Volatile Memory	Data Variable	Initial Setting
03	Data Format	ARRAY of BYTE	Get/Set	N	None	None

Data Format

Attribute ID #03 reports the assembly data for the specified instance.

Supported Assembly Instances

Input and output assembly instances are defined relative to the network, as specified by ODVA.

Table 22: Supported Static Input Assembly Instances

Instance		Data
(hex)	(int)	
0x01	(1)	Flow Reading (Integer)
0x02	(2)	Status and Flow Reading (Integer)
0x03	(3)	Status, Flow Reading (Integer), and Valve (Integer)
0x06	(6)	Status, Flow Reading, Flow Setpoint, Override, and Valve (Integer)
0x0E	(14)	Status and Flow Reading (Real)
0x12	(18)	Status, Flow Reading, Flow Setpoint, Override, and Valve (Real)

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Table 23: Assembly Object Static Input Instances

Assembly Instance ID# (hex)	Description	Data			Class Code ID# (hex)	Instance ID# (hex)	Attribute ID# (hex)
01	Poll Response #1	Flow β	INT byte 0 byte 1	INT Flow β (low byte) Flow β (high byte)	31	01	06
02	Poll Response #2	Status β Flow β	USINT INT byte 0 byte 1	 INT Flow β (low byte) Flow β (high byte)	30 31	01 01	0C 06
03	Poll Response #3	Status β Flow β Valve β	USINT INT byte 0 byte 1 INT byte 0 byte 1	 INT Flow β (low byte) Flow β (high byte) INT Valve β (low byte) Valve β (high byte)	30 31 32	01 01 01	0C 06 06
06	Poll Response #4	Status β Flow β Setpoint β Override β Valve β	USINT INT byte 0 byte 1 INT byte 0 byte 1 USINT INT byte 0 byte 1	 INT Flow β (low byte) Flow β (high byte) INT Setpoint β (low byte) Setpoint β (high byte) INT Valve β (low byte) Valve β (high byte)	30 31 33 32 32	01 01 01 01 01	0C 06 06 05 06
0E	Poll Response #5	Status β Flow β	USINT REAL byte 0 byte 1 byte 2 byte 3	 REAL Flow β (low byte) Flow β Flow β Flow β (high byte)	30 31	01 01	0C 06
12	Poll Response #6	Status β Flow β Setpoint β Override β Valve β	USINT REAL byte 0 byte 1 byte 2 byte 3 REAL byte 0 byte 1 byte 2 byte 3 USINT REAL byte 0 byte 1 byte 2 byte 3	 REAL Flow β (low byte) Flow β Flow β Flow β (high byte) REAL Setpoint β (low byte) Setpoint β Setpoint β Setpoint β (high byte) REAL Valve β (low byte) Valve β Valve β Valve β (high byte)	30 31 33 32 32	01 01 01 01 01	0C 06 06 05 06

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β refers to data that is received from the mass flow device. δ refers to data that is sent to the mass flow device. Assembly instance 0x01, 0x02, 0x06, 0x0E, and 0x12 are used to generate the POLL response packet and consists of the data described in the table above. Assembly instance 0x07, 0x08, 0x13, and 0x14 are used to consume the POLL request packet and consists of the data described in the table below.

The poll response is ***always*** returned when an I/O poll request is issued.

Poll Response #1

Assembly instance ID #01 reports:

Indicated Flow Value from the S-Analog Sensor Object in integer representation (refer to Indicated Flow Value, page 71)

Poll Response #2

Assembly instance ID #02 reports:

Exception Status from the S-Device Supervisor Object (refer to Exception Status, page 66)

Indicated Flow Value from the S-Analog Sensor Object in integer representation (refer to Indicated Flow Value, page 71)

Poll Response #3

Assembly instance ID #03 reports:

Exception Status from the S-Device Supervisor Object (refer to Exception Status, page 66)

Indicated Flow Value from the S-Analog Sensor Object in integer representation (refer to Indicated Flow Value, page 71)

Valve Drive Level Value from the S-Analog Actuator Object in integer representation (refer to Valve Drive Level Value, page 75)

Poll Response #4

Assembly instance ID #06 reports:

Exception Status from the S-Device Supervisor Object (refer to Exception Status, page 66)

Indicated Flow Value from the S-Analog Sensor Object in integer representation (refer to Indicated Flow Value, page 71)

Set Point Value from the S-Single Stage Controller Object in integer representation (refer to Setpoint, page 78)

Valve Override Selector from the S-Analog Actuator Object (refer to Valve Override Selector, page 75)

Valve Drive Level Value from the S-Analog Actuator Object in integer representation (refer to Valve Drive Level Value, page 75)

Poll Response #5

Assembly instance ID #0E reports:

Exception Status from the S-Device Supervisor Object (refer to Exception Status, page 66)

Indicated Flow Value from the S-Analog Sensor Object in floating point representation (refer to Indicated Flow Value, page 71)

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Poll Response #6

Assembly instance ID #12 reports:

Exception Status from the S-Device Supervisor Object (refer to Exception Status, page 66)

Indicated Flow Value from the S-Analog Sensor Object in floating point representation (refer to Indicated Flow Value, page 71)

Set Point Value from the S-Single Stage Controller Object in floating point representation (refer to Setpoint, page 78)

Valve Override Selector from the S-Analog Actuator Object (refer to Valve Override Selector, page 75)

Valve Drive Level Value from the S-Analog Actuator Object in floating point representation (refer to Valve Drive Level Value, page 75)

Table 24: Supported Static Output Assembly Instances

Instance		Data
(hex)	(int)	
0x07	(7)	Flow Setpoint (Integer)
0x08	(8)	Override and Flow Setpoint (Integer)
0x13	(19)	Flow Setpoint (Real)
0x14	(20)	Override and Flow Setpoint (Real)

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Table 25: Assembly Object Static Output Instances

Assembly Instance ID# (hex)	Description	Data			Class Code ID# (hex)	Instance ID# (hex)	Attribute ID# (hex)
07	Poll Request #1	Setpoint δ	INT byte 0 byte 1	INT Setpoint δ (low byte) Setpoint δ (high byte)	33	01	06
08	Poll Request #2	Override δ Setpoint δ	USINT INT byte 0 byte 1	 INT Setpoint δ (low byte) Setpoint δ (high byte)	32 33	01 01	05 06
13	Poll Request #3	Setpoint δ	REAL byte 0 byte 1 byte 2 byte 3	REAL Setpoint δ (low byte) Setpoint δ Setpoint δ Setpoint δ (high byte)	33	01	06
14	Poll Request #4	Override δ Setpoint δ	USINT REAL byte 0 byte 1 byte 2 byte 3	 REAL Setpoint δ (low byte) Setpoint δ Setpoint δ Setpoint δ (high byte)	32 33	01 01	05 06

Poll Request #1

Assembly instance ID #07 reports:

Set Point Value from the S-Single Stage Controller Object in integer representation (refer to Setpoint, page 78)

Poll Request #2

Assembly instance ID #08 reports:

Valve Override Selector from the S-Analog Actuator Object (refer to Valve Override Selector, page 75)

Set Point Value from the S-Single Stage Controller Object in integer representation (refer to Setpoint, page 78)

Poll Request #3

Assembly instance ID #13 reports:

Set Point Value from the S-Single Stage Controller Object in floating point representation (refer to Setpoint, page 78)

Poll Request #4

Assembly instance ID #08 reports:

Valve Override Selector from the S-Analog Actuator Object (refer to Valve Override Selector, page 75)

Set Point Value from the S-Single Stage Controller Object in integer representation (refer to Setpoint, page 78)

Assembly Object Supported Service

The Assembly Object is supported by the DeviceNet common service listed in Table 26.

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Table 26: Assembly Object Supported Services

Service ID# (hex)	Service Name	Data Type	Service Type	Description
0E	Get_Attribute_Single	USINT	Request	Reads the object attribute.
10	Set_Attribute_Single	USINT	Request	Sets the object attribute.

Connection Object

The Connection Object (Class Code 05_{hex}) contains the attributes that define the messaging connections in the device. Each connection is defined by the type of messaging (Explicit or I/O) it supports. As a Group 2 Slave Only device, the MC20A supports one explicit message connection and a POLL message connection.

Explicit Messaging

Explicit messaging connections use a direct request / response format, per the DeviceNet Specification.

Poll Request / Response Messaging

The Poll Request is an I/O message transmitted by the Master. It is directed towards a single, specific Slave (point-to-point). A Master must transmit a separate Poll Request Message for each slave to be polled. The Poll Response is an I/O message that a Slave transmits back to the Master in response to the Poll Request. Within a Slave, a single Connection Object receives and transmits the Poll Request and Poll Response messages.

Table 27: Connection Object Instances

Instance ID# (hex)	Description
01	Explicit Messaging
02	I/O Poll Messaging

Table 28 describes the Connection Object explicit messaging attributes.

Table 28: Connection Object (Explicit Messaging) Attributes

Attribute ID# (dec)	Description	Data Type	Explicit Connection	Default Setting
01	State of Object	USINT	Get	
02	Instance Type	USINT	Get	0 = Explicit Message
03	Transport Class Trigger	USINT	Get	0x83
04	Produced Connection ID	UINT	Get/Set*	
05	Consumed Connection ID	UINT	Get/Set*	
06	Initial Communication Characteristics	USINT	Get/Set*	0x21=Explicit
07	Produced Connection Size	UINT	Get/Set*	128
08	Consumed Connection Size	UINT	Get/Set*	17
09	Expected Packet Rate	UINT	Get/Set**	2500 msec
12	Watchdog Timeout Action	USINT	Get/Set**	0
13	Produced Connection Path Length	UINT	Get	0
14	Produced Connection Path	Array of: USINT	Get/Set*	Empty

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15	Consumed Connection Path Length	UINT	Get	0
16	Consumed Connection Path	Array of: USINT	Get/Set*	Empty
* Set only when the connection is in configuring mode.				
** Set not allowed when the connection is waiting for a connection ID.				

Table 29 describes the Connection Object I/O polled messaging attributes.

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Table 29: Connection Object (I/O Polled Messaging) Attributes

Attribute ID# (dec)	Description	Data Type	I/O Connection	Default Setting
01	State of Object	USINT	Get	
02	Instance Type	USINT	Get	1 = I/O Messsaging
03	Transport Class Trigger	USINT	Get	0x83
04	Produced Connection ID	UINT	Get	
05	Consumed Connection ID	UINT	Get	
06	Initial Communication Characteristics	USINT	Get	0x01=I/O
07	Produced Connection Size	UINT	Get	
08	Consumed Connection Size	UINT	Get	
09	Expected Packet Rate	UINT	Get/Set	2500 msec
12	Watchdog Timeout Action	USINT	Get/Set	0
13	Produced Connection Path Length	UINT	Get	6
14	Produced Connection Path	STRUCT of: USINT USINT USINT USINT USINT USINT	Get	 0x20 0x04 0x24 0x02 (default) 0x30 0x03
15	Consumed Connection Path Length	UINT	Get	6
16	Consumed Connection Path	STRUCT of: USINT USINT USINT USINT USINT USINT	Get	 0x20 0x04 0x24 0x07 (default) 0x30 0x03
* Set only when the connection is in configuring mode.				
** Set not allowed when the connection is waiting for a connection ID.				

State of Object

Attribute #1 indicates the device state as a value between 1 and 5. Table 30 lists the meanings of the values.

Table 30: State Value Descriptions

Value	State Name	Description
0	Nonexistent	No connection exists.
1	Configuring	The connection exists and is waiting for configuration.
2	Waiting For Connection	Consumed or produced connection ID not set.
3	Established	The connection has been configured; configuration is applied.
4	Timed Out	May result from an Inactivity/Watchdog timeout.

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Produced Connection ID

Attribute ID #04 reports the produced connection ID for the specified instance according to the following table.

Connection 1 Produced Connection ID: 10xxxxxx011
Connection 2 Produced Connection ID: 01111xxxxxx

where xxxxxx represents the Network Address of the device.

Consumed Connection ID

Attribute ID #05 reports the consumed connection ID for the specified instance according to the following table.

Connection 1 Consumed Connection ID: 10xxxxxx100
Connection 2 Consumed Connection ID: 10xxxxxx101

where xxxxxx represents the Network Address of the device.

Produced Connection Size

Attribute ID #07 reports the produced connection size for the specified instance according to the following table, where the Assembly ID# refers to the Assembly Instance from the Assembly Object chosen for the POLL Request of the I/O poll messaging.

Table 31: Produced Connection Size

Assembly ID# (hex)	Size
01	2
02	3
06	8
0E	5
12	14

Consumed Connection Size

Attribute ID #08 reports the consumed connection size for the specified instance according to the following table, where the Assembly ID# refers to the Assembly Instance from the Assembly Object chosen for the POLL Response of the I/O poll messaging.

Table 32: Consumed Connection Size

Assembly ID# (hex)	Size
07	2
08	3
13	4
14	5

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Watchdog Timeout Action

Attribute ID #12 reports the action taken by the device on a condition when the watchdog timer has expired during either explicit or I/O polled messaging.

Table 33: Watchdog Timeout Action

Watchdog Value	Behavior
0	Timeout
1	Auto Delete
2	Auto Reset

Connection Object Supported Services

The supported Connection Object services are listed in Table 34.

Table 34: Connection Object Supported Services

Service ID# (hex)	Service Name	Data Type	Service Type	Description
05	Reset	USINT	Request	Place the object into its INITIALIZING state.
0E	Get_Attribute_Single	USINT	Request	Reads the object attribute.
10	Set_Attribute_Single	USINT Attribute Data Type	Request	Modify the object attribute.

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S-Device Supervisor Object

The S-Device Supervisor Object (Class Code 30_{hex}) manages the functions and behaviors of all the S-type objects. Table 35 lists the attributes contained in this object.

The S-Device Supervisor Object includes most of the same information, in a different format, that is available in the Identity Object, in accordance with the ODVA DeviceNet Specification, Volume II [2]. In addition, the S-Device Supervisor Object includes attributes specific to the MKS mass flow device, which comply with the SEMI Standards Common and Specific Device Models [3, 5].

One instance of the S-Device Supervisor Object is supported with 23 instance attributes and eight DeviceNet services.

Table 35: S-Device Supervisor Object Attributes

Attribute ID# (hex)	Description	Data Type	Run Mode Access	Cal Mode Access	Non Volatile Memory	Data Variable	Initial Setting
03	Device Type	SHORT STRING [8]	Get	Get	Yes	MFC/MFM	MFC
04	SEMI Standard Revision Level	SHORT STRING [9]	Get	Get	Yes	None	E54--0997
05	Manufacturer Name	SHORT STRING [20]	Get	Get	Yes	None	MKS Instruments
06	Manufacturer Model Number	SHORT STRING [20]	Get	Get	Yes	None	MC20A
07	Firmware Revision	SHORT STRING [5]	Get	Get	Yes	Current Revision	1.000
08	Hardware Revision	SHORT STRING [5]	Get	Get	Yes	Current Revision	1.000
09	Serial Number	SHORT STRING [30]	Get	Get	Yes	None	device specific
0B	Device Status	USINT	Get	Get	No	0=Undefined 1=Self Test 2=Idle 3=Self Test Exc 4=Executing 5=Abort 6=Critical Fault	0
0C	Exception Status	USINT	Get	Get	No	None	0x80

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Table 35: S-Device Supervisor Object Attributes (continued)

Attribute ID# (hex)	Description	Data Type	Run Mode Access	Call Mode Access	Non Volatile Memory	Data Variable	Initial Setting
0D	Exception Detail Alarm		Get	Get	No	None	0
	Common Exception Detail	STRUCT of:					
	Size	USINT					
	Detail	Array of:					
	Detail n	BYTE					
	Device Exception Detail	STRUCT of:					
	Size	USINT					
	Detail	Array of:					
	Detail n	BYTE					
	Manufacturer Exception Detail	STRUCT of:					
	Size	USINT					
	Detail	Array of:					
	Detail n	BYTE					
0E	Exception Detail Warning		Get	Get	No	None	0
	Common Exception Detail	STRUCT of:					
	Size	USINT					
	Detail	Array of:					
	Detail n	BYTE					
	Device Exception Detail	STRUCT of:					
	Size	USINT					
	Detail	Array of:					
	Detail n	BYTE					
	Manufacturer Exception Detail	STRUCT of:					
	Size	USINT					
	Detail	Array of:					
	Detail n	BYTE					
0F	Alarm Enable	BOOL	Get/Set	Get/Set	Yes	0=Disable 1=Enable	0
10	Warning Enable	BOOL	Get/Set	Get/Set	Yes	0=Disable 1=Enable	0

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Device Type

Attribute ID #03 reports the type of device on the network using an ASCII string. In the response, the unit is defined as either a mass flow controller (MFC) or a mass flow meter (MFM).

