参考出図

SPECIFICATION OF FA-CODER

SI35-17bit-LPS-5V

TS5668N20

REVISIONS

No.	DATE	PAGES	DESCRIPTION	APP'D	No.	DATE	PAGES	DESCRIPTION	APP'D

ED'NNo.3 00.03.29

DS'D	DATE	MODEL No.	TITLE
T. Fukuda	98. 12. 14	TS5668 N20	Specification of FA-CODER
CH'D M. Kubota K. Tamura			
APP'D			

DWG No.	3	4	5	6	7	8	9	10	11	12	SHEET
0566800	0	5	S	4	0						1/24

参考出図

SPECIFICATION OF
FA-CODER
TS5668N20

1. Scope

This document defines the specification of the instrument described below.

(1) Name: FA-CODER

(2) Model number: TS5668 N20

(3) Classification of function: SI35-17bit-LPS-5V

2. Basic Function

This FA-CODER has basic functions as follows.

(1) This FA-CODER is one of full absolute encoders that have the resolution of 17 bits per revolution and transmit the output of absolute position data as serial digital data responding to external request.

(2) It is capable to write the desired data into E^2PROM at any time when it is needed.

3. Environmental Conditions

Item		Specification	Remarks
Operating temperature range		− 10 ～+ 85 ℃	−−
Storage temperature range		− 20 ～+ 90 ℃	−−
Humidity		90 % RH max.	at 40 ℃, 96 hrs, without dew condensed
Vibration	Test condition	5 ～ 58 Hz, Double amplitude 1.5 mm 58 ～ 2,000 Hz, 98 m/s^2 (10 g's)	2 hours for each axis, total 6 hours
Shock	Test condition	1,960 m/s^2 (200 g's), 11 ms	3 times for each axis, total 18 times

参考出図

4. Mechanical Specification

Item	Specification	Remarks
Outline	056685002F30	－－
Protecting structure	Open	－－

Item	Specification Ta=25 ℃			Remarks	Unit
	Min.	Typ.	Max.		
Mass	－	－	0.03	Only FA-CODER itself except cable	kg
Moment of inertia	－	0.24	－	$GD^2/4g$	$\times 10^{-6}$ kg-m^2
Permissible rotational speed	－	－	100 (6,000)	－－	s^{-1} (min^{-1})
Permissible angular acceleration	－	－	80,000	－－	rad/s^2

第 3 版

DWG NO.	3	4	5	6	7	8	9	10	11	12	SHEET
0	5	6	6	8	0	0	0	5	S	4	0	3

参考出図

5. Electrical Specification

5.1 Electrical Connections

Color of Lead Wire	Function	Remarks
White	Vcc	Power supply: DC +5 V ± 5 %
Black	GND	−−
Light blue	SD	Serial data signal
Purple	$\overline{SD}$	

5.2 Absolute Maximum Rating

Item	Specification	Unit
Power supply voltage	5.5	V

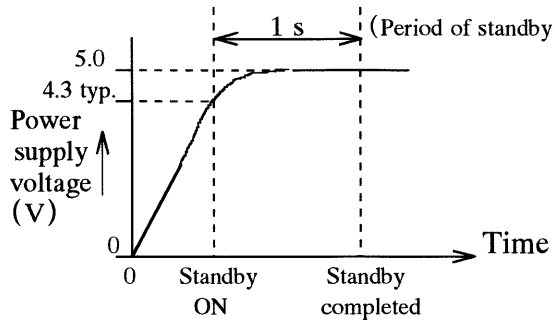
5.3 Common Electrical Specification

Item		Specification Ta=25 ℃			Remarks	Unit
		Min.	Typ.	Max.		
Power supply voltage		4.75	5	5.5	−−	V
Power supply current consumption		−	70	110	At no load	mA
Output signal	"H"	3.5	−	−	At 5V of power supply	V
	"L"	−	−	1.7	At 5V of power supply	V
Rise time/Fall time		−	−	100	At no load	ns
Insulation resistance		20	−	−	100 ns, by DC 500 V Megohm meter, between case & GND	MΩ
Dielectric strength		100 AC	−	−	1 minute, between case & GND	V
Standby period at power turning-on (Note 1)		−	−	1		s
Electrical life time		−	24000	−	MTBF at 75 ℃	hour

参考出図

Note 1

During the standby period at power-on (Refer to Fig. 1), any external request is not accepted. The line driver output circuit of FA-CODER is the state of Hi-Z (High impedance) during the standby period at power-on.



Power supply voltage for standby ON (V)		
Min.	Typ.	Max.
4.1	4.3	4.5

Fig. 1 Standby Period at Power Turning-on

第 3 版

DWG. NO.												
3	4	5	6	7	8	9	10	11	12	SHEET
0	5	6	6	8	0	0	0	5	S	4	0	5

5.3.1 Electric Specification for One Revolution Signal

Item		Specification Ta=25 ℃	Remarks
Resolution	Absolute data ABSA	2^{17}	When power supply is turned on, the accuracy is 5 bits. After the rotation of maximum 11.25 ° at 100 min^{-1} or less, the accuracy is 17 bits. (Note 2)
	Incremental data ABSS	2^{17}	Accuracy is 5 bits.
Maximum rotational speed		100 s^{-1} (6,000 min^{-1})	— —
Maximum angular acceleration		80,000 rad/s^2	— —
Output code		Pure binary	— —
Direction increasing		CCW	In view from the shaft end of FA-CODER
Repeatability at power-on (Absolute data ABSA)		According to Table 2	— —

Note 2 :

(1) When one revolution data of 2^{17} is not guaranteed, Full Absolute Status comes out as a status flag. (See Function of Status flag in para. 6.4)

(2) In case where power supply is turned on while the rotational speed is less than 100 min^{-1} in one direction, the operation of FA-CODER is shown in Fig. 2.

(3) The change of Full Absolute Status is as Table 1. But after one revolution is reset, the one revolution data may be shifted depending on its angle position when one revolution is reset.

