Upgrading Note
PCA82C250/251 ➔ TJA1040, TJA1050

V1.0

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Summary

From a functional point of view the TJA1040 is the direct successor of the PCA82C250/251. Both transceivers provide a Standby Mode with remote wake-up capability via the bus. However, the standby current of the TJA1040 (max. 15μA) has been significantly reduced compared to the C250/251 (max. 170μA). Due to functional and pinning compatibility the C250/251 can be easily replaced with the TJA1040 within existing applications. The TJA1050 is similar to the TJA1040, but it does not offer a dedicated Standby Mode. Thus, for applications not requiring a Standby Mode, the TJA1050 is the first choice when replacing the C250/251.

The C250/251, TJA1050 and TJA1040 (also TJA1041) are compliant to ISO11898. This ensures interoperability between the transceivers, allowing a gradually migration from the C250/251 to the TJA1050 or TJA1040.

This report describes all items to be taken into account, when an existing application using the C250/251 should be upgraded towards the TJA1050 or TJA1040.

Revision History

Version	Remarks
V1.0	Initial version

Contents

1. INTRODUCTION

The TJA1040, like the TJA1050 and C250/251, is an ISO11898 compliant CAN High-Speed transceiver for use in automotive and industrial applications.

The TJA1050 is designed to offer the latest achievements in terms of EMC. It is processed in the advanced Silicon-on-Insulator (SOI) technology. As a result the TJA1050 shows an improvement of about 20dB in emission compared to the C250/251 (using split termination). The TJA1050 mainly focuses on typical "clamp-15" applications, which are left un-powered during ignition-off. Accordingly, the TJA1050 does not provide a Standby Mode. Special attention was paid on achieving passive behaviour in un-powered condition.

The TJA1040 bases on the design of the TJA1050. Employing the same SOI technology the TJA1040 shows the same excellent EMC performance as the TJA1050. The main difference is that the TJA1040 provides a Standby Mode with remote wake-up capability via the bus as known from the C250/251. Thus, the TJA1040 can be regarded as the functional successor of the C250/251. Moreover, the TJA1040 is compatible to the C250/251 with both transceivers featuring the same pinning and functionality. This allows easy replacing of the C250/251 by the TJA1040. Especially the TJA1040 offers for the first time ideal passive behaviour when un-powered.

The TJA1040 has several advantages compared to the C250/251:

- Completely passive to the bus if un-powered (not visible to the bus if Vcc is off)
- Very low current consumption in Standby Mode (max. 15µA)
- Improved electromagnetic emission (EME) performance
- Improved electromagnetic immunity (EMI) performance
- "SPLIT" pin (replacing "Vref" pin) for effective DC stabilization of the bus

The TJA1040 is designed to be downward compatible to the C250/251 and can be used in most existent C250/251 applications without any changes in hardware and software. The following chapters discuss all issues concerning the migration from the C250/251 to the TJA1040 or TJA1050.

2. DIFFERENCES BETWEEN C250/251, TJA1050, TJA1040

Table 2.1 lists the main differences between the C250/251, TJA1050 and TJA1040 from an application point of view.

Feature	PCA82C250	PCA82C251	TJA1050	TJA1040
Supply voltage range	4.5-5.5V	4.5-5.5V	4.75-5.25V	4.75-5.25V
Max. DC voltage at Bus pins (6,7)	-8V … +18V	-36V … +36V	-27V … +40V	-27V … +40V
Loop Delay (TXD→RXD) (dom.→ rec.)	(Rs=0) 190ns (Rs=24k) 320ns	(Rs=0) 190ns	250ns	255ns
Standby Mode with remote wake-up	< 170µA	< 275µA	Not supported	< 15µA
Slope Control	Variable	Variable	EMC optimized	EMC optimized
Passive behaviour if un-powered (Leakage current of bus pins for Vcc=0V)	< 1mA ($V_{CANH/L}$=7V)	< 2mA ($V_{CANH/L}$=7V)	< 250µA ($V_{CANH/L}$=5V)	0µA ($V_{CANH/L}$=5V)
DC Stabilization of common mode voltage	No	No	No	Yes

Table 2.1: Main differences between C250/251, TJA1050, TJA1040 ([1] [2] [3] [4])

3. PINNING

Figure 3.1 shows the pinning of the C250/251, TJA1050 and TJA1040. Apart from renaming two pins the pinning of the three transceivers is identical.