Standard Revision Level

Attribute ID #04 reports the most recent version of the SEMI Standards Device Model to which the unit adheres. The response is a 9 character (maximum) ASCII string "ENNNNNNYY" where:

E = SEMI assigned value

NNNNNN = Number of the standard [6]

YY = Year of the published standard

The default string is "E54--0997."

Manufacturer Name

Attribute ID #05 reports the maker of the mass flow device, using an ASCII string. The manufacturer of the unit is always reported as MKS Instruments, identified with the ASCII string "MKS Instruments"

Manufacturer Model Number

Attribute ID #06 reports the model number of the instrument with an ASCII string. The response reports the type of mass flow device in use, identified with the ASCII string "180A" or "185" or "1480A" or "1485A"

Firmware Revision Level

Attribute ID #07 reports the version of microprocessor code in the instrument. The firmware revision will be a text string of the major and minor revision level as listed in the Identity Object. The format of the attribute is "X.YYY", where X is the major revision level and YYY is the minor revision level. The default firmware revision level is "1.000."

Hardware Revision Level

Attribute ID #08 designates the hardware version of your device with a text string of the major and minor revision level. The format of the attribute is "X.YYY", where X is the major revision level and YYY is the minor revision level. The default hardware revision level is "1.000."

Serial Number

Attribute ID #09 reports the serial number of the device with an ASCII string of up to 30 characters.

Device Status

Attribute ID #0B designates the state of the S-Device Supervisor Object. The possible object states and their corresponding values are listed in Table 36. The response reports the attribute value for the appropriate object state.

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Table 36: Device Status Attribute Values

Attribute Value	S-Device Supervisor Object State
0	Unknown
1	Initialized / Self Testing
2	Idle
3	Self Test Exception
4	Executing
5	Abort from Idle or Executing
6	Critical Fault
7 to 255	Reserved

Exception Status

Attribute ID #0C reports the type of alarm or warning condition detected by the instrument. The alarms and warnings are identified as being:

- Device Common—alarm/warning common to all SEMI devices
- Device Specific—specific to mass flow devices
- Manufacturer Specific—specific to the MKS unit

The response is a byte structured as a bit mapped variable [3]. The device supports the expanded mode of reporting exceptions. The bit map defining this variable is listed in Table 37.

Table 37: Exception Status Bit Map

Bit (Least significant to Most Significant)	Hex Value	Meaning
0	01	Alarm – Device Common
1	02	Alarm – Device Specific
2	04	Alarm – Manufacturer Specific
3	08	Reserved – Set to 0
4	10	Warning – Device Common
5	20	Warning – Device Specific
6	40	Warning – Manufacturer Specific
7	80	1 – Expanded Method

The response returns a binary value with the least significant bit (bit 0) as the last digit. The response values are additive, therefore, one hexadecimal (hex) value reports all alarm conditions. For example, if the unit detects a device specific alarm condition, the unit reports a hex value of “82”, where:

$82_{hex} = 1\ 0\ 0\ 0\ 0\ 0\ 1\ 0$

Exception Detail Alarm

Attribute ID #0D identifies the specific alarm condition(s) detected by your mass flow device. The response is a byte with each bit representing a specific exception (alarm) condition, as listed below. Any bit that is set indicates that the alarm assigned to that bit is active. The response values are additive, therefore, one value

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reports all alarm conditions. The response returns a binary (hex) value with the least significant bit (bit 0) as the last digit. The exception detail alarm conditions are reported in an *unlatched* format; the exception status bit automatically clears as soon as the alarm condition is corrected.

Table 38: Exception Detail Device Common Alarm Bit Map

Byte [0]	Hex Value	Meaning
0	01	Exception – Internal Diagnostics
1	02	Exception – Microprocessor
2	04	Exception – ROM / FLASH Memory
3	08	Exception – EEPROM
4	10	Exception – RAM Memory
5	20	Reserved
6	40	Exception – Internal Timer
7	80	Reserved
Byte [1]	**Hex Value**	**Meaning**
0	01	Reserved
1	02	Reserved
2	04	Reserved
3	08	Exception – Power Supply Input Voltage
4	10	Reserved
5	20	Exception – Notify Manufacturer
6	40	Exception – Reset
7	80	Reserved

Table 39: Exception Detail Device Specific Alarm Bit Map

Byte [0]	Hex Value	Meaning
0	01	Exception – Flow Reading Valid
1	02	Exception – Flow Low
2	04	Exception – Flow High
3	08	Exception – Flow Control
4	10	Exception – Valve Low
5	20	Exception – Valve High
6	40	Reserved
7	80	Reserved

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Table 40: Exception Detail Manufacturer Specific Alarm Bit Map

Byte [0]	Hex Value	Meaning
0	01	Exception – Speedup Result Invalid
1	02	Exception – Bridge Controller Error
2	04	Exception – Valve Circuit Error
3	08	Exception – No Gas Table Available
4	10	Exception – Power Ground Level Invalid
5	20	Exception – AD / DA Circuitry Error
6	40	Exception – Temperature Out of Range
7	80	Exception – Bus Controller Error

Exception Detail Warning

Attribute ID #0E identifies the specific warning condition(s) detected by your mass flow device. The response is a byte with each bit representing a specific exception (warning) condition. Any bit that is set indicates that the alarm assigned to that bit is active. The response values are additive, therefore, one value reports all warning conditions. The response returns a binary (hex) value with the least significant bit (bit 0) as the last digit. The exception detail warning conditions are reported in an *unlatched* format; the exception status bit automatically clears as soon as the warning condition is corrected.

Alarm Enable

Attribute ID #0F specifies whether an alarm condition will be set in the exception status attribute of the S-Device Supervisor Object (refer to Exception Detail Alarm, page 66), where:

0 = Disable
1 = Enable (default)

Warning Enable

Attribute ID #10 specifies whether a warning condition will be set in the exception status attribute of the S-Device Supervisor Object (refer to Exception Detail Warning, above), where:

0 = Disable
1 = Enable (default)

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Table 41: S-Device Supervisor Object Supported Services

Service ID# (hex)	Service Name	Data Type	Service Type	Description
0E	Get_Attribute_Single	USINT	Request	Reads the object attribute.
10	Set_Attribute_Single	USINT Attribute Data Type	Request	Modify the object attribute.
05	Reset	USINT	Request	Place the object into its INITIALIZING state.
15	Restore_Defaults	USINT	Request	Restore object attributes to their factory defaults: 1= restore all atributes in this object 2= restore all objects in this device
32	Lock	None	Request	Place the device into the User mode. Restrict access to read-only attributes.
33	Unlock	UINT	Request	Place the device into Calibration mode. Make read-only attributes modifiable.
4B	Abort	None	Request	Place the device in its ABORT state.
4C	Recover	None	Request	Cause the device to transition from the ABORT state to the OPERATING state.

Visual Indicator

Attribute ID 0x65 controls the behavior of the visual indicator (the wink function) on the device. This attribute controls the flashing of the Module Status LED, which is useful for visually identifying a particular device on the network, where:

0 = Off (default)
1 = On

It is not in the non-volatile memory; therefore, it is off after a power cycle.

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S-Analog Sensor Object

The S-Analog Sensor Object (Class Code 31_{hex}) allows you to report the indicated (corrected) flow value, set and report the high and low trip point alarms, and report various status information on the system flow.

One instance of the S-Analog Sensor Object is supported with 19 instance attributes and four DeviceNet services.

Table 42: S-Analog Sensor Object Attributes

Attribute ID# (hex)	Description	Data Type	Run Mode Access	Cal Mode Access	Non-Volatile Memory	Data Variable	Initial Setting
03	Flow Data Type	USINT	Get/Set	Get/Set	Yes	$C3_{hex}$=INT CA_{hex}=REAL	$C3_{hex}$
04	Flow Units	UINT	Get	Get	Yes	0x1001 counts 0x1400 sccm 0x1401 slm	0
05	Flow Reading Valid	BOOL	Get	Get	No	0=Invalid 1=Valid	0
06	Indicated Flow Value	Specified by Flow Data Type	Get	Get	No	-20 to 140% FS or –400 to 28000 counts	0
07	Trip Point Status	BYTE	Get	Get	No	0=Cleared 1=Set	0
0A	Flow Full Scale	Specified by Flow Data Type	Get	Get	Yes	50 slm to 200 slm	
0C	Zero (Offset-A)	Specified by Flow Data Type	Get/Set	Get/Set	Yes	-5% to +5% FS	0
11	Alarm Trip Point High	Specified by Flow Data Type	Get/Set	Get/Set	Yes	-20 to 140% FS or –400 to 28000 counts	FS
12	Alarm Trip Point Low	Specified by Flow Data Type	Get/Set	Get/Set	Yes	-20 to 140% FS or –400 to 28000 counts	FS
15	Warning Trip Point High	Specified by Flow Data Type	Get/Set	Get/Set	Yes	-20 to 140% FS or –400 to 28000 counts	FS
16	Warning Trip Point Low	Specified by Flow Data Type	Get/Set	Get/Set	Yes	-20 to 140% FS or –400 to 28000 counts	FS
1C	Autozero Status	BOOL	Get	Get	No	0=autozero active 1=autozero not active	0
20	Overrange	Specified by Flow Data Type	Get/Set	Get/Set	Yes		FS
21	Underrange	Specified by Flow Data Type	Get/Set	Get/Set	Yes		0
23	Select Active Gas	UINT	Get/Set	Get/Set	Yes	None	1
C8	Flow Hours	UDINT	Get	Get	Yes	None	0
C9	Flow Totalizer	ULINT	Get/Set	Get/Set	No	None	0

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Flow Data Type

Attribute ID #03 defines the data type for certain attributes in this object, where:

$C3_{hex}$ = Integer (16 bit; default)

CA_{hex} = Real (floating point)

The attributes in this object which are affected by the flow data type include:

Indicated Flow (ID #06)

Flow Full Scale (ID # 0A)

Zero Data Type (ID #0B)

Zero (ID # 0C)

Alarm Trip Points (ID #s11 and 12)

Warning Trip Points (ID #s15 and 16)

Flow Units

Attribute ID #04 defines the flow units reported with Attribute ID #03 in this object, where:

0x1001 = Counts (default)

0x1400 = sccm

0x1401 = slm

The attributes in this object which are affected by the choice of flow units include:

Indicated Flow (ID #06)

Flow Full Scale (ID # 0A)

Alarm Trip Points (ID #s11 and 12)

Warning Trip Points (ID #s15 and 16)

Flow Reading Valid

Attribute ID #05 reports whether or not the flow value reported by Attribute ID #06 in this object is valid, where:

0 = Invalid (default)
1 = Valid

Indicated Flow Value

Attribute ID #06 reports the value of the indicated flow; the format of the response is dependent on the data type selected with Attribute ID #03 in this object (refer to Flow Data Type, above, for more information).

When Attribute ID #03 is set to $C3_{hex}$, the flow is reported as an integer; the range of the response is -20 to 133% of full scale. When Attribute ID #03 is set to CA_{hex}, the flow is reported as a real, floating point value; the range of the response is -400 to +28000 counts.

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Trip Point Status

Attribute ID #07 reports the status of the alarm and warning exceptions in this object, as defined in Table 43, page 72.

Table 43: Trip Point Status Bit Map

Byte [0]	Hex Value	Meaning
0	01	High Alarm Exception
1	02	Low Alarm Exception
2	04	High Warning Exception
3	08	Low Warning Exception
4	10	Reserved
5	20	Reserved
6	40	Reserved
7	80	Reserved

Trip Point Alarm / Warning Enable

Attribute IDs #08 and #09 specify whether the high and low point alarms and warnings will be reported to the exception status attribute of the S-Device Supervisor Object (refer to Exception Status, page 66), where:

0 = Disable (default)
1 = Enable

Attribute ID #08 controls the high and low alarms; Attribute ID #09 controls the high and low warnings.

If the trip point alarms are enabled, the actual alarm values (set with Attribute IDs #11, 12, 15, and 16 in this object) are compared to the indicated flow value.

Flow Full Scale

Attribute ID #0A reports the 100% full scale flow value in the units selected with Attribute ID #04 in this object. The acceptable range of this attribute is 0 to 24576 (0x6000); where 0 corresponds to 0% flow, and 24576 (0x6000) corresponds to 100% flow.

Zero

Attribute ID #0C specifies an offset, in the units selected with Attribute ID #04 in this object, which is applied to the indicated (corrected) flow value for the active programmed gas, where:

Indicated Flow (ID #06) = Sensor Reading + Zero (ID #0C)

The acceptable input range is -5 to +5% of full scale, in the current flow units.

Alarm/Warning High Trip Points

Attribute ID #11 specifies the value for the high trip point alarm. Attribute ID #15 specifies the value for the high trip point warning.

If the indicated flow value is *greater than* the specified value, an alarm/warning status indicator is generated.

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Alarm/Warning Low Trip Points

Attribute ID #12 specifies the value for the low trip point alarm. Attribute ID #16 specifies the value for the low trip point warning.

If the indicated flow is *less than* the specified value, an alarm/warning status indicator is generated.

Autozero Status

Attribute ID #1C specifies the current status of the autozero function execution. If the autozero function is actively executing the attribute returns a value of 1. If the autozero function is not actively executing, the attribute returns a value of 0.

Overrange

Attribute ID #20 specifies the highest valid value for the flow output reading.

Underrange

Attribute ID #21 specifies the lowest valid value for the flow output reading.

Select Active Programmed Gas (Gas Calibration Object Instance)

Attribute ID #23 specifies the current active programmed gas (the gas you want to monitor) from the programmed gas calibration tables that are stored in your device.

Flow Totalizer

Attribute ID #5F reports the volume of gas in standard cubic centimeters (sccm) that has flowed through the device since the last time the flow totalizer attribute was set to 0. This attribute can only be reset to 0. This value is not reset at power up.

Flow Hours

Attribute ID #60 reports the total number of hours the unit has been flowing gas. The resolution of the response is 1 hour. This value is not reset at power up.

S-Analog Sensor Object Supported Services

The S-Analog Sensor Object is supported by the four DeviceNet services.

Table 44: S-Analog Sensor Object Supported Services

Service ID# (hex)	Service Name	Data Type	Service Type	Description
0E	Get_Attribute_Single	USINT	Request	Reads the object attribute.
10	Set_Attribute_Single	USINT Attribute Data Type	Request	Modify the object attribute.

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S-Analog Actuator Object

The S-Analog Actuator Object (Class Code 32_{hex}) contains information on the valve.

Note The S-Analog Actuator Object is valid for mass flow controllers only. An error message is returned if you use this object for a mass flow meter. The DeviceNet General Error Codes are listed in the ODVA DeviceNet Specification, Volume I [1].

One instance of the S-Analog Actuator Object is supported with 10 attributes and three DeviceNet common services.

Table 45: S-Analog Actuator Object Attributes

Attribute ID# (hex)	Description	Data Type	Run Mode Access	Call Mode Access	Non-Volatile Memory	Data Variable	Initial Setting
03	Valve Data Type	USINT	Get/Set	Get/Set	Yes	$C3_{hex}$=INT CA_{hex}=REAL	$C3_{hex}$
04	Valve Data Units	UINT	Get/Set	Get/Set	Yes	7=%FS	7
05	Valve Override Selector	USINT	Get/Set	Get/Set	No	0=Normal 1= Off/Closed 2=On/Open 4=Safe State	0
06	Valve Drive Level Value	Specified by Flow Data Type	Get/Set	Get/Set	No	-20 to 140% FS or –400 to 28000 counts	FS
07	Valve Exception Status	BYTE	Get	Get	No	None	0
15	Valve Safe State	USINT	Get/Set	Get/Set	Yes	0=Closed	0

Valve Data Type

Attribute ID #03 defines the data type for certain attributes in this object, where:

$C3_{hex}$ = Integer (16 bit; default)

CA_{hex} = Real (floating point)

The attributes in this object which are affected by the valve data type include:

Valve Drive Level (ID #06)

Valve Data Units

Attribute ID #04 reports the units that the Valve Drive Level (reported with Attribute ID #06 in this object), is reported in, where:

0x1001 = counts

0x1007 =% Full Scale

0x2D00 = Volts

0x2D01 = mVolts

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Valve Override Selector

Attribute ID #05 allows you to override the control valve in accordance with the specification in [5], where:

0 = Normal (default)

1 = Closed

2 = Open

4 = Safe State

The override only takes effect when the device is in the EXECUTING sate. When the device transitions to the ABORT state, this attribute is automatically set to "4", causing the valve to move to its safe state; that is the valve closes (refer to Valve Safe State, below). This attribute cannot be written when the device is in the ABORT state.