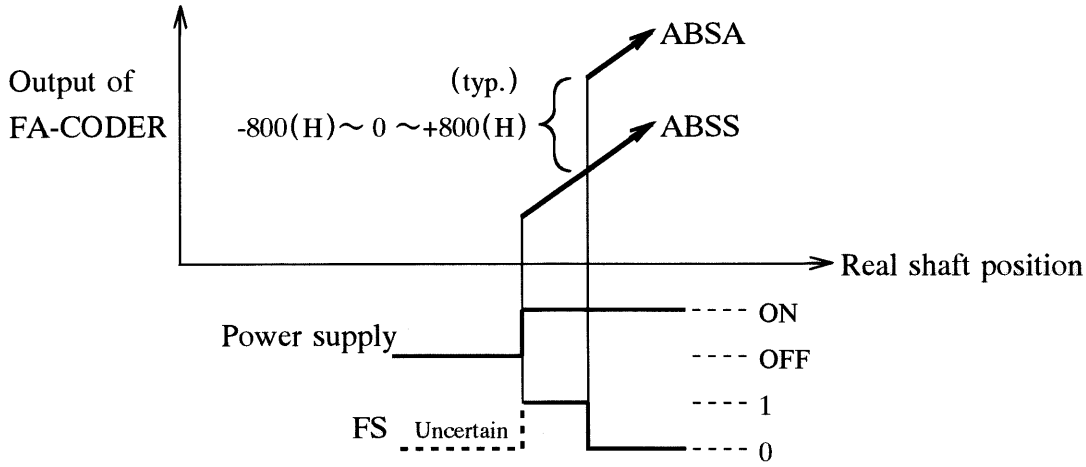
(4) In case where the power supply is turned on within the range of changing point of Full Absolute Status shown in Table 1, the accuracy of ABSA is 17 bits and Full Absolute Status does not come out.

(5) Relation between FS at power-on and ABSA & ABSS

(i) In case where FS = 1 at power-on, (that is turned on out of the range of the changing point of Full Absolute Status),

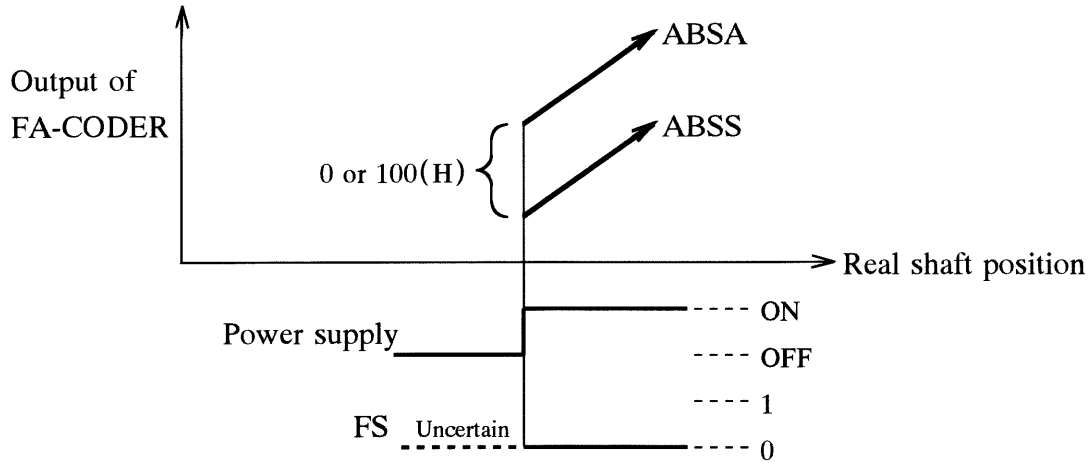
(a) FS = 1 ABSA = ABSS

(b) After the shaft is rotated by maximum 11.25 °,
it becomes FS = 0 ABSA ≠ ABSS or ABSA = ABSS .



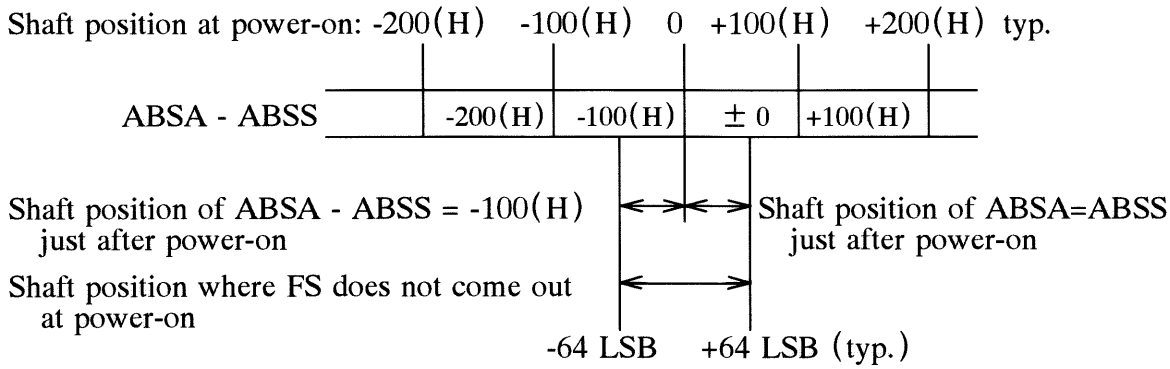
(ii) In case where FS = 0 at power-on, (that is turned on within the range of the changing point of Full Absolute Status),

FS = 0 ABSA ≠ ABSS or ABSA = ABSS .



(6) Relation between the shaft position at power-on and ABSA & ABSS at FS = 0

Example: The shaft position at delivery is around 0°. (After One Revolution is reset, One Revolution data may be shifted depending on the shaft position when One Revolution is reset.)