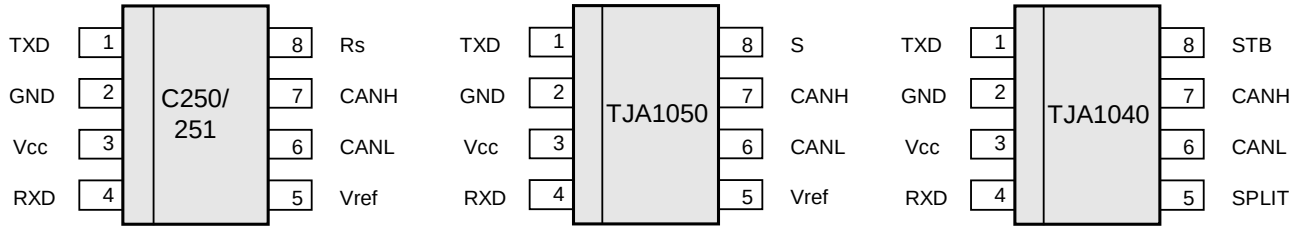


Figure 3.1: Pinning of the C250/251, TJA1050 and TJA1040

3.1 Mode Control Pin (pin 8)

Pin 8 of the transceiver is used to control the operation mode. Its symbol is "STB" for the TJA1040 referring to the Standby Mode, "Rs" for the C250/251 referring to the slope control resistor and "S" for the TJA1050 referring to the Silent Mode. Although there are different symbols, the mode control is the same, that means the Normal or Highspeed Mode is selected with a LOW signal at pin 8. Applying a HIGH signal the transceivers would enter its Standby (C250/251, TJA1040) or Silent Mode (TJA1050).

3.2 Voltage Reference Pin (pin 5)

Pin 5 of the transceivers provides an output voltage of Vcc/2. In case of the C250/251 and TJA1050 the pin 5 is attributed the symbol "Vref". The purpose of the pin "Vref" was to provide a voltage reference for former analog comparators within CAN-controller to properly read the bit values on the bus. Nowadays a CAN-controller usually has a digital input for the RXD signal and the pin "Vref" has become obsolete.

In case of the TJA1040 the pin 5 is attributed the symbol "SPLIT". The function of the pin is to provide a voltage source of Vcc/2. The relatively low impedance (typ. 600Ω) of the source allows stabilizing the common mode voltage to nominal Vcc/2. For that purpose the pin "SPLIT" should be connected to the center tap of the split termination. This way the common mode voltage can be maintained to nearly nominal Vcc/2 even if there are significant leakage currents flowing from the bus to GND due to possibly unpowered nodes.

4. OPERATION MODES

As mentioned before the operation mode of the transceivers is controlled via the pin 8. Table 4.1 gives an overview of the operation modes along with the provided features and the corresponding settings on pin 8.

Operation Mode	Provided Features of Operation Mode	Signal level at Pin 8		
		TJA1040	C250/251	TJA1050
Normal (Highspeed)	- Transmit capability - Receive capability	LOW	LOW or unconnected	LOW or unconnected
Standby	- Reduced current - remote wake-up - "Babbling Idiot" protection	HIGH or unconnected	HIGH	Not implemented
Slope Control	- variable slope	Not needed	GND via 10k<Rs<180k	Not needed
Silent	- "Babbling Idiot" protection - "Receive-Only" behaviour	Not implemented	Not implemented	HIGH

Table 4.1: Operation Modes with their corresponding settings on pin 8

Following chapters give a short description of the different operation modes along with their provided functionality. It turns out that the TJA1040 essentially provides the same functionality as the C250/251.