Note When the valve moves to its safe state, the unit acts as if there was a power cycle. Once the device returns to the OPERATING state, you must reset this attribute by sending a setpoint command. Refer to S-Single Stage Controller Object, page 77, for more information.

Valve Drive Level Value

Attribute ID #06 reports the value of the valve drive level; the format of the response is dependent on the data type selected with Attribute ID #03 in this object.

When Attribute ID #03 is set to $C3_{hex}$, the flow is reported as an integer; the range of the response is -20 to 140% of full scale.

When Attribute ID #03 is set to CA_{hex}, the flow is reported as a real, floating point value; the range of the response is -400 to +28000 counts.

Valve Exception Status

Attribute ID #07 reports the status of the alarm and warning exceptions in this object. Your mass flow device does not support the standard S-Analog Actuator valve alarms, therefore, this required attribute always reports the status as 0.

Table 46: Exception Status Bit Map

Byte [0]	Hex Value	Meaning
0	01	High Alarm Exception
1	02	Low Alarm Exception
2	04	High Warning Exception
3	08	Low Warning Exception
4	10	Reserved
5	20	Reserved
6	40	Reserved
7	80	Reserved

Valve Safe State

Attribute ID #15 defines the normal behavior of the valve whenever there is a loss of power or communication to the device, where:

0 = Closed

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1 = Open
2 = Hold Last Value

Note Any time there is a power loss or your device is disconnected from the network, the device transitions from the EXECUTING state to the IDLE state, and the valve closes. To reset the valve, you must send a setpoint command (refer to S-Single Stage Controller Object, page 77, for more information).

S-Analog Actuator Object Supported Services

The S-Analog Actuator Object is supported by the three DeviceNet common services.

Table 47: S-Analog Actuator Object Supported Services

Service ID# (hex)	Service Name	Data Type	Service Type	Description
0E	Get_Attribute_Single	USINT	Request	Reads the object attribute
10	Set_Attribute_Single	USINT	Request	Modify the object attribute

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S-Single Stage Controller Object

The S-Single Stage Controller Object (Class Code 33_{hex}) contains 25 attributes. The supported DeviceNet Object Services include:

Table 48: S-Single Stage Controller Object Attributes

Attribute ID# (hex)	Description	Data Type	Run Mode Access	Call Mode Access	Non-Volatile Memory	Data Variable	Initial Setting
03	Setpoint Data Type	USINT	Get/Set	Get/Set	Yes	$C3_{hex}$=INT CA_{hex}=REAL	$C3_{hex}$
04	Setpoint Data Units	UINT	Get/Set	Get/Set	Yes	Counts=0x1001 %F.S.=0x1007 slm=0x1401 sccm=0x1400	Counts
06	Setpoint	Set by Attribute #03	Get/Set	Get/Set	No		0
0A	Status	BYTE	Get	Get	No	Bit 0:Alarm Exception 0=cleared 1=set Bit 1: Warning 0=cleared 1=set	0
13	Ramp Rate	UDINT	Get/Set	Get/Set	Yes	0=disables value=msec to reach setpoint	0

Setpoint Data Type

Attribute ID #03 defines the data type for certain attributes in this object, where:

$C3_{hex}$ = Integer (16 bit; default)

CA_{hex} = Real (floating point)

The attributes affected by the choice of the setpoint data type include:

- Setpoint Value (ID #06)

Setpoint Data Units

Attribute ID #04 reports the units for the setpoint value reported with Attribute ID #06 in this object, where:

0x1001 = counts

0x1007 =% Full Scale

0x2D00 = Volts

0x2D01 = mVolts

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Setpoint

Attribute ID #06 defines the value of the setpoint value (the value to which the device is controlling the flow of gas). The format of the response is dependent on the data type selected with Attribute ID #03 in this object (refer to Setpoint Data Type, page 77).

When Attribute ID #03 is set to C3hex, Attribute ID #06 defines the setpoint as an integer. The range of the setpoint value attribute is 0 to 100% of full scale.

Status

Attribute ID #0A reports the status of the alarm and warning exceptions in this object.

Table 49: Controller Status Bit Map

Byte [0]	Hex Value	Meaning
0	01	Alarm Exception
1	02	Warning Exception
2	04	Reserved
3	08	Reserved
4	10	Reserved
5	20	Reserved
6	40	Reserved
7	80	Reserved

Ramp Rate

Attribute ID #13 defines the ramp rate at which this object tracks toward the current setpoint value. The ramp rate specifies how quickly the setpoint is ramped from the previous setpoint value to the current setpoint value. The acceptable input range is 0 to 12000 milliseconds (msec); the default setting is 0.0.

S-Single Stage Controller Object Supported Services

The S-Single Stage Controller Object is supported by the three DeviceNet common services.

Table 50: S-Single Stage Controller Object Supported Services

Service ID# (hex)	Service Name	Data Type	Service Type	Description
0E	Get_Attribute_Single	USINT	Request	Reads the object attribute.
10	Set_Attribute_Single	USINT	Request	Modify the object attribute.

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S-Gas Calibration Object

The S-Gas Calibration Object (Class Code 34_{hex}) reports the total number of programmed gas calibration tables stored in your device, and allows you to access and modify the calibration data within these tables. Your device can store up to 20 programmed gas calibration tables, each consisting of 21 calibration parameters.

Table 51: S-Gas Calibration Object Class Attributes

Attribute ID# (hex)	Description	Data Type	Run Mode Access	Cal Mode Access	Non-Volatile Memory	Data Variable	Initial Setting
02	Max Object Instances	UINT	Get	Get	Yes	20	20

Max Object Instances (Total Gas Calibrations)

Attribute ID #02 reports the total number of programmed gas calibration tables that are stored in your mass flow device. Your device can store 20 gas calibration tables; five (5) *default* calibration tables and up to fifteen (15) user-selected calibration tables.

Only one of the programmed gas tables—for the gas you are monitoring (the active programmed gas)—can be active at a time. The active programmed gas is selected with the Select Active Gas Attribute (ID #23) in the S-Analog Sensor Object. Refer to S-Analog Sensor Object Supported Services, page 73, for more information.

Table 52: S-Gas Calibration Object Attributes

Attribute ID# (hex)	Description	Data Type	Run Mode Access	Call Mode Access	Non-Volatile Memory	Data Variable	Initial Setting
03	Gas Standard Number	UINT	Get	Get	Yes		13
04	Valid Sensor Instance	UINT	Get	Get	Yes	None	1
05	Gas Standard Symbol	SHORT STRING	Get	Get	Yes	None	0
06	Full Scale Range	STRUCT of: REAL UINT	Get	Get	Yes	None	500 (range), 1024 (units)
07	Additional Scalar	REAL	Get/Set	Get/Set	Yes		1.00
08	Calibration Date	DATE	Get	Get/Set	Yes	None	0
09	Calibration (Reference) Gas Standard Number	UINT	Get	Get/Set	Yes	None	13
5F	Calibration Pressure (kPa)	REAL	Get	Get/Set	Yes	None	101.32
60	Calibration Temperature (K)	REAL	Get	Get/Set	Yes	None	273.0

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Gas Standard Number

Attribute ID #03 reports the SEMI assigned code (or *gas standar*d) number for the specified instance. The gas standard numbers for the gases and vaporizable material that may be used with your mass flow device are listed in Appendix B, Gas Correction Factors, page 91.

Note The number of instances in the S-Gas Calibration Object equals the number of gases stored in your device. For example, to retrieve the gas standard number for stored gas #2, send the Get_Attribute_Single service for Instance ID #2. If the gas stored at index #2 is Argon, the response returns its assigned gas standard number of 4.

Valid Sensor Instance

Attribute ID #04 reports the active sensor instance; the value is always reported as 1. This attribute was designed to identify the active sensor in instruments that can accommodate multiple sensors.

Gas Standard Symbol

Attribute ID #05 reports the gas symbol as a short string. This is generally the ASCII text abbreviation of the molecular structure.

Full Scale Range

Attribute ID #06 reports the factory set full scale range, in the specified flow units, for the active programmed gas.

0x1001 = Counts (default)

0x1007 = % Full Scale

0x1400 = sccm

0x1401 = slm

Additional Scalar

Attribute ID #07 reports the scalar correction for the gas referenced in the current instance. This additional scalar reference can be used to contain the Gas Correction Factor for a specific device.

Calibration Date

Attribute ID #08 specifies the date of a user calibration for a specific programmed gas. The acceptable input range is D#1972-01-01, the start of the Coordinated Universal Time (UTC) era, to D#2151-06-06 (a total range of 65,565 days).

Calibration Gas Standard Number

Attribute ID #09 reports the SEMI assigned code number for the calibration (or *reference*) gas, as listed in Appendix B, Gas Correction Factors, page 91. Nitrogen, which is typically used as the calibration gas, has an assigned gas standard number of 13.

Calibration Pressure

Attribute ID #5F specifies the standard pressure in kiloPascals (kPa) at which your unit was calibrated for the active programmed gas. The default pressure is 101.32.

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Calibration Temperature

Attribute ID #60 specifies the standard temperature in Kelvin (K) at which your unit was calibrated for the active programmed gas. The default temperature is 273.16 (0° C).

S-Gas Calibration Object Supported Services

The S-Gas Calibration Object is supported by the seven DeviceNet services.

Table 53: S-Gas Calibration Object Supported Services

Service ID# (hex)	Service Name	Data Type	Service Type	Description
0E	Get_Attribute_Single	USINT	Request	Reads the object attribute.
10	Set_Attribute_Single	USINT	Request	Modify the object attribute.
4B	Get_All_Instances	None	Request	Request a list of all available object instances with their respective gas numbers that are supported by the device

The response to the Get_All_Instances service is shown in the table below:

Table 54: Get_All_Instances Response Format

Parameter Name	Data Type	Description
List Size	USINT	Reads the object attribute.
Gas Calibration List	ARRAY of: STRUCT of: UINT UINT UINT	 S-Gas Calibration Object Instance ID Gas Standard Number Valid Sensor Instance

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Controller Calibration Object

The Controller Calibration Object (Class Code 66_{hex}) allows calibration of the parameters which affect the performance of the device under operating conditions.

One instance of the Controller Calibration Object is supported with 50 instance attributes and two DeviceNet services.

Table 55: Controller Calibration Object Attributes

Attribute ID# (hex)	Description	Data Type	Run Mode Access	Cal Mode Access	Non-Volatile Memory	Data Variable	Initial Setting
01	Controller P	REAL	Get	Get/Set	Yes		Varies*
02	Controller I	REAL	Get	Get/Set	Yes		Varies*
03	Controller D	REAL	Get	Get/Set	Yes		Varies*
0A	Speedup Tau	REAL	Get	Get/Set	Yes		Varies*
1A	Flow Cal Point 0 Sensor Value 0 Flow Value 0	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
1B	Flow Cal Point 1 Sensor Value 1 Flow Value 1	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
1C	Flow Cal Point 2 Sensor Value 2 Flow Value 2	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
1D	Flow Cal Point 3 Sensor Value 3 Flow Value 3	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
1E	Flow Cal Point 4 Sensor Value 4 Flow Value 4	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
1F	Flow Cal Point 5 Sensor Value 5 Flow Value 5	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
20	Flow Cal Point 6 Sensor Value 6 Flow Value 6	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
21	Flow Cal Point 7 Sensor Value 7 Flow Value 7	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
22	Flow Cal Point 8 Sensor Value 8 Flow Value 8	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
23	Flow Cal Point 9 Sensor Value 9 Flow Value 9	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
24	Flow Cal Point 10 Sensor Value 10 Flow Value 10	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
25	Flow Cal Point 11 Sensor Value 11 Flow Value 11	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*

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Table 55: Controller Calibration Object Attributes (continued)

Attribute ID# (hex)	Description	Data Type	Run Mode Access	Cal Mode Access	Non-Volatile Memory	Data Variable	Initial Setting
26	Flow Cal Point 12 Sensor Value 12 Flow Value 12	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
27	Flow Cal Point 13 Sensor Value 13 Flow Value 13	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
28	Flow Cal Point 14 Sensor Value 14 Flow Value 14	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
29	Flow Cal Point 15 Sensor Value 15 Flow Value 15	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
2A	Flow Cal Point 16 Sensor Value 16 Flow Value 16	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
2B	Flow Cal Point 17 Sensor Value 17 Flow Value 17	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
2C	Flow Cal Point 18 Sensor Value 18 Flow Value 18	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
2D	Flow Cal Point 19 Sensor Value 19 Flow Value 19	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
2E	Flow Cal Point 20 Sensor Value 20 Flow Value 20	STRUCT of: REAL REAL	Get	Get/Set	Yes		Varies*
65	Counts Full Scale	UINT	Get	Get/Set	Yes	Number of counts equal to 100 % Full Scale.	0x6000
* Initial value varies with the calibration of the particular mass flow device.							

The attributes within this object instance are only settable when the calibration mode for the device has been entered. To enter the calibration mode, send the service data 0x02 0x9D using the Set_Attribute_Single service through an explicit message connection to Object Class Code 0x01, Instance 0x01, Attribute 0x00.

Controller P

P component of the PID controller.

Controller I

I component of the PID controller. High P component values give the possibility of high I component values.

Controller D

D component of the PID controller. Should be zero.

Table 56: Controller Calibration Object Supported Services

Service ID# (hex)	Service Name	Data Type	Service Type	Description

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0E	Get_Attribute_Single	USINT	Request	Reads the object attribute.
10	Set_Attribute_Single	USINT	Request	Modify the object attribute.

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Chapter Five: Maintenance

General Information

In general, no maintenance is required other than proper installation and operation. Periodically check for wear on the cables and inspect the enclosure for visible signs of damage. If a mass flow device fails to operate properly on receipt, check for shipping damage, and check the DeviceNet cable for proper power supply. Any damage should be reported to the freight carrier and MKS Instruments immediately. If there is no obvious damage, and the unit fails to operate properly through the DeviceNet network, obtain an RMA Number (Return Material Authorization Number) before returning the unit to MKS Instruments for service to expedite handling and ensure proper servicing of your instrument.

Zero Adjustment

For best accuracy and repeatability, you should check the zero output periodically and reset it, if necessary. Refer to the zero adjustment procedure, How to Zero the Flow Device page 43.

Calibration

It is also recommended that the instrument be recalibrated annually if no other time interval has been specifically established. Refer to the inside of the back cover of this instruction manual for a complete list of MKS Calibration and Service Centers.

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Chapter Six: Troubleshooting

Troubleshooting Chart

Table 57: Troubleshooting Chart

Symptoms	Possible Cause	Remedy
Device does not power up.	Improper DeviceNet cable. Malfunctioning electronics.	Check DeviceNet network. Return unit for service to MKS Calibration and Service Center.
Device indicates negative flow.	Incorrect instrument installation (backwards) in process system.	Reinstall instrument in process system such that gas flow occurs in the direction of the arrow on the front of the instrument.
Controller does not track setpoint.	Improper PID settings.	Tune controller according to procedures outlined in instruction manual.
Controller mass flow rate oscillates	Too high controller gain Incorrect upstream pressure regulator Upstream pressure too high Excessive valve preload	Reduce gain through DeviceNet interface. Check manufacturer's specifications for correct upstream pressure regulator Reduce upstream pressure Return unit for service to MKS Calibration and Service Center.
Controller has excessive closed conductance.	Inadequate valve preload.	Return unit for service to MKS Calibration and Service Center.
Device does not achieve full flow.	Upstream pressure is too low for the system. Excessive valve preload (controller).	Increase upstream pressure. Return unit for service to MKS Calibration and Service Center.

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Appendix A: Product Specifications

Performance Specifications

Accuracy Mass Flow Device	 1% of reading from 25% to 100% F.S. (with N_2 calibration gas) 0.25% of F.S. < 25% F.S. (with N_2 calibration gas)
CE Compliance Electromagnetic Compatibility*	 EMC Directive 89/336/EEC
Control Adjustments Derivative Integral Proportional	
Control Repeatability (controller only)	±0.2% Reading.
Leak Integrity Internal to external Through closed control valve	 $<10^{-10}$ scc/sec He 1% F.S. (N_2 at 25 psig to atmosphere differential)
Maximum Operating Differential Pressure	20-50 psid (atmospheric outlet)
Maximum Operating Inlet Pressure	150 psig
Mass Flow Control Range	2 to 100% F.S.
Resolution (measurement)	≤0.1% F.S.
Temperature Coefficient Zero Span	 ≤ ±0.05% F.S./°C ≤ ±0.08% Reading/°C
Settling Time, from zero setpoint	10 – 100% SP <= 2 sec. typical
Warm Up Time	30 minutes
* An overall metal braided shielded cable, properly grounded at both ends, is required during use.	