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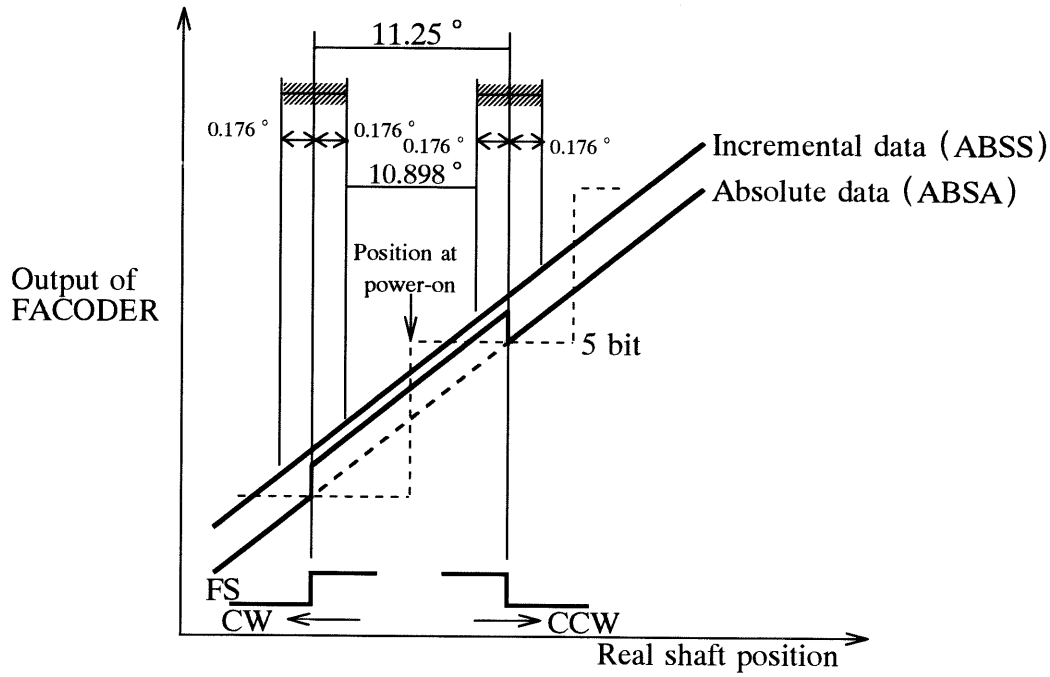


Fig. 2 Relation between the Real Shaft Position and FA-CODER Output

Note: In case where power supply is turned on in the shaft position except shown in Table 1 and FS comes out.

Shaft Position	Absolute Data ABSA
0 ° ± 0.176 (typ.)°	0 ± 64 (typ.)LSB
11.25 ° ± 0.176 (typ.)°	4096 ± 64 (typ.)LSB
22.5 ° ± 0.176 (typ.)°	8192 ± 64 (typ.)LSB
33.75 ° ± 0.176 (typ.)°	12288 ± 64 (typ.)LSB
45 ° ± 0.176 (typ.)°	16384 ± 64 (typ.)LSB
56.25 ° ± 0.176 (typ.)°	20480 ± 64 (typ.)LSB
67.5 ° ± 0.176 (typ.)°	24576 ± 64 (typ.)LSB
78.75 ° ± 0.176 (typ.)°	28672 ± 64 (typ.)LSB
90 ° ± 0.176 (typ.)°	32768 ± 64 (typ.)LSB
101.25 ° ± 0.176 (typ.)°	36864 ± 64 (typ.)LSB
112.5 ° ± 0.176 (typ.)°	40960 ± 64 (typ.)LSB
123.75 ° ± 0.176 (typ.)°	45056 ± 64 (typ.)LSB
135 ° ± 0.176 (typ.)°	49152 ± 64 (typ.)LSB
146.25 ° ± 0.176 (typ.)°	53248 ± 64 (typ.)LSB
157.5 ° ± 0.176 (typ.)°	57344 ± 64 (typ.)LSB
168.75 ° ± 0.176 (typ.)°	61440 ± 64 (typ.)LSB

Shaft Position	Absolute Data ABSA
180 ° ± 0.176 (typ.)°	65536 ± 64 (typ.)LSB
191.25 ° ± 0.176 (typ.)°	69632 ± 64 (typ.)LSB
202.5 ° ± 0.176 (typ.)°	73728 ± 64 (typ.)LSB
213.75 ° ± 0.176 (typ.)°	77824 ± 64 (typ.)LSB
225 ° ± 0.176 (typ.)°	81920 ± 64 (typ.)LSB
236.25 ° ± 0.176 (typ.)°	86016 ± 64 (typ.)LSB
247.5 ° ± 0.176 (typ.)°	90112 ± 64 (typ.)LSB
258.75 ° ± 0.176 (typ.)°	94208 ± 64 (typ.)LSB
270 ° ± 0.176 (typ.)°	98304 ± 64 (typ.)LSB
281.25 ° ± 0.176 (typ.)°	102400 ± 64 (typ.)LSB
292.5 ° ± 0.176 (typ.)°	106496 ± 64 (typ.)LSB
303.75 ° ± 0.176 (typ.)°	110592 ± 64 (typ.)LSB
315 ° ± 0.176 (typ.)°	114688 ± 64 (typ.)LSB
326.25 ° ± 0.176 (typ.)°	118784 ± 64 (typ.)LSB
337.5 ° ± 0.176 (typ.)°	122880 ± 64 (typ.)LSB
348.75 ° ± 0.176 (typ.)°	126976 ± 64 (typ.)LSB

Table 1 Range of changing point of Full Absolute Status ①

Note: ABSA is the data before One Revolution is reset.