Due to the excellent CAN signal symmetry both the TJA1050 and TJA1040 do not need a dedicated Slope Control Mode.

4.1 Normal/Highspeed Mode

The Normal (Highspeed) Mode is the same for all transceivers considered here. It is used for normal CAN communication. The digital bit stream, input at TXD, is transferred into corresponding analog bus signals. Simultaneously the transceiver monitors the bus, converting the analog bus signals into the corresponding digital bit stream, output at RXD.

4.2 Standby Mode

Both the C250/251 and the TJA1040 offer a dedicated Standby Mode. In this mode the current consumption is reduced to a minimum (e.g. <15µA max. for the TJA1040 and <170µA max. for the C250). A dedicated low-power receiver ensures remote wake-up capability via the bus. The transmitter of the TJA1040 and C250/251 is completely disabled in Standby Mode regardless of the signal on TXD. This way the TJA1040 and C250/251 provides silent behaviour necessary to cope with "babbling idiot" nodes. The main difference between the TJA1040 and the C250/251 in this mode concerns the bus bias. While the C250/251 maintains a bus bias of Vcc/2, the TJA1040 pulls the bus weakly to GND. This allows very low current consumption for the TJA1040 during low-power operation.

4.3 Slope Control Mode

The Slope Control Mode is provided by the C250/251 only. A resistor connected between the Rs pin and GND level is used to adjust the slope. Due to the excellent symmetry performance, the TJA1050 and TJA1040 do not need a slope control. They both feature a fixed slope, adjusted to optimize the EMC performance and to minimize the loop delay. Even with the fixed slope EMC measurements revealed an improvement of about 20dB in emission over the C250/251. Thus the TJA1040 and TJA1050 offer the possibility to get rid of the common mode choke.

4.4 Silent Mode

The TJA1050 provides a dedicated Silent Mode, in which the transmitter is completely disabled, thus making sure that no signal can be driven from TXD to the bus lines. As with the TJA1040 in its Standby Mode this silent behaviour can be used to establish a "babbling idiot" protection. In Silent Mode the receiver keeps active, thus implementing a "Receive-Only" behaviour.

5. TARGET APPLICATIONS FOR THE TJA1050 AND TJA1040/1041

Application of CAN High-Speed focuses on the powertrain bus. Here increasing power management requirements established a kind of partial networking. During ignition-off (when the engine is off) one part of the network is left un-powered by the "Clamp-15" supply line, while the other part keeps powered all the time by the so-called "Clamp-30". Thus "Clamp-30" nodes need the possibility to minimize the current consumption. Otherwise they would discharge the battery within a short time. Nodes switched off completely during ignition-off must behave passive towards the remaining bus as far as possible.