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Physical Specifications

Burst Pressure	≥1000 psig
Dimensions	1.49” W x 3.00” L (less fittings) x 5.90” H 1.49” W x 5.28” L (face-to-face) x 5.90” H
Fittings	Cajon® 4-VCR® male compatible (50 SLM range only) Cajon® 8-VCR® male compatible
Full Scale Ranges Flow	 50, 100, and 200 SLM
Input Power	11-25 VDC, 500 mA max @ 11 VDC (230 mA @ 24 VDC nominal)
Maximum Cable Length	DeviceNet band dependent
Valve (controller only) Type Seat Material	 Normally closed Viton®, Buna-N, and Kalrez®
Surface Finish	16 µinches, Ra
Weight	Approx. 3 lbs. (1.4 kg.)
Wetted Materials (excluding valve seat)	316L VAR stainless steel, Elgiloy, nickel, KM-45 SST

Environmental Specifications

Ambient Operating Temperature Range	10° to 45° C (50° to 113° F)
Storage Temperature Range	-20° to 65° C (-4° to 149° F)
Storage Humidity Range	0 to 95% Relative Humidity, non-condensing

These product specifications are subject to change without notice.

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Appendix B: Gas Correction Factors

Table 58 lists the gas names, symbols, and code numbers for gases and vaporizable materials that may be used with your digital mass flow device. The gas names are listed alphabetically. Your mass flow device can store information on a maximum of 20 of these gases.

The information in Table 58 is taken from the SEMI® Standard E52-95, *Practice for Referencing Gases Used in Digital Mass Flow Controllers*. The code numbers are integers assigned by SEMI to identify a particular gas. Contact MKS Instruments for information on materials that are not listed in Table 58.

Note Standard Pressure is defined as 760 mmHg (14.7 psia).
Standard Temperature is defined as $0^{o}C$.

Table 58: Gas Correction Factors

Gas	Symbol	Code Number	Density g/l @ $0^{o}C$	Conversion Factor
Air	- - -	8	1.293	1.00
Ammonia	NH_3	29	0.760	0.73
Argon	Ar	4	1.782	1.39
Arsine	AsH_3	35	3.478	0.67
Boron Trichloride	BCl_3	70	5.227	0.41
Bromine	Br_2	21	7.130	0.81
Carbon Dioxide	CO_2	25	1.964	0.70
Carbon Monoxide	CO	9	1.250	1.00
Carbon Tetrachloride	CCl_4	101	6.86	0.31
Carbon Tetraflouride (Freon - 14)	CF_4	63	3.926	0.42
Chlorine	Cl_2	19	3.163	0.86
Chlorodifluoromethane (Freon - 22)	$CHClF_2$	57	3.858	0.46
Chloropentafluoroethane (Freon - 115)	C_2ClF_5	119	6.892	0.24
Chlorotrifluoromethane (Freon - 13)	$CClF_3$	74	4.660	0.38
Cyanogen	C_2N_2	59	2.322	0.61
Deuterium	D_2	14	0.1799	1.00

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Diborane	B_2H_6	58	1.235	0.44
Dibromodifluoromethane	CBr_2F_2		9.362	0.19
Dichlorodifluoromethane (Freon - 12)	CCl_2F_2	84	5.395	0.35
Dichlorofluoromethane (Freon - 21)	$CHCl_2F$	65	4.592	0.42
Dichloromethysilane	$(CH_3)_2SiCl_2$		5.758	0.25

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Table 58: Gas Correction Factors (continued)

Gas	Symbol	Code Number	Density g/l @ 0°C	Conversion Factor
Dichlorosilane	SiH_2Cl_2	67	4.506	0.40
1,2-Dichlorotetrafluoroethane (Freon - 114)	$C_2Cl_2F_4$	125	7.626	0.22
1,1-Difluoroethylene (Freon - 1132A)	$C_2H_2F_2$	64	2.857	0.43
2,2-Dimethylpropane	C_5H_{12}	122	3.219	0.21
Ethane	C_2H_6	54	1.342	0.50
Fluorine	F_2	18	1.695	0.98
Fluoroform (Freon - 23)	CHF_3	49	3.127	0.50
Freon - 11	CCl_3F		6.129	0.33
Freon - 12	CCl_2F_2		5.395	0.35
Freon - 13	$CClF_3$		4.660	0.38
Freon - 13 B1	$CBrF_3$		6.644	0.37
Freon - 14	CF_4		3.926	0.42
Freon - 21	$CHCl_2F$		4.592	0.42
Freon - 22	$CHClF_2$		3.858	0.46
Freon - 23	CHF_3		3.127	0.50
Freon - 113	$C_2Cl_3F_3$		8.360	0.20
Freon - 114	$C_2Cl_2F_4$		7.626	0.22
Freon - 115	C_2ClF_5		6.892	0.24
Freon - 116	C_2F_6		6.157	0.24
Freon - C318	C_4F_8		8.93	0.164
Freon - 1132A	$C_2H_2F_2$		2.857	0.43
Helium	He	1	0.1786	1.45
Hexafluoroethane (Freon - 116)	C_2F_6	118	6.157	0.24
Hydrogen	H_2	7	0.0899	1.01
Hydrogen Bromide	HBr	10	3.610	1.00
Hydrogen Chloride	HCl	11	1.627	1.00
Hydrogen Fluoride	HF	12	0.893	1.00
Isobutylene	C_4H_8	106	2.503	0.29
Krypton	Kr	5	3.739	1.543
Methane	CH_4	28	0.715	0.72

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Methyl Fluoride	CH_3F	33	1.518	0.56
Molybdenum Hexafluoride	MoF_6	124	9.366	0.21
Neon	Ne	2	0.900	1.46
Nitric Oxide	NO	16	1.339	0.99
Nitrogen	N_2	13	1.250	1.00

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Table 58: Gas Correction Factors (continued)

Gas	Symbol	Code Number	Density g/l @ 0°C	Conversion Factor
Nitrogen Dioxide	NO_2	26	2.052	0.74*
Nitrogen Trifluoride	NF_3	53	3.168	0.48
Nitrous Oxide	N_2O	27	1.964	0.71
Octafluorocyclobutane (Freon - C318)	C_4F_8	129	8.93	0.164
Oxygen	O_2	15	1.427	0.993
Pentane	C_5H_{12}		3.219	0.21
Perfluoropropane	C_3F_8	128	8.388	0.17
Phosgene	$COCl_2$	60	4.418	0.44
Phosphine	PH_3	31	1.517	0.76
Propane	C_3H_8	89	1.967	0.36
Propylene	C_3H_6	69	1.877	0.41
Silane	SiH_4	39	1.433	0.60
Silicon Tetrachloride	$SiCl_4$	108	7.580	0.28
Silicon Tetrafluoride	SiF_4	88	4.643	0.35
Sulfur Dioxide	SO_2	32	2.858	0.69
Sulfur Hexafluoride	SF_6	110	6.516	0.26
Trichlorofluoromethane (Freon - 11)	CCl_3F	91	6.129	0.33
Trichlorosilane	$SiHCl_3$	147	6.043	0.33
1,1,2-Trichloro – 1,2,2-Trifluoroethane	CCl_2FCClF_2		8.360	0.20
(Freon - 113)	or		13.28	0.25
Tungsten Hexafluoride	$(C_2Cl_3F_3)$	121	5.858	1.32
Xenon	WF_6	6		
	Xe			

* Consult MKS Instruments for this application.

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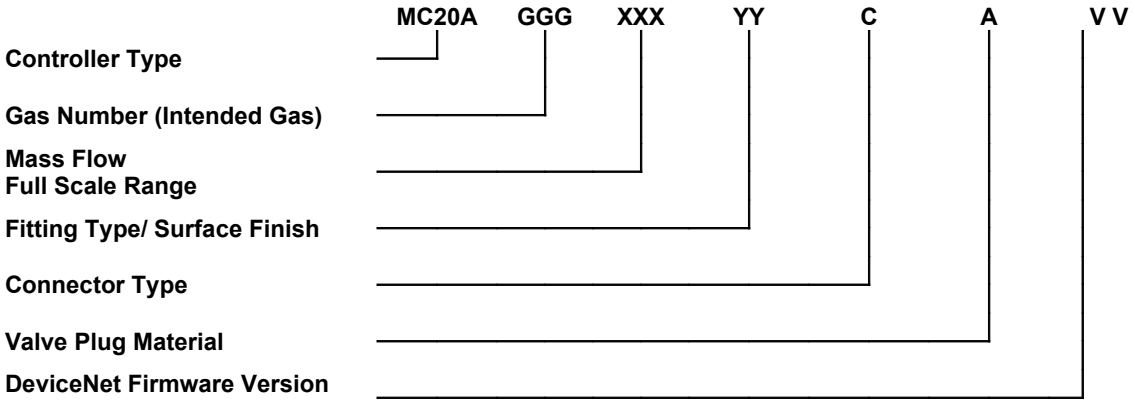
Appendix C: Model Code Explanation

Model Code Description

The model code of the MC20A MFC defines features of the unit such as controller type, flow range, fittings, valve configuration, connector type, and seal material and firmware revision.

The model code is identified as follows: **MC20AGGGXXXYYCAVV**

where:



Controller Type

The type identifies your unit as a specific model MC20A MFC.

SEMI Gas Code (GGG)

The Gas to be calibrated for is identified as the SEMI Gas Code. A partial listing is shown below. The full list is shown in SEMI Document E052-0703, and may be found on the SEMI website, www.semi.org, or a complete list shown on the MKS Website at www.MKSINST.com.

Gas	Gas Ordering Code	Gas	Gas Ordering Code
Helium	001	Carbon Dioxide	025
Argon	004	Methane	028
Hydrogen	007	Ammonia	029
Air	008	Silane	039
Nitrogen	013	Acetylene	042
Oxygen	015	Sulfur Hexafluoride	110
		Chlorine	019

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Mass Flow Full Scale Range (XXX)

The MC20A MFC's full scale range is indicated by a two digit/one letter code. The first two digits of this code are the flow full scale range in exponential form. The third letter is the flow units. L stands for Standard Liters per Minute.

Example: **12L = 100 SLM**

Mass Flow Rate	Ordering Code
50 SLM	51L
100 SLM	12L
200 SLM	22L

FittingType Plus Internal MFC Surface Finish (YY)

The MC20A MFC's fitting options are designated by an alphanumeric code.

Fitting Style/Internal Finish	Ordering Code	
4 VCR fitting / 16 ra finish	R2	Available for 50 SLM range only.
8 VCR fitting / 16 ra finish	M2	

Connector (W)

The MC20A Mass Flow Device's connector is designated by a single number code. The MC20A Mass Flow Devices are also available with a DeviceNet connector.

Connector Type	Ordering Code
DeviceNet	6

Valve Plug Material (A)

The MC20A MFC's valve plug material option is designated by a letter code. The plug material is chosen for chemical compatibility with the intended process gas. Viton (code V) is most common.

Valve Plug Material	Ordering Code
Viton	V
Buna-N	B
Kalrez	K

Firmware Version (V V)

The MC20A Mass Flow Device's firmware version options are designated by a two digit number code.

Example: The initial release of the MC20A Mass Flow Controller uses firmware version 10.

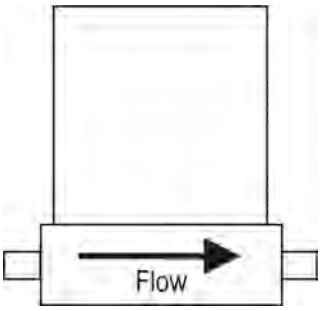
DeviceNet Firmware Version	Ordering Code
Normally Closed	10

Note Unless otherwise specified, MKS will ship firmware current to date of order. To receive

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previous software revision levels, please specify to customer service at order placement.

Note **The standard MC20A product is intended for installation in horizontal, base down (HBD) orientation (SEMI E80-U299 Attitude #1).**



Check the orientation label on the outlet end of the device (on the enclosure). If no label is present, the device is configured for use in the standard HBD orientation. If you intend to install in alternative orientations, contact the MKS Service Department for assistance in reconfiguring.

To order MC20A MFCs with any of the following additional configurations, please consult the MKS factory:

- Alternative gases (other then N_2) and/or special full scale ranges

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Appendix D: DeviceNet Attribute Summary

DeviceNet Information

The MC20A Digital MFC device operates as a slave on the DeviceNet network. The unit supports Explicit Messages and Polled I/O Messages of the predefined master/slave connection set. It does not support the Explicit Unconnected Message Manager (UCMM).

DeviceNet Message Types

As a group 2 slave device the MC20A DIGITAL MFC supports the following message types.

Table 59: DeviceNet Message Types

CAN IDENTIFIER	GROUP 2 Message Type
10xxxxxx111	Duplicate MACID Check Message
10xxxxxx110	Unconnected Explicit Request Message
10xxxxxx101	Master I/O Poll Command Message
10xxxxxx100	Master Explicit Request Message
xxxxxx = Node Address	

DeviceNet Class Services

As a group 2 slave device the MC20A DIGITAL MFC supports the following class services and instance services.

Table 60: DeviceNet Class Services

Service Code	Service Name
05 (0x05)	Reset
14 (0x0E)	Get Attribute Single
16 (0x10)	Set Attribute Single
75 (0x4B)	Allocate Group 2 Identifier Set
76 (0x4C)	Release Group 2 Identifier Set

DeviceNet Object Classes

The MC20A DIGITAL MFC device supports the following DeviceNet object classes.

Table 61: DeviceNet Object Classes

Class Code	Object Type
01 (0x01)	Identity
02 (0x02)	Router
03 (0x03)	DeviceNet
04 (0x04)	Assembly
05 (0x05)	Connection

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Table 61: DeviceNet Object Classes (continued)

Class Code	Object Type
48 (0x30)	S-Device Supervisor
49 (0x31)	S-Analog Sensor
50 (0x32)	S-Analog Actuator
51 (0x33)	S-Single Stage Controller
52 (0x34)	S-Gas Calibration
*100 (0x64)	Bulk Word
*101 (0x65)	Bulk Float
102 (0x66)	Controller Calibration
* These Objects are only available in Factory mode.	

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Identity Object, Class Code: 01 (0x01)

The Identity Object is required on all devices and provides identification of and general information about the device.

Table 62: Identity Object Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Object Instance	UINT	1
6	Get	Max Class Identifier	UINT	7
7	Get	Max Instance Attribute	UINT	8

Table 63: Identity Object Instance Attributes

Attribute	Access	Name	Type	Value
1	Get	Vendor	UINT	36
2	Get	Product Type	UINT	26
3	Get	Product Code	UINT	4
4	Get	Revision	STRUCT OF	
		Major Revision	USINT	See Below
		Minor Revision	USINT	
5	Get	Device Status	UINT	See Below
6	Get	Serial Number	UDINT	See Below
7	Get	Product Name	STRUCT OF	
		Length	USINT	16
		Name	STRING [16]	MC20A Digital MFC
8	Get	State	USINT	See Below
100	Get	Controller Revision	STRUCT OF	(5)
		Major Revision	USINT	
		Minor Revision	USINT	

Table 64: Common Services

Service Code	Class	Instance	Service Name
05 (0x05)	No	Yes	Reset
14 (0x0E)	Yes	Yes	Get_Attribute_Single

Revision – Attribute 4

MKS/DIP maintains strict revision control. The major revision number will increment as functional enhancements are implemented. The minor revision will increment if minor changes are incorporated.

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Device Status – Attribute 5

bit 0	owned	0=not owned 1=owned (allocated)
bit 1	reserved	0
bit 2	configured	0
bit 3	reserved	0
bit 4-7	vendor specific	0
bit 8	minor cfg fault	0=no fault 1=minor fault
bit 9	minor dev.fault	0=no fault 1=minor device fault
bit 10	major cfg.fault	0=no fault 1=major cfg. fault
bit 11	major dev.fault	0=no fault 1=major device fault
bit 12-15	reserved	0

Serial Number – Attribute 6

The serial number is encoded in the product during the manufacturing cycle and is guaranteed to be unique across all product lines produced by DIP/MKS.

State – Attribute 8

The Device State reflects whether any errors have occurred and the severity. The following states are supported. The only exit from a Major Unrecoverable fault condition is power cycling the device.

Table 65: Device States

State	Interpretation	Causes
0	Non-existent	
1	Self Test	
2	Standby	
3	Operating	Normal operating mode
4	Major Recoverable fault	See S_Device_Supervisor Alarm Detail
5	Major Unrecoverable fault	See S_Device_Supervisor Alarm Detail

Controller Revision – Attribute 100

MKS Instruments maintains strict revision control. The major revision number will increment as functional enhancements are implemented to the Controller firmware. The minor revision will increment if minor changes are incorporated to the Controller Firmware.