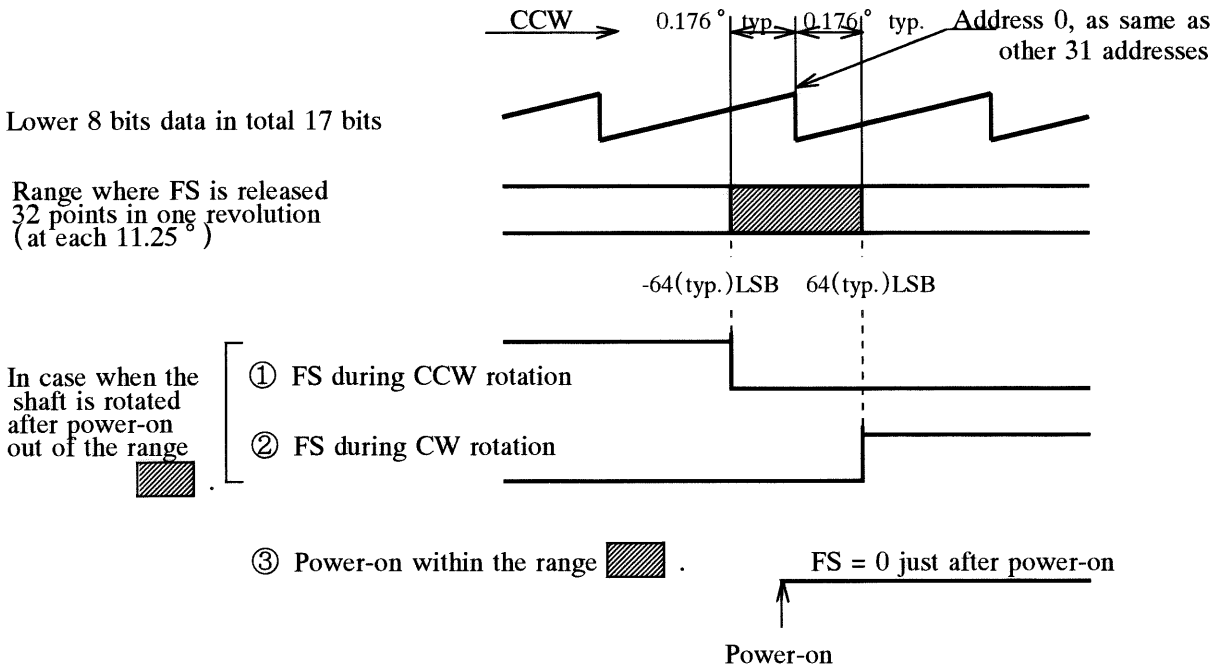


Fig. 3 Range of changing point of Full Absolute Status ②

Note: Fig. 3 shows the enlargement for one of the range of Table 1. In this figure,

① shows the changing status of SF during CCW rotation

② shows the changing status of FS during CW rotation

③ shows the changing status of FS in case of power-on at the shaft position within the range shown in Table 1.

Rotational speed at power-on \ The rotational speed till the first changing point of Full Absolute Status after power-on		100 min^{-1} or less	More than 100 min^{-1}
100 min^{-1} or less	Accuracy	5 bits → 17 bits	5 bits → 5 bits
	Transition of Full Absolute Status	"1" → "0"	"1" → "1"
More than 100 min^{-1}	Accuracy	5 bits → 17 bits	5 bits → 5 bits
	Transition of Full Absolute Status	"1" → "0"	"1" → "1"

Table 2 Accuracy of Absolute Data at Power-ON

(Absolute data ABSA)

Note: In case when power is turned on at the shaft position out of the range shown in Table 1.

参考出図

6. Specification for Serial Communication

6.1 General Specification

Item	Specification	Remarks
Communication code	Binary code	— —
Transmitting circuit	Differential line driver	Equivalent to RS 485
Receiving circuit	Differential line receiver	Equivalent to RS 485
Transmission data	Absolute data ABSA	17 bits
	Incremental data ABSS	17 bits
	Status flag	(1) Full Absolute Status (2) Counting Error
Synchronizing method	Base band NRZ	— —
Transmission rate	2.5 Mbps	— —
Flame format	See details in & after para. 6.2	— —

6.1.1 Specification of E^2PROM

Item	Specification	Remarks
Available address to be accessed	0 ~ 79	All data is "0" at shipping.
Allowable times to rewrite	Total 100,000 times	1 writing for each access

6.2 Frame Format

6.2.1 Data Readout from FA-CODER

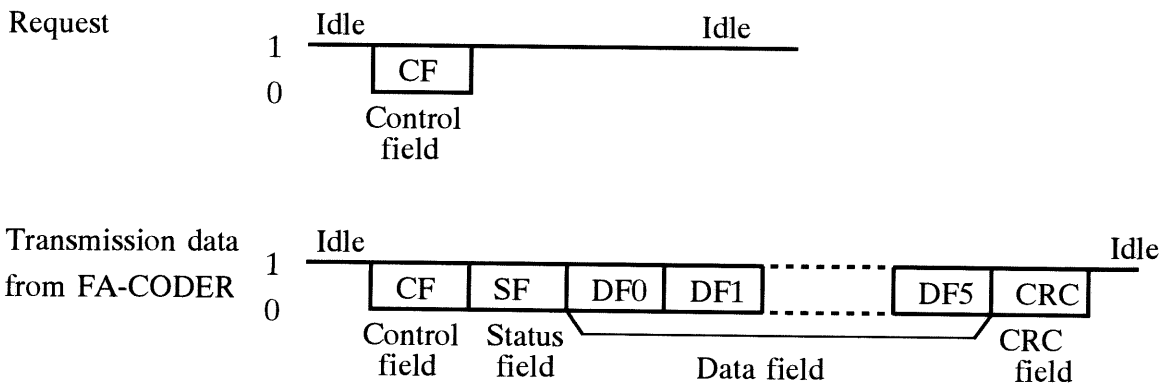
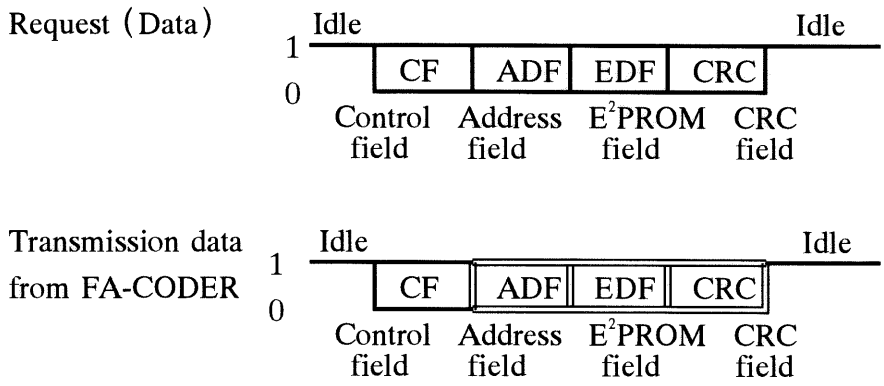