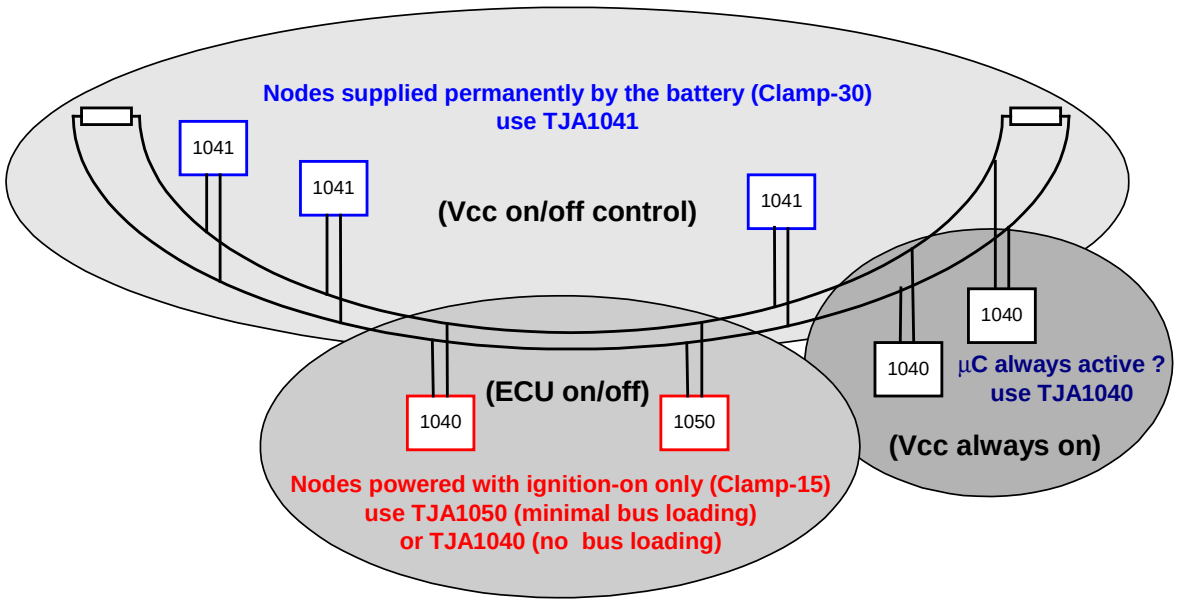


Figure 5.1: Target applications for the TJA1050 and TJA1040/1041

The TJA1041, capable of controlling the ECU voltage regulator(s) via the pin INH, focuses on applications, which are supplied permanently by the battery. Its power management allows reducing the current consumption of the whole ECU to max. 30µA, making use of an INH-controlled ECU voltage regulator. For applications, which need the microcontroller and Vcc being always active, the TJA1040 is preferred due to its very low-current Standby Mode (< 15µA). Both the TJA1040 and TJA1041 provide remote wake-up capability via the bus.

For clamp-15 nodes, which are left un-powered during ignition-off, the TJA1050 or the TJA1040 are preferred. Their passive behaviour in un-powered state ensures that the remaining bus will not be degraded. With the TJA1040 there is even no bus loading.

6. INTEROPERABILITY

Since the C250/251, TJA1050 and TJA1040, TJA1041 are compatible with the ISO11898 standard, interoperability during normal operation is guaranteed. There is one issue related to the different bus biasing behaviour during low-power operation, which shall be considered in more detail. Table 6.1 shows the bus biasing in the different operation modes as well as in un-powered condition. Whenever there is a difference in the bus biasing, a steady biasing compensation current will flow within the system. The common mode input resistance mainly defines the amount of compensation current. This is shown in Figure 6.1 for a bus in recessive state containing TJA1040 and C250 nodes. Due to the big common mode input resistance CAN communication is not affected in case parts of the network are still within low-power mode, while other nodes have already started communication. However, degradation of the emission performance is expected.

Condition	C250/251		TJA1050		TJA1040	
	Mode	Bus Bias	Mode	Bus Bias	Mode	Bus Bias
LOW (pin 8)	Normal	Vcc/2	Normal	Vcc/2	Normal	Vcc/2
HIGH (pin 8)	Standby	Vcc/2	Silent	Vcc/2	Standby	GND
Unconnected (pin 8)	Normal	Vcc/2	Normal	Vcc/2	Standby	GND
Unpowered	---	GND	---	GND	---	floating

Table 6.1: Bus biasing depending on operation mode

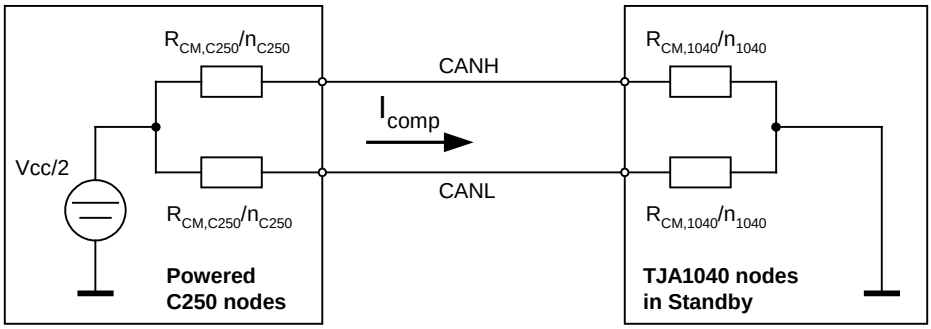


Figure 6.1: Equivalent bus circuit for a mixed system of TJA1040 nodes in Standby Mode and powered C250 nodes (in Standby or Normal Mode)