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Router Object, Class Code: 02 (0x02)

The Message Router Object provides a messaging connection point through which a Client may address a service to any object class or instance residing in the physical device.

Table 66: Router Object Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
6	Get	Max Class Identifier	UINT	7
7	Get	Max Instance Attribute	UINT	2

Table 67: Router Object, Instance 1 Attributes

Attribute	Access	Name	Type	Value
2	Get	Number of Connections	UINT	2

Table 68: Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single

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DeviceNet Object, Class Code: 03 (0x03)

Table 69: DeviceNet Object Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1

Table 70: DeviceNet Object, Instance 1 Attributes

Attribute	Access	Name	Type	Value
1	Get/Set	MACID	USINT	See Below
2	Get/Set	Baud Rate	USINT	See Below
3	Get/Set	Bus Off Interrupt	BOOL	See Below
4	Get/Set	Bus Off Counter	USINT	See Below
5	Get/Spc	Allocation Information Choice Byte Master Node Addr.	STRUCT of BYTE USINT	See Below
6	Get	Mac Switch Changed	BOOLEAN	
7	Get	Baud Switch Changed	BOOLEAN	
8	Get	Current Mac Switch	USINT	
9	Get	Current Baud Switch	USINT	

Table 71: Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single
75 (0x4B)	No	Yes	Allocate Master/Slave
76 (0x4C)	No	Yes	Release Master/Slave

MACID – Attribute 1

The MACID is set using two BCD rotary switches located on the front panel. Valid MACID addresses are 0 to 63 (0 to 3F Hex). Setting the switch address to a value greater than 63 will disable the switch and allow software setting of the MACID. The software setting defaults to the last hardware setting. The switch is only read during power up.

Baud Rate – Attribute 2

Settable only if the Baud Rate switch is set to a value greater than 2. Value returned will be switch value if less than 4 or the last value set.

Switch/Value	Speed
0	125 kbits
1	250 kbits
2	500 kbits
3	Software settable

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Bus Off Interrupt – Attribute 3

Bus Off Interrupt (BOI) determines the action if a Bus Off state is encountered.

BOI	Action
0	Hold chip in OFF state (default)
1	If possible reset CAN chip

Bus Off Counter – Attribute 4

Bus Off Counter will be forced to 0 whenever set regardless of the data value provided.

Allocation Information – Attribute 5

Allocation_byte

bit 0	explicit	set to 1 to allocate
bit 1	polled	set to 1 to allocate
bit 2	strobed	(not supported)
bit 3-7	reserved	(always 0)

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Assembly Object, Class Code: 04 (0x04)

The Assembly Objects bind attributes of multiple objects to allow data to or from each object to be sent or received over a single connection.

Table 72: Assembly Object Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Object Instance	UINT	20

Table 73: Assembly Object, Instance 1 Attributes

Attribute	Access	Name	Type	Value
3***	Get	Flow β	INT	See S-Analog Sensor, Attribute 6

Table 74: Assembly Object, Instance 2 Attributes

Attribute	Access	Name	Type	Value
3***	Get	Data Status β Flow β	STRUCT of BYTE INT	 See S-Device Supervisor, Attribute 12 See S-Analog Sensor, Attribute 6

Table 75: Assembly Object, Instance 6 Attributes

Attribute	Access	Name	Type	Value
3***	Get	Data Status β Flow β Setpoint Override β Valve β	STRUCT of BYTE INT INT USINT INT	 See S-Device Supervisor, Attribute 12 See S-Analog Sensor, Attribute 6 See S-Single Stage Controller, Attribute 6 See S-Analog Actuator, Attribute 5 See S-Analog Actuator, Attribute 6

Table 76: Assembly Object, Instance 7 Attributes

Attribute	Access	Name	Type	Value
3***	Get/Set	Setpoint δ	INT	See S-Single Stage Controller, Attribute 6

Table 77: Assembly Object, Instance 8 Attributes

Attribute	Access	Name	Type	Value
3***	Get/Set	Data Override δ Setpoint δ	STRUCT of USINT INT	 See S-Analog Actuator, Attribute 5 See S-Single Stage Controller, Attribute 6

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Table 78: Assembly Object, Instance 14 Attributes

Attribute	Access	Name	Type	Value
3***	Get	Data Status β Flow β	STRUCT of BYTE REAL	 See S-Device Supervisor, Attribute 12 See S-Analog Sensor, Attribute 6

Table 79: Assembly Object, Instance 18 Attributes

Attribute	Access	Name	Type	Value
3***	Get	Data Status β Flow β Setpoint Override β Valve β	STRUCT of BYTE REAL REAL USINT REAL	 See S-Device Supervisor, Attribute 12 See S-Analog Sensor, Attribute 6 See S-Single Stage Controller, Attribute 6 See S-Analog Actuator, Attribute 5 See S-Analog Actuator, Attribute 6

Table 80: Assembly Object, Instance 19 Attributes

Attribute	Access	Name	Type	Value
3***	Get/Set	Setpoint δ	REAL	See S-Single Stage Controller, Attribute 6

Table 81: Assembly Object, Instance 20 Attributes

Attribute	Access	Name	Type	Value
3***	Get/Set	Data Override δ Setpoint δ	STRUCT of USINT REAL	 See S-Analog Actuator, Attribute 5 See S-Single Stage Controller, Attribute 6

β: Data that is received from the MFC processor.

δ: Data that is sent to the MFC processor.

Table 82: Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

(1) Assembly instance 1, 2, 6, 14, and 18 are used to generate the POLL response packet and consists of the data described in the table below.

(2) Assembly instance 7, 8, 19, and 20 are used to consume the POLL request packet and consists of the data described in the table below.

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Table 83: Assembly Instances

Instance	Byte	Data	
1	0	Flow (low byte)	
	1	Flow (high byte)	*S-Analog Sensor, Attribute 6
2	0	Status	*S-Device Supervisor, Attribute 12
	1	Flow (low byte)	
	2	Flow (high byte)	*S-Analog Sensor, Attribute 6
6	0	Status	*S-Device Supervisor, Attribute 12
	1	Flow (low byte)	
	2	Flow (high byte)	*S-Analog Sensor, Attribute 6
	3	Setpoint (low byte)	
	4	Setpoint (high byte)	*S-Single Stage Controller, Attribute 6
	5	Override	*S-Analog Actuator, Attribute 5
	6	Valve (low byte)	
	7	Valve (high byte)	*S-Analog Actuator, Attribute 6
7	0	Setpoint (low byte)	
	1	Setpoint (high byte)	*S-Single Stage Controller, Attribute 6
8	0	Override	*S-Analog Actuator, Attribute 5
	1	Setpoint (low byte)	
	2	Setpoint (high byte)	*S-Single Stage Controller, Attribute 6
14	0	Status	*S-Device Supervisor, Attribute 12
	1	Flow (low byte)	
	2	Flow	
	3	Flow	
	4	Flow (high byte)	*S-Analog Sensor, Attribute 6
18	0	Status	*S-Device Supervisor, Attribute 12
	1	Flow (low byte)	
	2	Flow	
	3	Flow	
	4	Flow (high byte)	*S-Analog Sensor, Attribute 6
	5	Setpoint (low byte)	
	6	Setpoint	
	7	Setpoint	
	8	Setpoint (high byte)	*S-Single Stage Controller, Attribute 6
	9	Override	*S-Analog Actuator, Attribute 5
	10	Valve (low byte)	
	11	Valve	
	12	Valve	
	13	Valve (high byte)	*S-Analog Actuator, Attribute 6

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Table 83: Assembly Instances (continued)

19	0	Setpoint (low byte)
	1	Setpoint
	2	Setpoint
	3	Setpoint (high byte) *S-Single Stage Controller, Attribute 6
20	0	Override *S-Analog Actuator, Attribute 5
	1	Setpoint (low byte)
	2	Setpoint
	3	Setpoint
	4	Setpoint (high byte) *S-Single Stage Controller, Attribute 6

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Connection Object, Class Code: 05 (0x05)

The Connection Objects manage the characteristics of each communication connection. As a Group II Only Slave device the unit supports one explicit message connection and a POLL message connection.

Table 84: Connection Object Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1

Table 85: Connection Object, Instance 1 Attributes (Explicit Message)

Attribute	Access	Name	Type	Value
1	Get	State	USINT	See Below
2	Get	Instance Type	USINT	0 = Explicit Message
3	Get	Transport Class Trigger	USINT	0x83
4	Get	Production Connection	UINT	See Below
5	Get	Consumed Connection	UINT	See Below
6	Get	Initial Comm. Char.	USINT	0x21
7	Get	Production Size	UINT	128
8	Get	Consumed Size	UINT	17
9	Get/Set	Expected Packet Rate	UINT	default 2500 msec
12	Get/Set	Timeout Action	USINT	See Below
13	Get	Prod. Path Length	USINT	0
14	Get	Production Path		(null)
15	Get	Cons. Path Length	USINT	0
16	Get	Consumed Path		(null)

Table 86: Connection Object, Instance 2 Attributes (POLL connection)

Attribute	Access	Name	Type	Value
1	Get	State	USINT	See Below
2	Get	Instance Type	USINT	1 = I/O Message
3	Get	Transport Class Trigger	USINT	0x83
4	Get	Production Connection	UINT	See Below
5	Get	Consumed Connection	UINT	See Below
6	Get	Initial Comm. Char.	USINT	0x1
7	Get	Production Size	UINT	See Below
8	Get	Consumed Size	UINT	See Below
9	Get/Set	Expected Packet Rate	UINT	default 2500 msec
12	Get/Set	Timeout Action	USINT	See Below
13	Get	Prod. Path Length	USINT	See Below

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Table 86: Connection Object, Instance 2 Attributes (POLL connection) (continued)

Attribute	Access	Name	Type	Value
14	Get/Set	Production Path	STRUCT of	
		Log. Seg., Class	USINT	0x20
		Class Number	USINT	0x04
		Log.Seg., Instance	USINT	0x24
***		Instance Number	USINT	0x02 (default)
		Log.Seg., Attribute	USINT	0x30
		Attribute Number	USINT	0x03
15	Get	Cons. Path Length	USINT3	6
16	Get/Set	Consume Path	STRUCT of	
		Log. Seg., Class	USINT	0x20
		Class Number	USINT	0x04
		Log.Seg., Instance	USINT	0x24
***		Instance Number	USINT	0x07 (default)
		Log.Seg., Attribute	USINT	0x30
		Attribute Number	USINT	0x03

Table 87: Common Services

Service Code	Class	Instance	Service Name
05 (0x05)	Yes	Yes	Reset
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

State – Attribute 1

Connection States:

0 = non-existent
1 = configuring
3 = established
4 = timed out

Connection ID's – Attributes 4 and 5

Connection 1 Produced Connection ID: 10xxxxxx011
Connection 1 Consumed Connection ID: 10xxxxxx100

Connection 2 Produced Connection ID: 01111xxxxxx
Connection 2 Consumed Connection ID: 10xxxxxx101

xxxxxx = Node Address.

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Production and Consumed Sizes – Attributes 7 and 8

The Production and Consumed sizes will change based on what Assembly Instance is chosen for the POLL request and POLL response. The table below will define the Production and Consumed sizes with their respective Assembly.

Table 88: Production and Consumed Sizes

Assembly	Production Size	Consumed Size
1	2	
2	3	
6	8	
7		2
8		3
14	5	
18	14	
19		4
20		5

Watch Dog Timeout Activity – Attribute 12

0 = Timeout (I/O Messaging default)
1 = Auto Delete (Explicit Messaging, fixed value)
2 = Auto Reset

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S-Device Supervisor Object, Class Code: 48 (0x30)

Table 89: S-Device Supervisor Object Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Object Instance	UINT	1
6	Get	Max Class Identifier	UINT	7
7	Get	Max Instance Attribute	UINT	100

Table 90: S-Device Supervisor Object Instance 1

Attribute	Access	Name	Type	Value
3	Get	Device Type	SHORT STRING	MFC
4	Get	SEMI Standard Revision Level	SHORT STRING	E54-0997
5	Get	Manufacturer's Name	SHORT STRING	MKS Instruments
6	Get	Manufacturer's Model Number	SHORT STRING	MC20A Digital MFC
7	Get	Software Revision Level	SHORT STRING	See Below
8	Get	Hardware Revision Level	SHORT STRING	See Below
9	Get	Manufacturer's Serial Number	SHORT_STRING	MFC Serial Number
11***	Get	Device Status	USINT	See Below
12***	Get	Exception Byte	BYTE	See Below
13	Get	Exception Detail Alarm	STRUCT of	
		Common Exception Detail	STRUCT of	
		Size	USINT	2
		Detail	ARRAY of	
***		Detail[0]	BYTE	See Below
***		Detail[1]	BYTE	See Below
		Device Exception Detail	STRUCT of	
		Size	USINT	1
		Detail	ARRAY of	
***		Detail[0]	BYTE	See Below
		Manufacturer Exception Detail	STRUCT of	
		Size	USINT	1
		Detail	ARRAY of	
***		Detail[0]	BYTE	See Below

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Table 90: S-Device Supervisor Object Instance 1 (continued)

Attribute	Access	Name	Type	Value
14	Get	Exception Detail Warning	STRUCT of	
		Common Exception Detail	STRUCT of	
		Size	USINT	2
		Detail	ARRAY of	
***		Detail[0]	BYTE	See Below
***		Detail[1]	BYTE	See Below
		Device Exception Detail	STRUCT of	
		Size	USINT	1
		Detail	ARRAY of	
***		Detail[0]	BYTE	See Below
		Manufacturer Exception Detail	STRUCT of	
		Size	USINT	1
		Detail	ARRAY of	
***		Detail[0]	BYTE	See Below
15***	Get/Set	Alarm Enable	BOOL	0=Disable, 1=Enable
16***	Get/Set	Warning Enable	BOOL	0=Disable, 1=Enable
100	Get	Mode	USINT	0 = User 1 = Calibration
101***	Get/Set	Visual Indicator	USINT	0=Off, 1=On

Table 91: Common Services

Service Code	Class	Instance	Service Name
05 (0x05)	No	Yes	Reset
06 (0x06)	No	Yes	Start
07 (0x07)	No	Yes	Stop
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

Table 92: Object-Specific Services

Service Code	Class	Instance	Service Name
75 (0x4B)	No	Yes	Abort
76 (0x4C)	No	Yes	Recover
78 (0x4E)	No	Yes	Perform_Diagnostics

Parameter	Form	Description
TestID	USINT	Type of diagnostic test to be performed

Test ID Parameter	Type of diagnostics to be performed
0	Standard

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Table 93: Manufacturer-Specific Services

Service Code	Class	Instance	Service Name
50 (0x32)	No	Yes	Change Mode
Parameter	**Form**	**Description**	
Password	USINT	0x0000 = User 0x1234 = Calibration	

Software Revision Level – Attribute 7

The Software Revision will be a text string of the Major and Minor revision information of the Identity object. It will have the format X.YYY, where X is the major revision and YYY is the Minor revision. The revision code will match that provided by the Identity object.

Hardware Revision Level – Attribute 8

The Hardware Revision will be a text string reflecting the current revision of the hardware. It will have the format X.YYY, where X is the major revision and YYY is the Minor revision.

Device Status – Attribute 11

0 = Undefined
1 = Self Testing
2 = Idle
3 = Self-Test Exception
4 = Executing
5 = Abort
6 = Critical Fault

Exception Status – Attribute 12

Table 94: Exception Status – Attribute 12

Bit	Function
0	ALARM/ device-common
1	ALARM/ device-specific
2	ALARM/ manufacturer-specific
3	Reserved – set to 0
4	WARNING/ device-common
5	WARNING/ device-specific
6	WARNING/ manufacturer-specific
7	1 = Expanded Method

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Common Exception Detail – Attribute 13 and 14

Table 95: Common Exception Detail – Attribute 13 and 14

Bit	Common Exception Detail[0]	Bit	Common Exception Detail[1]
0	Internal diagnostic exception	0	0
1	Microprocessor exception	1	0
2	ROM/FLASH exception	2	0
3	EEPROM exception	3	Power supply input voltage
4	RAM exception	4	0
5	0 - Reserved by DeviceNet	5	Notify manufacturer
6	Internal real-time exception	6	Reset exception
7	0 - Reserved by DeviceNet	7	0 = Reserved by DeviceNet

Internal Diagnostic Exception:

Bad or no HW calibration
No factory setup

ROM/FLASH exception:

ALARM if there is an exception
WARNING if the FLASH counter overflows

MFC Exception Detail – Attributes 13 and 14

Table 96: MFC Exception Detail – Attributes 13 and 14

Bit	MFC Device Exception Detail	
0	Reading Valid	S-Analog Sensor *
1	Flow Low	S-Analog Sensor
2	Flow High	S-Analog Sensor
3	Flow Control	S-Single Stage Controller
4	Valve Low	S-Analog Actuator
5	Valve High	S-Analog Actuator
6	Reserved = 0	
7	Reserved = 0	
* Only used in Warning Detail. This bit is always 0 in Alarm Detail.		