Fig. 4 Frame Format for Reading-out FA-CODER Data

6.2.2 Access (Writing) to E²PROM

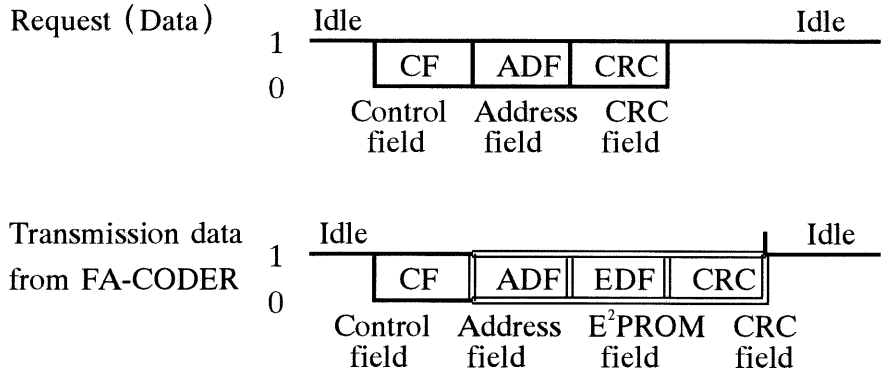


means the field that changes its information depending on the request

CF is transmitted as the same content of its request.

Fig. 5 Frame Format for Writing to FA-CODER

6.2.3 Access (Readout) from E²PROM



means the field that changes its information depending on the request.

CF is transmitted as the same content of its request.

Fig. 6 Frame Format for Readout from FA-CODER

6.3 Details of Each Field

6.3.1 Control Field (CF)

The structure of Control field is shown in Fig. 7.

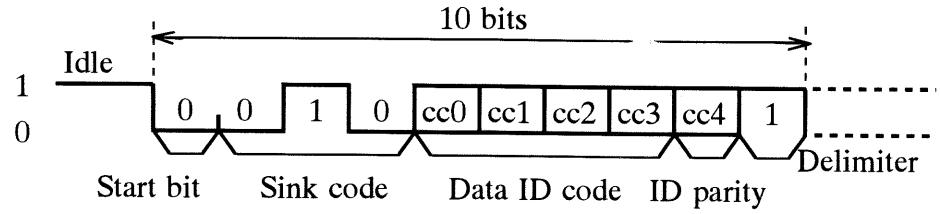


Fig. 7 Structure of Control Field

(1) Start bit : Fixed.
(2) Sink code : Fixed.
(3) Data ID code : By means of designating one of Data ID code shown in Table 3, the data shown in Table 4 is transmitted from FA-CODER.

Designate the Data ID code according to the application shown in Table 3. For example, never use Data ID code for Reset instead of Data ID code for Readout.

(4) ID parity : It is a Parity for Data ID code.
(5) Delimiter : Fixed.

Table 3 List of Data ID Code

Application	Data ID	Code				Parity
		cc0	cc1	cc2	cc3	cc4
Data readout	Data ID 0	0	0	0	0	0
	Data ID 2	0	1	0	0	1
	Data ID 3	1	1	0	0	0
Writing to E^2PROM	Data ID 6	0	1	1	0	0
Readout from E^2PROM	Data ID D	1	0	1	1	1
Reset	Data ID 8	0	0	0	1	1

6.3.2 Status Field (SF)

The structure of Status field is shown in Fig. 8.

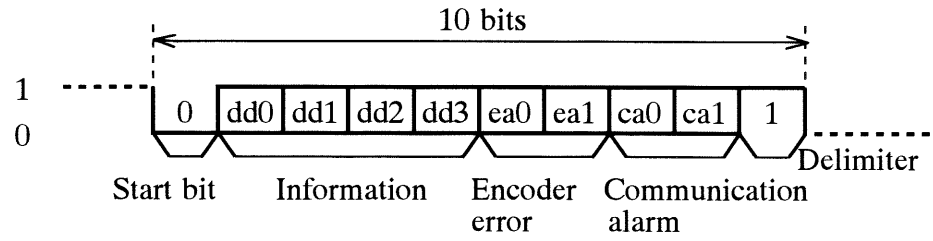


Fig. 8 Structure of Status Field

(1) Start bit : Fixed.
(2) Information : All are fixed to "0".
(3) Encoder error : Logic "1" is transmitted when each error is occurred in FA-CODER.

Bit	ea0	ea1
Logic when the error is occurred	1	1
Description of error	Counting error	Full absolute status

(4) Communication alarm : Logic "1" is transmitted when each error is occurred in FA-CODER.

Bit	ca0	ca1
Logic when the error is occurred	1	1
Description of error	Parity error in Request frame is occurred. Parity bit in Request Frame is located at cc4 of Data ID code.	Delimiter error in Request frame is occurred.

When the Communication alarm is occurred, the received data should be invalid without fail, and transmit the same Request signal again. When the Communication alarm is occurred, the data of Data ID 3 is transmitted from FA-CODER in spite of any kind of Transmission request.

(5) Delimiter : Fixed.

6.3.3 Data Field (DF0 ~ DF5)

The relation between Data ID code and Data field is shown in Table 4.

Table 4 List of Data Field

Data ID code	DF0	DF1	DF2	DF3	DF4	DF5	DF6	DF7
Data ID 0	ABSA0	ABSA1	ABSA2					
Data ID 2	ENID							
Data ID 3	ABSA0	ABSA1	ABSA2	ENID	ABSS0	ABSS1	ABSS2	ALMC
Data ID 8	ABSA0	ABSA1	ABSA2					

Note: Blank in above table means no data to be transmitted.

ABSA0 ~ ABSA2 : Absolute data in one revolution.

ABSA0 is located to lower bite and ABSA2 is located to higher bite in total 24 bits frame. Higher 7 bits in ABSA2 is always "0", then the valid data consists of total 17 bits.

ABSS0 ~ ABSS2 : Incremental data in one revolution.

It is the integrated value corresponding to the rotational angle of shaft regardless ABSA0 ~ ABSA2.