The following formula allows calculation of the whole biasing compensation current in a mixed system of TJA1040 and C250 nodes.

$$I_{comp,\max} = \frac{Vcc/2}{R_{CM}(C250)/2n_{C250} + R_{CM}(TJA1040)/2n_{TJA1040}}$$

with n_{C250}: number of nodes of powered C250

$n_{TJA1040}$: number of nodes of TJA1040 in Standby/Sleep Mode

$R_{CM,\min}(C250)$=5k: min. common mode input resistance of C250 at pin CANH/L

$R_{CM,\min}(TJA1040)$=15k: min. common mode input resistance of TJA1040 at pin CANH/L

6.1 TJA1040 mixed with C250/C251/TJA1050

Table 6.2 identifies the conditions leading to different bus biasing and thus compensation current. There is some compensation current in case TJA1040 nodes are in Normal (Highspeed) Mode, while other C250/C251/TJA1050 nodes are left un-powered. Moreover, compensation current occurs when TJA1040 nodes are in Standby Mode, while other C250/C251/TJA1050 nodes are kept powered in any operation mode. **Despite some compensation current flowing in this case the current saving effect using the Standby Mode of the TJA1040 is higher than using the Standby Mode of the C250/251.** The lowest current consumption in such a mixed system will be achieved when the C250/C251/TJA1050 nodes are left un-powered while the TJA1040 nodes are in Standby Mode.

C250/251 1050 / TJA1040	All Modes	Unpowered
Normal/Highspeed	--	X
Standby	X	--
Unpowered	--	--

Table 6.2: Conditions leading to bus biasing compensation current
X : biasing compensation currents
-- : no biasing compensation currents

6.2 TJA1040 mixed with TJA1041 nodes

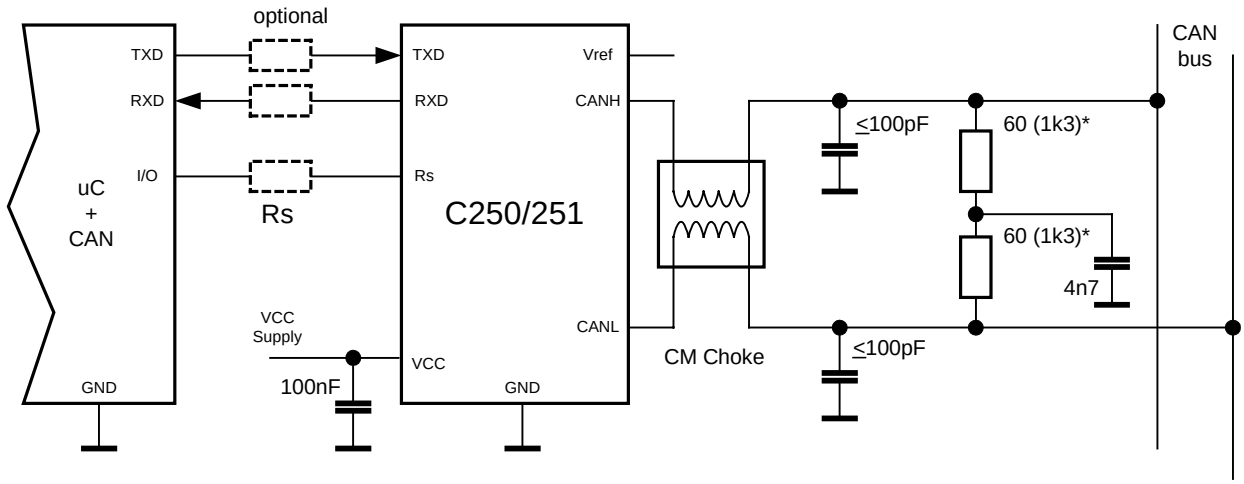
Table 6.3 reveals that in a mixed system of TJA1040 and TJA1041 nodes it is not expected to have situations of different bus biasing. In the low-power modes both the TJA1040 and TJA1041 show a weak termination to GND. Thus when the bus is in power-down with all nodes either in Standby or Sleep Mode, there will be no biasing compensation currents. During normal CAN operation, when all nodes are into Normal (Highspeed) or Pwon/Listen-Only mode for diagnosis features, the bus is collectively biased to Vcc/2. There will be no biasing compensation current.