Flow Low/Flow High:

Signal overflow

Flow Control:

Flow controller unstable
Setpoint not reached in time

Manufacturer Exception Detail – Attributes 13 and 14

Table 97: Manufacturer Exception Detail – Attributes 13 and 14

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Bit	Manufacturer Exception Detail
0	Speedup Result Invalid
1	Bridge Controller Error
2	Valve Circuit Error
3	No Gas Table Available or Used
4	Power Ground Level Invalid
5	AD or DA Circuitry Error
6	Temperature Out Of Range
7	Bus Controller Error

AD/DA Circuitry Error:

Analog ground level invalid
Reference voltage incorrect
AD device error
DA device error

Attribute 0x65—Visual Indicator

Attribute ID 0x65 controls the behavior of the visual indicator (the wink function) on the device. This attribute controls the flashing of the Module Status LED, which is useful for visually identifying a particular device on the network, where:

0 = Off (default)
1 = On

It is not in the non-volatile memory therefore is off after power cycle.

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S-Analog Sensor Object, Class Code: 49 (0x31)

Table 98: S-Analog Sensor Object Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Object Instance	UINT	1
6	Get	Max Class Identifier	UINT	7
7	Get	Max Instance Attribute	UINT	99

Table 99: S-Analog Sensor Object Instance 1

Attribute	Access	Name	Type	Value
Attribute	Access	Name	Type	Value
3***	Get/Set	Data Type	USINT	0xC3=INT, 0xCA=REAL
4***	Get/Set	Data Units	UINT	0x1001=counts, 0x1400=sccm
5***	Get	Reading Valid	BOOL	0=invalid, 1=valid
6***	Get	Value (Flow)	(See Data Type)	See Below
7***	Get	Status	BYTE	See Below
10***	Get	Full Scale	(See Data Type)	See Below
17***	Get/Set	Alarm Trip Point High	(See Data Type)	See Below
18***	Get/Set	Alarm Trip Point Low	(See Data Type)	See Below
21***	Get/Set	Warning Trip Point High	(See Data Type)	See Below
22***	Get/Set	Warning Trip Point Low	(See Data Type)	See Below
28***	Get	Autozero Status	BOOL	See Below
32***	Get	Overrange	(See Data Type)	See Below
33***	Get	Underrange	(See Data Type)	See Below
35***	Get/Set	Gas Calibration Object Instance	UINT	See Below
95***	Get Set	Flow Totalizer	ULINT	See Below
96***	Get/Set	Flow Hours	UDINT	See Below
99	Get	Subclass	UINT	1 = Flow Diagnostics

Table 100: Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

Table 101: Object-Specific Services

Service Code	Class	Instance	Service Name
75 (0x4B)	No	Yes	Zero_Adjust

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Value (Flow) – Attribute 6

The corrected, converted, calibrated final value of the sensor.

Status – Attribute 7

Table 102: Status – Attribute 7

Bit	Definition
0	High Alarm Exception
1	Low Alarm Exception
2	High Warning Exception
3	Low Warning Exception
4	0 – Reserved
5	0 – Reserved
6	0 – Reserved
7	0 – Reserved

Full Scale – Attribute 10

The value of attribute Value corresponding to the Full Scale calibrated measurement of the sensor. Default value will be maximum allowable value for the Data Type.

Alarm Trip Point High Attribute 17

Determines the Value above which an Alarm condition will occur.

Alarm Trip Point Low – Attribute 18

Determines the Value below which an Alarm condition will occur.

Warning Trip Point High – Attribute 21

Determines the Value above which a Warning condition will occur.

Warning Trip Point Low – Attribute 22

Determines the Value below which an Warning condition will occur.

Auto Zero Status – Attribute 28

0 = Device is not in process of nulling.
1 = Device in process of nulling.

Overrange – Attribute 32

Specifies the highest valid value.

Underrange – Attribute 33

Specifies the lowest valid value.

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Gas Calibration Object Instance – Attribute 35

Value is the selected S-Gas Calibration Object instance.

Flow Totalizer – Attribute 95

Total Gas flowed through the device since this value was last set to zero.

Flow Hours – Attribute 96

Total time device has been powered and flowing gas since this value was last set to zero.

Subclass – Attribute 99

Attributes 95 and 96 of the subclass are supported.

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S-Analog Actuator Object, Class Code: 50 (0x32)

Table 103: S-Analog Actuator Object Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Object Instance	UINT	1
6	Get	Max Class Identifier	UINT	7
7	Get	Max Instance Attribute	UINT	21

Table 104: S-Analog Actuator Object Instance 1

Attribute	Access	Name	Type	Value
3 ***	Get/Set	Data Type	USINT	0xC3=INT, 0xCA=REAL
4***	Get/Set	Data Units	UINT	See Below
5***	Get/Set	Override	USINT	See Below
6***	Get/Set	Value (Valve)	(See Data Type)	See Below
7***	Get	Status	BYTE	See Below
21***	Get/Set	Safe State	USINT	See Below

Table 105: Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

Data Units – Attribute 4

0x1001 = counts
0x1007 = % Full Scale
0x2D00 = Volts
0x2D01 = mVolts

Override – Attribute 5

0 = Normal
1 = Off/Closed
2 = On/Open
3 = Hold
4 = Safe State

Value (Valve) – Attribute 6

The uncorrected value sent to the analog output for the valve.

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Status – Attribute 7

Table 106: Status – Attribute 7

Bit	Definition
0	High Alarm Exception
1	Low Alarm Exception
2	High Warning Exception
3	Low Warning Exception
4	0 - Reserved
5	0 - Reserved
6	0 - Reserved
7	0 - Reserved

Safe State – Attribute 21

0 = Zero / Off / Closed
1 = Full Scale / On / Open
2 = Hold Last Value

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S-Single Stage Controller Object, Class Code: 51 (0x33)

Table 107: S-Single Stage Controller Object Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Object Instance	UINT	1
6	Get	Max Class Identifier	UINT	7
7	Get	Max Instance Attribute	UINT	19

Table 108: S- Single Stage Controller Object Instance 1

Attribute	Access	Name	Type	Value
Attribute	Access	Name	Type	Value
3***	Get/Set	Data Type	USINT	0xC3=INT, 0xCA=REAL
4***	Get/Set	Data Units	UINT	0x1001=counts, 0x1400=sccm
6 ***	Get/Set	Setpoint	(See Data Type)	See Below
10 ***	Get	Status	BYTE	See Below
19 ***	Get/Set	Ramp Rate	UDINT	See Below

Table 109: Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

Setpoint – Attribute 6

The Setpoint sent to the device actuator.

Status – Attribute 10

Table 110: Status – Attribute 10

Bit	Definition
0	Alarm Exception
1	Warning Exception
2	0 – Reserved
3	0 – Reserved
4	0 – Reserved
5	0 – Reserved
6	0 – Reserved
7	0 – Reserved

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Ramp Rate – Attribute 19

Time in msec to reach the set point.

S-Gas Calibration Object, Class Code: 52 (0x34)

Table 111: S-Gas Calibration Object Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Object Instance	UINT	20
6	Get	Max Class Identifier	UINT	7
7	Get	Max Instance Attribute	UINT	99

Table 112: S- Gas Calibration Object Instance 1…20

Attribute	Access	Name	Type	Value
3 ***	Get/Set Ω	Gas Standard Number	UINT	See Below
4 ***	Get	Valid Sensor Instance	UINT	1
5	Get/Set	Gas Symbol	SHORT STRING	Gas Type Name
6 ***	Get	Full Scale Amount Units	STRUCT of: REAL UINT	 See Below 0x1400 = sccm
7 ***	Get/Set	Additional Scaler	REAL	See Below
8	Get	Calibration Date	DATE	See Below
9	Get	Calibration Gas Number	UINT	See Below
95	Get	Calibration Pressure	REAL	See Below
96	Get	Calibration Temperature	REAL	See Below
99	Get	Subclass	UINT	1 = Standard T & P

Table 113: Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

Table 114: Object-Specific Services

Service Code	Class	Instance	Service Name
75 (0x4B)	Yes	No	Get_All_Instances

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Table 115: Get All Instances Response

Parameter	Data Type	Description
Size of List	UINT	Specifies the number of elements in the array.
List of Gas Calibrations	ARRAY of STRUCT of UINT UINT UINT	Supported List S-Gas Calibration Object Instance ID Gas Standard Number Valid Sensor Instance

Gas Standard Number – Attribute 3

0 = No gas type specified

Full Scale – Attribute 6

Amount = The amount, Mass Flow, corresponding to the Full Scale of the associated S-Analog Sensor Object.

Additional Scaler – Attribute 7

Correction for a gas other than the type identified for the object instance by attribute 3.

Calibration Date – Attribute 8

The date this instance was last calibrated. This value is the number of days since 01/01/1972.

Calibration Gas Number – Attribute 9

The gas number used to calibrate the object instance.

Calibration Pressure – Attribute 95

The gas pressure in KiloPascal used during calibration.

Calibration Temperature – Attribute 96

The gas temperature in Degrees C used during calibration.

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Controller Calibration Object, Class Code: 102 (0x66)

Table 116: Controller Calibration Object Class Attributes

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	3

Table 117: Controller Calibration Object Instance 1…20

Attribute	Access	Name	Type	Value
1	Get/Set Ω	Controller P	REAL	See Below
2	Get/Set Ω	Controller I	REAL	See Below
3	Get/Set Ω	Controller D	REAL	See Below
25	Get/Set Ω	Gas Table Length	USINT	
26	Get/Set Ω	Flow Cal Point 0 Sensor Value 0 Flow Value 0	STRUCT of REAL REAL	
27	Get/Set Ω	Flow Cal Point 1 Sensor Value 1 Flow Value 1	STRUCT of REAL REAL	
28	Get/Set Ω	Flow Cal Point 2 Sensor Value 2 Flow Value 2	STRUCT of REAL REAL	
29	Get/Set Ω	Flow Cal Point 3 Sensor Value 3 Flow Value 3	STRUCT of REAL REAL	
30	Get/Set Ω	Flow Cal Point 4 Sensor Value 4 Flow Value 4	STRUCT of REAL REAL	
31	Get/Set Ω	Flow Cal Point 5 Sensor Value 5 Flow Value 5	STRUCT of REAL REAL	
32	Get/Set Ω	Flow Cal Point 6 Sensor Value 6 Flow Value 6	STRUCT of REAL REAL	
33	Get/Set Ω	Flow Cal Point 7 Sensor Value 7 Flow Value 7	STRUCT of REAL REAL	
34	Get/Set Ω	Flow Cal Point 8 Sensor Value 8 Flow Value 8	STRUCT of REAL REAL	
35	Get/Set Ω	Flow Cal Point 9 Sensor Value 9 Flow Value 9	STRUCT of REAL REAL	

(Continued on next page)

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Table 117: Controller Calibration Object Class Attributes (continued)

Attribute	Access	Name	Type	Value
36	Get/Set Ω	Flow Cal Point 10 Sensor Value 10 Flow Value 10	STRUCT of REAL REAL	
37	Get/Set Ω	Flow Cal Point 11 Sensor Value 11 Flow Value 11	STRUCT of REAL REAL	
38	Get/Set Ω	Flow Cal Point 12 Sensor Value 12 Flow Value 12	STRUCT of REAL REAL	
39	Get/Set Ω	Flow Cal Point 13 Sensor Value 13 Flow Value 13	STRUCT of REAL REAL	
40	Get/Set Ω	Flow Cal Point 14 Sensor Value 14 Flow Value 14	STRUCT of REAL REAL	
41	Get/Set Ω	Flow Cal Point 15 Sensor Value 15 Flow Value 15	STRUCT of REAL REAL	
42	Get/Set Ω	Flow Cal Point 16 Sensor Value 16 Flow Value 16	STRUCT of REAL REAL	
43	Get/Set Ω	Flow Cal Point 17 Sensor Value 17 Flow Value 17	STRUCT of REAL REAL	
44	Get/Set Ω	Flow Cal Point 18 Sensor Value 18 Flow Value 18	STRUCT of REAL REAL	
45	Get/Set Ω	Flow Cal Point 19 Sensor Value 19 Flow Value 19	STRUCT of REAL REAL	
46	Get/Set Ω	Flow Cal Point 20 Sensor Value 20 Flow Value 20	STRUCT of REAL REAL	
101	Get/Set Ω	Counts Full Scale	UINT	The number of counts that equal 100% Full Scale. [default] = 0x6000

Table 118: Common Services

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

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Table 119: Manufacturer-Specific Services

Service Code	Class	Instance	Service Name
50 (0x32)	Yes	No	Do Raw Zero

This service is only available in Factory Mode.

Ψ : This attribute is only available in Factory mode.
Ω : This attribute is as follows:
Get in all modes.
Set in Calibration mode as long Factory Tag attribute is equal to 0.
Set in Factory mode.
τ: This attribute is as follows:
Get in all modes.
Set in Factory mode only.

Controller P – Attribute 1

P component of the PID controller.

Controller I – Attribute 2

I component of the PID controller. High P component values give the possibility of high I component values.

Controller D – Attribute 3

D component of the PID controller. Should be zero.

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Appendix E: Mass Flow Device Sizing Guidelines

General Information

To select the correct controller for an application, you must determine the:

- Flow controller range
- Appropriate valve configuration

The flow controller range depends on the desired flow rate and the gas correction factor for the gas to be used. MKS states the flow controller ranges based on flow rate of nitrogen; the flow rate for other gases may vary.

The proper valve configuration depends upon the flow range, inlet pressure, differential pressure across the unit, and density of the gas. Proper valve configurations have been established for all standard flow ranges flowing nitrogen under standard operating pressures. These configurations are suitable for virtually all gases and pressure conditions.

How to Determine the Flow Controller Range

The controller is available in ranges of 50, 100, and 200 SLM (N_2 equivalent). To select the appropriate range, you must determine the flow rate of nitrogen that is equivalent to the flow rate of the desired gas. Calculate the ratio of the GCF of nitrogen (1.00) to the GCF of the desired gas (refer to Appendix B*, Gas Correction Factors*, page 91), as shown in the following example.

Caution **Choose the mass flow controller range for which the N_2 equivalent of the desired process gas and range falls between 55 and 105%.**

Example

You need a flow rate of 100 SLM of argon (Ar). What range flow controller should you use?

1. Find the Gas Correction Factor of Ar (1.39, as shown in Appendix B*, Gas Correction Factors*, page 91).
2. Insert the GCF of Ar in the following formula:

where x is the equivalent flow rate of nitrogen (sccm).

$$\frac{(1.00)}{(1.39)} = \frac{(x)}{(100\ \text{SLM Ar})}$$

$$x = 72\ \text{SLM}\ N_2$$

A flow rate of 100 SLM of Ar will produce a flow rate output equivalent to 72 SLM of N_2. This falls within the range of a 100 SLM flow controller.

When calculating equivalent N_2 flows using gas correction factors, be sure to use a flow controller with a sufficient flow rate range. For example, if the calculated equivalent N_2 flow in the example shown above is 105 SLM, use a 200 SLM flow controller. The 200 SLM instrument can then be calibrated such that 105 SLM N_2 = full scale.

When using a gas with a density *higher* than nitrogen, be sure that the control valve Full Scale range can accommodate the desired flow rate. Please call the MKS Applications group if you have any questions.

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Appendix F: MC20A Digital MFC Graphical User Interface (GUI)

Overview

The MC20A line of digital mass flow devices have calibration and tuning features, which can be altered to expand the operating range of the devices. Specifically:

- Calibration tables can be copied to new gas tables to allow device re-ranging or use of alternative gases.
- Entirely new calibration tables can be created by users who have appropriate flow standards.
- Each gas table for flow controllers has different PID tuning parameters associated with it. These can be edited to provide optimum control performance for a particular gases or process conditions. In some cases, a user might create a new gas table where the gas and full scale flow range remain the same as an existing table but only the PID parameters are changed.
- The MC20A Mass Flow Devices have a 20 gas table capacity.

To support these features, MKS Instruments provides a graphical user interface (GUI), which provides digital access to the MC20A flow devices. This appendix describes use of the GUI, which supports the DeviceNet version of the product.

The GUI is part of a complete software/hardware interface kit, which includes the following components:

- The GUI software on a CD.
- A security hard-key that attaches to either the parallel or USB ports of the Windows-based personal computer.