ABSS0 is located to lower bite and ABSS2 is located to higher bite in the frame of all channels. Higher 7 bits of ABSS2 is always "0", then the valid data consists of total 17 bits.

(The relation between ABSA and ABSS is according to Fig. 2.)

ENID : Encoder ID (Written at shipping. 8 bits: "0")

ALMC : Encoder error (See Table 5.)

Table 5 ALMC

Bit	d_{70}	d_{71}	d_{72}	d_{73}	d_{74}	d_{75}	d_{76}	d_{77}
Logic when the error is occurred	—	1	1	—	—	—	—	—
Name & its symbol	"0"	Full Absolute Status	Counting Error	"0"	"0"	"0"	"0"	"0"
		FS	CE					

The structure of each Data field is shown in Fig. 9.

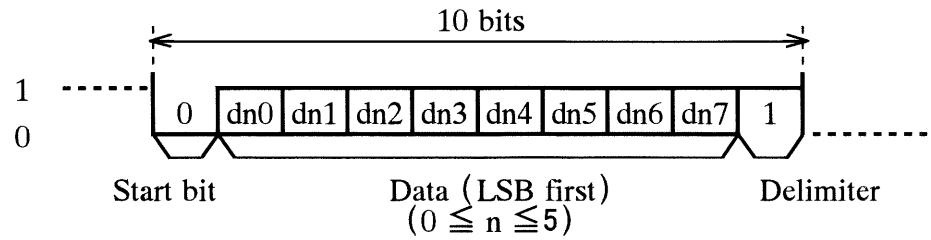


Fig. 9 Structure of Data Field

(1) Start bit : Fixed.
(2) Data : Arranged with LSB first.
(3) Delimiter : Fixed.

6.3.4 CRC Field (CRC)

The structure of CRC field is shown in Fig. 10.

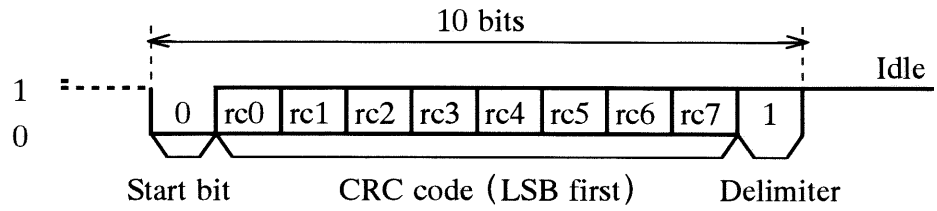


Fig. 10 Structure of CRC Field

(1) Start bit : Fixed.

(2) CRC code : This code conforms with the equation of $G(X)=X^8+1$ (X = rc0 ~ rc7).
The data is arranged in LSB first.
The code is calculated from all bits without Start bit and Delimiter, of all fields except CRC field.

(3) Delimiter : Fixed.

6.3.5 Address Field (ADF) and E²PROM Field (EDF)

The structure of ADF field is shown in Fig. 11.

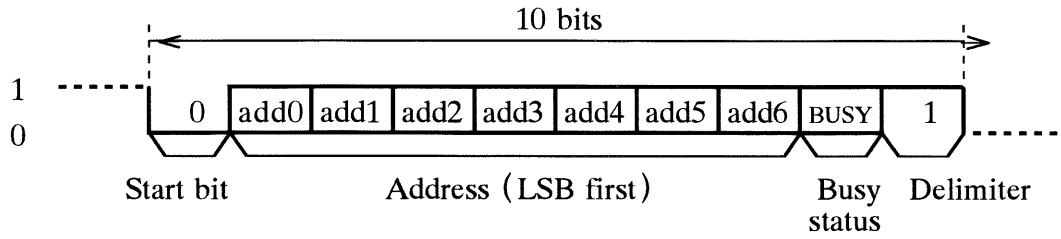


Fig. 11 Structure of ADF Field

(1) Start bit : Fixed.

(2) Address : Address of E²PROM (0 ~ 79). LSB is first.

(3) Busy status : Accessing state to E²PROM can be checked by Busy status. The relation between Busy status and the data transmitted from FA-CODER is shown in Table 6.

Table 6 Busy Status and Data transmitted

	Request	Transmission data from FA-CODER			Description
		ADF		EDF	
	Busy	Busy	Address		
Read-out	0	0	Address of the Request	Proper Data of E²PROM	Readout is properly completed.
		1	Address of the Request	00 [HEX]	Writing is in practice, and any request for Readout is invalid.
Writ-ing	0	0	Address of the Request	EDF of Request	Request for Writing is accepted.
		1	Address of the Request	00 [HEX]	Writing is in practice. and any request for Writing is invalid.

When the logic of Busy status in the data transmitted from FA-CODER is "1", Writing is in practice. Writing by Request cannot be performed.

In order to confirm that Writing to E²PROM is properly completed, transmit the Readout request (Data ID D), because it is not possible to confirm by the response of Readout request (Data ID 6).

(4) Delimiter: Fixed.

(5) EDF: 8 bits data (LSB first)

The structure of Data field is equivalent to Fig. 9.

6.4 Description of Status Flag

Name	Function	Action
Full Absolute Status FS (Not latched)	Logic "1" is transmitted, just after power supply is turned on at the shaft position out of the range of changing point of Full Absolute Status shown in Table 1. When the shaft of FA-CODER is rotated to the angle of maximum 11.25 ° at the rotational speed of 100 min^{-1} or less, the flag is automatically released and logic "0" is transmitted. But in case of rotating at more than 100 min^{-1}, the flag is not released automatically. Logic "0" is transmitted, in case where power supply is turned on at the shaft position within the range of changing point of Full Absolute Status shown in Table 1. The accuracy of one revolution data ABSA is 5 bits while logic "1" is trnasmitted and 17 bits while logic "0" is transmitted.	Make the rotational speed slow down to less than 100 min^{-1}, and rotate the shaft of FA-CODER by max. 11.25 ° to release the flag automatically.
Counting Error CE (Not latched)	Logic "1" is transmitted when the absolute data in one revolution is wrong because of any malfunction or defect during power-on. Because the error is detected at each mechanical angle of 45 °, this flag means that the error of more than ± 22.5 ° (typ.) for the absolute data in one revolution or the incremental data in one revolution may be occurred. The flag is automatically released for each 45 ° by returning the deviation of mechanical angle within ± 22.5 ° (typ.).	Stop the servo system immediately. Error status is released automatically. Turn off and on the power supply.