TJA1041 / TJA1040	Normal/ Highspeed	Pwon/ Listen-Only	Standby	Sleep	Unpowered
Normal/Highspeed	--	--	X	X	X
Standby	X	X	--	--	--
Unpowered	--	--	--	--	--

Table 6.3: Combinations of operation modes of the TJA1040 and TJA1041
X : biasing compensation currents
-- : no biasing compensation currents

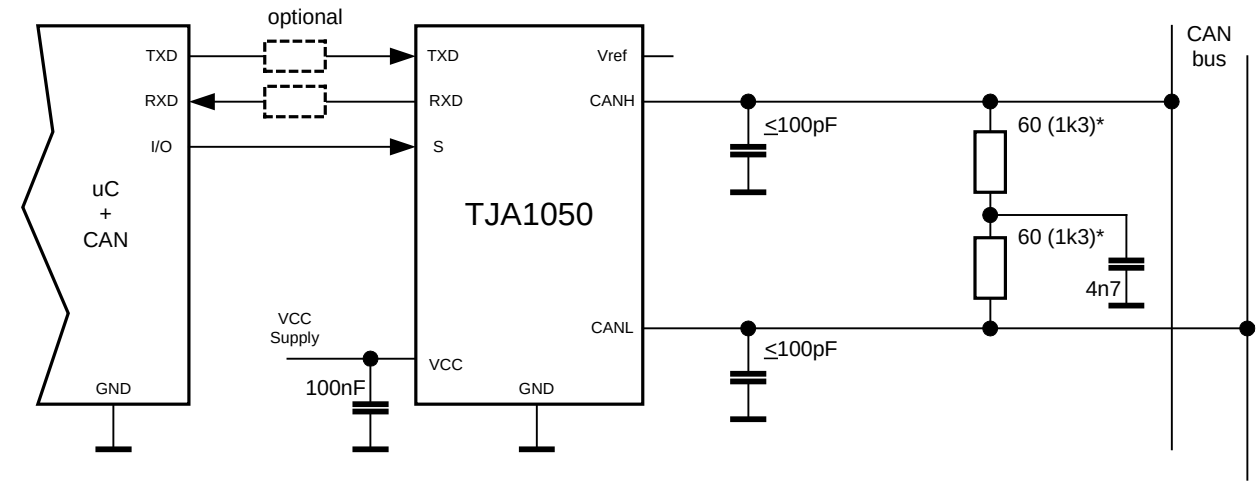
7. HARDWARE ISSUES

Figure 7.1 and Figure 7.2 show a typical application circuit for the C250/251 and TJA1050, respectively. Figure 7.3 shows the equivalent circuit for the TJA1040.