The kit is available in two configurations:

With USB port security hard key	MKS P/N 133900-G1
With parallel port security hard key	MKS P/N 133900-G2

Software Setup

The MC20A digital Mass Flow Controller or Mass Flow Meter with DeviceNet interface can run under Windows 98/WinNT/2000/XP only.

1. Insert the MC20A DeviceNet Application Kit CD into your CD-ROM drive. The setup wizard will automatically start.

   If the installation does not automatically start, run *Setup.exe* from the *Setup* directory.

2. Follow the instructions in the Setup wizard.
3. After completing the GUI software installation, install the Hasp Device Driver by going to Start → Programs → MC20A DeviceNet MFC. Click on the "Hasp Device Driver" pull-down option and allow the driver to install.

Now you can start running the program.

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Equipment Needed

You will need the following equipment:

- MC20A digital Mass Flow Controller or Mass Flow Meter with DeviceNet interface.
- Elements included in the DeviceNet interface kit:

— Graphical user interface (GUI) software, “MC20ADeviceNetMFC.exe”

— One security hard-key, linked to the GUI software

Standard DeviceNet communication cables

One SST brand DeviceNet communication card

Power supply (24V).

Assorted DeviceNet cables.

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Equipment Setup

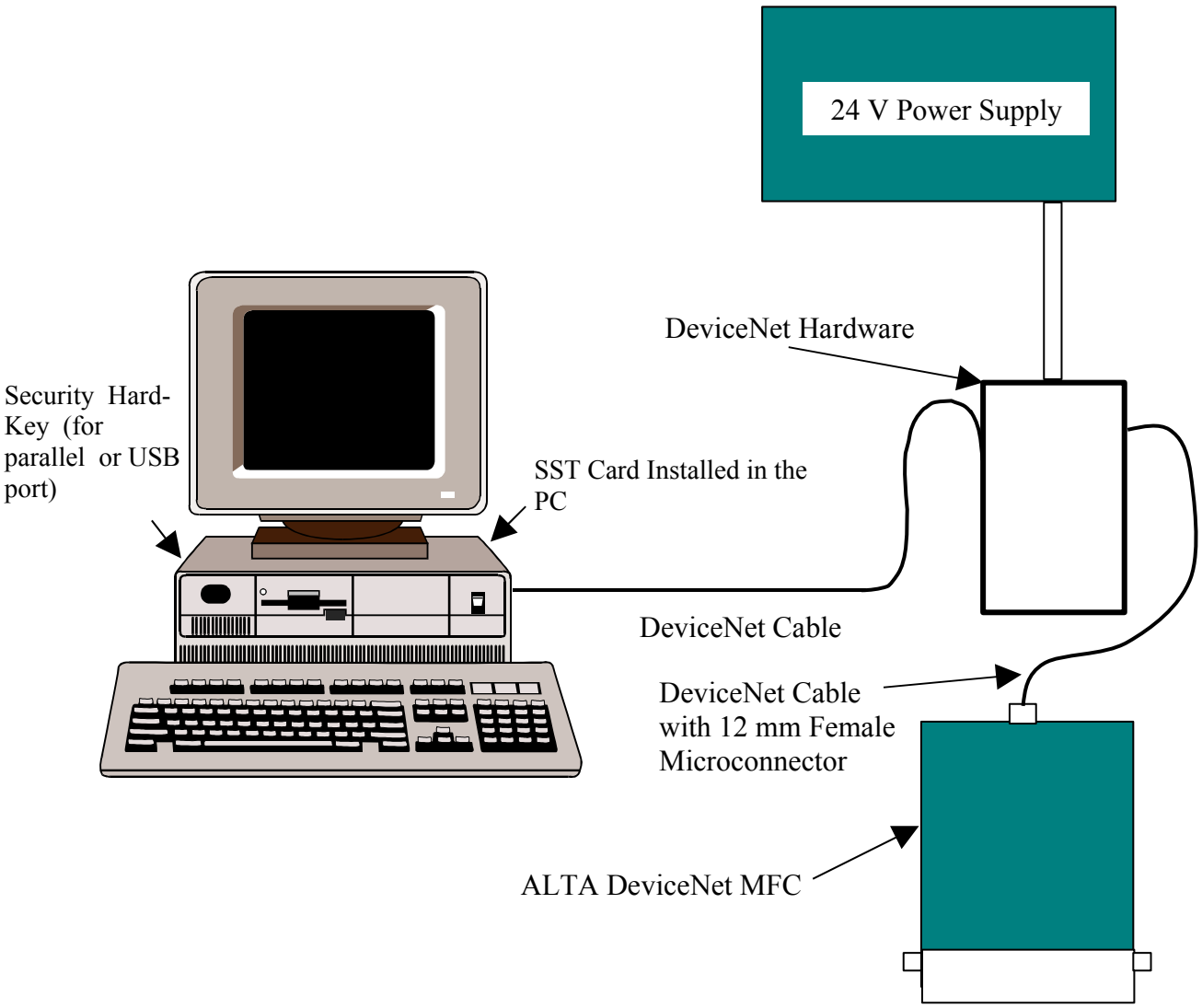


Figure 16: Equipment Setup

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Starting the GUI

1. Double click the "MC20ADeviceNetMFC.exe" shortcut on your computer desktop. The program starts and following window appears:

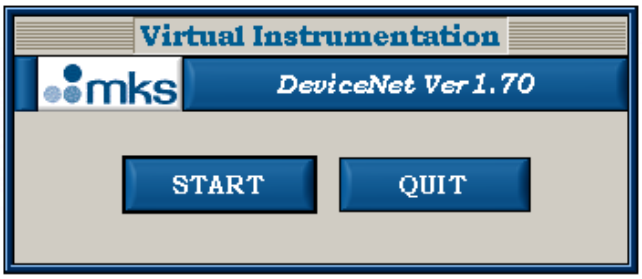


Figure 17: Start Window

2. Click START to continue. After clicking START, the following Communications setup window appears.

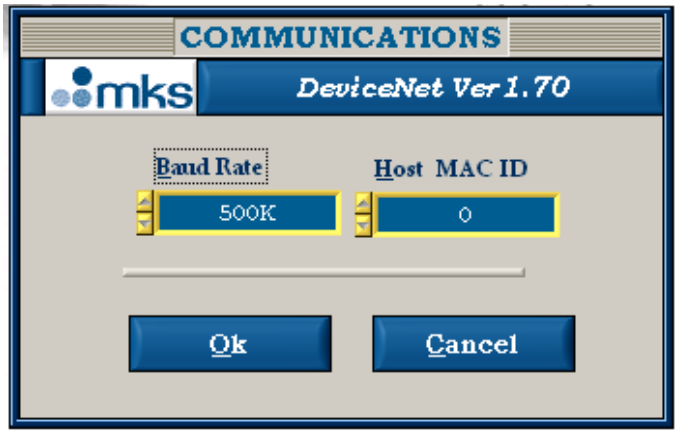


Figure 18: Communications Setup Window

3. Choose the Baud Rate you selected for your DeviceNet network(500 K, 250 K or 125 K).
4. Choose the Host MAC ID(0 to 63). This is a dedicated address for the SST card. It must be different from the MAC ID of the other devices on the same network.
5. Click OK to continue. The following panel appears as the software scans the device network.

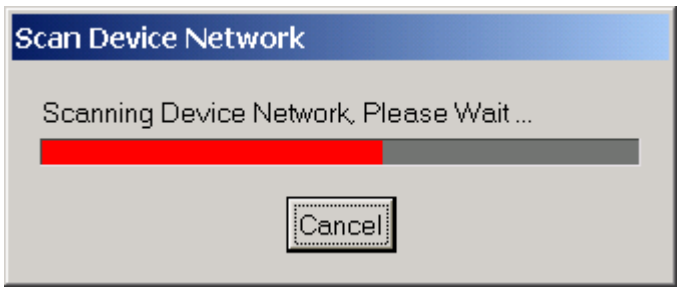


Figure 19: Scan Device Network

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The Main Control Panel appears:

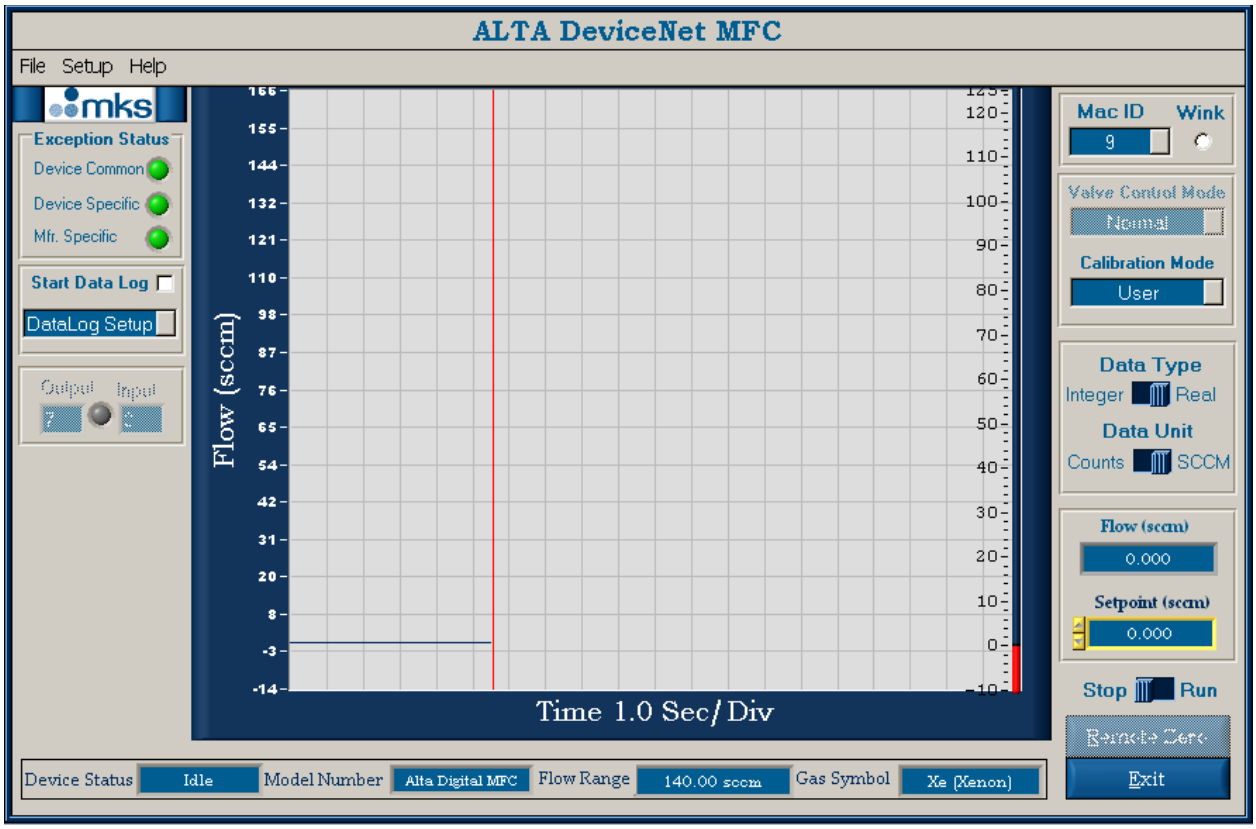


Figure 20: Main Control Panel

Exiting the GUI

Always formally exit the program before disconnecting the Mass Flow device. If you hot plug any device, software must be restarted.

- Click on the "Exit" button in the lower right corner of the Main Control Panel.

Or:

- Click on "File" pull-down and then "Exit."

Description of the Main Control Panel

Data Type The Data Type switch is used to change the data type. Either Integer or Real data type can be used in the operation.

Data Unit The Data Unit switch is used to change the data unit. Either Counts or SCCM data unit can be used in the operation.

Run/Stop The Run/Stop switch toggles the control mode (run versus stop).

Run The GUI puts the MFC in executing state.

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Stop The GUI puts the MFC in idle state.

Remote Zero The Remote Zero button zeros the MC20A DeviceNet MFC. Refer to How to Zero the Flow Device, page 43, for proper zeroing procedures. This is available only in calibration mode.

Exit The Exit button stops the application. Always formally exit the program before disconnecting the Mass Flow device. If you hot plug any device, software must be restarted.

Setpoint The Setpoint control sets the flow setpoint in sccm or counts.

Valve Control Mode The Valve Control Mode sets whether the device is controlling flow, driving its valve full open, or closing its valve. Simply click on the desired mode.

Flow The Flow text box displays the current flow rate in sccm or counts.

Calibration Mode The Calibration Mode is used to select the GUI access level as user or calibration. A password is required for calibration access. Refer to User Mode and Calibration Mode, page 139.

Start Data Log Checking the Start Data Log check box will cause data to be logged in the DataLog.csv file in the current PC drive. This can be opened with Microsoft Excel and then saved as a spreadsheet.

Exception Status The Exception Status is used to tell if the unit is running OK or has problem. Green LED indicates that the unit is running OK. Red LED indicates the unit has problem. Double click the LED to show what might go wrong. See ODVA specifications for detail.

Menu Items

The **File Menu** includes two options:

Exit

Print Graph (send to your default printer)

The **Setup Menu** has the following options:

Calibrate Flow is used to calibrate the gas table.

Edit Gas (Add/Select) is used to select, add, or delete gas tables.

Tuning Parameters is used to set PID values for device control tuning.

Trip Point Setup is used to set the Alarm/Warning trip point values.

Password is used to edit the user password in calibration mode.

Choose IO Assembly Instance is used to choose one of the predefined polled IO connection instances.

User Mode and Calibration Mode

The GUI has two access levels, User and Calibration, selected in the Calibration Mode field in the upper right corner of the Main Control Panel.

User Mode When in User mode, the operator has the ability to provide the unit with flow setpoints and then view flow response and flow read-back.

Calibration Mode When in Calibration mode, the operator has nearly full access to the key device calibration and tuning features. Calibration mode access is password protected. The GUI

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is delivered with a standard password, which can be changed by the responsible administrator. Also, multiple users can be added, each with their own password.

Note

All tagged gas tables are protected factory-set gas tables. Users are not permitted to make any changes to tagged gas tables in the User of Calibration Mode.

A more detailed summary is provided in the table below.

Table 120: Summary of User and Calibration Mode Capabilities

User Mode	Calibration Mode
Pick Run versus Stop operation.	Same as User mode.
Provide setpoint and view output.	Same as User mode.
Pick control mode: control, close, open.	Same as User mode.
Log flow output data to .csv format file.	Same as User mode.
	Create Calibration mode access passwords.
	Create new gas tables by copying calibration tables; apply new gas correction factors (GCFs) and full scale ranges.
	Change PID tuning parameters associated with particular gas tables.
	Create new calibration tables, if certified flow standard is available (Advanced feature).

Calibration Mode Access

Choosing Calibration mode is done on the Main Control Panel.

1. Click in the Calibration Mode field to reveal a list of choices, which include User and Calibration.
2. Click on Calibration. A small window with fields for the user name and password appears.

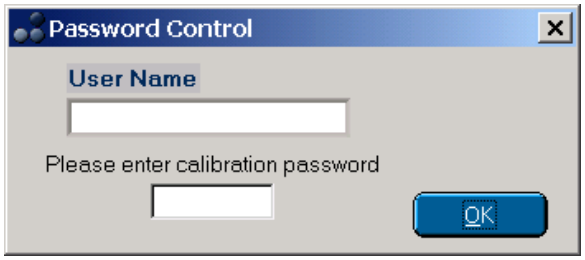


Figure 21: Password Control

3. Input the user name and password in the appropriate fields. The GUI is shipped from MKS with the following default assignments:

   User Name: Admin
   Password: cal

   The password may be changed or new usesr with their own password added (as described below).

Note

The User Name and Password are *case sensitive*.

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4. Click OK.

Changing a Password for Calibration Mode Access

1. On the Main Control Panel, choose Setup → Password → Change. The following window appears:



Figure 22: Change Password Window

2. Enter the User Name, Old Password, and New Password in the fields provided.
3. Re-type the new password into the Confirm Password field.
4. Click OK.

Adding a Calibration Mode Password for a New User

1. On the Main Control Panel, choose Setup → Password → New. The following window appears:



Figure 23: Adding a Calibration Mode Password for a New User

2. Enter a new User Name and New Password in the fields provided.
3. Re-type the new password in the Confirm Password field.
4. Click OK.

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Setting, Adding, and Deleting Gas Tables

Note In order to work with gas tables, the GUI must be in Calibration mode. This is set on the Main Control Panel, on the lower right side.