7. Detecting Data Readout Frame

7.1 Detection of Starting Frame

In the Control field (CF) the first logic "0" after the idle is detected as starting of frame, and if the following 3 bits are conformed with Sink code, it is judged as a true Starting frame. If they are not conformed with Sink code, it continues to search and detect another first logic "0".

The Data frame is transmitted at 3 μ seconds (typ.) after receiving the Delimiter signal of Request frame.

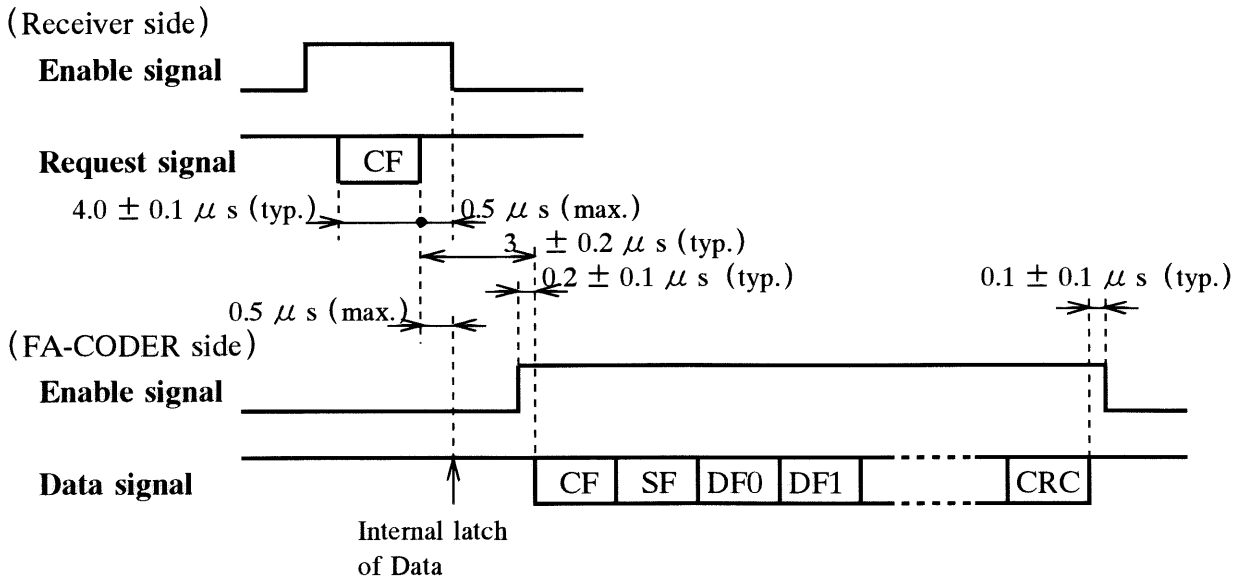


Fig. 12 Detection of Frame

7.2 End of Frame

After the Starting frame is detected, if there is no Start bit after the Delimiter, End of Frame is judged. Therefore there is no field that means the end of frame.

7.3 Idle

Idle means a space between each frame and its next frame. The logic of output in transmission side is fixed to "1".

7.4 Transmission Data at Abnormal Request

When any received Request is abnormal, the transmission data from FA-CODER is shown in Table 7.

Table 7 Transmission Data at Abnormal Request

No.	Condition	Transmission Data
1	Logic of Sink code is abnormal.	Data is not transmitted.
2	Data ID code is not 0, 1, 2, 3 or 8.	The data as same as Data ID 3 is transmitted. (See Table 4)
3	Logic of Parity is abnormal.	
4	Logic of Delimiter is abnormal.	

8. Detecting Access Frame to E²PROM

8.1 Detection of Start Frame

The first logic "0" after the idle is detected as starting of frame, and if the following 3 bits are conformed with Sink code, it is judged as a true Starting frame. If they are not conformed with Sink code, it continues to search and detect another first logic "0".

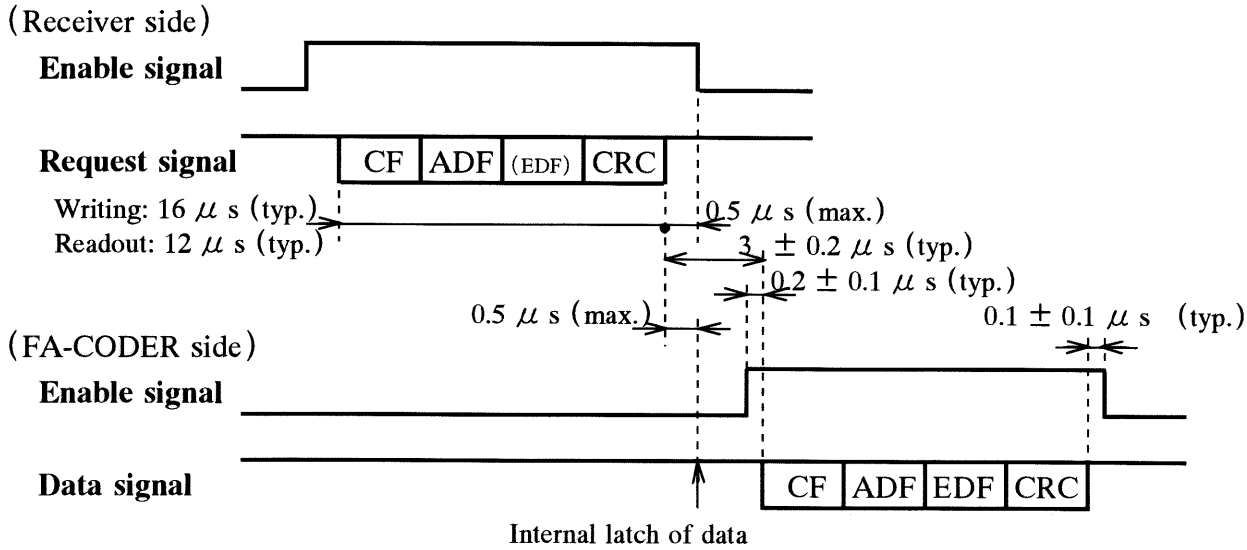


Fig. 13 Detection of Frame

* FA-CODER starts to transmit the response data at 3 μ s (typ.) after it receives a Access request to E²PROM (Data ID 6, D). Note that the response data for Writing request (Data ID 6) means only to receive a Data ID 6 but not to complete its writing process. (The completion of writing data to E²PROM is at 18 ms max. after receiving its Request.)