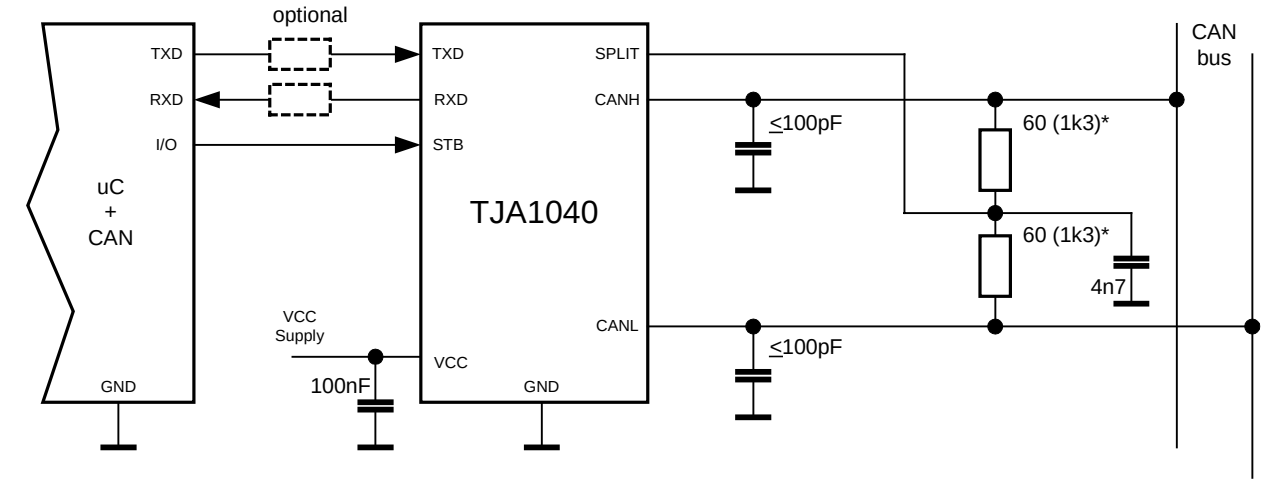
* For stub nodes a "weak" termination improves the EMC behaviour of the system in terms of emission.

Figure 7.1: Typical application circuit for the C250/251



* For stub nodes a "weak" termination improves the EMC behaviour of the system in terms of emission.

Figure 7.2: Typical application circuit for the TJA1050



* For stub nodes a "weak" termination improves the EMC behaviour of the system in terms of emission.

Figure 7.3: Typical application circuit for the TJA1040

7.1 Hardware Check-List C250/251 → TJA1050

Comparing the application circuits in Figure 7.1 and Figure 7.2, the following things have to be checked when replacing the C250/251 by the TJA1050:

- If the mode control pin 8 of the C250 was applied with a slope control resistor Rs for slope control, this resistor must be removed. The corresponding pin of the TJA1040 (pin "STB") should be directly connected to an output port of the microcontroller.
- Due to the excellent symmetry performance, the TJA1050 does not necessarily need a common mode choke. However, the split termination is highly recommended as it ensures lowest emission, especially in the AM-band.

7.2 Hardware Check-List C250/251 → TJA1040

Comparing the application circuits in Figure 7.1 and Figure 7.3, the following things have to be checked when replacing the C250/251 by the TJA1040:

- If the pin "SPLIT" should be used for DC stabilization of the common mode voltage, the pin "SPLIT" (corresponds to pin "Vref" of C250/251) is connected to the center tap of the split termination. The pin "SPLIT" can simply be left open if not used.
- If the mode control pin 8 of the C250 was applied with a slope control resistor Rs for slope control, this resistor must be removed. The corresponding pin of the TJA1040 (pin "STB") should be directly connected to an output port of the microcontroller.
- The TJA1040 does not necessarily need a common mode choke. The split termination is highly recommended as it ensures lowest emission, especially in the AM-band.

8. REFERENCES

[1] Data Sheet PCA82C250, CAN controller interface, Philips Semiconductors, 2000 Jan 13

[2] Data Sheet PCA82C251, CAN controller interface, Philips Semiconductors, 2000 Jan 13

[3] Data Sheet TJA1050, High speed CAN transceiver, Philips Semiconductors, 2000 May 18

[4] Preliminary Data Sheet TJA1040, High speed CAN transceiver, Philips Semiconductors, 2001 Nov 12

[5] Preliminary Data Sheet TJA1041, High speed CAN transceiver, Philips Semiconductors, 2001 Nov 12