Accessing Gas Table Editing

Pull down the Setup submenu and choose Edit Gas (Add/Select). The module will load the gas tables and the following window appears:

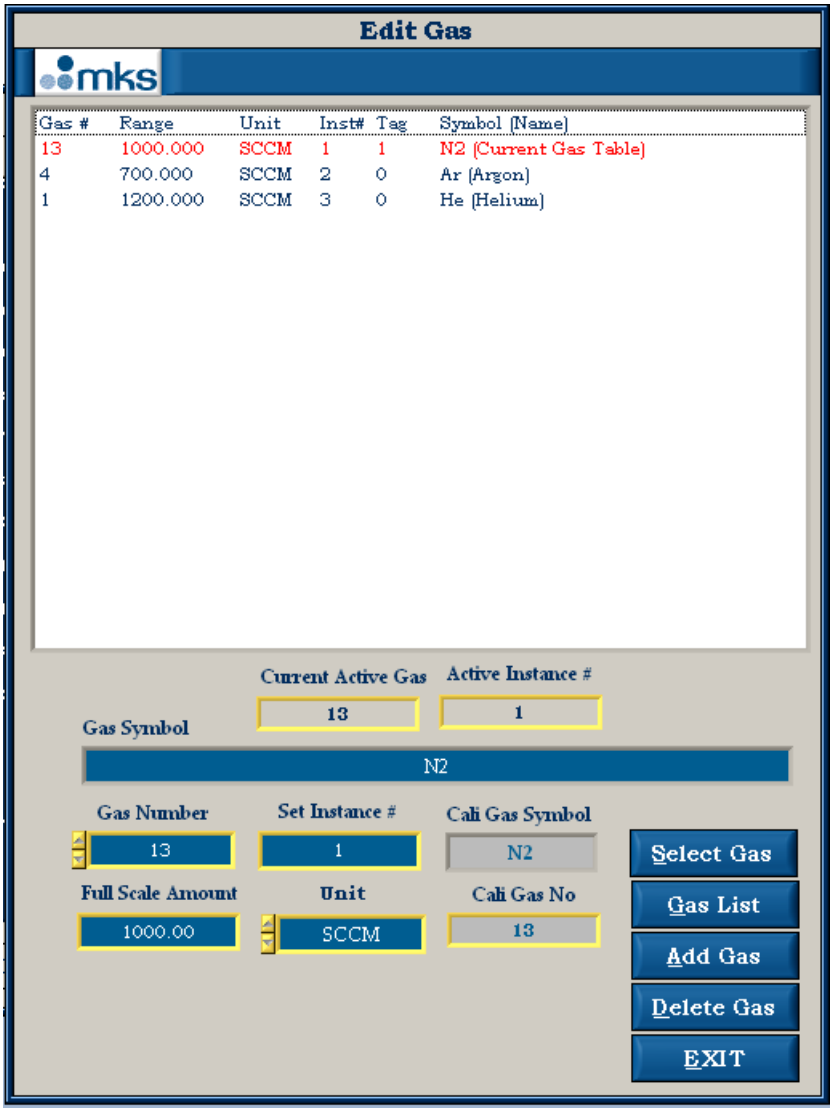


Figure 24: Edit Gas

The currently active gas table (Instance ID 1, in this example) is highlighted in red lettering.

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Setting a Gas Table and Making the Table Active

1. Point to desired gas table and highlight by clicking on it.
2. Click the Select Gas button.

The gas table choice will be downloaded into the Mass Flow device and made active. It will be highlighted in red in the Edit Gas window.

Adding a Gas Table

Adding gas is based on copying existing tables. There are several guidelines:

- Tagged gas table instances can be created only by the MKS Factory. They cannot be edited or deleted.
- When creating a new table, you may copy only from tables originally created by the Factory
- The full scale flow range of any new tables must fall between 40 and 110% of the original calibration gas equivalent. For example:

A device with a standard 200 sccm N2 calibration allows tables to be created with N2 equivalent full scale flows of 80 to 220 sccm. Thus, an additional N2 table with 80 sccm full scale is permitted; but, in creating an Ar gas table (GCF = 1.39), the specified full scale flow may not be below 111.2 sccm (80 x 1.39). On the other hand, a full scale flow as high as 305.8 sccm (220 x 1.39) is possible.

If an incorrect flow setpoint is input, an error warning will appear. Try again.

The specific steps for adding a new gas table are:

1. In the Edit Gas window, enter the new table instance number in the Set Instance # field.
2. Click the Gas List button and the gas list will appear:

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	Gas Number	GCF	Symbol	Name
1	184	0.340	C3H6O	Acetone
2	173	0.000	C2H3N	Acetonitrile
3	42	0.580	C2H2	Acetylene
4	8	1.000	Air	Air
5	66	0.430	C3H4	Allene
6	29	0.730	NH3	Ammonia
7	4	1.390	Ar	Argon
8	96	0.000	AsF5	Arsenic Pentafluoride
9	35	0.670	AsH3	Arsine
10	79	0.000	BBr3	Boron Tribromide
11	70	0.410	BCl3	Boron Trichloride
12	48	0.510	BF3	Boron Trifluoride
13	21	0.810	Br2	Bromine
14	116	0.260	BrF5	Bromine Pentafluoride
15	76	0.380	BrF3	Bromine Trifluoride
16	105	0.000	C2BrF3	Bromotrifluoroethylene
17	80	0.370	CBrF3	Bromotrifluoromethane (R-13b1)

Figure 25: Gas List

3. Scroll through the list of available gases to find the desired gas. To choose the gas, double click on any box in the row for that gas.

   The program will return to the Edit Gas window.

4. Click the Add Gas button. The Copy Cal Table window will open.

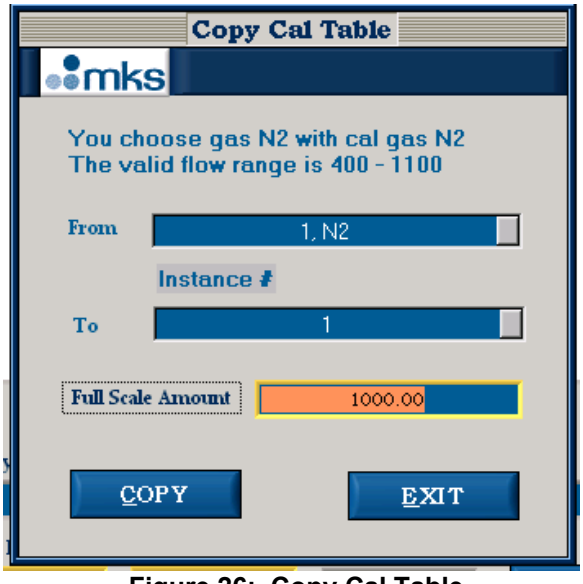


Figure 26: Copy Cal Table

5. Click on the drop down box associated with the From field and choose the desired table to be copied.

   Your choice must be among the factory set instances.

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6. Enter the input target Full Scale amount.

   To assure device accuracy, this value must be within the limits given in the message box on the top.

7. Click the Copy button to create the new table.

Deleting a Gas Table

1. Highlight the gas table to be deleted.

   Tagged gas table instances may be altered by the MKS Factory only. These may not be deleted.

2. Click the Delete Gas button. The table will be deleted from the gas table list.

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Adjusting PID Tuning Parameters

Note The PID tuning parameters may not be adjusted on factory "tagged" tables. To update the tuning parameters on such tables, it is necessary to first copy the table to a new instance.

1. Make the desired gas table active. To do so:

   Access the Add/Select Gas menu on the Main Control Panel by choosing Setup → Edit Gas (Add/ Select).

   Choose the gas table associated with the PID parameters to be updated. Make it active by highlighting and clicking the Select Gas button.

2. Return to the Main Control Panel and select Setup → Tuning Parameters. The following window appears:

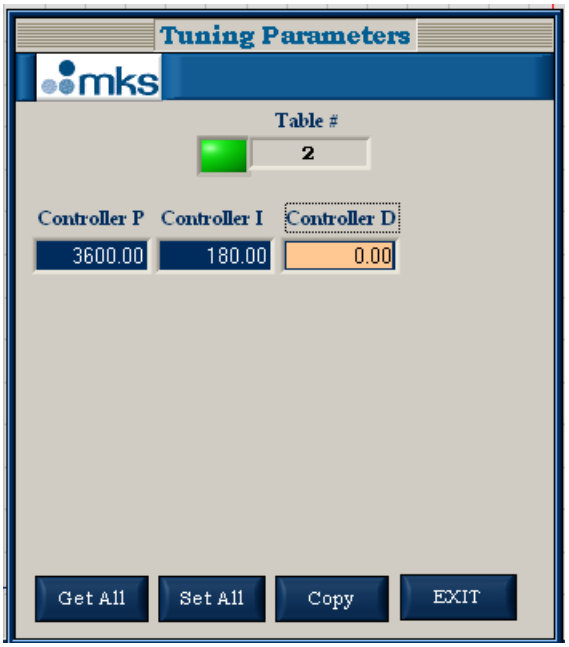


Figure 27: Tuning Parameters

Use this window to get, modify, and set the PID parameters.

Retrieve values in the active table of the MC20A Mass Flow Controller by clicking the Get All button.

Update the parameters as desired. Note that MKS generally recommends keeping the Controller D set at zero.

Download all parameters into the device by clicking the Set All button.

Copy one set of PID to another by clicking the Copy button.

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Creating and Modifying Calibration Tables

It is possible to perform gas calibration or adjust existing calibration tables using the Calibration Table Operations window, which is accessed through Set-up → Calibration Flow on the Main Control Panel. This is an *advanced feature*.

Editing Calibration Tables

Warning **Creating and editing calibration tables is an advanced topic, requiring great care and certified flow standards. Do not proceed unless properly equipped and experienced in MFC/MFM calibration.**

1. On the Main Control Panel, choose the Setup → Calibrate Flow. The following window appears:

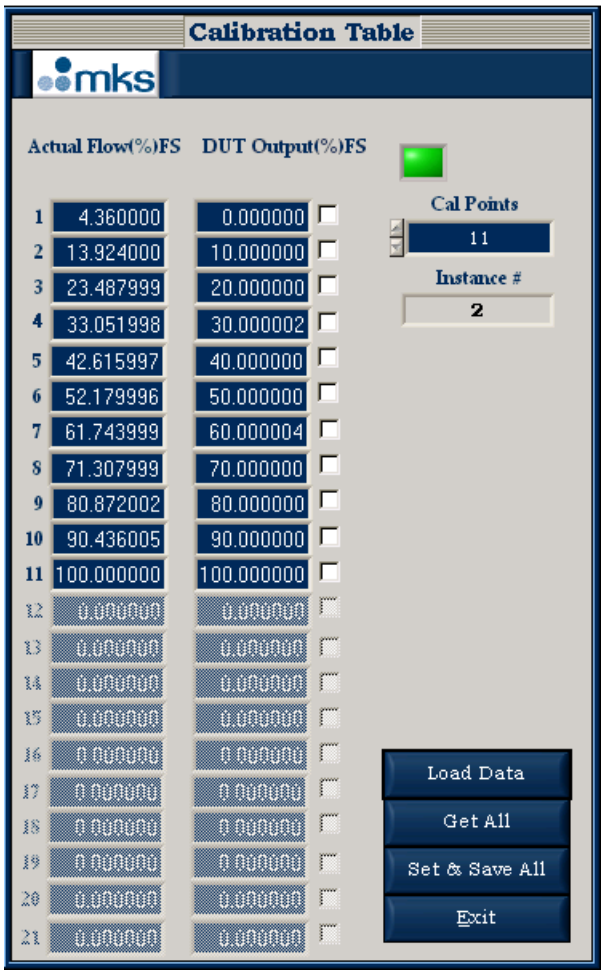


Figure 28: Calibration Table

2. Use this window to modify and re-load data. Up to 21 calibration data points are permitted. The default number for factory calibrations is 11 points, including zero.

Note Factory tagged tables may not be edited.

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Modifying Existing Calibration Table (Non-Tagged)

Note If you make a mistake, just click the Get All button to go back to where you were.

1. Use the Calibration Table Operations window as in creating a new table (above).
2. Click the Get All button.
3. Keep the displayed number of calibration points the same.
4. Based on flow data, edit the table as desired for improved accuracy.

Warning **Do not perform any accuracy testing unless the device is properly zeroed. Refer to How to Zero the Flow Device, page 43, for proper zeroing procedures.**

5. Click the Set and Save All button. This downloads the data to the proper location in the device for the specified instance. At the same time, it saves the calibration data in the text file called:

   CalData_mm-dd-yy_hh-mm-ss.txt

   where:

mm	month
dd	date
yy	year
hh	hour
mm	minute
ss	second

   For example, ***CalData_05-27-2003_13-57-06.txt***

6. To load the calibrated table file from your computer, click the Load Data button. Then, choose the calibration data file to be loaded. The calibration data will be loaded in the GUI.

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Configuring Polled IO Connection

There are 10 polled IO connections available. To change the desired polled IO connection.

Before proceeding, refer to pages 53 and 56 for definitions of assembly instances.

1. From the Main Control Panel, choose the Setup → Choose IO Assembly Instance. The following appears:

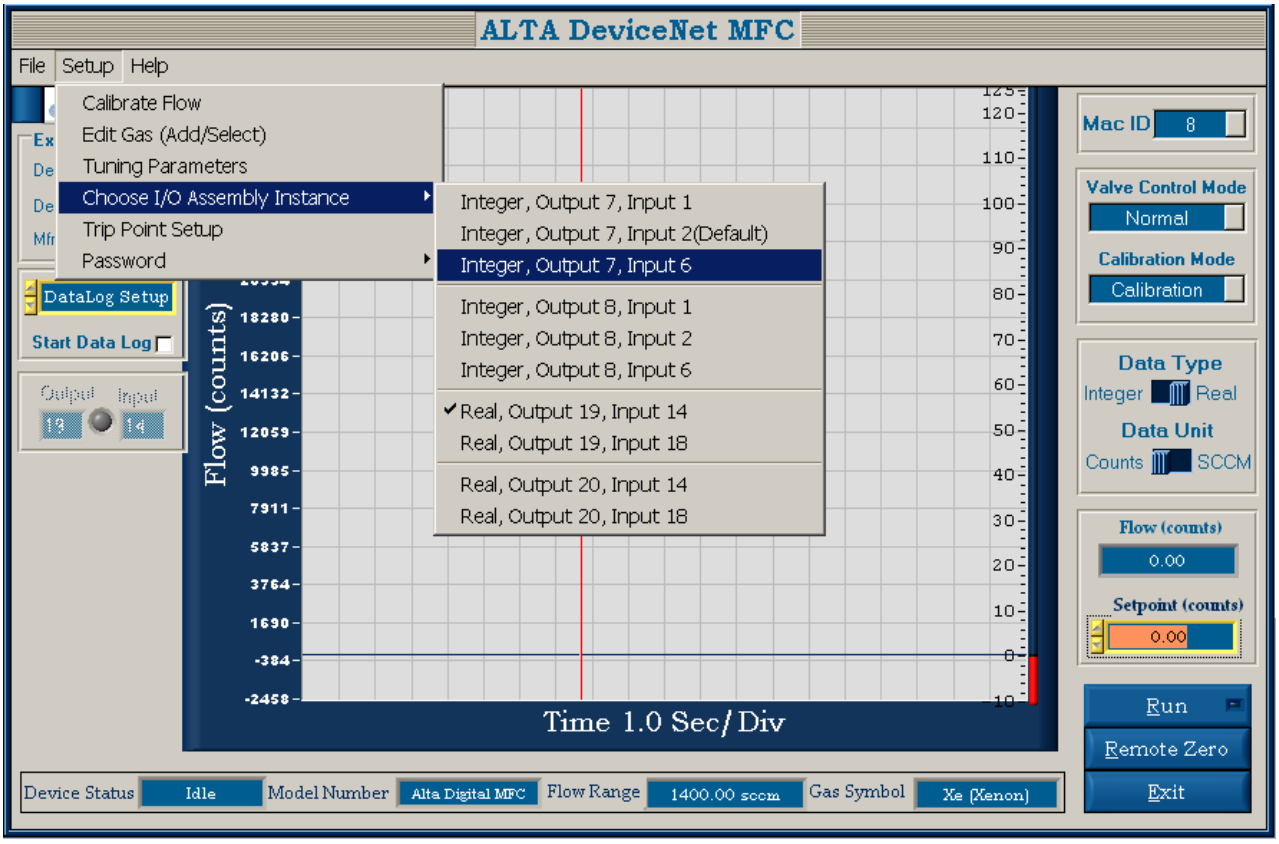


Figure 29: Choose IO Assembly Instanace

2. Click the instances you want and then the software will configure the polled IO connection correctly. The new Output and Input instance number will appear in the Output and Input message box on the left side of this panel.

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