8.2 End of Frame

After the Starting frame is detected, if there is no Start bit after the Delimiter, End of Frame is judged. Therefore there is no field that means the end of frame.

8.3 Idle

Idle means a space between each frame and its next frame. The logic of output in transmission side is fixed to "1".

8.4 Transmission Data at Abnormal Request

When any received Request is abnormal, the transmission data from FA-CODER is shown in Table 8.

Table 8 Transmission Data at Abnormal Request

No.	Condition	Transmission Data
1	Logic of Sink code is abnormal.	Data is not transmitted.
2	Address area not to be open for user is designated.	The data as same as Data ID 3 is transmitted. (See Table 4)
3	Data ID code is not 6 or D.	
4	Logic of Parity is abnormal.	
5	Logic of Delimiter is abnormal.	
6	Logic of CRC is abnormal.	

9. Note for Transmission Request

Function	Data ID	Description
Readout of data	0, 2, 3	Transmit Data ID code (Table 3) based on the List of Data Field (Table 4) to FA-CODER. Because the receiver IC conformed with RS-485 is used in FA-CODER, transmit by the driver IC that is conformed with RS-485 (for example, ADM485) or equivalent.
Resetting one revolution data	8	Transmit 10 times in one sequence to FA-CODER with the interval of 40 μ s or more at stationary of the shaft. (※) One revolution data is reset at $0 \pm 0.35°$ (max.) in mechanical angle position. The angle position that is reset once is kept even after the power supply is turned off.
Access to E^2PROM	6	"User Data" of 8 bits can be written to the address designated. It is recommended to confirm that the writing was properly performed by means of designating "Data ID D". (For confirming the data, it is not needed to turn off and on the power supply.)
	D	"User Data" of 8 bits can be read out from the address designated. Regarding the transmission method for Readout request, refer to para. 6.2.3 and 6.3.5.

Note (※) : FA-CODER transmits the response data described in Table 4 at the time when each Request is received. However any error information in the response data is not reset until Reset is executed.

For resetting one revolution data, it takes maximum 18 ms until the Reset is executed after Request data ID 8 is received 10 times, because the writing process to E^2PROM should be carried out.

10. Circuit Diagram of Transmitter and Receiver

An example of circuit diagram of the transmitter and receiver is shown in Fig. 14.

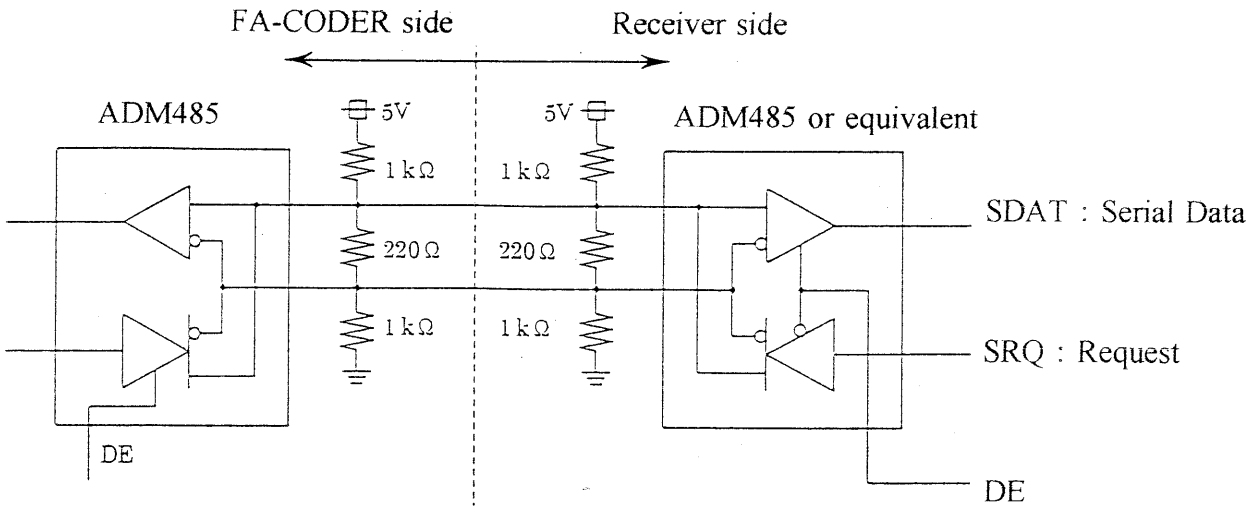


Fig. 14 Example of Transmitter and Receiver Circuit

Never transmit any Request to FA-CODER while FA-CODER transmits the data. The interface circuit of FA-CODER may be broken down if any Request is transmitted to FA-CODER by mistake during this period.

FA-CODER is always receiving mode except it is transmitting data.

11. Guarantee of Products

Guaranteed term of these products without payment is within one year after delivery, except the case of defect or worse quality caused by disassembling, changing, re-assembling, mis-using, or other intention or fault by customer.

However we, Tamagawa Seiki Co., Ltd., could continue to maintain the products properly even after above guaranteed term to keep performances of the products with payment by request.

The predicted Mean Time Before Failure (MTBF) of these products will be enough long, but the failure rate is not zero. Therefore we would request the customers of these instruments that the customer should assume all troubles resulted when the products may be failed, and put some multiple measures for them into the customer's systems and/or products for avoiding to extend to a serious system failure.